X

SUPPLEMENT

TO THE THIRD EDITION OF THE

ENCYCLOPÆDIA BRITANNICA,

OR, A

DICTIONARY

OF

ARTS, SCIENCES,

AND

MISCELLANEOUS LITERATURE.

IN TWO VOLUMES.

Illustrated with Fifty Copperplates.

By GEORGE GLEIG, LL. D. F. R. S. EDIN.

NON IGNORO, QUÆ BONA SINT, FIERI MELIORA POSSE DOCTRINA, ET QUÆ NON OPTIMA, ALIQUO MODO ACUI TAMEN, ET CORRIGI POSSE.—*CICERO.*

VOL. II.

Edinburgh:
PRINTED FOR THOMSON BONAR, PARLIAMENT-SQUARE;
BY *JOHN BROWN*, ANCHOR CLOSE, EDINBURGH.

1801.

SUPPLEMENT

TO THE

ENCYCLOPÆDIA BRITANNICA.

INCREMENT, is the ſmall increaſe of a variable quantity. Newton, in his Treatiſe on Fluxions, calls theſe by the name *Moments;* and obſerves, that they are proportional to the velocity or rate of increaſe of the flowing or variable quantities in an indefinitely ſmall time. He denotes them by ſubjoining a cypher o to the flowing quantity whoſe moment or increment it is; thus, xo the moment of x. In the doctrine of Increments, by Dr Brooke Taylor and Mr Emerſon, they are denoted by points below the variable quantities; as $\underset{\cdot}{x}$. Some have alſo denoted them by accents underneath the letter, as $\underset{'}{x}$; but it is now more uſual to expreſs them by accents over the ſame letter; as $\overset{'}{x}$.

METHOD OF INCREMENTS, a branch of Analytics, in which a calculus is founded on the properties of the ſucceſſive values of variable quantities, and their differences or increments.

The inventor of the method of increments was the learned Dr Taylor, who, in the year 1715, publiſhed a treatiſe upon it; and afterwards gave ſome farther account and explication of it in the Philoſ. Tranſ. as applied to the finding of the ſums of ſeries. And another ingenious and eaſy treatiſe on the ſame, was publiſhed by Mr Emerſon, in the year 1763. The method is nearly allied to Newton's Doctrine of Fluxions, and ariſes out of it. Alſo the Differential method of Mr Stirling, which he applies to the ſummation and interpolation of ſeries, is of the ſame nature as the method of increments, but not ſo general and extenſive.

INDETERMINATE PROBLEM. See ALGEBRA, Part I. Chap. VI. *Encycl.*

Diophantus was the firſt writer on indeterminate problems, which, after the publication of his work in 1621 by Bachet, employed much of the time of the moſt celebrated mathematicians in Europe. Afterwards ſuch problems were neglected as uſeleſs, till the public attention was again drawn to them by Euler and la Grange. The example of ſuch men was followed by Mr John Leſlie, a very eminent and ſelf-taught mathematician; who, in the ſecond vol. of the Tranſactions of the Royal Society of Edinburgh, has publiſhed an ingenious paper on indeterminate problems, reſolving them by a new and general principle. "The doctrine of indeterminate equations (ſays Mr Leſlie) has been ſeldom treated in a form equally ſyſtematic with the other parts of algebra. The ſolutions commonly given are devoid of uniformity, and often require a variety of aſſumptions. The object of this paper is to reſolve the complicated expreſſions which we obtain in the ſolution of indeterminate problems, into ſimple equations, and to do ſo, without framing a number of aſſumptions, by help of a ſingle principle, which, though extremely ſimple, admits of a very extenſive application.

"Let $A \times B$ be any compound quantity equal to another, $C \times D$, and let m be any rational number aſſumed at pleaſure; it is manifeſt that, taking equimultiples, $A \times m\,B = C \times m\,D$. If, therefore, we ſuppoſe that $A = mD$, it muſt follow that $mB = C$, or $B = \frac{C}{m}$. Thus two equations of a lower dimenſion are obtained. If theſe be capable of farther decompoſition, we may aſſume the multiples n and p, and form four equations ſtill more ſimple. By the repeated application of this principle, an higher equation, admitting of diviſors, will be reſolved into thoſe of the firſt order, the number of which will be one greater than that of the multiples aſſumed."

For example, reſuming the problem at firſt given, viz. to find two rational numbers, the difference of the ſquares of which ſhall be a given number. Let the given number be the product of a and b; then by hypotheſis, $x^2 - y^2 = ab$; but theſe compound quantities admit of an eaſy reſolution, for $\overline{x+y} \times \overline{x-y} = a \times b$. If, therefore, we ſuppoſe $x + y = ma$, we ſhall obtain $x - y = \frac{b}{m}$; where m is arbitrary, and if rational, x and y muſt alſo be rational. Hence the reſolution of theſe two equations gives the values of x and y, the numbers ſought, in terms of m; viz. $x = \frac{m^2a + b}{2m}$, and $y = \frac{m^2a - b}{2m}$.

INDUCTION, in logic, is that proceſs of the underſtanding by which, from a number of *particular* truths perceived by ſimple apprehenſion, and diligently compared together, we infer another truth which is always *general* and ſometimes *univerſal*. It is perhaps needleſs to obſerve, that in the proceſs of induction the truths to be compared muſt be of the ſame kind, or relate to objects having a ſimilar nature; for the mereſt tyro in ſcience knows that phyſical truths cannot be compared with moral truths, nor the truths of pure mathematics with either.

That the method of induction is a juſt logic, has been ſufficiently evinced elſewhere (ſee Logic, Part III. chap. V. and Philosophy, nº 73—78. *Encycl.*), and is now indeed generally admitted. It is even admitted by Britiſh philoſophers to be the only method of reaſoning by which any progreſs can be made in the phyſical ſciences; for the laws of Nature can be diſcovered only by accurate experiments, and by carefully noting the agreements and the differences, however minute, which are thus found among the phenomena apparently ſimilar. It is not, however, commonly ſaid that *induction* is the method of reaſoning employed by the mathematicians; and the writer of this article long thought, with others, that in pure geometry the reaſoning is ſtrictly *ſyllogiſtical*. Mature reflection, however, has led him to doubt, with Doctor Reid [*], the truth of the generally received opinion, to doubt even whether by categorical ſyllogiſms any thing whatever can be proved.

To the idolaters of Ariſtotle we are perfectly aware that this will appear an extravagant paradox; but to the votaries of truth, we do not deſpair of making it very evident, that for ſuch doubts there is ſome foundation.

We are led into this diſquiſition to counteract, in ſome degree, what we think the pernicious tendency of the philoſophy of Kant, which attempts have been lately made to introduce into this country. Of this philoſophy we ſhall endeavour to give ſomething like a diſtinct view in the proper place. It is ſufficient to obſerve here, that it reſts upon the hypotheſis, that "we are in poſſeſſion of certain notions *à priori*, which are abſolutely *independent of all experience*, although the *objects of experience* correſpond with them; and which are diſtinguiſhed by *neceſſity* and ſtrict *univerſality*." Theſe innate and univerſal notions, Kant conſiders as a ſet of *categories*, from which is to be deduced all ſuch knowledge as deſerves the name of ſcience; and he talks, of courſe, or at leaſt his Engliſh tranſlators repreſent him talking, with great contempt, of inductive reaſoning, and ſubſtituting ſyllogiſtic demonſtration in its ſtead.

As his categories are not familiar to our readers, we ſhall, in this place, examine ſyllogiſms connected with the categories of Ariſtotle, which are at leaſt more intelligible than thoſe of Kant, and which, being likewiſe general notions, muſt, in argument, be managed in the ſame way. Now the fundamental axiom upon which every categorical ſyllogiſm reſts, is the well known propoſition, which affirms, that "whatever may be predicated of a whole *genus*, may be predicated of every *ſpecies* and of every *individual* comprehended under that genus." This is indeed an undoubted truth; but it cannot conſtitute a foundation for reaſoning from the *genus* to the *ſpecies* or the *individual*; becauſe we cannot poſſibly know what can be predicated of the *genus* till we know what can be predicated of all the *individuals* ranged under it. Indeed it is only by aſcertaining, through the medium of induction, what can be predicated, and what not, of a number of individuals, that we come to form ſuch notions as thoſe of *genera* and *ſpecies*; and therefore, in a ſyllogiſm ſtrictly categorical, the propoſitions, which conſtitute the *premiſes*, and are taken for granted, are thoſe alone which are capable of proof; whilſt the concluſion, which the logician pretends to demonſtrate, muſt be evident to intuition or experience, otherwiſe the premiſes could not be known to be true. The analyſis of a few ſyllogiſms will make this apparent to every reader.

Dr Wallis, who, to an intimate acquaintance with the Ariſtotelian logic, added much mathematical and phyſical knowledge, gives the following ſyllogiſm as a perfect example of this mode of reaſoning in the firſt figure, to which it is known that all the other figures may be reduced:—

Omne animal eſt *ſenſu præditum.*
Socrates eſt *animal.* Ergo
Socrates eſt *ſenſu præditus.*

Here the propoſition to be demonſtrated is, that Socrates is endowed with ſenſe; and the propoſitions aſſumed as ſelf-evident truths, upon which the demonſtration is to be built, are, that "every animal is endowed with ſenſe;" and that "Socrates is an animal." But how comes the demonſtrator to know that "every animal is endowed with ſenſe?" To this queſtion we are not aware of any anſwer which can be given, except this, that mankind have agreed to call every being, which they perceive to be endowed with ſenſe, an *animal*. Let this, then, be ſuppoſed the true anſwer: the next queſtion to be put to the demonſtrator is, How he comes to know that *Socrates* is an *animal?* If we have anſwered the former queſtion properly, or, in other words, if it be eſſential to this genus of beings to be endowed with ſenſe, it is obvious that he can know that Socrates is an *animal* only by perceiving him to be *endowed with ſenſe;* and therefore, in this ſyllogiſm, the propoſition to be proved is the very firſt of the three of which the truth is perceived; and it is perceived intuitively, and not inferred from others by a proceſs of reaſoning.

Though there are ten categories and five predicables, there are but two kinds of categorical propoſitions, viz Thoſe in which the property or accident is predicated of the ſubſtance to which it belongs, and thoſe in which the *genus* is predicated of the *ſpecies* or *individual*. Of the former kind is the propoſition pretended to be proved by the ſyllogiſm which we have conſidered; of the latter, is that which is proved by the following:

Quicquid ſenſu præditum, eſt animal.
Socrates eſt ſenſu præditus. Ergo
Socrates eſt animal.

That this is a categorical ſyllogiſm, legitimate in mode and figure, will be denied by no man who is not an abſolute ſtranger to the very firſt principles of the Ariſtotelian logic; but it requires little attention indeed to perceive that it proves nothing. The impoſition of names is a thing ſo perfectly arbitrary, that the being, or claſs of beings, which in Latin and Engliſh is called *animal*, is with equal propriety in Greek called ζωον, and in Hebrew בפש. To a native of Greece, therefore, and to an ancient Hebrew, the major propoſition of this ſyllogiſm would have been wholly unintelligible; but had either of thoſe perſons been told by a man of known veracity, and acquainted with the Latin tongue, that every thing endowed with ſenſe was, by the Romans, called *animal*, he would then have underſtood the propoſition, admitted its truth without heſitation, and have

---

[*] Appendix to Vol. III of *Sketches of the Hiſtory of Man.*

henceforth known that Socrates and Moſes, and every thing elſe which he perceived to be endowed with ſenſe, would at Rome be called *animal*. This knowledge, however, would not have reſted upon demonſtrative reaſoning of any kind, but upon the credibility of his informer, and the intuitive evidence of his own ſenſes.

It will perhaps be ſaid, that the two ſyllogiſms which we have examined are improper examples, becauſe the truth to be proved by the former is ſelf evident, whilſt that which is meant to be eſtabliſhed by the latter is merely verbal, and therefore arbitrary. But the following is liable to neither of theſe objections:

All animals are *mortal.*
Man is *an animal;* therefore
Man is *mortal.*

Here it would be proper to aſk the demonſtrator, upon what grounds he ſo confidently pronounces all animals to be mortal? The propoſition is ſo far from expreſſing a ſelf evident truth, that, previous to the entrance of ſin and death into the world, the firſt man had ſurely no conception of mortality. He acquired the notion, however, by experience, when he ſaw the animals die in ſucceſſion around him; and when he obſerved that no animal with which he was acquainted, not even his own ſon, eſcaped death, he would conclude that all animals, without exception, are mortal. This concluſion, however, could not be built upon ſyllogiſtic reaſoning, nor yet upon intuition, but partly upon experience and partly on analogy. As far as his experience went, the proof, by induction, of the mortality of all animals was complete; but there are many animals in the ocean, and perhaps on the earth, which he never ſaw, and of whoſe mortality therefore he could affirm nothing but from analogy, *i. e.* from concluding, as the conſtitution of the human mind compels us to conclude, that Nature is uniform throughout the univerſe, and that ſimilar cauſes, whether known or unknown, will, in ſimilar circumſtances, produce, at all times, ſimilar effects. It is to be obſerved of this ſyllogiſm, as of the firſt which we have conſidered, that the propoſition, which it pretends to demonſtrate, is one of thoſe truths known by experience, from which, by the proceſs of induction, we infer the major of the premiſes to be true; and that therefore the reaſoning, if reaſoning it can be called, runs in a circle.

Yet by a concatenation of ſyllogiſms have logicians pretended that a long ſeries of important truths may be diſcovered and demonſtrated; and even Wallis himſelf ſeems to think, that this is the inſtrument by which the mathematicians have deduced, from a few poſtulates, accurate definitions, and undeniable axioms, all the truths of their demonſtrative ſcience. Let us try the truth of this opinion by analyſing ſome of Euclid's demonſtrations.

In the ſhort article PRINCIPLE (*Encycl.*), it has been ſhewn, that all our *firſt* truths are *particular*, and that it is by applying to them the rules of induction that we form general truths or axioms—even the axioms of pure geometry. As this ſcience treats not of real external things, but merely of *ideas* or *conceptions*, the creatures of our minds, it is obvious, that its definitions may be perfectly accurate, the induction by which its axioms are formed complete, and therefore the axioms themſelves *univerſal* propoſitions. The uſe of theſe axioms is merely to ſhorten the different proceſſes of geometrical reaſoning, and not, as has ſometimes been abſurdly ſuppoſed, to be made the *parents* or *cauſes* of *particular* truths. No truth, whether general or particular, can, in any ſenſe of the word, be the cauſe of another truth. If it were not true that all individual figures, of whatever form, comprehending a portion of ſpace equal to a portion comprehended by any other individual figure, whether of the ſame form with ſome of them, or of a form different from them all, are equal to one another, it would not be true that "things in *general*, which are equal to the ſame thing, or that magnitudes which coincide, or exactly fill the ſame ſpace," are reſpectively equal to one another; and therefore the firſt and eight of Euclid's axioms would be falſe. So far are theſe axioms, or general truths, from being the parents of particular truths, that, as conceived by us, they may, with greater propriety, be termed their *offſpring*. They are indeed nothing more than general expreſſions, comprehending all particular truths of the ſame kind. When a mathematical propoſition therefore is enounced, if the terms, of which it is compoſed, or the figures of which a certain relation is predicated, can be brought together and immediately compared, no demonſtration is neceſſary to point out its truth or falſehood. It is indeed intuitively perceived to be either comprehended under, or contrary to ſome known *axiom* of the ſcience; but it has the evidence of truth or falſehood in itſelf, and not in *conſequence* of that axiom. When the figures or ſymbols cannot be immediately compared together, it is then, and only then, that recourſe is had to demonſtration; which proceeds, not in a ſeries of ſyllogiſms, but by a proceſs of ideal menſuration or induction. A figure or ſymbol is conceived, which may be compared with each of the principal figures or ſymbols, or, if that cannot be, with one of them, and then another, which may be compared with it, till through a ſeries of well known intermediate relations, a compariſon is made between the terms of the original propoſition, of which the truth or falſehood is then perceived.

Thus in the 47th propoſition of the firſt book of Euclid's Elements, the author propoſes to demonſtrate the equality between the ſquare of the hypothenuſe of a right angled triangle, and the ſum of the ſquares deſcribed on the other two ſides; but he does not proceed in the way of categorical ſyllogiſms, by raiſing his demonſtration on ſome univerſal truth relating to the *genus* of *ſquares*. On the contrary, he proceeds to *meaſure* the three ſquares of which he has affirmed a certain relation; but as they cannot be immediately compared together, he directs the largeſt of them to be divided into two parallelograms, according to a rule which he had formerly aſcertained to be juſt; and as theſe parallelograms can, as little as the ſquare of which they are the conſtituent parts, be compared with the ſquares of the other two ſides of the triangle, he thinks of ſome intermediate figure which may be applied as a common meaſure to the ſquares and the parallelograms. Accordingly, having before found that a parallelogram, or ſquare, is exactly double of a triangle ſtanding on the ſame baſe and between the ſame parallels with it, he conſtructs triangles upon the ſame baſe, and between the ſame parallels with his parallelograms, and the ſquares of the ſides containing the right angle of the original triangle; and finding, by a proceſs formerly ſhewn to be juſt, that the triangles on the baſes of the parallelograms are preciſely equal to the triangles on the baſes of the ſquares, he perceives at once that the two parallelograms, of which the largeſt ſquare is compoſed, muſt be equal to the ſum of the two leſſer ſquares; and the truth of the propoſition is demonſtrated.

In the courſe of this demonſtration, there is not ſo much as one truth *inferred* from another by *ſyllogiſm*, but all are perceived in ſucceſſion by a ſeries of ſimple apprehenſions. Euclid, indeed, after finding the triangle conſtructed on the baſe of one of the parallelograms to be equal to the triangle conſtructed on the baſe of one of the ſquares, introduces an *axiom*, and ſays, "but the doubles of equals are equal to one another; *therefore* the parallelogram is equal to the ſquare." But if from this mode of expreſſion any man conceive the axiom or univerſal truth to be the *cauſe* of the truth more particular, or ſuppoſe that the *latter* could not be apprehended without a *previous* knowledge of the former, he is a ſtranger to the nature of evidence, and to the proceſs of *generalization*, by which axioms are formed.

If we examine the problems of this ancient geometrician, we ſhall find that the truth of them is proved by the very ſame means which he makes uſe of to point out the truth of his theorems. Thus, the firſt problem of his immortal work is, "to deſcribe an equilateral triangle on a given finite ſtraight line;" and not only is this to be done, but the method by which it is done muſt be ſuch as can be ſhewn to be incontrovertibly juſt. The ſides of a triangle, however, cannot be applied to each other ſo as to be immediately compared; for they are conceived to be immoveable among themſelves. A common meaſure, therefore, or ſomething equivalent to a common meaſure, muſt be found, by which the triangle may be conſtructed, and the equality of its three ſides afterwards evinced; and this equivalent Euclid finds in the *circle*.

By contemplating the properties of the circle, it was eaſy to perceive that all its *radii* muſt be equal to one another. He therefore directs two circles to be deſcribed from the oppoſite extremities of the given finite ſtraight line, ſo as that it may be the radius of each of them; and from the point in which the circles interſect one another, he orders lines to be drawn to the extreme points of the given line, affirming that theſe three lines conſtitute an equilateral triangle. To convince his reader of the truth of this affirmation, he has only to put him in mind, that from the properties of the circle, the lines which he has drawn muſt be each equal to the given line, and of courſe all the three equal to one another; and this mutual equality is perceived by ſimple apprehenſion, and not inferred by ſyllogiſtic reaſoning. Euclid, indeed, by introducing into the demonſtration his firſt axiom, gives to it the form of a ſyllogiſm: but that ſyllogiſm proves nothing; for if the equality of the three ſides of the triangle were not intuitively perceived in their poſition and the properties of the circle, the firſt axiom would itſelf be a falſehood. So true it is that categorical ſyllogiſms have no place in geometrical reaſoning; which is as ſtrictly experimental and inductive as the reaſoning employed in the various branches of phyſics.

But if this be ſo, how come the truths of pure geometry to be neceſſary, ſo that the contrary of any one of them is clearly perceived to be impoſſible; whilſt phyſical truths are all contingent, ſo that there is not one of them of which the direct contrary may not eaſily be conceived?

That there is not one phyſical truth, of which the contrary may not be conceived, is not perhaps ſo certain as has generally been imagined; but admitting the fact to be as it has commonly been ſtated, the apparent difference between this claſs of truths and thoſe of pure geometry, may be eaſily accounted for, without ſuppoſing that the former reſts upon a kind of evidence totally different from that which ſupports the fabric of the latter.

The objects of pure geometry, as we have already obſerved, are the creatures of our own minds, which contain in them nothing concealed from our view. As the mathematician treats them merely as meaſurable quantities, he knows, with the utmoſt preciſion, upon what particular properties the relation affirmed to ſubſiſt between any two or more of them muſt abſolutely depend; and he cannot poſſibly entertain a doubt but it will be found to have place among all quantities having the ſame properties, becauſe it depends upon them, and upon them alone. His proceſs of induction, therefore, by a ſeries of ideal meaſurements, is always complete, and exhauſts the ſubject; but in phyſical enquiries the caſe is widely different. The ſubjects which employ the phyſical enquirer are not his own ideas, and their various relations, but the properties, powers, and relations of the bodies which compoſe the univerſe; and of thoſe bodies he knows neither the ſubſtance, internal ſtructure, nor all the qualities: ſo that he can very ſeldom diſcover with certainty upon what particular property or properties the phenomena of the corporeal world, or the relations which ſubſiſt among different bodies, depend. He expects, indeed, with confidence, not inferior to that with which he admits a mathematical demonſtration, that any corporeal phenomenon, which he has obſerved in certain circumſtances, will be always obſerved in circumſtances exactly ſimilar; but the misfortune is, that he can very ſeldom be aſcertained of this ſimilarity. He does not know any one piece of matter *as it is in itſelf*; he cannot ſeparate its various properties; and of courſe cannot attribute to any one property the effects or apparent effects which proceed excluſively from it. Indeed, the properties of bodies are ſo cloſely interwoven, that by human means they cannot be completely ſeparated; and hence the moſt cautious inveſtigator is apt to attribute to ſome one or two properties, an event which in reality reſults perhaps from many. (See PHILOSOPHY and PHYSICS, *Encycl.*) This the geometrician never does. He knows perfectly that the relation of equality which ſubſiſts between the three angles of a plain triangle and two right angles, depends not upon the ſize of the triangles, the matter of which they are conceived to be made, the particular place which they occupy in the univerſe, or upon any one circumſtance whatever beſides their triangularity, and the angles of their corrolets being exactly right angles; and it is upon this power of diſcrimination which we have in the conceptions of pure geometry, and have not in the objects of phyſics, that the truths of the one ſcience are perceived to be neceſſary, while thoſe of the other appear to be contingent; though the mode of demonſtration is the

ſame

ſame in both, or at leaſt equally removed from categorical ſyllogiſms.

INERTIA. See DYNAMICS and IMPULSION in this *Supplement*.

INFLAMMATION has been ſufficiently explained in the *Encyclopædia*, and in the article CHEMISTRY in this *Supplement ;* but it cannot be improper, in this place, to give an account of ſome remarkable

Spontaneous INFLAMMATIONS, which, as different ſubſtances, are liable to them, have been, and may again be, the cauſe of many and great misfortunes

The ſpontaneous inflammation of eſſential oils, and that of ſome fat oils, when mixed with nitrous acid, are well known to philoſophers ; ſo alſo is that of powdered charcoal with the ſame acid (lately diſcovered by M. Prouſt), and thoſe of phoſphorus, of pyrophorus, and of fulminating gold. Theſe ſubſtances are generally to be found only in the laboratories of chemiſts, who are perfectly well acquainted with the precautions which it is neceſſary to take to prevent the unhappy accidents which may be occaſioned by them.

The burning of a ſtore houſe of ſails, which happened at Breſt in the year 1757, was cauſed by the ſpontaneous inflammation of ſome oiled cloths, which, after having been painted on one ſide, and dried in the ſun, were ſtowed away while yet warm ; as was ſhewn by ſubſequent experiments *.

Vegetables boiled in oil or fat, and left to themſelves, after having been preſſed, inflame in the open air. This inflammation always takes place when the vegetables retain a certain degree of humidity ; if they are firſt thoroughly dried, they are reduced to aſhes, without the appearance of flame. We owe the obſervation of theſe facts to MM. Saladin and Carette †.

The heaps of linen rags which are thrown together in paper manufactories, the preparation of which is haſtened by means of fermentation, often take fire, if not carefully attended to.

The ſpontaneous inflammation of hay has been known for many centuries ; by its means houſes, barns, &c. have been often reduced to aſhes. When the hay is laid up damp, the inflammation often happens ; for the fermentation is then very great. This accident very ſeldom occurs to the firſt hay (according to the obſervation of M. de Bomare), but is much more common to the ſecond ; and if, through inattention, a piece of iron ſhould be left in a ſtalk of hay in fermentation, the inflammation of that ſtalk is almoſt a certain conſequence. Corn heaped up has alſo ſometimes produced inflammations of this nature. Vanieri, in his *Prædium Rusticum*, ſays,

> *Quæ vero (gramina) nondum ſatis inſolata recondens*
> *Imprudens, ſubitis pariunt incendia flammis.*

Dung alſo, under certain circumſtances, inflames ſpontaneouſly.

In a paper, publiſhed in the *Repertory of Arts and Manufactures*, by the Rev. William Tooke, F. R. S. &c. we have the following remarkable inſtances of ſpontaneous inflammation. "A perſon of the name of Rüde, an apothecary at Bautzen, had prepared a pyrophorus from rye-bran and alum. Not long after he had made the diſcovery, there broke out, in the next village of Nauſlitz, a great fire, which did much miſchief, and was ſaid to have been occaſioned by the treating of a ſick cow in the cow-houſe. Mr Rüde knew, that the countrymen were uſed to lay an application of parched rye-bran to their cattle for curing the thick neck ; he knew alſo, that alum and rye bran, by a proper proceſs, yielded a pyrophorus ; and now he wiſhed to try whether parched rye-bran alone would have the ſame effect. Accordingly, he roaſted a quantity of rye-bran by the fire, till it had acquired the colour of roaſted coffee. This roaſted bran he wrapped up in a linen cloth; in the ſpace of a few minutes there aroſe a ſtrong ſmoke through the cloth, accompanied by a ſmell of burning. Not long afterwards the rag grew as black as tinder, and the bran, now become hot, fell through it on the ground in little balls. Mr Rüde repeated the experiment at various times, and always with the ſame reſult. Who now will any longer doubt, that the frequency of fires in cow-houſes, which in thoſe parts are moſtly wooden buildings, may not be occaſioned by this common practice, of binding roaſted bran about the necks of the cattle? The fire, after conſuming the cattle and the ſhed, communicates itſelf to the adjoining buildings ; great damage enſues ; and the ignorant look for the cauſe in wilful and malicious firing, conſequently in a capital crime."

The ſame author informs us, that in the ſpring of the year 1780, a fire was diſcovered on board a Ruſſian frigate lying in the road of Cronſtadt ; which, if it had not been timely extinguiſhed, would have endangered the whole fleet. After the ſevereſt ſcrutiny, no cauſe of the fire was to be found ; and the matter was forced to remain without explanation, but with ſtrong ſurmiſes of ſome wicked incendiary being at the bottom of it. In the month of Auguſt, in the ſame year, a fire broke out at the hemp-magazine at St Peterſburgh, by which ſeveral hundred thouſand poods ‡ of hemp and flax were conſumed. The walls of the magazine are of brick, the floors of ſtone, and the rafters and covering of iron ; it ſtands alone on an iſland in the Neva, on which, as well as on board the ſhips lying in the Neva, no fire is permitted. In St Peterſburgh, in the ſame year, a fire was diſcovered in the vaulted ſhop of a furrier. In theſe ſhops, which are all vaults, neither fire nor candle is allowed, and the doors of them are all of iron. At length the probable cauſe was found to be, that the furrier, the evening before the fire, had got a roll of new cere-cloth (much in uſe here for covering tables, counters, &c. being eaſily wiped and kept clean), and had left it in his vault, where it was found almoſt conſumed.

In the night between the 20th and 21ſt of April 1781, a fire was ſeen on board the frigate Maria, which lay at anchor, with ſeveral other ſhips, in the road off the iſland of Cronſtadt ; the fire was, however, ſoon extinguiſhed ; and, by the ſevereſt examination, little or nothing could be extorted concerning the manner in which it had ariſen. The garriſon was threatened with a ſcrutiny that ſhould coſt them dear ; and while they were in this cruel ſtate of ſuſpence, an order came from the ſovereign, which quieted their minds, and gave riſe to ſome very ſatisfactory experiments.

It having been found, upon juridical examination, as well as private inquiry, that in the ſhip's cabin, when the ſmoke appeared, there lay a bundle of matting, containing Ruſſian lamp-black prepared from fir-ſoot, moiſtened with hemp oil varniſh, which was perceived

---

* See Memoires de l'Academie de Paris, 1760.

† Journal de Phyſique, 1784.

‡ A pood conſiſts of 40 pounds Ruſs, or 36 Engliſh.

to have ſparks of fire in it at the time of the extinction, the Ruſſian admiralty gave orders to make various experiments, in order to ſee whether a mixture of hemp-oil varniſh and the forementioned Ruſſian black, folded up in a mat and bound together, would kindle of itſelf.

They ſhook 40 pounds of fir-wood ſoot into a tub, and poured about 35 pounds of hemp oil varniſh upon it; this they let ſtand for an hour, after which they poured off the oil. The remaining mixture they now wrapped up in a mat, and the bundle was laid cloſe to the cabin, where the midſhipmen had their birth. To avoid all ſuſpicion of treachery, two officers ſealed both the mat and the door with their own ſeals, and ſtationed a watch of four ſea officers, to take notice of all that paſſed the whole night through; and as ſoon as any ſmoke ſhould appear, immediately to give information to the commandant of the port.

The experiment was made the 26th of April, about 11 o'clock A. M. in preſence of all the officers named in the commiſſion. Early on the following day, about ſix o'clock A. M. a ſmoke appeared, of which the chief commandant was immediately informed by an officer: he came with all poſſible ſpeed, and through a ſmall hole in the door ſaw the mat ſmoking. Without opening the door, he diſpatched a meſſenger to the members of the commiſſion; but as the ſmoke became ſtronger, and fire began to appear, the chief commandant found it neceſſary, without waiting for the members of the commiſſion to break the ſeals and open the door. No ſooner was the air thus admitted, than the mat began to burn with greater force, and preſently it burſt into a flame.

The Ruſſian admiralty, being now fully convinced of the ſelf-enkindling property of this compoſition, tranſmitted their experiment to the Imperial Academy of Sciences; who appointed Mr Georgi, a very learned and able adjunct of the academy, to make farther experiments on the ſubject. Previous to the relation of theſe experiments, it is neceſſary to obſerve, that the Ruſſian fir-black is three or four times more heavy, thick, and unctuous, than that kind of painters black which the Germans call *kien-rahm*. The former is gathered at Ochta, near St Peterſburgh, at Moſco, at Archangel, and other places, in little wooden huts, from reſinous fir-wood, and the unctuous bark of birch, by means of an apparatus uncommonly ſimple, conſiſting of pots without bottoms ſet one upon the other; and is ſold very cheap. The famous fine German *kien-rahm* is called in Ruſſia *Holland's black*. In what follows, when raw oil is ſpoken of, it is to be underſtood of linſeed-oil or hemp oil; but moſt commonly the latter. The varniſh is made of five pounds of hemp oil boiled with two ounces and a half of minium. For wrapping up the compoſition, Mr Georgi made uſe of coarſe hemp-linen, and always ſingle, never double. The impregnations and commixtures were made in a large wooden bowl, in which they ſtood open till they were wrapped up in linen.

Three pounds of Ruſſian fir-black were ſlowly impregnated with five pounds of hemp-oil varniſh; and when the mixture had ſtood open five hours, it was bound up in linen. By this proceſs it became clotted; but ſome of the black remained dry. When the bundle had lain ſixteen hours in a cheſt, it was obſerved to emit a very nauſeous, and rather putrid, ſmell, not quite unlike that of boiling oil. Some parts of it became warm, and ſteamed much; this ſteam was watery, and by no means inflammable. Eighteen hours after the mixture was wrapped up, one place became brown, emitted ſmoke, and directly afterwards glowing fire appeared. The ſame thing happened in a ſecond and a third place, though other places were ſcarcely warm. The fire crept ſlowly around, and gave a thick, grey, ſtinking ſmoke. Mr Georgi took the bundle out of the cheſt, and laid it on a ſtone pavement; when, on being expoſed to the free air, there aroſe a ſlow burning flame, a ſpan high, with a ſtrong body of ſmoke. Not long afterwards there appeared, here and there, ſeveral chaps or clefts, as from a little volcano, the vapour iſſuing from which burſt into flame. On his breaking the lump, it burſt into a very violent flame, full three feet high, which ſoon grew leſs, and then went out. The ſmoking and glowing fire laſted for the ſpace of ſix hours; and afterwards the remainder continued to glow without ſmoke for two hours longer. The grey earthy aſhes, when cold, weighed five ounces and a half.

In another experiment, perfectly ſimilar to the foregoing, as far as relates to the compoſition and quantities, the enkindling did not enſue till 41 hours after the impregnation: the heat kept increaſing for three hours, and then the accenſion followed. It is worthy of remark, that theſe experiments ſucceeded better on bright days than on ſuch as were rainy; and the accenſion came on more rapidly.

In another experiment, three pounds of Ruſſian fir-black were ſlowly impregnated with three pounds of raw hemp-oil; and the accenſion enſued after nine hours.

Three quarters of a pound of German *rahm* were ſlowly impregnated with a pound and a half of hemp-oil varniſh. The mixture remained 70 hours before it became hot and reeking; it then gradually became hotter, and emitted a ſtrong exhalation; the effluvia were moiſt, and not inflammable. The reaction laſted 36 hours, during which the heat was one while ſtronger, and then weaker, and at length quite ceaſed.

Stove or chimney ſoot, moſtly formed from birch-wood ſmoke, was mingled with the above-mentioned ſubſtances and tied up; the compound remained cold and quiet.

Ruſſian fir-black, mixed with equal parts of oil of turpentine, and bound up, exhibited not the leaſt reaction or warmth.

Birch oil, mixed with equal parts of Ruſſian fir-black, and bound up, began to grow warm and to emit a volatile ſmell; but the warmth ſoon went off again.

From the experiments of the admiralty and of Mr Georgi, we learn, not only the deciſive certainty of the ſelf-accenſion of ſoot and oil, when the two ſubſtances are mixed under certain circumſtances, but alſo the following particulars:

Of the various kinds of ſoot, or lamp-black, the experiments ſucceeded more frequently and ſurely with the coarſer, more unctuous, and heavier, like Ruſſian painters black, than with fine light German *rahm*, or with coarſe chimney-ſoot. In regard to oils, only thoſe experiments ſucceeded which were made with drying oils, either raw or boiled. The proportions of the ſoots to the oils were, in the ſucceſsful experiments, very various; the mixture kindled with a tenth, a fifth, a third, Inflammation.

with an equal, and likewiſe with a double, proportion of oil. In general, however, much more depends on the mode of mixture, and the manipulation, and, as Mr Georgi often obſerved, on the weather; for in moiſt weather the bundles, after becoming warm, would frequently grow cold again.

The inſtances of ſpontaneous inflammation hitherto mentioned have been only of vegetable ſubſtances; but we have examples of the ſame thing in the animal kingdom. Pieces of woollen cloth, which had not been ſcoured, took fire in a warehouſe. The ſame thing happened to ſome heaps of woollen yarn; and ſome pieces of cloth took fire in the road, as they were going to the fuller. Theſe inflammations always take place where the matters heaped up preſerve a certain degree of humidity, which is neceſſary to excite a fermentation; the heat reſulting from which, by drying the oil, leads them inſenſibly to a ſtate of ignition; and the quality of the oil, being more or leſs deſiccative, very much contributes thereto.

The woollen ſtuff prepared at Sevennes, which bears the name of Emperor's ſtuff, has kindled of itſelf, and burnt to a coal. It is not unuſual for this to happen to woollen ſtuffs, when in hot ſummers they are laid in a heap in a room but little aired.

In June 1781, the ſame thing happened at a woolcomber's in a manufacturing town in Germany, where a heap of wool combings, piled up in a cloſe warehouſe ſeldom aired, took fire of itſelf. This wool had been by little and little brought into the warehouſe; and, for want of room, piled up very high, and trodden down, that more might be added to it. That this combed wool, to which, as is well known, rape-oil mixed with butter is uſed in the combing, burnt of itſelf, was ſworn by ſeveral witneſſes. One of them affirmed that, ten years before, a ſimilar fire happened among the flocks of wool at a clothier's, who had put them into a caſk, where they were rammed hard, for their eaſier conveyance. This wool burnt from within outwards, and became quite a coal; it was very certain that neither fire nor light had been uſed at the packing, conſequently the above fires aroſe from ſimilar cauſes. In like manner, very credible cloth-workers have certified, that, after they have bought wool that was become wet, and packed it cloſe in their warehouſe, this wool has burnt of itſelf; and very ſerious conſequences might have followed, if it had not been diſcovered in time.

Nay, there are inſtances, though they be but rare, of human bodies being conſumed by ſpontaneous inflammation. In the Philoſophical Tranſactions, and in the Memoirs of the Academies of Paris and Copenhagen, it is related that an Italian lady (the Counteſs Cornelia Bandi) was entirely reduced to aſhes, except her legs; that an Engliſh woman, called Grace Pitt, was almoſt entirely conſumed by a ſpontaneous inflammation of her viſcera: and, laſtly, that a prieſt of Bergamo was conſumed in the ſame manner. Theſe ſpontaneous inflammations have been attributed to the abuſe of ſpirituous liquors; but though the victims of intemperance are indeed very numerous, theſe certainly do not belong to that number.

The mineral kingdom alſo often affords inſtances of ſpontaneous inflammation. Pyrites heaped up, if wetted and expoſed to the air, take fire. Pitcoal alſo, laid in heaps, under certain circumſtances, inflames ſpontaneouſly. M. Duhamel has deſcribed two inflammations of this nature, which happened in the magazines of Breſt, in the years 1741 and 1757. Cuttings of iron, which had been left in water, and were afterwards expoſed to the open air, gave ſparks, and ſet fire to the neighbouring bodies. For this obſervation we are obliged to M. de Charpentier.

Inflammation || Ink.

The cauſes of theſe phenomena the chemiſt will aſſign; but they are here recorded as a warning to tradeſmen and others. It is evident, from the facts which have been related, that ſpontaneous inflammations being very frequent, and their cauſes very various, too much attention and vigilance cannot be uſed to prevent their dreadful effects. And conſequently it is impoſſible to be too careful in watching over public magazines and ſtorehouſes, particularly thoſe belonging to the ordnance, or thoſe in which are kept hemp, cordage, lampblack, pitch, tar, oiled cloths, &c. which ſubſtances ought never to be left heaped up, particularly if they have any moiſture in them. In order to prevent any accident from them, it would be proper to examine them often, to take notice if any heat is to be obſerved in them, and, in that caſe, to apply a remedy immediately. Theſe examinations ſhould be made by day, it not being adviſable to carry a light into the magazines; for when the fermentation is ſufficiently advanced, the vapours which are diſengaged by it are in an inflammable ſtate, and the approach of a light might, by their means, ſet fire to the ſubſtances whence they proceed. Ignorance of the fore-mentioned circumſtances, and a culpable negligence of thoſe precautions which ought to be taken, have often cauſed more misfortunes and loſs than the moſt contriving malice: it is therefore of great importance that theſe facts ſhould be univerſally known, that public utility may reap from them every poſſible advantage.

INFORMED Stars, or Informes Stellæ, are ſuch ſtars as have not been reduced into any conſtellation; otherwiſe called Sporades.—There was a great number of this kind left by the ancient aſtronomers; but Hevelius, and ſome others of the moderns, have provided for the greater part of them, by making new conſtellations.

Sympathetic INK is an old invention. Among the methods by which Ovid teaches young women to deceive their guardians, when they write to their lovers, he mentions that of writing with new milk, and of making the writing legible by coal-duſt or ſoot.

> *Tuta quoque eſt, fallitque oculos, e lacte recenti*
> *Litera: carbonis pulvere tange, leges.*

It is obvious, that any other colourleſs and glutinous juice, which will hold faſt the black powder ſtrewed over it, will anſwer the purpoſe as well as milk; and therefore Pliny recommends the milky juice of certain plants to be uſed.

There are ſeveral metallic ſolutions perfectly colourleſs, or, at leaſt, without any ſtrong tint, which being wrote with, the letters will not appear until the paper be waſhed over with another colourleſs ſolution, or expoſed to the vapour of it; but among all theſe there is none which excites more aſtoniſhment, or from which naturaliſts can draw more concluſions, than that which conſiſts of a ſolution of lead in vegetable acid, and which by the vapour of arſenical liver of ſulphur becomes black, even at a conſiderable diſtance. This ink, which may

may be uſed by conjurors, proves the ſubtlety of vapour, and the poroſity of bodies; as the change or colouring takes place even when the writing is placed on the other ſide of a thin wall.

We knew before, that a ſolution of lead, treated in this manner, would anſwer the purpoſe of a ſympathetic ink (ſee that article *Encycl.*); but we did not know, nor do we yet believe, that the ſulphuric vapours will act upon the writing through *a wall.* Such, however, is the affirmation of Profeſſor Beckmann, who gives an account of a ſtill more wonderful ink from Peter Borel. This author, in a book called *Hiſtoriarum et obſervationum medico phyſic. centuriæ quatuor*, printed at Paris, firſt in 1653, and afterwards in 1657, gives a receipt for making this ink, which he calls *magnetic waters which act at a diſtance.* The receipt is as follows:

“ Let quick lime be quenched in common water, and while quenching, let ſome orpiment be added to it (this, however, ought to be done by placing warm aſhes under it for a whole day), and let the liquor be filtered, and preſerved in a glaſs bottle well corked. Then boil litharge of gold, well pounded, for half an hour with vinegar, in a braſs veſſel, and filter the whole through paper, and preſerve it alſo in a bottle cloſely corked. If you write any thing with this laſt water, with a clean pen, the writing will be inviſible when dry: but if it be waſhed over with the firſt water it will become inſtantly black. In this, however, there is nothing aſtoniſhing; but this is wonderful, that though ſheets of paper without number, and even a board, be placed between the inviſible writing and the ſecond liquid, it will have the ſame effect, and turn the writing black, penetrating the wood and paper without leaving any traces of its action, which is certainly ſurpriſing; but a fetid ſmell, occaſioned by the mutual action of the liquids, deters many from making the experiment. I am, however of opinion, that I could improve this ſecret by a more refined chemical preparation, ſo as that it ſhould perform its effect through a wall. This ſecret (ſays Borel) I received, in exchange for others, from J. Broſſon, a learned and ingenious apothecary of Montpelier.”

For making a ſympathetic ink of the fifth claſs mentioned in the *Encyclopædia*, the following proceſs by M. Meyer may be worthy of the reader's notice. It was entered upon in conſequence of a receipt for roſe-coloured ſympathetic ink ſhewn to him by a traveller. In that receipt cobalt was the principal ingredient, and therefore the firſt object was to procure cobalt; but M. Meyer, being unwilling to ſacrifice pure pieces of cobalt of any conſiderable ſize, made choice of one, which was viſibly mixed with biſmuth, iron, and quartz. He endeavoured to ſeparate the biſmuth as much as poſſible, and alſo the arſenic, if it ſhould contain any, by bringing it ſlowly to a red heat; and he ſucceeded pretty well, as the biſmuth flowed from it in abundance; and the arſenic, the quantity of which was ſmall, was volatiliſed: many globules of biſmuth ſtill adhered to it. By bringing it repeatedly to a red heat, and then quenching it in water, it was reduced to ſuch a ſtate as to be eaſily pulveriſed. Having poured nitrous acid upon the powder, he obtained by digeſtion a beautiful roſe red ſolution; the ſiliceous earth was ſeparated in the form of a white ſlime, and by diluting it with water there was depoſited a white powder, which was oxyd of biſmuth. The ſolution being filtered, he added to it a ſolution of potaſh, and obtained a precipitate inclining more to a yellow than to a red colour. He again poured over it a little of the nitrous acid, by which a part of the oxyd was re-diſſolved of a red colour: the remaining part, which had a dark brown colour, was oxyd of iron. From the ſolution, by the addition of potaſh, a precipitate was formed, which was now reddiſh. Having by this proceſs obtained it pure, that he might now prepare from it the wiſhed-for red ink, he diſſolved the waſhen pure oxyd of cobalt in different acids. That diſſolved in the nitrous acid with a mixture of nitre, gave a green ink like the common: that diſſolved in the ſulphurous acid, without the addition of ſalts, gave a reddiſh ink, which remained after it was expoſed to heat, and would not again diſappear, even when a ſolution of nitre was applied; and that diſſolved in the muriatic acid, gave a green ink, darker and more beautiful than the common. By diſſolving it, however, in the acetous acid, and adding a little nitre, he obtained what he had in view; for it gave, on the application of heat, an ink of a red colour, like that of the *roſa centifolia*, which again diſappeared when the paper became cold.

INORDINATE PROPORTION, is where the order of the terms compared is diſturbed or irregular. As, for example, in two ranks of numbers, three in each
rank, viz. in one rank, - - - 2, 3, 9,
and in the other rank, - - - 8, 24, 36,
which are proportional, the former to the latter, but in a different order, viz. - - 2 : 3 :: 24 : 36,
and - - 3 : 9 :: 8 : 24.
then, caſting out the mean terms in each rank, it is concluded that - - - - 2 : 9 :: 8 : 36,
that is, the firſt is to the 3d in the firſt rank,
as the firſt is to the 3d in the 2d rank.

INSECTS (See *Encycl.*). A number of non-deſcript little animals was diſcovered by La Martiniere the naturaliſt when accompanying Perouſe on his celebrated voyage of diſcovery. Theſe animals he called *inſects*, and to many of them he gave particular names. Of theſe we ſhall give his deſcription in this place, leaving our readers, as he has left his, to arrange them properly according to the Linnæan claſſification.

Plate XXX.

“ The inſect, which is figured N° 1. inhabits a ſmall priſmatic triangular cell, pointed at the two extremities, of the conſiſtence and colour of clear brittle ice; the body of the inſect is of a green colour, ſpotted with ſmall bluiſh points, among which are ſome of a golden tinge; it is fixed by a ligament to the lower part of its ſmall habitation: its neck is terminated by a ſmall blackiſh head compoſed of three converging ſcales, in the form of a hat, and encloſed between three fins, two of them large and channelled in the upper part (A) and one ſmall, ſemicircular (B). When it is diſturbed, it immediately withdraws its fins and its head into its cell, and gradually ſinks into the water by its own ſpecific gravity. Fig. 2. repreſents the under ſide of the priſm, ſhewing in what manner it is channelled, in order to allow free paſſage to the animal when it wiſhes to ſhut itſelf up in it. Fig. 3. repreſents the profile of the ſame. The movement carried on by the two larger fins, which are of a ſoftiſh cartilaginous ſubſtance, may be compared to that which would be produced by the two hands joined together in the ſtate of pronation, and forming, alternately, two inclined planes and one horizontal plane: it is by means of this motion that it ſupports itſelf on the top of the water, where it probably

bly feeds on fat and oily ſubſtances on the ſurface of the ſea." Our author found it near Nootka, on the north-weſt coaſt of America, during a calm.

Fig. 4. repreſents a collection of inſects, as our author calls them, conſiſting only of oval bodies, ſimilar to a ſoap bubble, arranged in parties of three, five, ſix, and nine: among them are alſo ſome ſolitary ones. Theſe collections of globules, being put into a glaſs filled with ſea water, deſcribed a rapid circle round the glaſs by a common movement, to which each individual contributed by ſimple compreſſion of the ſides of its body, probably the effect of the re-action of the air with which they were filled. It is not, however, eaſy to conceive how theſe diſtinct animals (for they may be readily ſeparated without deranging their economy) are capable of concurring in a common motion. "Theſe conſiderations (ſays our author), together with the form of the animal, recalled to my mind, with much ſatisfaction, the ingenious ſyſtem of M. de Buffon; and I endeavoured to perſuade myſelf, that I was about to be witneſs to one of the moſt wonderful phenomena of Nature, ſuppoſing that theſe molecules, which were now employed in increaſing or diminiſhing their number, or performing their revolutions in the glaſs, would ſoon aſſume the form of a new animal of which they were the living materials. My impatience led me to detach two from the moſt numerous group, imagining that this number might perhaps be more favourable to the expected metamorphoſis. I was, however, miſtaken. Theſe I examined with more attention than the reſt; and the following account is of their proceedings alone. Like two ſtrong and active wreſtlers, they immediately ruſhed together, and attacked each other on every ſide: ſometimes one would dive, leaving its adverſary at the ſurface of the water; one would deſcribe a circular movement, while the other remained at reſt in the centre; their motions at length became ſo rapid as no longer to allow me to diſtinguiſh one from the other. Having quitted them for a ſhort time, on my return I found them reunited as before, and amicably moving round the edge of the glaſs by their common exertions."

Fig. 5. repreſents a ſingular animal, which has a conſiderable reſemblance to a little lizard; its body is of a firm, gelatinous conſiſtence; its head is furniſhed on each ſide with two ſmall gelatinous horns, of which the two hindermoſt are ſituate the furtheſt inward: its body is provided with four open fan-like paws, and ſome appendages near the inſertion of the tail, and terminates like that of a lizard: the ridge of the back is divided the whole way down by a band of a deep blue; the reſt of the body, as well as the inſide of its paws, is of a bright ſilvery white. It appears to be very ſluggiſh in its motions; and when diſturbed by the finger, merely turned itſelf belly upwards, ſoon afterwards reſuming its former poſition. Fig. 6. repreſents it reverſed. Martiniere caught it during a calm at the landing place on the Baſhee Iſlands.

INSTITUTE is a name which has lately been ſubſtituted for *ſchool* or *academy*. Formerly *inſtitution*, in the propriety of the Engliſh language, was ſometimes uſed as a word of the ſame import with *inſtruction*; and now *inſtitute* is employed, eſpecially by the admirers of French innovations, to denote what had hitherto been called an academy. When royalty was aboliſhed in France, it would have been abſurd to continue the titles *Royal* Academy of Sciences, '*Royal* Academy of Inſcriptions, &c.; but inſtead of merely aboliſhing the word *royal*, and ſubſtituting *national* in its ſtead, it occurred to the fertile brain of Condorcet, to aboliſh the ſeven academies themſelves, or rather to melt them all down into one great academy; to which was given the appellation of the

National INSTITUTE, or *New Academy of Arts and Sciences*. This academy, founded on a decree of the new conſtitution, was opened on the 7th of December 1795, when BENEZECH, the then miniſter for the home department, attended, and the decree of foundation was read; which was to the following purport:

"The Academy of Arts and Sciences belongs to the whole republic, and Paris is its place of reſidence. Its employment is to aim at bringing all arts and ſciences to the utmoſt perfection of which they are capable. It is to notice every new attempt, and all new diſcoveries, and to keep up a correſpondence with all foreign literary ſocieties. And by the particular orders of the Executive Directory, its firſt ſtudies are to be directed to thoſe ſubjects which more immediately tend to the reputation and advantage of the French republic."

The academy is to conſiſt of 288 members, half of whom are to reſide in Paris, the other half in the departments; and to them is to be added a certain number of foreigners, as honorary members, confined at preſent to twenty-four.

The academy is divided into three claſſes, each claſs into ſections, each ſection to contain twelve members.

1ſt claſs. Mathematics and natural philoſophy. This claſs is divided into ten ſections. 1. Mathematics. 2. Mechanical arts. 3. Aſtronomy. 4. Experimental philoſophy. 5. Chemiſtry. 6. Natural hiſtory. 7. Botany. 8. Anatomy and animal hiſtory. 9. Medicine and ſurgery. 10. Animal œconomy, and the veterinary ſcience.

2d claſs. Morality and politics. This claſs conſiſts of ſix ſections. 1. Analyſis of ſenſations and ideas. 2. Morals. 3. Legiſlature. 4. Political economy. 5. Hiſtory. 6. Geography.

3d claſs. Literature and the fine arts. This claſs conſiſts of eight ſections. 1. Univerſal grammar. 2. Ancient languages. 3. Poetry. 4. Antiquities. 5. Painting. 6. Sculpture. 7. Architecture. 8. Muſic.

For each claſs a particular room in the Louvre is appropriated. No one can be a member of two claſſes at the ſame time, but a member of one claſs may be preſent at the meetings of any other. Each claſs is to print, yearly, an account of its tranſactions.

Four times a-year there are to be public meetings. On theſe occaſions, the three claſſes meet together. At the end of each year, they are to give a circumſtantial account to the legiſlative body of the progreſs made in that year in the arts and ſciences. The prizes given yearly by each claſs are to be publicly notified at certain times. The ſums requiſite for the ſupport of the inſtitution are to be decreed yearly by the legiſlative body, upon a requiſition made by the Executive Directory.

The firſt forty-eight members were choſen by the Executive Directory, to whom the choice of the remaining members was confided. To the members, reſidentiary in Paris, is reſerved the choice both of the department and the foreign members. On a vacancy in any claſs, three candidates are named by the claſs for the choice of the body at large.

Each claſs is to have, at its place of meeting, a collection of the products, both of nature and art, and a library, according to its particular wants.

The regulations of the inſtitution, with reſpect to the times of meeting, and its employments, are to be drawn up by the body at large, and laid before the legiſlative aſſembly.

The hall in which the body at large holds its meetings, forms part of the weſt wing of the Old Louvre, at preſent called the Muſeum It formerly went by the appellation of the Hall of Antiques (*Salle des Antiques*); and as long as the kings inhabited this part of the palace, was occupied by their guards, from which circumſtance it obtained the name of the Hall *des Cent Suiſſes.* It was likewiſe appropriated to banquets and entertainments, given by the court on gala days; and it was to this place that Henry IV. was conveyed, on his aſſaſſination by Ravaillac, in the *Rue de la Ferronnerie.*

It was built at the ſame time with the reſt of this part of the Louvre, about the year 1528, after the deſigns of Pierre Leſcot, abbot of Clagny. It is 144 feet in length, and 40 in breadth, and holds from 1000 to 1200 perſons. In order to adapt it to its new deſtination, the floor has been ſunk, which gives a greater air of lightneſs to the roof. In the centre ſtands a double table, in the form of a horſe-ſhoe, ſupported by ſphinxes, at which the members of the inſtitute take their ſeats. This table is ſurrounded by two tiers of benches, which are raiſed for the accommodation of ſpectators, who have likewiſe ſeats provided for them in the vaſt embraſures of the windows, and at each extremity of the hall.

Whether ſcience will be advanced by the ſeven royal academies having been melted into one, time muſt determine; but candour compels us to acknowledge, that the proceedings of the national inſtitute have hitherto been abundantly intereſting. Intimately connected with the national inſtitute is the French ſyſtem of

National INSTRUCTION, which is likewiſe novel, and therefore ſufficiently curious to deſerve notice in a Work of this kind. When the Chriſtian religion was aboliſhed in France, it was impoſſible to continue the univerſities and other ſeminaries which were founded by Chriſtians, and obliged by their conſtitution to teach, whether pure or not, the doctrines of Chriſtianity. They were accordingly all ſwept away, and a new ſyſtem of education planned, which was to be carried on in what they call

The Primary Schools.
The Central Schools.
The School of Health.
The School of Oriental Languages.
The Polytechnic School.
The National Inſtitute.
The Jury of Public Inſtruction.
The Commiſſion of Public Inſtruction.
The Legiſlative Committee of Inſtruction. And various other national eſtabliſhments for the improvement of particular ſciences.

The firſt degree of public inſtruction is to be met with in the *Ecoles Primarées*, eſtabliſhed by a decree of the convention of the ſecond *Pluvioſe*, in the ſecond year of the republic (A). Every diſtrict is furniſhed with one of theſe ſchools; the profeſſors or maſters in which are paid from the national treaſury; and to which every head of a family, without exception, is compelled by law to ſend its children for inſtruction. The ſubjects taught in theſe primary or elementary ſchools are divided into nine claſſes:

1*ſt*, Inſtructions connected with the phyſical and moral ſituation of children, prior to their entering into theſe ſchools. 2*d*, Similar inſtructions as a guide to teachers in the national ſchools. 3*d*, The arts of reading and writing. 4*th*, The elements of French grammar. 5*th*, Elements of arithmetic and geometry, with the theory of the new menſuration. 6*th*, The elements of geography. 7*th*, Explanations of the principal phenomena and productions of nature. 8*th*, Elements of agriculture. 9*th*, Elements of republican morals.

Next to the primary ſchools in rank and conſequence are the *Ecoles Centrales*, which were eſtabliſhed by a decree of the Convention of the ſeventh *Ventoſe* in the third year. They are ſituated in the capital of every department, bearing the proportion of one central ſchool to 300,000 inhabitants. In theſe ſchools the republican youths are taught the ſciences, and their application in real life. In each of them are profeſſors for the following branches:

1. For mathematics. 2. Experimental philoſophy and chemiſtry. 3. Natural hiſtory. 4. Agriculture and commerce. 5. Logic and metaphyſics. 6. Political economy and legiſlation. 7. The philoſophical hiſtory of nations. 8. The art of healing. 9. Arts and manufactures. 10. Univerſal grammar. 11. The belles lettres. 12. The ancient languages. 13. The modern languages. 14. The fine arts.

Each central ſchool is furniſhed with an extenſive public library—a botanic garden—a cabinet of natural hiſtory—an apparatus for experimental philoſophy—and a collection of machines and models connected with the arts and manufactures.

The profeſſors of each ſchool hold, every month, a public ſitting, in which conferences are held relative to ſubjects connected with the improvement of letters, the ſciences, and the arts, which are the moſt beneficial to ſociety.

The object in the eſtabliſhment of the primary and central ſchools was, the general inſtruction of all claſſes of the citizens; and it being incompatible with the perfect completion of that important purpoſe, to expect from them the propagation of particular branches of ſcience, it became neceſſary to eſtabliſh other literary and ſcientific academies.

Accordingly, the French government have founded, 1*ſt*, Schools of health (*les ecoles de ſante*), in Paris, Straſburgh, and

---

(A) We would tranſlate this chronological jargon into the language of Chriſtian Europe, were we not perſuaded that the French calendar, the French conſtitution, and the French inſtitutes, will have the ſame duration as we truſt in God not a long duration. For *Pluvioſe*, and the other fantaſtical names of months introduced into this article, ſee REVOLUTION, *Encycl.* nº 184.

and Montpelier, where medicine and ſurgery are ſtudied; which ſchools are affirmed, by thoſe who find nothing wrong in France, to be the moſt perfect of their kind, as well as new and unparalleled models for ſuch inſtitutions.

2*d*, Two ſchools for Oriental languages, in the national library, and in the college of France.

3*d*, The Polytechnic ſchool in Paris, or central ſchool for the direction of public works. This eſtabliſhment is very generally admired and conſidered as a model for imitation. It contains more than 400 young perſons, previouſly educated in the mathematics, and the majority of them intended for engineers in various lines; and they labour under the immediate direction of their tutors nine hours every day. It occupies the principal part of the *Palais de Bourbon* in Paris, and is furniſhed with a large collection of inſtruments and models. The journal of the Polytechnic ſchool, which is publiſhed by the bookſellers Regent and Bertrand at Paris, is a perfectly original work, and admirably calculated to convey uſeful information.

Of the national inſtitute a ſufficient account has been given in the preceding article. We proceed therefore to the jury of public inſtruction (*Le Jury Central d'Inſtruction*), of which the principal buſineſs is to ſuperintend the primary and central ſchools. It appoints the profeſſors in theſe ſchools, and examines into their conduct. Like the legiſlative body it is renewed by a third every half year. When they have choſen a profeſſor for a central ſchool, they ſubmit their choice to the department; and, in caſe of diſapprobation, they make another appointment. To this jury of public inſtruction the profeſſors in the central ſchools are amenable for all miſconduct connected with their offices; it may expel them, but all its deciſions muſt be ſubmitted for confirmation to the tribunal of the department.

There is alſo eſtabliſhed at Paris a ſupreme council, called The Commiſſion of Public Inſtruction, to which is entruſted the whole executive department. The preſervation of the national monuments, of public libraries, muſeums, cabinets, and valuable collections; the ſuperintendance of all the ſchools and the modes of inſtruction; all new inventions and ſcientific diſcoveries; the regulation of weights and meaſures; national ſtatiſtics and political economy, are all placed under the authority of this ſupreme commiſſion. For the commodious and regular execution of ſo many complicated branches of buſineſs, there is a large office, called *Le Secretariat*, which is divided into three departments.

1. For the regulation of the different kinds of inſtruction; of the modes of education in the ſchools; and for the choice of elementary books. 2. For weights and meaſures; inventions and diſcoveries; libraries and bibliography; muſeums, works of art, and literary rewards and encouragements. 3. For theatres, national feaſts, republican inſtitutions, and the erection of monuments.

As all public eſtabliſhments require the ſuperintendance and occaſional correction of the legiſlature, in addition to that of their own immediate executive authority, it has been deemed neceſſary to appoint a permanent committee of inſtruction in the legiſlative body, to provide ſuch ſums as may be neceſſary for the preſervation and improvement of this ſyſtem of inſtruction. This legiſlative committee are inveſted with due authority for theſe purpoſes. Their objects are preciſely the ſame as thoſe of the commiſſion of public inſtruction above deſcribed, only with this difference, that the latter ſuperintends the execution of exiſting laws, whilſt the former receives and improves them, or propoſes new ones. This committee is divided into three departments, as is the commiſſion, with exactly the ſame arrangement of their reſpective labours. The committee being charged with the enaction of all new laws, its members, with a view to obtain accurately all the requiſite information relative to the numerous branches of the arts, have procured from the legiſlative body the appointment of a *commiſſion temporaire des arts* to be annexed to them, and to meet in the ſame houſe with them; which temporary commiſſion is divided into ſixteen claſſes: viz. 1. For Zoology; 2. Botany; 3. Mineralogy; 4. Phyſics; 5. Chemiſtry; 6. Anatomy; 7. Machinery; 8. Geography; 9. Artillery and Fortification; 10. Medals and Antiquities; 11. Bibliography; 12. Painting; 13. Architecture; 14. Sculpture; 15. Bridges and Cauſeways; and, 16. Muſical Inſtruments.

The improvements of the national literary and ſcientific eſtabliſhments are numerous and important.

1*ſt*, By a decree of the convention of the 11th *Prairial*, in the ſecond year, it was enacted, that means ſhould be adopted by which every poſſible advantage might be derived from the botanic gardens of the republic, in Turkey and other foreign countries. This politic decree clearly tended to render France, in the language of the reporter, *L'abregé de tous les climats, et l'entrepôt de l'Europe.* "The epitome of every climate, and the magazine of Europe." Thoſe plants which thrive between the tropics may be cultivated in the ſouth of France; and thoſe which are the produce of northern climates, may be cultivated in the northern departments; by which means, France will be in poſſeſſion of all foreign plants and drugs, without the exportation of ſpecie.

2*d*, The National Bibliography was decreed in the ſitting of 22d *Germinal*, in the ſecond year. It conſiſts of a complete catalogue of books of all deſcriptions, the property of the nation; it was then aſcertained, that the republic poſſeſſed more than ten millions of books. The titles of them were to be adjuſted by actual compariſons; the manuſcripts to be regiſtered ſeparately; anonymous productions were to be arranged according to their ſubjects; and thoſe of known authors in the alphabetical order of the names. The ſeveral editions to be claſſed according to their dates: and what may be deemed more important, this French National Bibliography will contain a dictionary of anonymous books, as well as thoſe publiſhed under fictitious names, a deſideratum in the republic of letters.

3*d*, The annihilation of all *patois*, or dialects, decreed in the ſitting of the 16th *Prairial*, in the ſecond year. Notwithſtanding the univerſality of the French language, and that it was excluſively ſpoken in the majority of the inland departments, yet there exiſted thirty various dialects in France. It is more aſtoniſhing that Rozier had remarked, that between one neighbouring village and another, there was ſo conſiderable a difference in the dialect, that the inhabitants could not underſtand each other; and the vineſtock had thirty different names. The naturaliſt, Villars, has ſtated, that in the nomenclature of vegetables, in the departments, he had only met with an hundred which had a common appellation.

Inſtitute.

4*th*, The eſtabliſhment of the *Conſervatoire des Arts et Métiers*, was decreed in the ſitting of the 8th of *Vendemiaire*, in the third year. This conſiſts of a ſpacious hall, in the form of an amphitheatre, and contains the inſtruments and the models of machinery connected with the arts, and a deſcription of their uſes, with every book relating to them. Annexed to this eſtabliſhment are three expoſitors and a draughtſman, who explain to the ſtudents the uſe of each inſtrument, and who regiſter every new diſcovery, which is preſented to the *Bureau de Conſultation*, to the lyceum of arts, the *ci-devant* academy of ſciences, or to the board of commerce.

5*th*, The eſtabliſhment of the board of longitnde was decreed in the ſitting of the 7th of *Meſſidor*, third year. It was certainly a diſgrace under the monarchy, that an aſtronomical and nautical eſtabliſhment, which had already proved ſo beneficial to Great Britain, ſhould not have been adopted in France. In conſequence of this decree, the French board is now as complete as the Engliſh. It conſiſts of ten members, and has under its juriſdiction the national obſervatory at Paris, and all the aſtronomical inſtruments belonging to the republic. It correſponds with foreign aſtronomers; delivers public lectures on aſtronomy and navigation; and its proceedings are annually recited in a public ſitting.

6*th*, The general ſchool of the Oriental languages was eſtabliſhed by a decree of the 10th of *Germinal*, in the fourth year. This ſchool adjoins to the national library, and all the books and manuſcripts relative to Oriental literature are depoſited in it.

7*th*, The national muſeum of antiquities was decreed in the ſitting of 20th of *Prairial*, fourth year. A ſchool of this deſcription was ſucceſsfully eſtabliſhed at Vienna, by Eckel; at Gottingen, by Heyne; at Leipſick, by Erneſt; and even at Straſburgh, by the celebrated Oberlin: Paris was, however, without one. This national archeology, or ſcience of antiquity, is divided into nine different claſſes: inſcriptions, characters, ſtatues, *bas reliefs*, ſculptures, paintings, moſaics, medals, civil, religious, and military inſtruments. This extenſive eſtabliſhment is under the direction of two principal profeſſors; *le Conſervateur Profeſſeur, et le Conſervateur Bibliothecaire*. The province of the former is to deliver public lectures on the ſeveral branches of antiquities, to teach the theory of medals and engravings, the hiſtory of the arts among the ancients, &c. The duties of the latter are merely of a bibliographical nature.

8*th*, The new modelling of the Grand National Library, was decreed in the ſitting of 25th *Vendemiaire*, in the fourth year. By virtue of this decree, the place of librarian in chief was ſuppreſſed, and the whole eſtabliſhment placed under a *conſervatoire* of eight members; of whom two were appointed for the ſuperintendance of printed books; two for manuſcripts; two for antiquities; and two for engravings. From theſe a temporary director is annually choſen, who ſuperintends the whole acts occaſionally as preſident of this aſſembly, and maintains a regular correſpondence with the conſtituted authorities relative to the concerns of the library.

9*th*, The augmentation of the Muſeum of Natural Hiſtory, formerly called *Le Jardin Royal des Plantes*. This eſtabliſhment was decreed the 15th *Brumaire*, third year, upon a report of Thibadeau, in the name of the committee of Public Inſtruction. Beſides the addition of large rooms, and various other buildings, there are new collections of natural curioſities and productions; and the library is much increaſed. It is open to the public three times a week. At ſtated periods all the naturaliſts in Paris deliver courſes of lectures in the various branches of natural hiſtory. The muſeum is ſaid to have received greater improvements from this augmentation than from all the labours of Buffon, or from its foundation, ſince the time of Tournefort.

10*th*, The *Ecole des Mines* was eſtabliſhed in the *Hotel des Monnaies*, and has for its direction the naturaliſt Le Sage. This inſtitution is unrivalled in Europe; and the collection of mineralogical curioſities ſurpaſſes whatever can be conceived.

11*th*, The ſociety of natural hiſtory in Paris, deſervedly claſſes among thoſe which have rendered the greateſt ſervices to the cauſe of ſcience ſince the revolution. A lecture of public inſtruction is held every ten days, which is generally given by one of the members, and which is open to all the lovers of natural hiſtory. Premiums are propoſed for diſſertations; one of which, by the late C. Herman, jun. (whoſe early deceaſe was a great loſs to the republic of letters) on the *apterous* claſs of inſects, may be ſaid to conſtitute an epocha in the annals of natural hiſtory. The ſociety has publiſhed a volume of memoirs, in folio, entitled, "*Tranſactions of the Society of Natural Hiſtory*." It has likewiſe erected a ſtatue to the great Linnæus, in the national garden of plants; and, at the period when every public inſtruction was ſuſpended, gave lectures on the different branches of ſcience belonging to its department. Several intelligent and ſkilful navigators, among others thoſe ſent in ſearch of the unfortunate La Pérouſe, as well as thoſe which accompanied Buonaparte on his romantic expedition to Egypt, were members of this ſociety.

This ſtatement of facts relative to the preſent ſtate of public inſtruction, the ſciences, the arts, and the progreſs of national literature in France, has been taken from a miſcellany, of which the principal writers are well acquainted with what is doing in that diſtracted country. They call it a ſublime ſyſtem; and ſeem to conſider the increaſe of the national library, the improvement of the botanic gardens, and the diſcoveries that have been made by the different ſchools or inſtitutes, as furniſhing a demonſtration that the republican government is more favourable to the advancement of ſcience, than the monarchical, whether abſolute or limited. But it ſhould not be forgotten, that this ſyſtem is yet in its infancy; and that in proſecuting new ſchemes, all men, and more eſpecially Frenchmen, are actuated by an enthuſiaſm which gradually cools as their purſuits become familiar. We ſhall therefore venture to predict, that the different ſchools will not diſplay ſuch ardour ſeven years hence as they do at preſent; and that if the republican government continue a dozen of years in France, the progreſs of ſcience in that country will not be more rapid than it was under the monarchy. We muſt remember, too, that the French libraries, muſeums, and picture galleries, have been improved by means which the morals of other governments do not employ—by rapine and robbery.

That ſomething may be learned from this ſyſtem to improve the modes of education in other countries, we admit; and it is for that reaſon that we have inſerted an account of it. But if it contains ſomething worthy of imitation, it contains likewiſe much to be ſhunned. We do not think it conſiſtent with the *rights of man* to *compel* parents to ſend their children to be educated in *particular* ſchools; eſpecially in ſchools where not only religious inſtruction is omitted, but where, there is reaſon to believe, that the profeſſors are at pains to raze all religious impreſſions from the youthful mind. In a nation denying the truth of Chriſtianity, it is not to be ſuppoſed that the Chriſtian religion will be publicly taught; but in a nation of philoſophers, as the French call themſelves, it might have been expected that the laws of religious toleration would have been ſo far regarded, that Chriſtian parents would not have been *compelled* to ſend their children to *antichriſtian* ſchools! But it is not Chriſtianity alone that is neglected in this *ſublime* ſyſtem of education. Though the legiſlative body has ſome time ago decreed that there is a God, there is not in any one of thoſe ſchools the ſmalleſt care taken to inſtruct the republican youth in the principles even of natural religion! We might indeed have looked for it under the title *Metaphyſics*, had not the conſtitution of the National Inſtitute taught us, that French metaphyſics attend to nothing but the analyſis of ſenſations and ideas. Yet the legiſlators might have liſtened on this ſubject to a republican as ſound as themſelves, and who was likewiſe no friend to ſuperſtition. "Nam et Majorum inſtituta tueri ſacris, ceremoniiſque retinendis ſapientis eſt. Non ſolum ad religionem pertinet, ſed etiam ad *civitatis* ſtatum, ut ſine iis, qui ſacris publice præſunt, religioni privatæ ſatisfacere non poſſunt." *Cicero de Nat. Deorum.*

INSURANCE, in law and commerce, though an excellent inſtitution, is not of high antiquity. The oldeſt laws and regulations concerning inſurance, with which the indefatigable Beckmann is acquainted, are the following:

On the 28th of January 1523, five perſons appointed for that purpoſe drew up at Florence ſome articles which are ſtill employed on the exchange at Leghorn. Theſe important regulations, together with the preſcribed form of policies, which may be conſidered as the oldeſt, have been inſerted, in Italian and German, by Magens, in his Treatiſe on Inſurance, average, and bottomry, publiſhed at Hamburgh in 1753.

There is ſtill preſerved a ſhort regulation of the 25th May 1537, by the Emperor Charles V. reſpecting bills of exchange and inſurance, in which the ſtrictly fulfilling only of an agreement of inſurance is commanded.

In the year 1556, Philip II. king of Spain, gave to the Spaniſh merchants certain regulations reſpecting inſurance, which are inſerted by Magens, with a German tranſlation, in his work before-mentioned. They contain ſome forms of policies on ſhips going to the Indies.

In the year 1598, the *Kamer von aſſurantie*, chamber of inſurance, was eſtabliſhed at Amſterdam. An account of the firſt regulations of this inſurance office may be ſeen in Pontanus's Hiſtory of the city of Amſterdam, and in other works.

In the year 1600, regulations reſpecting inſurance were formed by the city of Middelburg in Zealand.

It appears that the firſt regulations reſpecting inſurances in England, which may be ſeen in *Anderſon's Hiſtory of Commerce*, were made in the year 1601. We find by them, that inſurers had before that period conducted themſelves in ſuch a manner, that the utmoſt confidence was repoſed in their honeſty, and that on this account few or no diſputes had ariſen.

Of the various policies for inſurance in England, a pretty accurate account will be found in the *Encyclopædia*; but there is one of them, of which our account muſt be acknowledged to be now defective. This is,

INSURANCE on lives; which is a policy that has greatly increaſed, in conſequence of its utility being more generally underſtood. Of the two offices for life aſſurances, noticed in that article, the former, entitled the *Amicable Society*, has extended the number of its ſhares to 4000; but, as we have already obſerved, the nature of the inſtitution is too limited to become of general importance. The latter, entitled, the *Society for Equitable Aſſurances on Lives and Survivorſhip*, is undoubtedly one of the moſt important inſtitutions of the kind, as will appear by the following account, with which we have been favoured by an obliging correſpondent, and upon the accuracy of which our readers may depend:

The members of the equitable ſociety, finding, in June 1777, that their affairs were in a flouriſhing ſituation, reſolved to reduce their annual premiums one tenth; and in 1782, adopted new tables agreeable to the probabilities of life at Northampton, in lieu of thoſe they had hitherto uſed, formed from the London bills of mortality. But though it was evident, that the new tables were much better adapted for aſſuring promiſcuouſly perſons reſiding in the country, or in large towns, it was thought proper, for greater ſecurity, to make an addition of 15 per cent. to the real value of the aſſurances, as computed from the table of mortality at Northampton; and with the view of making an adequate compenſation to the aſſured for their former payments, which had been ſo much higher than would be required by the new rates, an addition was made to their claims of L.1 : 10s. per cent. for every premium they had paid. The conſequence of theſe meaſures proved highly favourable to the ſociety; for its buſineſs increaſed ſo faſt, that in 1785 it was nearly doubled; the ſums aſſured amounting to upwards of L.720,000. At this period, the favourable reſult of a minute and very laborious inveſtigation of the ſtate of the ſociety, induced them to take off the 15 per cent. charged upon the premiums in 1782, and make a further addition to the claims of L.1 per cent. for every payment made prior to the 1ſt January 1786. A ſtill greater increaſe of ſucceſsful buſineſs determined them, in 1791, to make another addition of L.1 per cent. to the claims; and in the following year, a further addition of L.2 per cent.; by which the claims upon aſſurances of the year 1770 were more than doubled; and thoſe of an earlier date increaſed in a ſtill higher proportion. By theſe advantages to its members, and the honourable and truly equitable manner in which the concerns of the ſociety are tranſacted, the augmentation of their buſineſs has been ſo great, that on the 31ſt December 1794, the ſums aſſured (without including the additions made to them) amounted to upwards of L.3,000,000; and on the 31ſt December 1795, to about L.4,000,000.

The rates of aſſurance, as reduced to their real values in 1786, and according to which the ſociety now tranſact buſineſs, are as follows :

Sum Aſſured £. 100.

Age.	*One Year.*			*Seven Years.*			*Whole Life.*		
15	£. 0	17	11	£. 1	2	11	£. 1	18	7
20	1	7	3	1	9	5	2	3	7
25	1	10	7	1	12	1	2	8	1
30	1	13	3	1	14	11	2	13	4
35	1	16	4	1	18	10	2	19	10
40	2	0	8	2	4	1	3	7	11
45	2	6	8	2	10	10	3	17	11
50	2	15	1	3	0	8	4	10	10
55	3	5	0	3	12	0	5	6	4
60	3	18	1	4	7	1	6	7	4
65	4	15	2	5	10	10	7	16	9

The other offices in London for the aſſurance of lives are, the *Royal Exchange Aſſurance*, the *Weſtminſter Society*, and the *Pelican Life Office*.

The corporation of the *Royal Exchange Aſſurance* was empowered to aſſure lives by its ſecond charter, dated 29th April 1721; but the original object of the company being ſea aſſurances, and the true principles of aſſuring on lives being at that time little underſtood, this branch of their buſineſs was at firſt comparatively ſmall : they generally required a premium of five or ſix guineas per cent. without any regard to the age ; and the aſſurance, which was uſually for a ſmall ſum, was ſeldom for a greater term than one year. In this manner they continued to aſſure upon lives till the end of the year 1783, when the increaſing importance of this part of their buſineſs, which they had ſome years felt, induced them to adopt a regular table of rates of aſſurance, according to the Northampton regiſters of mortality, but with a greater addition to the real values than had been made by the "Society for Equitable Aſſurances on Lives and Survivorſhip." This was thought proper, from the conſideration that the aſſurers with the Royal Exchange company are not in any caſe liable to a call upon them beyond the premium they engage to pay, and have the ſecurity of the capital and funds of the company ariſing from the other branches of their buſineſs ; however, the company, finding themſelves ſucceſsful in their life aſſurances, determined, in 1790, to reduce their premiums ; and in 1797 made a ſtill greater reduction, by which they are brought very near to thoſe above ſtated. This company have agents in all the principal towns of Great Britain, and are impowered to aſſure lives in all parts of the world.

The *Weſtminſter Society* was eſtabliſhed in 1792, for aſſuring lives, and granting annuities. Their terms are nearly the ſame as thoſe of the Royal Exchange Aſſurance ; but not being a corporate body, every perſon aſſuring ſigns a declaration, that he accepts the joint ſtock of the ſociety as his ſecurity.

The *Pelican Life Office* was inſtituted in 1797, by ſome of the principal proprietors of the Phœnix Fire Office. The rates which they have publiſhed vary conſiderably from thoſe of the other offices ; but whether they are founded on more juſt principles, time and experience muſt determine. This ſociety alſo makes a new ſpecies of aſſurance, by way of endowment for daughters, or for children generally, when they ſhall attain the age of twenty-one years.

INTEGRAL CALCULUS, in the new analyſis, is the reverſe of the differential calculus, and is the finding of the integral from a given differential ; being ſimilar to the inverſe method of fluxions, or the finding the fluent to a given fluxion. See FLUXIONS, *Encycl.*

INTEREST, is the allowance given for the uſe of money by the borrower to the lender, and is either *ſimple* or *compound*. The method of computing both intereſts is explained in the article ALGEBRA, (*Encycl.*) page 427, &c. ; and the ſubject of ſimple intereſt is again reſumed in ARITHMETIC, (*Encycl.*) n° 20. The application of the canons for the computation of compound intereſt, to the value of annuities, the only caſe in which that intereſt is allowed by the laws of this country, may be ſeen in the articles ANNUITY and SURVIVORSHIP, (*Encycl.*) ; where various tables are given to facilitate the different computations. Some of our readers, however, have expreſſed a wiſh to have the rule for computing compound intereſt ſo ſtated, as to be underſtood by thoſe who are unacquainted with algebraic ſymbols. Their wiſh may be eaſily gratified.

The general formula $S = p\,R^t$ anſwers for the amount of any ſum, whether the intereſt be payable yearly, half-yearly, quarterly, or daily. Let R denote the amount of one pound for the firſt payment, and t the number of payments, the unit being from the commencement till the firſt payment is due ; alſo, let l denote the logarithm of any quantity before which it is wrote; then, from the known property of logarithms, the theorem may be expreſſed thus, $l.\,S = l.\,p + l.\,R \times t$.

Required the amount of L. 250 at 5 per cent. compound intereſt, for 12 years, reckoning the intereſt payable yearly, half-yearly, quarterly, and daily ?

Yearly. $p = 250,\ R = 1{\cdot}05,\ t = 12.$

$$\begin{array}{r}
0{\cdot}0211893 = l.\,R \\
12 \\
\hline
{\cdot}2542716 = l.\,R \times t. \\
2{\cdot}3979400 = l.\,p. \\
\hline
\end{array}$$

$$l.\,S = 2{\cdot}6522116 - \text{L. } 448 : 19 : 3\tfrac{1}{4} = \text{Amount.}$$

$$\begin{array}{r}
250 \\
\hline
198 : 19 : 3\tfrac{1}{4} = \text{Comp. intereſt.}
\end{array}$$

Half yearly, $p = 250,\ R = 1{\cdot}025,\ t = 24.$

$$\begin{array}{r}
0{\cdot}0107239 = l.\,R. \\
24 \\
\hline
428956 \\
214478 \\
\hline
{\cdot}2573736 = l.\,R \times t. \\
2{\cdot}3979400 = l.\,p. \\
\hline
\end{array}$$

$$l.\,S = 2{\cdot}6553136 - \text{L. } 452 : 3 : 7\tfrac{1}{4} = \text{Amount.}$$

$$\begin{array}{r}
250 \\
\hline
202 : 3 : 7\tfrac{1}{4} = \text{Intereſt.}
\end{array}$$

Quarterly. $p = 250$, $R = 1·0125$, $t = 48$.

0·0053950 = *l.* R.
48

431600
215800

·2589600 = *l.* R × *t*.
2·3979400 = *l.* *p*.

l. S = 2·6569000 — L. 453 : 16 : $8\frac{3}{4}$ = Amount.
250

203 : 16 : $8\frac{3}{4}$ = Intereſt.

Daily, $p = 250$, $R = 1 + \frac{·05}{365} = \frac{365·05}{365}$, $t = 365 \times 12$.

2·5623524
2·5622929

·0000595 = *l.* R.
4380

47600
1785
2380

·2606100 = *l.* R × *t*.
2·3979400 = *l.* *p*.

l. S = 2·6585500 — L. 455 : 11 : $3\frac{1}{2}$ = Amount.
250

205 : 11 : $3\frac{1}{2}$ = Intereſt.

INTERPOLATION, in the modern algebra, is uſed for finding an intermediate term of a ſeries, its place in the ſeries being given. See ALGEBRA and SERIES, *Encycl.*

The method of interpolation was firſt invented by Mr Briggs, and applied by him to the calculation of logarithms, &c. in his Arithmetica Logarithmica, and his Trigonometria Britannica; where he explains, and fully applies, the method of interpolation by differences. His principles were followed by Reginal and Mouton in France, and by Cotes and others in England. Wallis made uſe of the method of interpolation in various parts of his works; as his arithmetic of infinites, and his algebra, for quadratures, &c. The ſame was alſo happily applied by Newton in various ways: by it he inveſtigated his binomial theorem, and quadratures of the circle, ellipſe, and hyperbola. See Wallis's Algebra, chap. 85. &c. Newton alſo, in lemma 5. lib. 3. Princip. gave a moſt elegant ſolution of the problem for drawing a curve line through the extremities of any number of given ordinates; and in the ſubſequent propoſition, applied the ſolution of this problem to that of finding, from certain obſerved places of a comet, its place at any given intermediate time. And Dr Waring, who adds, that a ſolution ſtill more elegant, on ſome accounts, has been ſince diſcovered by Meſſ. Nichol and Stirling, has alſo reſolved the ſame problem, and rendered it more general, without having recourſe to finding the ſucceſſive differences. *Philoſ. Tranſ.* vol. 69. part 1. art. 7.

INTERSCENDENT, in algebra, is applied to quantities, when the exponents of their powers are radical quantities. Thus $x^{\sqrt{2}}$, $x^{\sqrt{a}}$, &c. are interſcendent quantities.

INTERSTELLAR, a word uſed by ſome authors to expreſs thoſe parts of the univerſe that are without and beyond the limits of our ſolar ſyſtem.

INTRADOS, the interior and lower ſide, or curve, of the arch of a bridge, &c. In contradiſtinction from the extrados, or exterior curve, or line on the upper ſide of the arch. See ARCH in this *Suppl.*

INVOLUTION and EVOLUTION, are terms introduced into geometry by the celebrated Mr Huyghens, to expreſs a particular manner of deſcribing curvilineal ſpaces which occurred to him when occupied in the improvement of his noble invention of pendulum clocks. Although he was even aſtoniſhed at the accuracy of their motion, and they ſoon ſuperſeded all balance clocks, he knew that the wide vibrations were ſomewhat ſlower than the narrow ones, and that a circle was not ſufficiently incurvated at the ſides to render all the vibrations iſochronous. The proper curve for this purpoſe became an intereſting object. By a moſt accurate inveſtigation of the motions of heavy bodies in curved paths, he diſcovered that the cycloid was the line required. Lord Brouncker had diſcovered the ſame thing, as alſo Dr Wallis. But we do not imagine that Huyghens knew of this; at any rate, he has the full claim to the diſcovery of the way of making a pendulum oſcillate in a cycloidal arch. It eaſily occurred to him, that if the thread by which the pendulum hangs be ſuſpended between two curved cheeks, it would alternately lap on each of them in its vibrations, and would thus be raiſed out of the circle which it deſcribes when ſuſpended from a point. But the difficulty was to find the proper form of thoſe cheeks. Mr Huyghens was a moſt excellent geometer, and was poſſeſſed of methods unknown to others, by which he got over almoſt every difficulty. In the preſent caſe there was fortunately no difficulty, the means of ſolution offering themſelves almoſt without thought. He almoſt immediately diſcovered that the curve in queſtion was the ſame cycloid. That is, he found, that while a thread unwinds from an arch of a cycloid, beginning at the vertex, its extremity deſcribes the complementary arch of an equal cycloid. Thus he added to this curve, already ſo remarkable for its geometrical properties, another no leſs curious, and infinitely exceeding all the others in importance.

The ſteps by which this property was diſcovered are ſuch direct emanations from general principles, that they immediately excited the mind of Mr Huyghens, which delighted in geometry, to proſecute this method of deſcribing or transforming curve lines by evolution. It is ſurpriſing that it had not ere this time occurred to the ancient geometers of the laſt century, and particularly to Dr Barrow, who ſeems to have racked his fancy for almoſt every kind of motion by which curve lines can be generated. Evolution of a thread from a curve is a much more obvious and conceivable geneſis than that of the cycloid invented by Merſennus, or that of the conchoid by Nicomedes, or thoſe of the conic ſections by Vieta. But except ſome vague expreſſions by Ptolemy and Gaſſendus, about deſcribing ſpirals

Involution.

by a thread unlapped from a cylinder, we do not recollect any thing of the kind among the writings of the mathematicians; and it is to Huyghens alone that we are indebted for this very beautiful and important branch of geometry. It well deſerves both of theſe epithets. The theorems which conſtitute the doctrines of evolution are remarkable for their perſpicuity and neatneſs. Nothing has ſo much contributed to give us clear notions of a very delicate ſubject of mathematical diſcuſſion, namely curvature, and the meaſure and variations of curvature. It had become the ſubject of very keen debate; and the notions entertained of it were by no means diſtinct. But nothing can give ſuch a preciſe conception of the difference of curvature, in the different parts of a cycloid or other curve, as the beholding its deſcription by a radius continually varying in length. This doctrine is peculiarly valuable to the ſpeculator in the higher mechanics. The intenſity of a deflecting force is eſtimated by the curvature which it induces on any rectilineal motion; and the variations of this intenſity, which is the characteriſtic of the force, or what we call its nature, is inferred from the variations of this curvature. The evolution and involution of curve lines have therefore great claim to our attention. But a Work like ours can only propoſe to exhibit an outline of the ſubject; and we muſt refer our readers to thoſe eminent authors who have treated it in detail. Varignon, in the Memoirs of the French Academy for 1706, has been at immenſe pains to preſent it in every form; James Bernoulli has alſo treated the ſubject in a very general and ſyſtematic manner. Some account is given of it in every treatiſe of fluxions. We recommend the original work of Mr Huyghens in particular; and do not heſitate to ſay, that it is the fineſt ſpecimen (of its extent) of phyſico-mathematical diſcuſſion that ever has appeared. Huyghens was the moſt elegant of all modern geometers; and both in the geometrical and phyſical part of this work, *De Horologio Oſcillatorio*, he has preſerved the utmoſt rigour of demonſtration, without taking one ſtep in which Euclid or Apollonius would not have followed him.

> ———— *juvat integros accedere fontes*
> *Atque haurire.*

Such authors form the taſte of the young mathematician, and help to preſerve him from the almoſt mechanical procedure of the expert ſymbolical analyſt, who arrives at his concluſion without knowing how he gets thither, or having any notions at all of the magnitudes of which he is treating.

There are two principal problems in this doctrine.

I. To aſcertain the nature of the figure generated by the evolution of a given curve.

II. To determine the nature of the curve by whoſe evolution a given curve may be generated.—We ſhall conſider each of theſe in order, and then take the opportunity which this ſubject gives of explaining a little the abſtruſe nature of curvature, and its meaſures and variations, and take notice of the opinions of mathematicians about the preciſe nature of the angle of contact.

Plate XXXI.

The curve line ABCDEF (fig. 1.) may be conſidered as the edge of a crooked ruler or mould; a thread may be ſuppoſed attached to it at F, and then lapped along it from F to A. If the thread be now led away from A, keeping it always tight, it is plain that the extremity A muſt deſcribe a curve line A*bcdef*, and that the detached parts of the thread will always be tangents to the curve ABCDEF. In like manner will the curve line F*d′c′b′*A′ be deſcribed by keeping the thread faſt at A, and unlapping it from the other end of the mould

This proceſs was called by Mr Huyghens the EVOLUTION of the curve ADF. ADF is called the EVOLUTE. A*df* was named by him the CURVE BY EVOLUTION. It has been ſince more briefly termed the EVOLUTRIX, or unlapper. It has alſo been called the INVOLUTE; becauſe, by performing the proceſs in the oppoſite direction *fd*A, the thread is lapped up on the mould, and the whole ſpace ADF*fd*A is folded up like a fan. The detached parts C*c*, D*d*, or C*c′*, D*d′*, &c. of the thread, are called RADII OF THE EVOLUTE; perhaps with ſome impropriety, becauſe they rather reſemble the momentary radii of the evolutrix. We may name them the EVOLVED RADII. The beginning A of evolution may be conſidered as the vertex of the curves, and the ends F and *f* may be called the TERMS.

There is another way in which this deſcription of curve lines may be conceived. Inſtead of a thread F*f* gradually lapped up on the mould, we may conceive F*f* to be a ſtraight edged ruler applied to the mould, and gradually rolled along it without ſliding, ſo as to touch it in ſucceſſion in all its points. It is evident, that by this proceſs the point *f* will deſcribe the curve *fd*A, while the point F deſcribes the other curve F*da*. This way of conceiving it gives a great extenſion to the doctrine, and homologates it with that geneſis of curve lines by which cycloids of all kinds are deſcribed, and which we may diſtinguiſh by the name of PROVOLUTION. For it is plain, that the relative motions of the points A and *b* are the ſame, whether the ruler *b*B*b′* roll on the mould ABF, or the mould roll on the ruler: but there will be a great difference in the form of the line traced by the deſcribing point, if we ſuppoſe the plane on which it is traced to be attached to the rolling figure. Thus, when a circle rolls on a ſtraight line, a point in its circumference traces a cycloid on the plane attached to the ſtraight line, while the point of the ſtraight line which quitted the circle deſcribes on the plane attached to the circle another line; namely, the involute of the circle. This mode of deſcription allows us to employ a curved ruler in place of the ſtraight one *b*B*b′*; and thus gives a vaſt extenſion to the theory. But at preſent we ſhall confine ourſelves to the employment of the ſtraight line *b*B*b′*, only keeping in mind, that there is an intimate connection between the lines of evolution and of provolution.

By the deſcription now given of this proceſs of evolution and involution, it is plain,

1. That the evolution is always made from the convex ſide of the evolute.

2. That the evolved radii B*b*, C*c*, D*d*, &c. are reſpectively equal to the arches BA, CA, DA, &c. of the evolute which they have quitted; and that *b*B*b′*, *c*C*c′*, *d*D*d*, &c. are always equal to the whole arch ADF.

3. That any point B of the lapped up thread deſcribes during its evolution a curve line B$\gamma\delta\varepsilon\phi$ parallel to *bcdef*; becauſe theſe curves are always equidiſtant from each other.

4. That if the thread extend beyond the mould as a tangent to it, the extremity α will deſcribe a parallel or equidiſtant

equidiſtant curve $\alpha\beta\gamma\delta\epsilon\varphi$, lying without A$bcdef$. From this it appears that B$\gamma\delta\epsilon\varphi$ is the complete evolutrix of FEDCB, while $bdcef$ is the evolutrix of that arch, and the added tangent Bb. In like manner, the lapped up thread ADF, with the added part Fφ', deſcribes the evolutrix $\varphi'\epsilon'\delta'\gamma'\beta'$ A′.

5. If from any point C of the evolute there be drawn lines Cb, Cc, Cd, Ce, &c. to the evolutrix, thoſe which are more remote from the vertex are greater than thoſe which are nearer. Draw Bb, cC, dD, eE, touching the evolute. Cb is leſs than CB + Bb; that is (2), than Cc. Again, DC + Cc is equal to Dd, which is leſs than DC + Cd. Therefore Cc is leſs than Cd. Now let Ce cut Dd in r. Then er + rDE is greater than eE. But eE is equal to dr + rDE. Therefore er is greater than dr; and er + rC is greater than dr + rC, which is greater than cC. Therefore eC is greater than cC.

6. Hence it follows, that a circle deſcribed round any point of the evolute, with a radius reaching to any point of the evolutrix, will cut the evolutrix in that point, and be wholly within it on the ſide remote from the vertex, and without it on the ſide next the vertex.

7. The evolved radius cuts every arch of the evolutrix perpendicularly, or a right line drawn through the interſection at right angles touches the evolutrix in that point. Through any point d draw the line mdt at right angles to dD. The part of it md next to the vertex is wholly without the curve, becauſe it is without the circle deſcribed round the centre D; and this circle is without the evolutrix on that ſide of d which is next the vertex (6). Any point t on the other ſide of d is alſo without the curve. For let teE be another evolved radius, cutting Dd in n: then nd is leſs than nt, becauſe ndt is a right angle by conſtruction; and therefore ntd is acute. But becauſe En + nD are greater than ED, En + nd are greater than ED + Dd, that is, than Ee, and nd is greater than ne. Therefore, ſince it is leſs than nt, it follows that ne is much leſs than nt, and t lies without the curve. Therefore the whole line mdt is without the curve, except in the point d. It therefore touches the curve in d, and the radius Dd cuts it at right angles in that point. By the ſame reaſoning, it is demonſtrated, that all the curves Abdf, $\alpha\beta\delta\varphi$, A′$b'd'f'$, $\alpha'\beta'\delta'\varphi'$, are cut perpendicularly by the tangents to the evolute. Alſo all theſe curves interſect the evolute at right angles in their vertexes

It follows from this propoſition, that from every point, ſuch as s, or i, or o, &c. in the ſpace AOF comprehended by the evolute and its extreme tangents AO, FO, two perpendiculars may be drawn to the evolutrix Adf; and that from any point in the ſpace within the angle Aof only one perpendicular can be drawn; and that no perpendicular can be drawn from any point on the other ſide of ADF. Apollonius had obſerved theſe circumſtances in the conic ſections, but had not thought of marking the boundary formed by the evolute ADF. Had he noticed this, he would certainly have diſcovered the whole theory of evolution, and its importance in ſpeculative geometry.

It alſo follows from this propoſition, that if a curve A$bcdef$ is cut by the tangents of ABCDEF at right angles in every point, it will be deſcribed by the evolution of that curve: For if the evolutrix, whoſe vertex is A, be really deſcribed, it will coincide with Abcd in A, and have the ſame tangent; it therefore does not deviate from it, otherwiſe their tangents would ſeparate, and would not both be at right angles with the lines touching the evolute. They muſt therefore coincide throughout.

8. The arches bcd and $\beta\gamma\delta$, intercepted by the ſame radii Bb and Dd, may be called *concentric*; and the angles contained between the tangents drawn thro' their extremities are equal. Thus the angle $\lambda\pi o$ is equal to lpo: but although equidiſtant, parallel, and containing the ſame angle between their tangents and between their radii, they are not ſimilar. Thus, the arch $\alpha\beta$ has a curvature at α that is the ſame with that of any circle whoſe radius is equal to Aα; but the curvature at A is incomparable with it, and unmeaſurable. The ſame may be ſaid of the curvatures at β and at B.

9. If a circle udz be deſcribed round the centre D with the radius Dd, it both touches and cuts the evolutrix in the point d, and no circle can be deſcribed touching the curve in that point, and paſſing between it and the circle udz: For ſince it touches the curve in d, its centre muſt be ſomewhere in the line dD perpendicular to mdt. It cannot be in any point n more remote from d than D is; for it would paſs without the arch du, and be more remote than du from the arch dc of the evolutrix. On the other ſide, it would indeed paſs without the arch dz, which lies within the arch de of the evolutrix: but it would alſo paſs without the curve. For it has been already demonſtrated (7) that nd is greater than ne; and the curve would lie between it and the circle dz.

Thus it appears, that a circle deſcribed with the evolved radius approaches nearer to the curve, or touches it more cloſely, than any other circle; all other circles either interſect it in meaſurable angles, or are within or without the curve on both ſides of the point of contact. This circle udz has therefore the ſame curvature with the curve in the point of contact and coaleſcence. It is the EQUICURVE CIRCLE, the circle of equal curvature, the OSCULATING CIRCLE (a name given it by Leibnitz). The evolved radius of the evolute is the RADIUS OF CURVATURE of the evolutrix, and the point of the evolute is the CENTRE OF CURVATURE at the point of contact with the evolutrix. The evolute is the geometrical locus of all the centres of curvature of the evolutrix.

This is the moſt important circumſtance of the whole doctrine of the involution and evolution of curve lines. It is aſſumed as a ſelf evident truth by the precipitant writers of elements. It is indeed very like truth: For the extremity of the thread is a momentary radius during the proceſs of evolution; and any minute arch of the evolute nearer the vertex muſt be conceived as more incurvated than the arch at the point of contact, becauſe deſcribed with ſhorter radii: for the ſame reaſon, all beyond the contact muſt be leſs incurvated, by reaſon of the greater radii. The curvature at the contact muſt be neither greater nor leſs than that of the circle. But we thought it better to follow the example of Huyghens, and to eſtabliſh this leading propoſition on the ſtricteſt geometrical reaſoning, acknowledging the ſingular obligation which mathematicians are under to him for giving them ſo palpable a method of fixing their notions on this ſubject. When the evolute of a curve is given, we have not only a clear view of the geneſis of the curve, with a neat and accurate mechanical method of deſcribing it, but alſo a diſtinct comprehenſion of the whole curvature, and a connected view of its gradual variations.

We ſpeak of curvature that is greater and leſſer; and every perſon has a general knowledge or conception of the difference, and will ſay, that an ellipſis is more curve at the extremities of the tranſverſe axis than any where elſe. But before we can inſtitute a compariſon between them with a preciſion that leads to any thing, we muſt agree about a meaſure of curvature, and ſay what it is we mean by a double or a triple curvature. Now there are two ways in which we may conſider curvature, or a want of rectitude: We may call that a double curvature which, in a given ſpace, carries us twice as far from the ſtraight line; or we may call that a double curvature by which we deviate twice as much from the ſame direction. Both of theſe meaſures have been adopted; and if we would rigidly adhere to them, there would be no room for complaint: but mathematicians have not been ſteady in this reſpect, and by mixing and confounding theſe meaſures, have frequently puzzled their readers. All agree, however, in their firſt and ſimple meaſures of curvature, and ſay, that the curvature of an arch of a circle is as the arch directly, and as the radius inverſely. This is plainly meaſuring curvature by the deflection from the firſt direction. In an arch of an inch long, there is twice as much deflection from the firſt direction when the radius of the circle is of half the length. If the radius is about 57¼th inches, an arch of one inch in length produces a final direction one degree different from the firſt. If the radius is 114½ inches, the deviation is but half of a degree. The linear deflection from the ſtraight path is alſo one half. In the caſe of circles, therefore, both meaſures agree: but in by far the greateſt number of caſes they may differ exceedingly, and the change of direction may be greateſt when the linear deviation is leaſt. Flexure, or change of direction, is, in general, the moſt ſenſible and the moſt important character of curvature, and is underſtood to be its criterion in all caſes. But our proceſſes for diſcovering its quantity are generally by firſt diſcovering the linear deviation; and, in many caſes, particularly in our philoſophical inquiries, this linear deviation is our principal object. Hence it has happened, that the mathematician has frequently ſtopped ſhort at this reſult, and has adapted his theorems chiefly to this determination. Theſe differences of object have cauſed great confuſion in the methods of conſidering curvature, and led to many diſputes about its nature, and about the angle of contact; to which diſputes there will be no end, till mathematicians have agreed in their manner of expreſſing the meaſures of curvature. At preſent we abide by the meaſure already given, and we mean to expreſs by curvature or flexure the change of direction.

This being premiſed, we obſerve, that the curvature of all theſe curves of evolution where they ſeparate from their evolutes, is incomparable with the curvature in any other place. In this point the radius has no magnitude; and therefore the curvature is ſaid to be infinitely great. On the other hand, if the evolved curve has an aſſymptote, the curvature of the evolutrix of the adjacent branch is ſaid to be infinitely ſmall. Theſe expreſſions becoming familiar, have occaſioned ſome very intricate queſtions and erroneous notions. There can be little doubt of their impropriety: For when we ſay, that the curvature at A is infinitely greater than at α, we do not recollect that the flexure of the whole arch A *b* is equal to that of the whole arch α β, and the flexure at A muſt either make a part of the whole flexure, or it muſt be ſomething diſparate.

The evolutrix A *b c d f* (fig. 2.) of the common equilateral hyperbola exhibits every poſſible magnitude of curvature in a very ſmall ſpace. At the vertex A of the hyperbola it is perpendicular to the curve; and therefore has the tranſverſe axis A φ A″ for its tangent. The curvature of the evolutrix at A is called infinitely great. As the thread unlaps from the branch ABC, its extremity deſcribes A *b c*. It is plain, that the evolutrix muſt cut the aſſymptote φ H at right angles in ſome point G, where the curvature will be what is called infinitely ſmall; becauſe the centre of curvature has removed to an infinite diſtance along the branch AF of the hyperbola. This evolutrix may be continued to the vertex of the hyperbola on the other ſide of the aſſymptote, by cauſing the thread to lap upon it, in the ſame way that Mr Huyghens completed his cycloidal oſcillation. Or we may form another evolutrix α β γ δ φ γ′ δ′ β′ A″, by lengthening the thread from G to φ, the centre of the hyperbola, and ſuppoſing that, as ſoon as the curve A δ φ is completed, by unlapping the thread from the branch ABC, another thread laps upon the hyperbola A″ F″. This laſt is conſidered as a more geometrical evolution than the other: For the mathematicians, extending the doctrine of evolution beyond Mr Huyghens's reſtriction to curves which had their convexity turned one way, have agreed to conſider as one continued evolution whatever will complete the curve expreſſed by one equation. Now the ſame equation expreſſes both the curves AF and A″F″, which occupy the ſame axis AA″. The cycloid employed by Huyghens is, in like manner, but one continuous curve, deſcribed by the continued provolution of the circle along the ſtraight line, although it appears as two branches of a *repeated* curve. We ſhall meet with many inſtances of this ſeemingly compounded evolution when treating of the ſecond queſtion.

Since the arch A *b d* G contains every magnitude of curvature, it appears that every kind of curvature may be produced by evolution. We can have no conception of a flexure that is greater than what we ſee at A, or leſs than what we ſee at G; yet there are caſes which ſeem to ſhew the contrary, and are familiarly ſaid, by the greateſt mathematicians, to exhibit curvatures infinitely ſmaller ſtill. Thus, let ABC (fig. 3.) be a conical parabola, whoſe parameter is AP. Let AEF be a cubical parabola, whoſe parameter is AQ. If we make AQ to AD as the cube of AP to the cube of AQ, the two parabolas will interſect each other in the ordinate DB. For, making AP $= p$, and AQ $= q$, and calling the ordinate of the conic parabola y, that of the cubic parabola z, and the indeterminate abſciſſa AD x, we have

$$p^3 : q^3 = q : x, = q^3 : z^3, \text{ and } p : q = q : z;$$

but $q : p = q : p$; therefore, by compoſition,

$$p^2 : q^2 = q^2 : p\,x = q^2 : y^2, \text{ and } p : q = q : y;$$

therefore $z = y$, and the parabolas interſect in B.

Now, becauſe in all parabolas the ordinates drawn at the extremity of the parameters are equal to the parameters,

meters, the interſections q and p will be in a line A qp, which makes half a right angle with the axis AP. Therefore, when AQ is greater than AP, the point q is without the conical parabola, and the whole arch of the cubical parabola cut off by the ordinate DB is alſo without it: but when AQ is leſs than AP, q is within the conical parabola, as is alſo the arch q B. Therefore the remaining arch BEA is without it, and is therefore leſs incurvated at A. An endleſs number of conical parabolas of ſmaller curvature may be drawn by enlarging AP; yet there will ſtill be an arch AEB of the cubical parabola which is without it, and therefore leſs incurvated. Therefore the curvature of a cubical parabola is leſs than that of any conical parabola: It is ſaid to be infinitely leſs, becauſe an infinity of cubical parabolas of *ſmaller curvature* than AEB may be drawn by enlarging AQ.

It may be demonſtrated in the ſame manner, that a paraboloid, whoſe ordinates are in the ſubbiquadrate ratio of the abſciſſæ, has an infinitely ſmaller curvature at the vertex than the cubical parabola. And the curvature of the paraboloid of the next degree is infinitely leſs than this; and ſo on continually. Nay, Sir Iſaac Newton, who firſt took notice of this remarkable circumſtance, demonſtrates the ſame thing of an endleſs ſucceſſion of paraboloids interpoſed between any two degrees of this ſeries. *Neque novit* (ſays he) *natura limitem.*

If this be the caſe, all curves cannot be deſcribed by evolution; for we have no conception of a radius of curvature that is greater than a line without limit. The theory of curvilineal motions delivered in the article DYNAMICS muſt be imperfect, or there muſt be curve lines which bodies cannot deſcribe by any powers of nature. The theory there delivered profeſſes to teach how a body can be made to deſcribe the cubical parabola, and many other curves which have theſe infiniteſimal curvatures; and yet its demonſtrations employ the radius of curvature, and cannot proceed without it. We profeſs ourſelves obliged to an attentive reader (who has not favoured us with his name) for making this obſervation. It merits attention.

There muſt be ſome paralogiſm or miſconception in all this language of the mathematicians. It does not neceſſarily follow from the arch AEB lying without the arch AIB, that it is leſs incurvated at A; it may be more incurvated between A and B. Accordingly we ſee, that the tangent BT of the conical parabola is leſs inclined to the common tangent AV than the tangent B t of the cubical parabola is; and therefore the flexure of the whole arch AEB is greater than that of the whole arch AIB; and we ſhall ſee afterwards, that there is a part of AEB that is more incurvated than any part of AIB. There is nothing correſponding to this unmeaning and inconceivable ſucceſſion of ſerieſes of magnitudes of one kind, each of which contains an endleſs variety of individuals, and the greateſt of one ſeries infinitely leſs than the ſmalleſt of the next, &c.; there is nothing like this demonſtrated by all our arguments. In none of theſe do we ever treat of the curvature at A, but of a curvature which is *not* at A. At A we have none of the lines which are indiſpenſably neceſſary for the demonſtration. Beſides, in the very ſame manner that we can deſcribe a cubical parabola, and prove that it has an arch lying without the conical parabola, we can deſcribe a circle, and demonſtrate that it has alſo an arch lying without the parabola. Theſe infiniteſimal curvatures, therefore, are not warranted by our arguments, nor does it yet appear that there are curves which cannot be deſcribed by evolution. We are always puzzled when we ſpeak of infinites and infiniteſimals as of ſomething preciſe and determinate; whereas the very denomination precludes all determination. We take the diſtinguiſhing circumſtance of thoſe different orders for a thing clearly underſtood; for we build much on the diſtinction. We conceive the curvature of the cubical parabola as verging on that of the common parabola, and the one ſeries of curvatures as beginning where the other ends. But Newton has ſhewn, that between theſe two ſerieſes an endleſs number of ſimilar ſerieſes may be interpoſed. The very names given to the curvature at the extremities of the hyperbolic evolutrix have no conceptions annexed to them. At the vertex of the hyperbola there is no line, and at the interſection with the aſſymptote there is no curvature. Theſe unguarded expreſſions, therefore, ſhould not make us doubt whether all curves may be deſcribed by evolution. If a line be incurvated, it is not ſtraight. If ſo, two perpendiculars to it muſt diverge on one ſide, and muſt converge and meet on the other in ſome point. This point will lie between two other points, in which the two perpendiculars touch that curve by the evolution, of which the given arch of the curve may be deſcribed. Finally (which ſhould decide the queſtion), we ſhall ſee by and bye, that the cubic, and all higher orders of paraboloids, may be ſo deſcribed by evolution from curves having aſſymptotic branches of determinable forms.

Such are the general affections of lines generated by evolution. They are not, properly ſpeaking, peculiar properties; for the evolutrixes may be any curve lines whatever. They only ſerve to mark the mutual relations of the evolutes with their evolutrixes, and enable us to conſtruct the one, and to diſcover its properties by means of our knowledge of the other. We proceed to ſhew how the properties of the evolutrix may be determined by our knowledge of the evolute.

This problem will not long occupy attention, being much limited by the conditions. One of the firſt is, that the length of the thread evolved muſt be known in every poſition: Therefore the length of the evolved arch muſt, in like manner, be known; and this, not only *in toto*, but every portion of it. Now this is not univerſally, or even generally the caſe. The length of a circular, parabolic, hyperbolic, arch has not yet been determined by any finite equation, or geometrical conſtruction. Therefore their evolutrixes cannot be determined otherwiſe than by approximation, or by compariſon with other magnitudes equally undetermined. Yet it ſometimes happens, that a curve is diſcovered to evolve into another of known properties, although we have not previouſly diſcovered the length of the evolved arch. Such a diſcovery evidently brings along with it the rectification of the evolute. Of this we have an inſtance in the very evolution which gave occaſion to the whole of this doctrine; namely, that of the cycloid; which we ſhall therefore take as our firſt example.

Let ABC (fig. 5.) be a cycloid, of which AD is the axis, and AHD the generating circle, and AG a tangent to the cycloid at A, and equal to DC. Let

BKE touch the cycloid in B, and cut AG in K. It is required to find the ſituation of that point of the line BE which had unfolded from A?

Draw BH parallel to the baſe DC of the cycloid, cutting the generating circle in H, and join HA. Deſcribe a circle KEM equal to the generating circle AHD, touching AG in K, and cutting BK in ſome point E. It is known, by the properties of the cycloid, that BK is equal and parallel to HA, and that BH is equal to the arch A *h* H. Becauſe the circles AHD and KEM are equal, and the angles HAK and AKE are equal, the chords AH and KE cut off equal arches, and are themſelves equal. Becauſe BHAK is a parallelogram, AK is equal to HB; that is, to the arch A *h* H, that is, to the arch K *m* E. But if the circle KEM had been placed on A, and had rolled from A to K, the arch diſengaged would have been equal to AK, and the point which was in contact with A would now be in E, in the circumference of a cycloid AEF, equal to CBA, having the line AG, equal and parallel to DC, for its baſe, and GF, equal and parallel to DA, for its axis. And if the diameter KM be drawn, and EM be joined, EM touches the cycloid AEF.

Cor. The arch BA of the cycloid is equal to twice the parallel chord HA of the generating circle: For this arch is equal to the evolved line BKE: and it has been ſhewn, that EK is equal to KB, and BE is therefore equal to twice BK, or to twice HA. This property had indeed been demonſtrated before by Sir Chriſtopher Wren, quite independent of the doctrine of evolution; but it is given here as a legitimate reſult of this doctrine, and an example of the uſe which may be made of it. Whenever a curve can be evolved into another which is ſuſceptible of accurate determination, the arch of the evolved curve is determined in length; for it always makes a part of the thread whoſe extremity deſcribes the evolutrix, and its length is found, by taking from the whole length of the thread that part which only touches the curve at its vertex.

This geneſis of the cycloid AEF, by evolution of the cycloid ABC, alſo gives the moſt palpable and ſatisfactory determination of the area of the cycloid. For ſince BE is always parallel to AH, AH will ſweep over the whole ſurface of the ſemicircle AHD, while BE ſweeps over the whole ſpace CBAEF; and ſince BE is always double of the ſimultaneous AH, the ſpace CBAEF is quadruple of the ſemicircle AHD. But the ſpace deſcribed in any moment by BK is alſo one-fourth part of that deſcribed by BE. Therefore the area GAEF is three times the ſemicircle AHD; and the ſpace DHABC is double of it; and the ſpace CBAG is equal to it.

Sir Iſaac Newton has extended this remarkable property of evolving into another curve of the ſame kind to the whole claſs of epicycloids, that is, cycloids formed by a point in the circumference of a circle, while the circle rolls on the circumference of another circle, either on the convex or concave ſide; and he has demonſtrated, that they alſo may all be rectified, and a ſpace aſſigned which is equal to their area (See *Principia.* B. I. prop. 48. &c.). He demonſtrates, that the whole arch is to four times the diameter of the generating circle as the radius of the baſe is to the ſum or difference of thoſe of the baſe and the generating circle. We recommend theſe propoſitions to the attention of the young reader who wiſhes to form a good taſte in mathematical reſearches; he will there ſee the geometrical principles of evolution elegantly exemplified.

We may juſt obſerve, before quitting this claſs of curves, that many writers, even of ſome eminence, in their compilations of elements, give a very faulty proof of the poſition of the tangent of a curve deſcribed by rolling. They ſay, for example, that the tangent of the cycloid at E is perpendicular to KE; becauſe the line KE is, at the moment of deſcription, turning round K as a momentary centre. This, to be ſure, greatly ſhortens inveſtigation; and the inference is a truth, not only when the rolling figure is a circle rolling on a ſtraight line, but even when any one figure rolls on another. Every point of the rolling figure really *begins* to move perpendicularly to the line joining it with the point of contact. But this geneſis of the arch E *e*, by the evolution of the arch B *b*, ſhews that K is by no means the centre of motion, nor HK the radius of curvature. Nor is it, in the caſe of epicycloids, trochoids, and many curves of this kind, a very eaſy matter to find the momentary centre. The circle KEM is both advancing and turning round its centre; and theſe two motions are equal, becauſe the circle does not ſlide but roll, the detached arch being always equal to the portion of the baſe which it quits. Therefore, drawing the tangents E *g*, M *g*, and completing the parallelogram E *f* M *g*, E *f* will repreſent the progreſſive motion of the centre, and E *g* the motion of rotation. EM, the motion compounded of theſe, muſt be perpendicular to the chord EK.

The inveſtigation that we have given of the evolutrix of the cycloid has been ſomewhat peculiar, being that which offered itſelf to Mr Huyghens at the time when he and many other eminent mathematicians were much occupied with the ſingular properties of this curve. It does not ſerve, however, ſo well for exemplifying the general proceſs. For this purpoſe, it is proper to avail ourſelves of all that we know of the cycloid, and particularly the equality of its arch BA to the double of the parallel chord HA. This being known, nothing can be more ſimple than the determination of the evolutrix, either by availing ourſelves of every property of the cycloid, or by adhering to the general proceſs of referring every point to an abſciſſa by means of perpendicular ordinates. In the firſt method, knowing that BE is double of BK, and therefore KE equal to HA, and KA = BH, = H *h* A, = K *m* E, we find E to be the deſcribing point of the circle, which has rolled from A to K. In the other method, we muſt draw EN perpendicular to AG; then, becauſe the point E moves, during evolution, at right angles to BE, EK is the normal to the curve deſcribed, and NK the ſubnormal, and is equal to the correſponding ordinate H I of the generating circle of the cycloid ABC. This being a characteriſtic property of a cycloid, E is a point in the circumference of a cycloid equal to the cycloid ABC.

Or, laſtly, in accommodation to caſes where we are ſuppoſed to know few of the properties of the evolute, or, at leaſt, not to attend to them, we may make uſe of the fluxionary equation of the evolute to obtain the fluxionary equation of the evolutrix. For this purpoſe, take a point *e* very near to E, and draw the evolving radius *b e*, cutting E *f* (drawn parallel to the baſe DC) in *o*; draw *e n* parallel to the axis of the evolute, cutting

ting E o in v; alſo draw $b\,h\,i$ parallel to the baſe, and B d perpendicular to it. If both curves be now referred to the ſame axis CGF, it is plain that B b, B d, and $d\,b$ are ultimately as the fluxions of the arch, abſciſs, and ordinate of the evolute, and that Ee, $e\,v$, and v E, are ultimately as the fluxions of the arch, abſciſſa, and ordinate of the evolutrix. Alſo the two fluxionary triangles are ſimilar, the ſides of the one being perpendicular, reſpectively, to thoſe of the other. If both are referred to one axis, or to parallel axes, the fluxion of the abſciſſa of the evolute is to that of its ordinate, as the fluxion of the ordinate of the evolutrix is to that of its abſciſſa. Thus, from the fluxionary equation of the one, that of the other may be obtained. In the preſent caſe, they may be referred to AD and FG, making CG equal to the cycloidal arch CBA. Call this a; AI, x; IB, y; and AB, or EB, z. In like manner, let F t be $= u$, t E $= v$, and FE $= w$; then, becauſe $DH^2 = DA^2 - AH^2$, and DA and AH are the halves of CF and BE, we have $DH^2 = \frac{a^2 - z^2}{4}$. Alſo $DI = \frac{DH^2}{DA} = \frac{a^2 - z^2}{4 \times \frac{1}{2} a}, = \frac{a^2 - z^2}{2\,a}$. But DI = F t. Therefore F t, or u, $= \frac{a^2 - z^2}{2\,a}$. Alſo $\dot{w} = \frac{\dot{u}\ \dot{z}}{\dot{y}}$, by what was ſaid above, that is, $\dot{w} = \frac{a\ \dot{u}}{\sqrt{a^2 - z^2}}$, $= \frac{a\,\dot{u}}{\sqrt{2\,a\,u}}$. Therefore we have $\dot{w} : \dot{u}\ (= a : \sqrt{2\,a\,u}) = \sqrt{\tfrac{1}{2}a} : \sqrt{u} = \sqrt{GF} : \sqrt{F\,t}$, which is the analogy competent to a cycloid whoſe axis is GF = DA.

It is not neceſſary to inſiſt longer on this in this place; becauſe all theſe things will come more naturally before us when we are employed in deducing the evolute from its evolutrix.

When the ordinates of a curve converge to a centre, in which caſe it is called a radiated curve, it is moſt convenient to conſider its evolutrix in the ſame way, conceiving the ordinates of both as inſiſting on the circumference of a circle deſcribed round the ſame centre. Spirals evolve into other ſpirals, and exhibit ſeveral properties which afford agreeable occupation to the curious geometer. The equiangular, logarithmic, or loxodromic ſpiral, is a very remarkable example. Like the cycloid, it evolves into another equal and ſimilar equiangular ſpiral, and is itſelf the evolutrix of a third. This is evident on the ſlighteſt inſpection. Let C $r\,q\,p$ (fig. 6.) be an equiangular ſpiral, of which S is the centre; if a radius SC be drawn to any point C, and another radius SP be drawn at right angles to it, the intercepted tangent CP is known to be equal to the whole length of the interior revolutions of the ſpiral, though infinite in number. If the thread CP be now unlapped from the arch C $r\,q$, it is plain that the firſt motion of the point P is in a direction PT, which is perpendicular to PC, and therefore cuts the radius PS in an angle SPT, equal to the angle SCP; and, ſince this is the caſe in every poſition of the point, it is manifeſt that its path muſt be a ſpiral PQR, cutting the radii in the ſame angle as the ſpiral C $r\,q\,p$. James Bernoulli firſt diſcovered this remarkable property. He alſo remarked, that if a line PH be drawn from every point of the ſpiral, making an angle with the tangent equal to that made by the radius (like an angle of reflection correſponding with the incident ray SP), thoſe reflected rays would all be tangents to another ſimilar and equal ſpiral I v H; ſo that PH = PS. S and H are conjugate foci of an infinitely ſlender pencil; and therefore the ſpiral I v H is the cauſtic by reflection of RQP for rays flowing from S. If another equal and ſimilar ſpiral $x\,v\,y$ roll on I v H, its centre z will deſcribe the ſame ſpiral in another poſition $w\,u\,z$. All theſe things flow from the principles of evolution alone: and Mr Bernoulli traces, with great ingenuity, the connection and dependence of cauſtics, both by reflection and refraction, of cycloidal, and all curves of provolution, and their origin in evolution or involution. A variety of ſuch repetitions of this curve (and many other ſingular properties), made him call it the SPIRA MIRABILIS. He deſired that it ſhould be engraved on his tombſtone, with the inſcription EADEM MUTATA RESURGO, as expreſſive of the reſurrection of the dead. See his two excellent diſſertations in *Act.* Erudit. 1692, March and May.

Another remarkable property of this ſpiral is, that if, inſtead of the thread evolving from the ſpiral, the ſpiral evolve from the ſtraight line PC, the centre S will deſcribe the ſtraight line PS. Of this we have an example in the apparatus exhibited in courſes of experimental philoſophy, in which a double cone deſcends, by rolling along two rulers inclined in an angle to each other (ſee *Graveſande's* Nat. Phil. I. § 210). It is pretty remarkable, that a rolling motion, ſeemingly round C, as a momentary centre, ſhould produce a motion in the ſtraight line SP; and it ſhews the inconcluſiveneſs of the reaſoning, by which many compilers of elements of geometry profeſs to demonſtrate, that the motion of the deſcribing point S is perpendicular to the momentary radius. For here, although this ſeeming momentary radius may be ſhorter than any line that can be named, the real radius of curvature is longer than any line that can be named.

But it is not merely an object of ſpeculative geometric curioſity to mark the intimate relation between the geneſis of curves by evolution and provolution; it may be applied to important purpoſes both in ſcience and in art. Mr M'Laurin has given a very inviting example of this in his account of the Newtonian philoſophy; where he exhibits the moon's path in abſolute ſpace, and from this propoſes to inveſtigate the deflecting forces, and *vice verſa.* We have examples of it in the arts, in the formation of the pallets of pendulums, the teeth of wheels, and a remarkable one in Meſſrs Watt and Boulton's ingenious contrivance for producing the rectilineal motion of a piſton rod by the combination of circular motions. M. de la Hire, of the Academy of Sciences at Paris, has been at great pains to ſhew how all motions of evolution may be converted into motions of provolution, in a memoir in 1706. But he would have done a real ſervice, if, inſtead of this ingenious whim, he had ſhewn how all motions of provolution may be traced up to the evolution which is equivalent to them. For there is no organic geneſis of a curvilineal motion ſo ſimple as the evolution of a thread from a curve. It is the primitive geneſis of a circle; and it is in evolution alone that any curvilineal motion is comparable with circular motion. A given curve line is an individual, and therefore its primitive organical geneſis muſt alſo be individual. This is ſtrictly true of evolution. A parabola

bola has but one evolute. But there are infinite motions of provolution which will deſcribe a parabola, or any curve line whatever; thereſore theſe are not primitive organical modes of deſcription. That this, however, is the caſe, may be very eaſily ſhewn. Thus let ABCD (fig. 7.) be a parabola, or any curve; and let *a b c d* be any other curve whatever. A figure E *m l k h i* may be found ſuch, that while it rolls along the curve *a b c d*, a point in it ſhall deſcribe the parabola. The proceſs is as follows: Let B *b*, C *c*, D *d*, &c. be a number of perpendiculars to the parabola, cutting the curve *a b c d* in ſo many points. The perpendiculars may be ſo diſpoſed that the points *a*, *b*, *c*, &c. ſhall be equidiſtant. Now we can conſtruct a triangle E *e h* ſo, that the three ſides E *e*, *eh*, and *h* E, ſhall be reſpectively equal to the three lines E *e*, *e f*, F *f*. In like manner may the whole figure be conſtructed, having the little baſes of the triangles reſpectively equal to the ſucceſſive portions of the baſe A *b c d*, and the radii equal to the perpendiculars B *b*, C *c*, D *d*, &c. Let this figure roll on this baſe *c*. While the little ſide *e k* moves from its preſent poſition, and applies itſelf to *e f*, the point E deſcribes an arch E ε of a circle round the centre *e*, and, falling within the parabola, is ſomewhere between E and F. Then continuing the provolution, while the next ſide *h i* turns round *f* till *i* applies to *g*, the point E deſcribes another arch ε F *o* round *f*, firſt riſing up and reaching the parabola in F, when the line *h* E coincides with *f* F, and then falling within the parabola till the point *h* begin to riſe again from *f* by the turning of the rolling figure round the point *g*. Reverſing the motion, the ſides *i h*, *h e*, *e k*, &c. apply themſelves in ſucceſſion to the portions *g f*, *f e*, *e d*, &c. of the baſe, and the point E deſcribes an undulating line, conſiſting of arches of circles round the ſucceſſive centres *g*, *f*, *e*, &c. Theſe circular arches all touch the parabola in the points G, F, E, &c. and ſeparate from it a little internally. By diminiſhing the portions of the baſe, and increaſing the number of the triangular elements of the rolling figure without end, it is evident that the figure becomes ultimately curvilineal inſtead of polygonal, and the point E continues in the parabola, and accurately deſcribes it. It is now a curvilineal figure, having its elementary arches equal to the portions of the baſe to which they apply in ſucceſſion, and the radii converging to E equal to the perpendiculars intercepted between the curve ABCD and the baſe. It may therefore be accurately conſtructed.

It is clear, that practical mechanics may derive great advantage from a careful ſtudy of this ſubject. We now ſee motions executed by machinery which imitate almoſt every animal motion. But theſe have been the reſult of many random trials of *wipers*, *ſnail-pieces*, &c. of various kinds, repeatedly corrected, till the deſired motion is at laſt accompliſhed. But it is, as we ſee, a ſcientific problem, to conſtruct a figure which ſhall certainly produce the propoſed motion; nor is the proceſs by any means difficult. But how ſimple, in compariſon, is the production of this motion by evolution. We have only to find the curve line which is touched by all the perpendiculars B *b*, C *c*, D *d*, &c. This naturally leads us to the ſecond problem in this doctrine, namely, to determine the evolute by our knowledge of the involute: a problem of greater difficulty and of greater importance, as it implies, and indeed teaches, the curvature of lines, its meaſure, and the law of its variation in all particular caſes. The evolute of a curve is the geometrical expreſſion, and exhibition to the eye, of both theſe affections of curve lines.

Since the evolved thread is always at right angles to the evolutrix and its tangent, and is itſelf always a tangent of the evolute, it follows, that all lines drawn perpendicular to the arch of any curve, touch the curve line which will generate the given curve by evolution. Were this evolved curve previouſly known to us, we could tell the preciſe point where every perpendicular would touch it; but this being unknown, we muſt determine the points of contact by ſome other method, and by this determination we aſcertain ſo many points of the evolute. The method purſued is this: When two perpendiculars to the propoſed curve are not parallel (which we know from the known poſition of the tangents of our curve), they muſt interſect each other ſomewhere on that ſide of the tangents where they contain an angle leſs than 180°. But when they thus interſect, one of them has already touched the evolute, and the other has not yet reached it. Thus let *b s*, *e s* (fig. 1.) be the two perpendiculars: being tangents to the evolute, the point *s* of their interſection muſt be on its convex ſide, and the unknown points of contact B and E muſt be on different ſides of *s*. Theſe are elementary truths.

Let *e* E approach toward *b* B, and now cut it in *x*. The contact has ſhifted from E to D, and *x* is ſtill between the contacts. When the ſhifting perpendicular comes to the poſition ι C, the interſection is at *i*, between the contacts B and C. And thus we ſee, that as the perpendiculars to the involute gradually approach, their contacts with the evolute alſo approach, and their interſection is always between them. Hence it legitimately follows, that the ultimate poſition of the interſection (which alone is ſuſceptible of determination by the properties of the involute) is the poſition of the point of contact, and therefore determines a point of the evolute. The problem is therefore reduced to the inveſtigation of this ultimate interſection of two perpendiculars to the propoſed curve, when they coaleſce after gradually approaching. This will be beſt illuſtrated by an example: Therefore let ABC (fig. 8.) be a parabola, of which A is the vertex, AH the axis, and AV one-half of the parameter; let BE and CK be two perpendiculars to the curve, cutting the axis in E and K, and interſecting each other in *r*; draw the ordinates BD, CV, and the tangent BT, and draw BF parallel to the axis, cutting CK in F, and CN in O.

Becauſe the perpendiculars interſect in *r*, we have $r\mathrm{E} : \mathrm{EB} = \mathrm{EK} : \mathrm{BF}$. If therefore we can diſcover the ratio of EK to BF, we determine the interſection *r*. But the ratio of EK to BF is compounded of the ratio of EK to BO, and the ratio of BO to BF. The firſt of theſe is the ratio of equality; for DE and VK are, each of them, equal to AV, or half the parameter. Take away the common part VE, and the remainders EK and DV are equal, and DV is equal to BO; therefore $\mathrm{EK} : \mathrm{BF} = \mathrm{BO} : \mathrm{BF}$; therefore $r\mathrm{E} : r\mathrm{B} = \mathrm{BO} : \mathrm{BF}$, and (by diviſion) $\mathrm{BE} : \mathrm{E}r = \mathrm{FO} : \mathrm{OB}$. Now let the point C continually approach to B, and at laſt unite with it. The interſection *r* will unite with a point of contact N on the evolute. The ultimate ratio of FO to OB, or of $f o : o\mathrm{B}$, is evidently that of ED to DT, or ED to 2DA; therefore BE : EN = ED : 2DA, or as half the parameter to twice the abſciſſa. Thus have we determined a point of the evolute; and we may, in like manner, determine as many as we pleaſe.

But we wiſh to give a general character of this evolute, by referring it to an axis by perpendicular ordinates. It is plain that V is one point of it, becauſe the point E is always diſtant from its ordinate DB by a line equal to AV; and therefore, when B is in A, E will be in V, and *r* will coincide with it. Now draw VP and NQ perpendicular to AH, and NM perpendicular to VP; let EB cut PV in *t*: then, becauſe AV and DE are equal, AD is equal to VE, and VE is equal to one-half of DT. Moreover, becauſe BD and NQ are parallel, DE : EQ = BE : EN = DE : DT; therefore DT = EQ, and VE = $\frac{1}{2}$EQ, and therefore = $\frac{1}{3}$VQ; therefore V*t* is $\frac{1}{3}$ of M*t*, and $\frac{1}{2}$MV. This is a characteriſtic property of the evolute. The ſubtangent is $\frac{3}{2}$ of the abſciſſa; in like manner, as in the common parabola, it is double of the abſciſſa. We know therefore that the evolute is a paraboloid, whoſe equation is $a x^2 = y^3$; that is, the cube of any ordinate MN is equal to the parallelopiped whoſe baſe is the ſquare of the abſciſſa VM, and altitude a certain line VP, called the parameter. To find VP, let CR be the perpendicular to the parabola in the point where it is cut by the ordinate at V; draw the ordinate RS of the paraboloid, and RG perpendicular to AH. Then it is evident, from what has been already demonſtrated, that VK is $\frac{1}{2}$ of KG, and $\frac{1}{3}$ of VG; therefore KG^2 = 4VK^2, and (in the parabola) VC^2 = 2VK^2. Alſo, becauſe KV : VC = KG : GR, we have GR^2 = 2KG^2 = 8VK^2; therefore VP × RG^2 = 8VP × VK^2. But VG^3 = 27VK^3, = 27VK × VK^2; therefore, becauſe in the paraboloid VP × VS^2, = SR^3, or VP × RG^2 = VG^3, we have 8VP × VK^2 = 27VK × VK^2, and 8VP = 27VK; or VK : VP; that is, AV : VP = 8 : 27; or VP = $\frac{27}{8}$ AV, or $\frac{27}{16}$ of the parameter of the parabola ABC. The evolute of the conical parabola is the curve called the ſemicubical parabola, and its parameter is $\frac{27}{16}$ of the conical parabola.

This inveſtigation is nearly the ſame with that given by Huyghens, which we prefer at preſent to the method generally employed, becauſe it keeps the principle of inference more cloſely in view.

Mr Huyghens has deduced a beautiful corollary from it. Since the parabola ABC is deſcribed by the evolution of the paraboloid VNR, the line RC is equal to the whole evolved arch RNV, together with the redundant tangent line AV. If therefore we take from CR a part Cκ equal to the redundant AV, the remainder κR is equal to the arch RNV of the paraboloid. We may do this for every poſition of the evolved radius, and thus obtain a ſeries of points V, β, γ, δ, ε, of the evolutrix of the paraboloid. We have even an eaſier method for obtaining the length of any part of the arch of the paraboloid, without the previous deſcription of the parabola ABC. Suppoſe P*y* the arch of the paraboloid, and *yz* the tangent; make P*z* = $\frac{8}{27}$ of the parameter, and deſcribe the arch P*uu* of a circle; then draw from every tangent *yz* a parallel line *xv*, cutting the circle in *u*. The length of the arch *y*P is equal to *yz* + *uv*. The celebrated author congratulates himſelf, with great juſtice, on this neat exhibition of a right line equal to the arch of a curve, without the employment of any line higher than the circle. It is the ſecond curve that has been ſo rectified, the cycloid alone having been rectified by plain geometry a very few years before by Sir Chriſtopher Wren. It is very true, and he candidly admits it, that this very curve had been rectified before by Mr William Neill, a young gentleman of Oxford, and favourite pupil of Dr Wallis; as alſo by Mr Van Heuraet, a Dutch gentleman of rank, and an eminent mathematician. But both of theſe gentlemen had done it by means of the quadrature of a curve, conſtructed from the paraboloid after the manner of Dr Barrow, *Lect. Geom.* XI. Nor was this a ſolitary diſcovery in the hands of Mr Huyghens, as the rectification of the cycloid had been in thoſe of Sir Chriſtopher Wren; for the method of inveſtigation furniſhed Mr Huyghens with a general rule, by which he could evolve every ſpecies of paraboloid and hyperboloid, two claſſes of curves which come in the way in almoſt every diſcuſſion in the higher geometry. He obſerves, that the ratio of B*f* to E*e*, being always compounded of the ratios of B*f* to B*o*, and of B*o*, or D*d*, to E*e*; and the ultimate ratio of B*f* to B*o* being that of TE to TD, which is given by the nature of the paraboloid, we can always find the ratio of BE to BN, if we know that of D*d* to E*e*. In all curves, the ratio of D*d* to E*e* (taken indefinitely near), is that of the ſubtangent to the ſum of the ſubtangent and ordinate of a curve conſtructed on the ſame abſciſſa, having its ordinates equal to the ſubnormals DE, *de*, VK, &c. In the conic ſections the ratio is conſtant, becauſe the line ſo conſtructed is a ſtraight line; and, in the parabola, it is parallel to the axis. See farther properties of it in Barrow's *Lect. Geom.* XI.

From this inveſtigation, Mr Huyghens has deduced the following beautiful theorem:

Let *a* be the parameter of the paraboloid, *x* its abſciſſa, and *y* its ordinate; and let the equation be $a^n x^n = y^{m+n}$; let the radius of the evolute meet the tangent through the vertex A in Z. We ſhall always have BN = $\frac{n}{m}$ BE + $\frac{m+n}{m}$ BZ. Thus,

$$\text{If}\ \left.\begin{array}{l} a\,x = y^2 \\ a^2 x = y^3 \\ a\,x^2 = y^3 \\ a\,x^3 = y^4 \\ a^3 x = y^4 \end{array}\right\}\ \text{then BN} = \left\{\begin{array}{l} \text{BE} + 2\,\text{BZ} \\ \tfrac{1}{2}\text{BE} + \tfrac{3}{2}\text{BZ} \\ 2\,\text{BE} + 3\,\text{BZ} \\ 3\,\text{BE} + 4\,\text{BZ} \\ \tfrac{1}{3}\text{BE} + \tfrac{4}{3}\text{BZ}. \end{array}\right.$$

&c. &c.

This is an extremely ſimple and perſpicuous method of determining the radius of the evolute, or radius of curvature; and it, at the ſame time, gives us the rectification of many curves. It is plain that every geometrical curve may be thus examined, becauſe the ſubnormals DE, VK are determined; and therefore their differences are determined. Theſe differences are the ſame with the differences of D*d* and E*e*; and therefore the ratio of D*d* to E*e* is determined; that is, the ſubſidiary curve now mentioned can always be conſtructed.

There is a ſingular reſult from this rule, which would hardly have been noticed, if the common method for determining BN had alone been employed. The equation of the paraboloid is ſo ſimple, that the increaſe of the ordinates and diminution of curvature ſeem to keep pace together; yet we have ſeen that, in the vertex of the cubical parabola, the curvature is leſs than any circular curvature that can be named. In the legs, the curvature certainly diminiſhes as they extend farther;

there muſt therefore be ſome intermediate point where the curvature is the greateſt poſſible. This is diſtinctly pointed out by Mr Huyghens's theorem. The evolute of this paraboloid (having $a^2x = y^3$) is a curve ONRNQ (fig. 9.) conſiſting of two branches RO, and RQ, which have a common tangent in R; the branch RQ has the axis AE for its aſſymptote. The thread unfolding from OR, its extremity, deſcribes the arch BC, and then, unfolding from RQ, it deſcribes the ſmall arch CB′A. When B′ is extremely near A, the thread has a poſition B′N′E, in which B′N is very nearly ½BE. At C, if CE be biſected in G, GR is $\frac{3}{2}$ of CZ. Here CR the radius of curvature is the ſhorteſt poſſible. The evolutes of all paraboloids conſiſt of two ſuch branches, if $m + n$ exceeds 2.

Such is the theory of evolution and involution as delivered by Mr Huyghens about the year 1672. It was cultivated by the geometers with ſucceſs. Newton prized it highly, and gave a beautiful ſpecimen of its application to the deſcription, rectification, and quadrature of epicycloids, trochoids, and epicycles of all kinds. But it was eclipſed by the fluxionary geometry of Newton, which included this whole theory in one propoſition, virtually the ſame with Mr Huyghens's, but more comprehenſive in its expreſſion, and much more ſimple in its application. Adopting the unqueſtionable principle of Mr Huyghens, that the evolved thread is the radius of a circle which has the ſame flexures with the curve, the point of the evolute will be obtained by finding the length of the radius of the equicurve circle. The formula for this purpoſe is given in the article FLUXIONS of the *Encyclopædia Britannica*; but is incorrectly ſtated $= \frac{\overline{a+4}|^{\frac{3}{2}}}{2\sqrt{a}}$, inſtead of $\frac{\overline{a+4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. The theorem alſo from which it is deduced $\left(r = \frac{\dot{z}^2}{-\dot{x}\ddot{y}}\right)$ is incorrectly printed, and is given without any demonſtration, thereby becoming of very little ſervice to the reader. For which reaſon, it is neceſſary to ſupply the defect in this place.

Therefore let AbcdEf (fig. 10.) be a circle, of which C is the centre, and ACE a diameter; let the points b, c, d, of the circumference be referred to this diameter by the equidiſtant perpendicular ordinates bi, cg, dk; draw the chords bc, cd, producing dc till it meet the ordinate bi in a, produce cg to the circle in f, and join bf, df; draw bh, cm, perpendicular to the ordinates; then bh, cm, hc, md, bc, cd, are ultimately proportional to the firſt fluxions of the abſciſſa AE, the ordinate cg, and the arch Ac; alſo ab, the difference between dm and ch is ultimately as the ſecond fluxion of the ordinate. The triangle abc is ſimilar to bdf; for the angle abc is equal to the alternate angle bcf, which is equal to bdf, ſtanding on the ſame ſegment. The angle acb is equal to bfd, ſtanding on the ſegment bcd; therefore the remaining angles bac and dbf are equal; therefore $ab : bc = bd : df = \frac{1}{2} bd : \frac{1}{2} df$. Now let the ordinates bi and dk continually approach the ordinate cg, and at laſt unite with it; we ſhall then have bc ultimately equal to $\frac{1}{2} bd$, and cg ultimately equal to $\frac{1}{2} df$. Therefore, ultimately, $ab : bc = bc : cg$, and $cg = \frac{bc^2}{ab}$.

Let u, v, w, repreſent the variable abſciſſa, ordinate, and arch. We have, for the fluxionary expreſſion of the ordinate of the equicurve circle, $v = \frac{\dot{w}^2}{-\ddot{v}}$ ($\ddot{v}$ muſt have the negative ſign, becauſe, as the arch increaſes, $\dot{v}$ diminiſhes). In the next place, it is evident that, ultimately, $bh : bc = cg : c$C, and $c\text{C} = \frac{cg \times bc}{bh}$. If r be the radius of the equicurve circle, we have $\dot{u} : \dot{w} = v : r$, and $r = \frac{v\dot{w}}{\dot{u}}$. But we had $v = \frac{\dot{w}^2}{-\ddot{v}}$. Subſtitute this in the preſent equation, and we obtain $r = \frac{\dot{w}^3}{-\dot{u}\ddot{v}}$. Laſtly, obſerve that $\dot{w}^2 = \dot{u}^2 + \dot{v}2$, and $\dot{w} = \sqrt{\dot{u}^2 + \dot{v}^2} = \overline{\dot{u}^2 + \dot{v}^2}|^{\frac{1}{2}}$. Therefore $\dot{w}^3 = \overline{\dot{u}^2 + \dot{v}^2}|^{\frac{3}{2}}$ and we have $r = \frac{\overline{\dot{u}^2 + \dot{v}^2}|^{\frac{3}{2}}}{-\dot{u}\ddot{v}}$, as the moſt general fluxionary expreſſion of the radius of a circle, in terms of the ſine, coſine, and arch.

When a curve and a circle have the ſame curvature, it is not enough that the firſt fluxions of their abſciſſæ, ordinates, and arches, are the ſame. This would only indicate the poſition of their common tangent. They muſt have the ſame deflection from that tangent. This is always equal to half of the ſecond fluxion of the ordinate. Therefore the circle and curve muſt have the ſame ſecond fluxion of their ordinates. Therefore let DbcdF be any curve coinciding with, or oſculated by, the circle Abcd. Let its axis be DG, parallel to the diameter AE; and let cn be its ordinate. Let Dn be $= x$, $cn = y$, and $bc = z$. We have $\dot{x}$, $\dot{y}$, $\dot{z}$, reſpectively equal to $\dot{u}$, $\dot{v}$, $\dot{w}$. Therefore the radius of the oſculating circle is $r = \frac{\dot{z}^3}{-\dot{x}\ddot{y}}$ or $r = \frac{\overline{\dot{x}^2 + \dot{y}^2}|^{\frac{3}{2}}}{-\dot{x}\ddot{y}}$, for all curves whatever. (We recommend the careful peruſal of the celebrated 2d corollary of the 10th propoſition of the 2d book of Newton's Principia, where the firſt principles of this doctrine are laid down with great acuteneſs.)

Inſtead of ſuppoſing the ordinates equidiſtant, and conſequently $\dot{x}$ invariable, we might have ſuppoſed the ordinates to increaſe by equal ſteps. In this caſe y would have had no ſecond fluxion. The radius would then be $= \frac{\dot{z}^3}{\dot{y}\ddot{x}}$. Or, laſtly, we might ſuppoſe (and this is very uſual) the arch z to increaſe uniformly. In this caſe $r = \frac{\dot{z}\dot{y}}{\ddot{x}}$: For becauſe $\dot{x}^2 + \dot{y}^2 = \dot{z}^2$, by taking the fluxion of it, $2\dot{x}\ddot{x} + 2\dot{y}\ddot{y} = 0$, and $\ddot{y} = \frac{\dot{x}\ddot{x}}{\dot{y}}$; and therefore $r = \frac{\dot{z}^3}{\dot{y}\ddot{x} - \dot{x}\ddot{y}}, = \frac{\dot{z}^3}{\dot{y}\ddot{x} + \frac{\dot{x}^2\ddot{x}}{\dot{y}}}, = \frac{\dot{y}\dot{z}^3}{\dot{y}^2 + \dot{x}^2 \times \ddot{x}}, = \frac{\dot{y}\dot{z}}{\ddot{x}}$.

Having thus obtained the radius of curvature, and conſequently a point of the evolute, we determine its form

form by reference to an abſciſs, without much farther trouble: It only requires the drawing Cp perpendicular to the axis of the propoſed curve, and giving the values of Cp and Dp. If we ſuppoſe $\dot x$ conſtant, then, cC being $= \frac{\dot z^3}{-\dot x \ddot y}$, we have Dp $(= Dn + gc, = Dn + \frac{\dot y}{\dot z} \times cC) = x + \frac{\dot y \dot z^2}{-\dot x \ddot y}$; and pC $(= cg - cn, = \frac{\dot x}{\dot z} \times cC - cn) = \frac{\dot z^2}{-\ddot y} - y$. But if we ſuppoſe $\dot y$ conſtant; then, cC being $= \frac{\dot z^3}{\dot y \ddot x}$, we have $Dp = x + \frac{\dot z^2}{\ddot x}$, and $pC = \frac{\dot x \dot z^2}{\dot y \ddot x} - y$. And if $\dot z$ be conſtant, then, cC being $= \frac{\dot y \dot z}{\ddot x}$, we ſhall have $Dp = x + \frac{\dot y^2}{\ddot x}$, and $pC = \frac{\dot x \dot y}{\ddot x} - y$.

Theſe formulæ are ſo many general expreſſions for determining both the curvature of the propoſed curve and the form of its evolute. They alſo give us the rectification of the evolute; becauſe cC is equal to the evolved arch, or to that arch, together with a conſtant part, which was a tangent to the evolute at its vertex, in thoſe caſes where the involute has a finite curvature at its vertex; as in the common parabola.

Let us take the example of the common parabola, that we may compare the two methods. The equation of this is $ax = y^2$, or $a^{\frac{1}{2}} x^{\frac{1}{2}} = y$. This gives $\dot y = \frac{1}{2} a^{\frac{1}{2}} \dot x x^{-\frac{1}{2}}, = \frac{a^{\frac{1}{2}} \dot x}{2 x^{\frac{1}{2}}}$, and (making $\dot x$ conſtant) $\ddot y = -\frac{1}{2} \times \frac{1}{2} a^{\frac{1}{2}} \dot x^2 x^{-\frac{3}{2}} = \frac{-a^{\frac{1}{2}} \dot x^2}{4 x^{\frac{3}{2}}}$. Wherefore $\dot z \ (= \sqrt{\dot x^2 + \dot y^2}) = \frac{\dot x}{2} \sqrt{\frac{4x + a}{x}}$, and the radius of curvature $\left(= \frac{\dot z^3}{-\dot x \ddot y}\right) = \frac{\overline{a + 4x}|^{\frac{3}{2}}}{2\sqrt{a}}$. At the vertex, where $x = 0$, the formula becomes $= \frac{1}{2} a$. Again, $Dp \left(= x + \frac{\dot y \dot z^2}{-\dot x \ddot y}\right)$ becomes $\frac{1}{2} a + 3x$; and therefore $Vp = 3x$, = the abſciſſa of our evolute. Likewiſe cp, its ordinate, $\left(= \frac{\dot z^2}{-\ddot y} - y\right) = \frac{4x^{\frac{3}{2}}}{\sqrt{a}}$; and $Cp^2 = \frac{16x^3}{a}$; and $Cp^2 \times a = 16x^3$. But $Vp = 3x$, and $Vp^3 = 27x^3$. Therefore $Cp^2 \times \frac{1}{16}$th $a = x^3, = \frac{1}{27}$th Vp^3, and $\frac{27}{16}$ths $a \times Cp^2 = Vp^3$. Therefore the evolute VC is a ſemicubical parabola, whoſe parameter is $\frac{27}{16} a$, as was ſhewn by Mr Huyghens. The arch VC is $= \frac{\overline{a + 4x}|^{\frac{3}{2}}}{2\sqrt{a}} - \frac{1}{2} a$.

We ſhall give one other example, which comprehends the whole claſs of paraboloids. Their general equation is $y = ax^n$. This gives us $\dot y = nax^{n-1}\dot x$, and $\ddot y = n \times \overline{n-1} \times ax^{n-2}\dot x^2$; therefore $\dot z$ $(= \sqrt{\dot x^2 + \dot y^2}) = \dot x\sqrt{1 + n^2a^2x^{2n-2}}$; $Cc \left(= \frac{\dot z^3}{-\dot x \ddot y}\right) = \frac{\overline{1 + n^2a^2x^{2n-2}}|^{\frac{3}{2}}}{-n \times \overline{n-1} \times ax^{n-2}}$; $Dp \left(= x + \frac{\dot y \dot z^2}{-\dot y \dot x}\right) = x - \frac{x + n^2a^2x^{2n-1}}{n-1}$; $Cp \left(= \frac{\dot z^2}{\ddot y} - y\right) = \frac{1 + \overline{2n-1} \times na^2x^{2n-2}}{-\overline{n-1} \times nax^{n-2}}$; and $DV = -\frac{n^2a^2o^{2n-1}}{n-1}$

This laſt formula expreſſes the radius of curvature at the vextex D, or the redundant part of the thread, by which it exceeds the arch VC of the evolute. If $n = \frac{1}{2}$, the formula becomes $\frac{a^2}{2}$: but if n be greater than this, VC will be $= o$; and if it be leſs, VC will be infinite. Hence it appears, that the radius of curvature at the vertex of a curve is a finite quantity only in the caſes where the firſt or naſcent ordinates are in the ſubduplicate ratio of their abſciſſæ. In all other caſes, the curvature is incomparable with that of any circle, being either what is called infinite (when n is greater than $\frac{1}{2}$) or nothing (when it is leſs).

We ſcruple not to ſay, that the method of Mr Huyghens is more luminous, more pleaſing to the imagination of a geometer, than this; and in all the caſes which occurred to us in our employment of it, it ſuggeſted more ready conſtructions, with the additional ſatisfaction of exhibiting, in a continuous train, what the *ſymbolical* method, proceeding by the fluxionary calculus, only indicates by points. We muſt alſo obſerve, that the ſubſidiary curve employed by Huyghens, having its ordinates equal to the ſubnormals of the involute under examination, is the geometrical expreſſion of that function of the involute which gives the ſecond fluxions $\ddot y$ and $\ddot x$ of the ordinate and abſciſſa. The young mathematician will find no difficulty in conſtructing this curve *in every caſe;* whereas we imagine that he will not find it a light matter to conſtruct the final equations of the ſymbolic method *almoſt in any caſe.* At the ſame time, the all-comprehending extent of the latter method, and the numberleſs general theorems which it ſuggeſts to the expert analyſt, give it a moſt deſerved preference, and make it almoſt an indiſpenſable inſtrument for all who would extend our phyſico-mathematical ſciences.

In the employment of the geometry of curve lines, eſpecially in the doctrine of centripetal forces, it is uſual to conſider the ordinates, not as inſiſting on a rectilineal abſciſſa, but as diverging from a centre. This is alſo the uſual way of conceiving all ſpirals and evolutrixes of curves which include ſpace; in ſhort, all RADIAL curves. The proceſs for finding their evolute, or their radius of curvature, is ſomewhat different from that hitherto exhibited; but it is more ſimple. Thus, let GPM (Fig. 10.) be the elliptical path of a planet, of which S is the focus. We require PC, the radius of curvature in the point P. Let Pp be a very ſmall arch. Draw the radii SP, Sp, the tangents PT, pt; and

and draw ST perpendicular to PT, cutting pt in t; and Po perpendicular to Sp. Let the arch GP be $= z$, the radius SP $= y$, and the perpendicular ST $= p$. Then, it is plain, that Pp, op, Tt, are ultimately proportional to $\dot{z}, \dot{y}, \dot{p}$. The triangles PC$p$, and T$pt$ or TPt are alſo ultimately ſimilar; as alſo the triangles PST and poP. Therefore, ultimately,

$$\text{T}t : \text{P}p = \text{PT} : \text{PC}$$

alſo $$\text{P}p : po = \text{PS} : \text{PT}$$

therefore $\text{T}t : po = \text{PS} : \text{PC}$, or, $\dot{p} : \dot{y} = y : r$, and $r = \frac{y\dot{y}}{\dot{p}}$; an expreſſion of the radius of curvature, extremely ſimple, and of eaſy application.

The logarithmic or equiangular ſpiral PQR (fig. 6.) affords an eaſy example of the uſe of this formula. The angle SPT, which the ordinate makes with the curve, is everywhere the ſame. Therefore let a be our tabular radius, and b the ſine of the angle SPT. We have $\text{ST} = \frac{by}{a}$; and therefore PC $\left(= \frac{y\dot{y}}{\dot{p}}\right) = \frac{ay\dot{y}}{b\dot{y}} = \frac{ay}{b}$. This is to SP or y in the conſtant ratio of a to b, or of SP to ST: that is, ST : SP = SP : PC, the triangles SPT and PCS are ſimilar, the angles at P and C equal, and C is a point of an equiangular ſpiral pyr round the centre S.

It is not meant that the conſtruction pointed out by this theory of involution, expreſſed in its moſt general and ſimple form, is always the beſt for finding the centre of the equicurve circle. Our knowledge of, or attention to, many other properties of the curve under conſideration, beſides thoſe which ſimply mark its relation to an abſciſs and ordinate, muſt frequently give us better conſtructions. But evolution is the natural geneſis of a line of varying curvature. Moreover, in the moſt important employment of mathematical knowledge, namely, mechanical philoſophy, it is well known, that the moſt certain and comprehenſive method of ſolving all intricate problems is by reference of all forces and motions to three co-ordinates perpendicular to each other. Thus, without any intentional ſearch, we have already in our hands the very fluxionary quantities employed in this doctrine; and the expreſſion which it gives of the radius of curvature requires only a change of terms to make it a mechanical theorem.

Thus have we conſidered the two chief queſtions of evolution and involution. We have done it with as cloſe attention to geometry as poſſible, that the reader's mind may become familiar with the *ipſa corpora* while acquiring the elementary knowledge, which is to be employed more expeditiouſly afterwards by the help of the ſymbolical analyſis. Without ſuch ideas in the mind, the occupation is oftentimes as much diveſted of thought as that of an expert accountant engaged in complex calculations; the attention is wholly turned to the rules of his art.

It now remains to conſider a little the nature of this curvature of which ſo much has been ſaid, and about which ſo many obſcure opinions have been entertained. We mentioned, in an early part of this article, the unwarranted uſe of the terms of infinite and infiniteſimal magnitude as applicable to curvature, and ſhewed its impropriety by the inconſiſtences into which it leads mathematicians. Nothing threw ſo much light on this ſubject as Mr Huyghens's Geometry of Evolution; and we ſhould have expected that all diſputes would have been ended by it. But this has not been the caſe; and even the moſt eminent geometers and metaphyſicians, ſuch as the Bernoullis and Leibnitz, have given explanations of orders of curvature that can have no exiſtence, and explanations of that coaleſcence which obtains between a curve line and its equicurve circle, which are not warranted by juſt principles.

Theſe errors (for ſuch we preſume to think them) aroſe from the method employed by the geometers of laſt century for obtaining a knowledge of the magnitude and variation of curvature. The ſcrupulous geometers of antiquity deſpaired of ever being able to compare a curve with a right line. The moderns, although taught by Des Cartes to define the nature of a curve by its equation, allowed that this only enabled them to exhibit a ſeries of points through which it paſſed, and to draw the polygon which connects theſe points, but gave no information concerning the continuous *incurvated* arches, of which the ſides of the polygon are the chords. They could not generally draw a tangent to any point, or from any point; but they could draw a chord through any two points. Des Cartes was the firſt who could draw a tangent. He contrived it ſo, that the equation which expreſſes the interſections of the curve with a circle deſcribed round a given centre ſhould have two equal roots. This indicates the coaleſcence of two interſections of the common chord of the circle and the curve. Therefore a perpendicular to the radius ſo determined muſt touch the curve in the point of their union. This was undoubtedly a great diſcovery, and worthy of his genius. It naturally led the way to a much greater diſcovery. A circle may cut a curve in more points than two: It may cut a conic ſection in four points; all expreſſed by one equation, having four roots or ſolutions. What if three of theſe roots ſhould be equal? This not only indicates a cloſer union than a mere contact, but alſo gives indication of the flexure of the intervening arch. For, before the union, the interſections were in the arch both of the curve and of the circle; and therefore the diſtinction between the union of two and of three interſections muſt be of the ſame kind with that between a ſtraight line and an arch of *this* circle. The flexure of a circle being the ſame in every part, it becomes a proper index; and therefore the circle, which is determined by the coaleſcence of three interſections, was taken as the meaſure of the curvature in that point of the curve, and was called the CIRCLE OF CURVATURE, the EQUICURVE CIRCLE. There is a certain progreſs to this coaleſcence which muſt be noticed. Let ABD (fig. 4.) be a common parabola, EBF a line touching it in B, and BO a line perpendicular to EBF. Taking ſome point O in the other ſide of the axis for a centre, a circle may be deſcribed which cuts the curve in four points a, b, c, and d. By enlarging the radius, it is plain that the points a and b muſt ſeparate, as alſo the points c and d. Thus, the points b and c approach each other, and at laſt coaleſce in a point of contact B, with the parabola, and with its tangent. In the mean time, a and d have retired to A and D. If we now bring the centre O nearer to B, the new circle will fall wholly within the laſt circle ABD; and therefore both

A and D will again approach to each other, and to B, which ſtill continues a point of contact. It is plain that A will approach faſter to B than D will do. At length, the centre being in o, the point A coaleſces with B, and we obtain a circle ϵ B δ, touching the curve in B, and cutting it in δ: Conſequently the arch B ϵ δ is wholly within, and B ϕ δ is wholly without the parabola; and the circle both touches and cuts the parabola in B. Here is certainly a cloſer union, at leaſt on the ſide of a. But perhaps a farther diminution of the circle may bring it cloſer on the ſide of D. Join B δ. Let a ſmaller circle be deſcribed, touching the parabola in B, and cutting it in ϕ. Draw $\phi\, c$ parallel to δ B. It may be demonſtrated that the new circle cuts the parabola in c. Now the arch between c and ϕ being without the parabola, the arch B C muſt be within it; and therefore this circle is within the parabola on both ſides of B, and is more incurvated than the parabola. We have ſeen, that a circle greater than ϵ B δ is without the parabola on both ſides of B; and therefore is leſs incurvated than the parabola. Therefore the individual circle ϵ B δ is neither more nor leſs curve than the parabola in the point B. Therefore the circle indicated by the coaleſcence of three interſections is properly named the equicurve circle; and, ſince we meaſure all curvatures by that of a circle, it is *properly* the circle of curvature, and its radius is the radius of curvature.

Had B been the vertex of the axis, every interſection on one ſide of B would have been ſimilar to an interſection on the other, and there would always have been two pairs of roots that are equal; and therefore when three interſections coaleſce, a fourth alſo coaleſces, and the contact is ſaid to be ſtill cloſer.

What has now been ſhewn with reſpect to a conic ſection is true of every curve. When two interſections coaleſce, there is a common tangent; when three coaleſce, there is an equal curvature, and no other circle can paſs between this circle and the curve. There cannot be a coaleſcence of four interſections, except when the diameter is perpendicular to the ordinates, and thoſe are biſected by the diameter.

Mr Leibnitz, who valued himſelf for metaphyſical refinement, and never fails to claim ſuperiority in this particular, notices the important diſtinction between a ſimple contact and this cloſer union, in a very well written diſſertation, publiſhed in the *Acta Eruditorum*, July 1686. He calls the contact of equal curvatures an OSCULATION, and the circle of equal curvature the OSCULATING CIRCLE, and delivers ſeveral very judicious remarks with the tone of a maſter and inſtructor. He alſo ſpeaks of different degrees or orders of oſculation, each of which is infinitely cloſer than the other, as a thing not remarked by geometers. But Sir Iſaac Newton had done all this before. The firſt twelve propoſitions of the *Principia* had been read to the Royal Society ſeveral years before, and were in the Regiſters. The *Principia* had received the imprimatur of the Society in July 1686; but was almoſt printed before that time. In the Scholium to the 11th Lemma, is contained the whole doctrine of contact and oſculation; and in the lemma and its corollaries, is crowded a body of doctrine, which has afforded themes for volumes. The author glances with an eagle's eye over the whole proſpect, and points out the prominent parts with the moſt compreſſed brevity; but with ſufficient preciſion for marking out the more important objects, and particularly the different orders of curvature. This lemma and its corollaries are continually employed in the twelve propoſitions already mentioned. In 1671 he had written the firſt draught of his method of fluxions, where this doctrine is ſyſtematically treated; and Mr Collins had a copy of it ever ſince 1676. It is well known that Leibnitz, when in London, had the free peruſal of the Society's records, and information at all times by his correſpondence with the ſecretary Oldenburgh and Mr Collins. His conduct reſpecting the theorems concerning the elliptical motion of the planets, and the reſiſtance of fluids, leave little room to doubt of his having availed himſelf in like manner of his opportunity of information on this ſubject. He gives a much better account of the Newtonian doctrine on this ſubject than in thoſe other inſtances, it being more ſuited to his refining and paradoxical diſpoſition.

In this and another diſſertation, he conſiders more particularly the nature of evolution, and of that oſculation which obtains between the evolutrix and the circle deſcribed by the evolved radius. He ſays, that it is equivalent to two ſimple contacts, each of which is equivalent to two interſections. An oſculation produced in the evolution of a curve is therefore equivalent to four interſections. And he adviſes, with an air of authority, the mathematicians to attend to theſe remarks, as leading them into the receſſes of ſcience. He is miſtaken, however; and the liſtening to him would prevent us from forming a juſt notion of oſculation, and from conceiving with diſtinctneſs the ſingular fact of a circle both touching and cutting a curve in the ſame point. James Bernoulli loſt his friendſhip, becauſe he preſumed to ſay that the preſence of four interſections in an oſculation is not warranted by the equation expreſſing thoſe interſections.

Mr Leibnitz was miſled by the way in which he had conſidered the oſculation in the evolution of curves. It merits attention. From any point within the ſpace ADFOA (fig. 1.), two perpendiculars may be drawn to the evolutrix A $b\,d\,f$; and therefore two circles may be deſcribed round that point, each touching the curve. Each contact is the union of two interſections. Therefore, as the centre approaches the evolute, the contacts approach each other, and they unite when the centre reaches the evolute. Therefore the oſculation of evolution is equivalent to four interſections.

But when two ſuch circles are deſcribed round a point s, ſo as that both may touch the evolutrix A $a\,f$, the point s is in the interſection of one evolved radius with the *prolongation* of another. The contact at the extremity b of the prolonged radius b B is an exterior contact, and the arch of the circle croſſes the evolutrix, from without inwards, in ſome point more remote from A. The contact at the extremity e of the radius e E is an interior contact; and if $e\,s$ be greater than the ſtraight line EA, the arch of this circle croſſes the curve, from within outwards, in ſome point nearer to A. Thus each contact is accompanied by an interſection on the ſide next the other contact, ſometimes beyond it, and ſometimes between the contacts. As the contacts approach, the interſections alſo approach, ſtill retaining their characters as interſections, as the contacts ſtill continue contacts. Alſo the circle next to A croſſes from without inwards, and that next to f croſſes from within outwards. They retain this character to the laſt; and when the contacts coaleſce, the two circles coaleſce over their whole circumference, ſtill, however, croſſing the curve in the ſame direction as before; that is, without the curve on the ſide of A, and within it on the ſide of *f*. The contacts unite as contacts, and the interſections as interſections. Thus it is that the oſculating circle both touches and interſects the curve in the ſame point.

At *f* the oſculation is indeed cloſer than anywhere elſe. The variation of curvature is leſs there than anywhere elſe, becauſe the radius changes more ſlowly. It is this circumſtance that determines the cloſeneſs of contact. If a circle oſculates a curve, it has the ſame curvature. If this curvature does not change in the vicinity of the contact, the curve and circle muſt coincide; and the deviation of the circle (the curvature of which is everywhere the ſame) from the curve muſt proceed entirely from the variation of its curvature. This, therefore, is the important circumſtance, and is indeed the characteriſtic of the figure as a curve line; and its other properties, by which the poſition of its different parts are determined, may be aſcertained by means of the *variation* of its curvature, as well as by its relation to co-ordinates. Of this we have a remarkable inſtance at this very time. The orbit of the newly diſcovered planet has been aſcertained with tolerable preciſion by means of obſervations made on its motions for three years. In this time it had not deſcribed the 20th part of its orbit; yet the figure of this orbit, the poſition of its tranſverſe axis, the place and time of its perihelion, were all determined within 100dth part of the truth by the *obſerved variation* of its curvature. It therefore merits our attention in the cloſe of this article. We know of no author who has treated the ſubject in ſo inſtructive a manner as Mr M‘Laurin has done, by exhibiting the theorem which conſtitutes Newton's 11th lemma in a form which points this out even to the eye (ſee *M‘Laurin's Fluxions*, Chap. xi. § 363, &c.). We earneſtly recommend this work to the young geometer, as containing a fund of inſtruction and agreeable exerciſe to the mathematical genius, and as greatly ſuperior in perſpicuity and in ideas which can be treaſured up and recollected, when required, to the greateſt part of the elaborate performances of the eminent analyſts of later times. By expreſſing every thing geometrically, the author furniſhes us with a ſort of picture, which the imagination readily reviews, and which exhibits in a train what mere ſymbols only give us a momentary glimpſe of.

“ As, of all right lines which can be drawn through a given point in the arch of a curve, that alone is the tangent which touches the arch ſo cloſely that no right line can paſs between them; ſo, of all circles which touch a curve in a given point, that circle alone has the ſame curvature which touches it ſo cloſely that no circle can paſs between them. It cannot coincide with the arch of the curve; and therefore the above condition is ſufficient for making it equicurve. As the curve ſeparates from the tangent by its flexure or curvature, it ſeparates from the equicurve circle by its *change* of curvature; and as its curvature is greater or leſs according as it ſeparates more or leſs from its tangent, ſo the variation of its curvature is greater or leſs according as it ſeparates more or leſs from its equicurve circle. There can be but one equicurve circle at one point of a curve, otherwiſe any other circle deſcribed between them through that point will paſs between the curve and the equicurve circle.

“ When two curves touch each other in ſuch a manner that no circle can paſs between them, they muſt have the ſame curvature; becauſe the arch which touches one of them ſo cloſely that no circle can paſs between them, muſt touch the other in like manner. But circles may touch the curve in this manner, and yet there may be indefinite degrees of more or leſs intimate contact between the curve and its equicurve circle.” This is ſhewn by the ingenious author in a ſeries of propoſitions, of which a very ſhort abridgment muſt ſuffice in this place.

Let any curve EMH (fig. 11.), and a circle ERB, touch a right line ET on the ſame ſide at E. Let any right line TK, parallel to the chord EB of the circle, meet the tangent in T, the curve in M, and a curve BKF (which paſſes through B) in K. Then, if $MT \times TK$ be everywhere equal to TE^2, the curvature of EMH in the point E is the ſame as that of the circle ERB; and the contact of EM and ER is ſo much the cloſer the ſmaller the angle is which is contained at B between the curve BKF and the equicurve circle BQE.

Let TK meet the circle in R and Q. Then, becauſe $RT \times TQ = TE^2$, it muſt be $RT \times TQ = MT \times TK$; and $RT : MT = TK : TQ$. The line BKF may have any form. It may croſs the circle BQR in B, as in the figure. It may touch it, or touch EB, &c. Let us firſt conſider what ſituations of the point M correſpond with the poſition of K, in that part of the curve BKF which lies without the circle BRE. Let TK move toward EB, always keeping parallel to it, till it coincide with it, or even paſs it. Then, while the point K deſcribes KB, it is evident that ſince TK is greater than TQ, TM muſt be leſs than TR, and the point M muſt always be found between T and R. The arch ME of the curve muſt be nearer to the tangent than the arch RE of the circle. If any circle be now deſcribed touching TE in E, and cutting off from EB a ſmaller chord than EB, it is clear that the whole of this ſegment muſt be within the ſegment BRE; therefore this ſmaller circle does not paſs between ERB and the curve EMH. But ſince we ſee that the curve lies without the circle, in the vicinity of E, perhaps a greater circle than ERB may paſs between it and the curve. A greater circle, touching at E, muſt cut off a chord greater than EB. Let E*r b* be ſuch a circle, cutting EB in *b*, and TQ in *q*. T*q* is neceſſarily greater than TQ. For ſince *b* is beyond B, and the arch BKF lies in the angle QB*b*, the circle E*r q* muſt croſs the curve FKB in ſome point; ſuppoſe F. Then while K is found in the arch FB, the point *q* muſt be beyond K, or T*q* muſt be greater than TK. Now $Tr \times Tq = TE^2, = TM \times TQ$. Therefore $TM : Tr = Tq : TQ$. Therefore T*q* being greater than TQ, T*r* muſt be leſs than TM, and the point *r* muſt lie without the curve, and the arch E*r* does not paſs between EMH and the circle ERB. In like manner, on the other ſide of EB, it will appear, that when the curve BK′F′ falls within the circle which touches EMH in E, and cuts off the chord EB, the arch of the curve correſponding to the arch BKF′, lying within the circle, alſo lies within the circle. For TK′ being leſs than TQ′, TM′ is greater than TR′, and the curve is within

within the circle. And, by ſimilar reaſoning, it is evident that a circle cutting off a greater chord falls without both the circle ER′B and the curve, and that a circle leſs than ER B muſt neceſſarily leave ſome part of the curve BK′F′ without it; and therefore TK′ will be greater than T*q*′, and the correſponding point *r*′ muſt be without the curve. All circles therefore touching TE in E fall without both ER and EM, or within them both, according as they cut off from EB a chord greater or leſs than EB, and no circle can paſs between them when the rectangle $MT \times TK$ is always equal to ET^2, and the focus of the point K paſſes through B; that is, ERB is the equicurve circle at E.

This corroborates the ſeveral remarks that we have made on the circumſtance of a circle touching and cutting a curve in the ſame point. No other circle can be made to paſs between it and the curve, and it therefore has the ſame curvature. This may therefore be taken as a ſufficient indication of the equicurve circle; the character peculiarly aſſured to it by the nature of evolution. It muſt be noted, however, that the curve is ſuppoſed to have its concavity in the vicinity of the contact turned all the ſame way. For if the contact be in a point of contrary fluxure, even a ſtraight line will both touch and cut it in that point.

The reader cannot but remark, that MK is always the chord of a circle touching TE in E, and paſſing through M.

Let E*m* be another curve, touching TE in E, ſuch, that the conjugate curve *k*B, which always gives $Tm \times Tk = TE^2$, alſo paſſes through B. Then, by what has now been demonſtrated, the two curves EM and E*m* have the ſame equicurve circle ERB, and conſequently the ſame curvature in E. Then, becauſe the rectangles $RT \times TQ$, $MT \times TK$, and $mT \times Tk$, are equal, we have $Tm : TM = TK : Tk$. Therefore if the arch B*k* paſs between BK and BQ, the curve E*m* muſt paſs between the curve EM and the circle ER. E*m* muſt therefore have a cloſer contact with ER than EM has with it; and the ſmaller the angle QBK is which is contained between the curve and its equicurve circle, the cloſer is the contact of the curve EM and its equicurve circle ER. Thus the length of the chord EB determines the *magnitude* or degree of curvature at E, when compared with another; and the angle contained between the equicurve circle and the conjugate curve BKF determines the cloſeneſs of the contact of the curve with its equicurve circle (the angle TEB being ſuppoſed the ſame in both).

It appears, from the proceſs of demonſtration, that the curve EMH falls without or within the equicurve circle according as its conjugate curve BKF does. Alſo, when BKF cuts BQR, HME alſo cuts it. But if FQB is on the ſame ſide of QB on both ſides of the interſection B, the curve HME is alſo on the ſame ſide of it on both ſides of the contact E. It is alſo very clear, that the contact or approach to coaleſcence between the curve and its circle of curvature, is ſo much the cloſer as the conjugate curve BKF comes nearer to the adjoining arch of this circle. It muſt be the cloſeſt of all when KB touches QB, and it muſt be the leaſt ſo when KB touches EB, or has EB for an aſſymptote. The ſpace QBK is a ſort of magnified picture of the ſpace MER; and we have a ſenſible proportion of TQ to TK as the repreſentation of the proportion of TM to TR, quantities which are frequently evaneſcent and inſenſible. When QBK is a finite angle, that is, when the tangents of BQ and BK do not coincide, the angle QBK can be meaſured. But no rectilineal angle can be contained as an unit in the curvilineal angle MER. They are incommenſurable, or incomparable. Let the curve KB touch the circle QB without cutting it. This angle is equally incomparable with the former QBK; yet it has a counterpart in MER. This muſt be incomparable with the former in the ſame manner; for there is the ſame proportion between the individuals of both pairs. Thus it appears plainly, that there are curvilineal angles incomparable with each other. Yet are they magnitudes of one kind; becauſe the ſmalleſt rectilineal angle muſt certainly contain them both; and one of them contains the other. But, further, there may be indefinite degrees of this coaleſcence or cloſeneſs of contact between a curve and a circle. The firſt degree is when the ſame right line touches both. This is a *ſimple contact*, and may obtain between any curve and any circle. The next is when EMH and ERB have the ſame curvature, and when the conjugate curve FKB interſects the circle QB in any aſſignable angle. This is an *oſculation*. The third degree of contact, and ſecond of oſculation, is when the curve KB touches the circle QB, but not ſo as to oſculate. The fourth degree of contact, and third of oſculation, is when KB and QB have the ſame curvature or oſculate in the firſt degree of oſculation. This gradation of more and more intimate contact, or (more properly ſpeaking) of approximation to coaleſcence, may be continued without end, "*neque novit natura limitem*," the contact of EM and ER being always two degrees cloſer than that of BK and BQ. Moreover, in each of thoſe claſſes of contact there may be indefinite degrees. Thus, when EM and ER have the ſame curvature, the angle QBK admits of indefinite varieties, each of which aſcertains a different cloſeneſs of contact at E. Alſo, though the angle QBK ſhould be the ſame, the contact at E will be ſo much the cloſer the greater the chord EB is.

For $TR : TM = TK : TQ$
Therefore $RM : TR = KQ : KT$
Or $RM : KQ = TR : TK; = TR \times TQ : TK \times TQ, = TE^2 : TK \times TQ$.

Therefore, when TE is given, RM (which is then the meaſure of the angle of contact) is proportional to KQ directly, and to the rectangle $TK \times TQ$ inverſely; and when KQ is given, RM is leſs in proportion as $KT \times TQ$ is greater. In the very neighbourhood of E and B, it is plain that $KT \times TQ$ is very nearly equal to EB^2, and therefore ultimately $RM : KQ = ET^2 : EB^2$.

It will greatly aſſiſt our conception of this delicate ſubject, if we view the origin of theſe degrees of contact as they are generated by the evolution of lines. A thread evolving from a polygon EDCBA (fig. 13.) deſcribes with its extremity *a* a line *e d b c a*, conſiſting of ſucceſſive arches of circles united in ſimple contacts. If it evolve from any continuous curve CBA, after having evolved from the lines ED, BC, the arch *cb* will be united with the circular arch *dc* by oſculation of the firſt degree. If any other curve FC touch this evolute in a ſimple contact, and if the two curves FCBA and DCBA are both evolved, they will touch each other in a ſimple oſculation in that point where they have the ſame radius. If FC touches DC in a ſimple oſculation, the evolved curves will touch in an oſculation of the ſecond degree; and, in general, the oſculation of the two generated curves is a degree cloſer than that of their evolutes; and in each ſtate of one of the oſculations, there is an indefinite variety of the other, according to the length of its radius of curvature. All this is very clear; and ſhews, that theſe degrees of contact do not indicate degrees of curvature, one of which infinitely exceeds another; for they are all finite.

The reader will do well to remark, that the magnitude, which is the ſubject of the above proportions, which is really of the ſame kind in them all, and conſidered as ſuſceptible of various degrees and orders of infiniteſimals, is not curvature, but lineal extenſion. It is RM, the ſubtenſe of the angle of contact MER. It is the linear ſeparation from the tangent, or from the equicurve circle. It is, however, uſually conſidered as the meaſure of curvature, or the proportions of this line are given as the proportions of the curvature. This is inaccurate; for curvature is unqueſtionably a change of direction only. As this line has generally been the intereſting object in the refined ſtudy of curve lines, eſpecially in the employment of it in the diſcuſſions of mechanical philoſophy, it has attracted the whole attention, and the language is now appropriated to this conſideration. What is called, by the moſt eminent mathematicians, variation of curvature, is, in fact, variation of the ſubtenſe of the angle of contact But it is neceſſary always to diſtinguiſh them carefully.

Variation of curvature is the remaining object of our attention.

Curvature is uniform in the circle alone. When the curvature of the arch EMH (fig. 11.) decreaſes as we recede from E, the arch, being leſs deflected from its primitive direction ET than the arch ER, muſt ſeparate leſs from the line ET, or muſt fall without the arch ER. The more rapidly its curvature decreaſes, the deſcribing point muſt be left more without the circle. It muſt be the contrary, if its curvature had increaſed from E toward M. It may change its curve equably or unequably. If equably, there muſt be a certain uniform rate, which would have produced the ſame final change of direction in a line of the ſame length, bending it into the uniformly incurvated arch of a circle. It is not ſo obvious how to eſtimate a rate of variation of curvature; and authors of eminence have differed in this eſtimation. Sir Iſaac Newton, who was much intereſted in this diſcuſſion, in his ſtudies on univerſal gravitation, ſeems to have adopted a meaſure which beſt ſuited his own views; and has been followed by the greater number. He gives a very clear conception of what he means, by ſtating what he thinks a caſe of an invariable rate of variation. This is the equiangular ſpiral, all the arches of which, comprehended in equal angles from the centre, are perfectly ſimilar, although continually varying in curvature. He calls this a curve EQUABLY VARIABLE, and makes its rate of variation (eſtimated in that ſenſe in which it is uniform) the meaſure of the rate of variation in all other curves. Let us ſee in what reſpect its variation of curvature is conſtant. It may be deſcribed by the evolution of the ſame ſpiral in another poſition (ſee fig. 6.), and the ratio between the radius of the evolute and that of the evolutrix is always the ſame; or (which amounts to the ſame thing) the arch of the evolutrix bears to the evolved arch of the evolute a conſtant ratio. The curvature of the ſpiral changes more rapidly in the ſame proportion as the ratio of the evolved arch to the arch of the evolutrix generated by it is greater, or as it cuts the radii in a more acute angle. Theſe arches may be infiniteſimal; therefore the fraction $\frac{\text{fluxion of evolute}}{\text{fluxion of evolutrix}}$ expreſſes the rate of the variation of curvature in this ſpiral. Now let *abcd* (fig. 13.) be any other curve, and ABCD its evolute; let *p* be the centre of curvature at the point B of the evolute, and B*o* the evolved arch; draw the radii *p*B, *po*, B*m*, *on*; join *pm*, and draw B*q* perpendicular to *pm*. It is evident that *mn* and B*o* have the ſame ratio with B*m* and B*p*; and that theſe two ſmall arches may be conceived as being portions of the ſame equiangular ſpiral (perhaps in another poſition), of which *q* is the centre; and that *p* is in the curve of another of the ſame. For $qp : q\text{B} = q\text{B} : q\text{M}, = p\text{B} : \text{B}m$; therefore the ratio of theſe infiniteſimal arches *mn* and B*o* will expreſs the rate of variation in any curve. This is evidently equivalent to ſaying, that the variation of curvature is proportional to the fluxion of the radius of curvature directly, and the fluxion of the curve inverſely. For *mn* and B*o* are ultimately as thoſe fluxions, and $\frac{\text{B}o}{mn}$ is equivalent to $\frac{-\dot{r}}{\dot{z}}$, where *z* is the arch of the ſpiral, and *r* the evolved radius of the other. Accordingly, this is the enunciation of the INDEX OF VARIATION given by Newton (See Newton's Fluxions, Prob. VI. § 3). Therefore, what Newton calls a uniform variation of curvature, is not an increaſe or diminution by equal arithmetical differences, but by equal proportions of the curvature in every point. The variation of curvature in ſimilar points of ſimilar arches is ſuppoſed to be the ſame.

It is evident that this ratio is the ſame with that of radius to the tangent of the angle *pm*B, or of 1 to its tabular tangent. The tangent therefore of this angle correſponding to any point of a curve is the meaſure of the variation of curvature in that point. Now it may be ſhewn (and it will appear by and bye), that the fluxion of TK in fig. 11. or the ultimate value of KQ, is always $\frac{2}{3}$ds of the fluxion of the radius of curvature. Therefore the tangent of the angle QBK is always $\frac{2}{3}$ds of that of *pm*B; and therefore the angle QBK, which we have ſeen to be an index of the cloſeneſs of contact, is alſo the index of the variation of curvature (See *M'Laurin*, § 386.).

Sir Iſaac Newton has given ſpecimens of the uſe of this meaſure in a variety of geometrical curves, by means of a general expreſſion of $\frac{\dot{r}}{\dot{z}}$. Thus, in the curve ABC (fig. 8.), let AB be $= z$, AD $= x$, DB $= y$, BN $= r$, and BE $= p$; we have $\frac{\text{N}n}{\text{B}b} = \frac{\dot{r}}{\dot{z}}$. Now DB : BE $= y : p, = \text{D}d : \text{B}b, = \dot{x} : \dot{z}$. Therefore $\dot{z} = \frac{p\dot{x}}{y}$, and $\frac{\dot{r}}{\dot{z}} = \frac{y\dot{r}}{p\dot{x}}$. Now, in every curve which we can expreſs by an equation, we can obtain all theſe quantities p, y, $\dot{r}$, and $\dot{z}$, and can therefore obtain the meaſure

of

Involution.

of the variation of curvature. It is alſo deſerves particular notice, that this inveſtigation of $\frac{\dot{r}}{\dot{z}}$ is equivalent with finding the centre and radius of curvature of the evolute, by which the curve under conſideration is generated; or with finding the centre q (fig. 13.) of an equiangular ſpiral, which will touch our curve in m, its evolute in B, and the evolute of the evolute in p, if put into different poſitions when neceſſary. This leads to very curious ſpeculations, for which, however, we have no room It has been ſaid, for inſtance, that the curvature at the interſection of a cycloid with its baſe is infinitely greater than that of any circle. If the evolution of the cycloid begin from this point, the curvature of its evolutrix will be infinitely greater ſtill upon the ſame principles; and we ſhall have one infinitely greater than this by evolving it. Yet all theſe infinites, multiplied to infinity, are contained in the central point of every equiangular ſpiral! In like manner, there are evolutrixes which coincide with a ſtraight line, and others of infinitely greater rectitude, and ſtill they are curves. Can this have any meaning? And can it be reconciled with the legitimate reaſoning from the ſame principles, that all theſe curvatures and angles of contact are producible by evolution; and that they may be, and certainly are every day deſcribed, by bodies moving in free ſpace, and acted on by accelerating forces directed to different bodies?

The parabola (conical) is the moſt ſimple of all the lines of unequably varying curvature, and becomes a very good ſtandard of compariſon. In the parabola ABC (fig. 8.) let the parameter be $2a$. The equation is then $2ax = y^2$; DE $= a$; p, or BE $= \sqrt{a^2+y^2}$ DQ $= a + 2x$ (by what was formerly demonſtrated). Moreover, DB : BE = DQ : BN; and BN $= \frac{pa+2px,}{a} = r$. Theſe equations give $2a\dot{x} = 2y\dot{y}, = 2p\dot{p}$; and $\frac{a\dot{p}+2x\dot{p}+2p\dot{x}}{a} = \dot{r}$. Now making $\dot{x} = 1$, and reducing the equations, we obtain $\dot{y} = \frac{a}{y}$; $\dot{p} = \frac{y\dot{y}}{p} = \frac{a}{p}$; and $\dot{r} = \frac{a\dot{p}+2x\dot{p}+2p}{a}$.

With theſe values of $\dot{y}, \dot{p}, \dot{r}$, we obtain a numerical value of $\frac{y\dot{r}}{p}$ moſt readily. Thus, in order to obtain the index of variation of curvature in the point where the ordinate at the focus cuts the parabola, make $a = 1$. Then $2x = y^2$; $x = \frac{1}{2}$, $y\ (= \sqrt{2x}) = 1$; $\dot{y}\left(= \frac{a}{y}\right) = 1$; $p\ (= \sqrt{a^2+y^2}) = \sqrt{2}$; $\dot{p}\left(= \frac{a}{p}\right) = \sqrt{\frac{1}{2}}$, and $\dot{r}\left(= \frac{a\dot{p}+2x\dot{p}+2p}{a}\right) = \sqrt{2} \times 3$. Therefore $\frac{y\dot{r}}{p} = 3, =$ the index of variation in the point B when D is the focus of the parabola; that is to ſay, the fluxion of the radius of curvature is three times the fluxion of the curve.

Involution.

The index of variation, where the ordinate is equal to the parameter, is had by making $x = 2$. This gives $y = 2$; $\dot{y} = \frac{1}{2}$; $p = \sqrt{5}$; $\dot{p} = \sqrt{\frac{1}{5}}$, and $\dot{r} = 3\sqrt{5}$. Wherefore $\frac{y\dot{r}}{p} = 6$, which is the index of variation. Moreover, ſince $\dot{p}$ and $\dot{r}$ are in a conſtant ratio, it appears that the index of variation of curvature in the parabola is proportional to the ordinate y. It is always $= 6\,\frac{\text{ordinate}}{\text{parameter}}$; and thus, with very little trouble, we can deſcribe the evolute of its evolute, *i e.* of the ſemicubical parabola.

In like manner, it may be ſhewn, that in all the conic ſections $\frac{\dot{r}}{\dot{z}}$ is always proportional to the rectangle of the ordinate DB and the ſubnormal DE, or to DB × DE. In the parabola, whoſe equation is $2ax = y^2$, we have $\frac{\dot{r}}{\dot{z}} = \frac{3y}{a}$. In an ellipſe, whoſe equation is $2ax - bx^2 = y^2$, we have $\frac{\dot{r}}{\dot{z}} = \frac{3-3b}{a} \times$ DB × DE, and in the hyperbola, whoſe equation is $2ax + bx^2$, $\frac{\dot{r}}{\dot{z}}$ is $= \frac{2+3b}{a} \times$ DB × DE. This ratio, in all the three ſections, is always as the tangent of the angle contained between the diameter and the normal at the point of contact. By this we may compare them with a parabola. In the cycloid at the point E (fig. 5) $\frac{\dot{r}}{\dot{z}}$ is $=$ tan. ∠ EKM, &c. &c.

All theſe things may be traced in the obſervations made on fig. 11. and 12. When the angle BET is a right angle, the angle KBQ indicates it directly, its tangent being always $= \frac{2\dot{r}}{3\dot{z}}$. It is eaſy alſo to ſee, that when the curve EMH is a parabola, the line BKF is a ſtraight line parallel to ET. It is alſo plain, that by the ſame ſteps that we proved that no circle can paſs between this parabola and its equicurve circle ERB, ſo no other parabola can paſs between them. Indeed the ſame reaſoning will prove that no curve of the ſame kind can paſs between any curve and its oſculating circle. In many caſes, it is more eaſy to reaſon from the curvature of a curve, by comparing it with an equicurve parabola than with an equicurve circle; particularly in treating of the curvilineal motions of bodies in free ſpace, actuated by deflecting forces.

If EMH be an ellipſe or hyperbola, BKF is another ellipſe or hyperbola (*M'Laurin*, § 373.)

WE have thus endeavoured to introduce our readers into this curious branch of ſpeculative geometry. An introduction is all that can be expected from a work of this kind. We have enlarged on particular points, in proportion as we thought that the notions entertained on the ſubject were inadequate, or even vague and indiſtinct; and we hope that ſome may be incited to acquire clearer conceptions by going to the fountain head. We conclude, by recommending to the young geometer the peruſal of the Fluxions of Sir Iſaac Newton, after

after he has read M'Laurin's Chapter with care. He will probably be ſurpriſed and delighted with ſeeing the whole compreſſed by a maſter's hand into ſuch narrow compaſs with ſuch beautiful perſpicuity.

JOAN D' ARC, the maid of Orleans, has been variouſly characteriſed; but all now agree, that ſhe was worthy of a better fate than the horrid death ſhe was doomed to die. (See JOAN *d'Arc*, *Encycl.*). But did ſhe actually die that death? An ingenious writer in the *Monthly Magazine* has proved, we think, that ſhe did not.

The biſhop of Beauvais (ſays he) is accuſed by all parties of treachery and trick in the conduct of the trial: it was his known propenſity to gain his ends by ſtratagem, craft, manœuvre, fraud, dexterity. He ſeeks out, and brings forward, ſuch teſtimony only as relates to eccleſiaſtical offences, and then hands over the deciſion to the ſecular judges, whoſe clemency he invokes. Joan ſays to him publicly, "You * *promiſed* to reſtore me to the church, and you deliver me to my enemies." The intention of the biſhop, then, muſt have been, that the ſecular judges, for want of evidence, ſhould ſee no offence againſt the ſtate; as the clerical judges, notwithſtanding the evidence, had declined to ſee any againſt the church. A fatal ſentence was, however, pronounced; and the fulfilment of it entruſted to the eccleſiaſtical authorities. Immediately after the *auto da fé*, one of the executioners ran to two friars, and ſaid, "that he had never been ſo ſhocked at any execution, and that the Engliſh had built up † a ſcaffolding of plaſter (*un echafaud de platre*) ſo lofty, that he could not approach the culprit, which muſt have cauſed her ſufferings to be long and horrid." She was, therefore, by ſome *unuſual* contrivance, kept out of the reach and obſervation even of the executioners.

Some time after, when public commiſeration had ſucceeded to a vindictive bigotry, a woman appeared at Metz ‡, who declared herſelf to be Joan of Arc. She was everywhere welcomed with zeal. At Orleans, eſpecially, where Joan was well known, ſhe was received with the honours due to the liberatreſs of the town. She was acknowledged by both her brothers, Jean and Pierre d'Arc. On their teſtimony ſhe was married by a gentleman of the houſe of Amboiſe, in 1436. At their ſolicitation her ſentence was annulled in 1456. The Pariſians, indeed, long remained incredulous: they muſt elſe have puniſhed thoſe eccleſiaſtics, whoſe humanity, perhaps, conſpired with the biſhop of Beauvais to withdraw her from real execution down a central chimney of brick and mortar; or, as the executioner called it, a ſcaffolding of plaſter. The king, for the woman ſeems to have ſhunned no confrontation, is ſtated to have received her with theſe words: "*Pucelle, m'amie, ſoyez la tres bien revenue, au nom de Dieu.*" She is then ſaid to have communicated to him, kneeling, the artifice practiſed. Can this woman be an impoſtor? Our author thinks not, and appeals to Voltaire, who, in his proſe works, ſeems willing to allow that ſhe was not, as is too commonly imagined, one of thoſe half inſane enthuſiaſts, employed as tools to work upon the vulgar; whom the one party endeavoured to cry up as a propheteſs, and the other to cry down as a witch; but that ſhe was a real heroine, ſuperior to vulgar prejudice, and no leſs remarkable by force of mind than for a courage and ſtrength unuſual in her ſex. This opinion is certainly countenanced by her behaviour in adverſity, and during her trial, which was firm without inſolence, and exalted without affectation.

JONES (Sir William), who was ſtyled by Johnſon the moſt enlightened of men, was the ſon of William Jones, Eſq; one of the laſt of thoſe genuine mathematicians, admirers, and contemporaries of Newton, who cultivated and improved the ſciences in the preſent century. Our author was born on the 28th of September 1746, and received his education at Harrow ſchool, under the care of Dr Robert Sumner, whom he has celebrated in an eulogium which will out-laſt braſs or marble. We are told that he was a claſs-fellow with Dr Parr, and at a very early age diſplayed talents which gave his tutor the moſt promiſing expectations, and which have ſince been amply juſtified. From Harrow he was ſent to Univerſity college, Oxford, where the rapidity and elegance of his literary acquiſitions excited general admiration; while a temper, ardently generous, and morals perfectly irreproachable, procured him teſtimonies of the moſt valuable eſteem. The grateful affection which he always cheriſhed for that venerable ſeat of learning, did as much honour to his ſenſibility, as Oxford herſelf has received by enrolling him among the number of her ſons.

In the twenty-third year of his age he travelled through France, and reſided ſome time at Nice, where he employed himſelf very differently from moſt other young men who make what is called the tour of Europe. *Man*, and the influence of various forms of *government*, were the principal objects of his inveſtigation; and in applying the reſult of his inquiries to the ſtate of his own country, he mingled the ſolicitudes of the Patriot with the honeſt partialities of an Engliſhman.

Mr Jones's firſt literary work was a tranſlation into French of a Perſian manuſcript, entitled "*Hiſtoire de Nadir Shah, connu ſous le nom de Thahmas Kuli Khan, Empereur de Perſe,*" in two vols. 4to; the hiſtory of which performance we ſhall give in his own words: "A great northern monarch, who viſited this country a few years ago, under the name of the Prince of Travendal, brought with him an eaſtern manuſcript, containing the life of Nadir Shah, the late ſovereign of Perſia, which he was deſirous of having tranſlated in England. The ſecretary of ſtate, with whom the Daniſh miniſter had converſed upon the ſubject, ſent the volume to me, requeſting me to give a literal tranſlation of it in the French language; but I wholly declined the taſk, alledging for my excuſe the length of the book, the dryneſs of the ſubject, the difficulty of the ſtyle, and chiefly my want both of leiſure and ability to enter upon an undertaking ſo fruitleſs and ſo laborious. I mentioned, however, a gentleman, with whom I had not then the pleaſure of being acquainted, but who had diſtinguiſhed himſelf by a tranſlation of a Perſian hiſtory, and was far abler than myſelf to ſatisfy the king of Denmark's expectations. The learned writer, who had other works upon his hands, excuſed himſelf on the account of his many engagements; and the application to me was renewed. It was hinted, that my compliance would be of no ſmall advantage to me at my entrance into life; that it would procure me ſome mark of diſtinction which might be pleaſing to me; and, above all, that it would be a reflec-

---

[*] *Villaret Hiſtoire de France*, tom. xv. p. 72.

[†] *Paſquier Hiſtoire d'Orleans*, liv. vi.

[‡] *Hiſtoire de la Pucelle par l'Abbé Lenglet.* See alſo *Mélanges Curieux Monſtrelet*; and the manuſcript authorities cited by the continuator of Velly.

tion upon this country, if the king ſhould be obliged to carry the manuſcript into France. Incited by theſe motives, and principally by the laſt of them, unwilling to be thought churliſh or moroſe, and eager for the bubble reputation, I undertook the work, and ſent a ſpecimen of it to his Daniſh Majeſty; who returned his approbation of the ſtyle and method, but deſired that the whole tranſlation might be perfectly literal, and the oriental images accurately preſerved. The taſk would have been far eaſier to me, had I been directed to finiſh it in Latin; for the acquiſition of a French ſtyle was infinitely more tedious; and it was neceſſary to have every chapter corrected by a native of France, before it could be offered to the diſcerning eye of the public, ſince in every language there are certain peculiarities of idiom, and nice ſhades of meaning, which a foreigner can never learn to perfection. But the work, how arduous and unpleaſing ſoever, was completed in a year, not without repeated hints from the ſecretary's office that it was expected with great impatience by the Court of Denmark." The tranſlation of the Hiſtory of Nadir Shah was publiſhed in the ſummer of the year 1770, at the expence of the tranſlator; and forty copies upon large paper were ſent to Copenhagen; one of them bound with uncommon elegance for the king himſelf, and the others as preſents to his courtiers*.

What marks of diſtinction our author received, or what fruits he reaped for his labour, he has not thought proper to diſcloſe; but if any dependence is to be placed on common fame, the reward beſtowed upon him for this laborious taſk conſiſted only in the thanks of his Daniſh Majeſty, and the honour of being enrolled in the Royal Society of Copenhagen. That diſtinction was indeed accompanied with a letter, recommending the learned tranſlator to the patronage of his own ſovereign; but, in the interim, his friend Lord Dartmouth, who was to have delivered it, had reſigned his office of ſecretary of ſtate, and the letter, we are told, was never preſented.

There is reaſon to think, that this early and ſevere diſappointment made a deep impreſſion on his mind, and induced him to renounce the muſes for a time, and to apply himſelf with aſſiduity to the ſtudy of juriſprudence. This we think apparent, from the ſtyle in which he writes of his return from the continent, and of the death of his beloved preceptor Dr Sumner.

"When I left Nice, (ſays he) where I had reſided near ſeven months, and after traverſing almoſt all France, returned to England, I moſt ardently deſired to paſs ſeveral years more in the ſtudy of polite literature; as then, I thought, I might enter into public life, to which my ambition had always prompted me, more mature and prepared: but with this fruit of my leiſure, either fortune, or rather Providence, the diſpoſer of all human events, would not indulge my ſloth; for on a ſudden, I was obliged to quit that very literature to which, from my childhood, I had applied myſelf; and he who had been the encourager and aſſiſtant of my ſtudies, who had inſtructed, taught, formed me ſuch as I was, or if I am any thing at all, Robert Sumner, within a year after my return, was ſnatched away by an untimely death (a)."

In 1771 Mr Jones publiſhed *Diſſertation ſur la Literature Orientale*, 8vo, and this was followed by *Lettre à Monſieur A** Du P***, dans laquelle eſt compris l'Examen de ſa Traduction des Livres attribues à Zoroaſtre*, 8vo. The diſſertation offered a favourable ſpecimen of the author's abilities as a linguiſt and as a critic; and the letter contained a ſpirited vindication of the univerſity of Oxford, from the very ſcurrilous reproaches, in which its incompetency in Oriental literature was aſſerted by the illiberal tranſlator of the ſuppoſed works of the Perſian philoſopher.

In the ſame year he gave to the public, "A Grammar of the Perſian language," 4to, and at the ſame time propoſed to republiſh Meninſki's Dictionary, with improvements from *De Labroſſee's Gazophylacium Linguæ Perſarum*, and to add in their proper place an Appendix ſubjoined to Gehaunagnire's Perſic Dictionary. The Grammar has been found extremely uſeful, and has

* *Preface to the Hiſtory of Nadir Shah*, 1773.

(a) As a ſpecimen of our author's latinity, we ſubjoin the epitaph on Dr Sumner, which is affixed to the wall of the ſouth tranſept of Harrow church.

H. S. E.
ROBERTUS SUMNER, S. T. P.
Collegii Regalis apud Cantab. olim Socius,
Scholæ Harrovienſis haud ita pridem Archididaſcalus.
Fuit hoc præſtantiſſimo Viro
Ingenium naturâ peracre, optimarum diſciplinis artium ſedulo
Excultum, uſu diuturno confirmatum, & quodammodo ſubactum.
Nemo enim aut in reconditis ſapientiæ ſtudiis illo ſubtilior extitit,
Aut humanioribus literis limatior: nemini fere vel felicius
Contigit judicii acumen, vel uberior eruditionis copia.
Egregiis hiſce cum dotibus naturæ, tum doctrinæ ſubſidiis,
Inſuper accedebat in ſcriptis mira ac prope perfecta eloquentia.
In ſermone facetiarum lepor plane Atticus, & gravitate ſuaviter
Aſpera urbanitas; in moribus ſingularis quædam integritas & fides;
Vitæ denique ratio conſtans ſibi, & ad virtutis normam diligenter ſevereque,
Exculta. Omnibus qui vel amico eſſent eo, vel magiſtro uſi, doctrinæ,
Ingenii, virtutis triſte reliquit deſiderium, ſubitâ, eheu! atque immaturâ
Morte correptus prid. Id. Sept. A. D.
1771, Æt. 41.

has been reprinted ſeveral times; but the deſign of the Dictionary, though an object of even national importance, for want of due encouragement was obliged to be laid aſide.

In 1772 he publiſhed "Poems; conſiſting chiefly of Tranſlations from the Aſiatic Languages. To which are added two Eſſays; 1. On the Poetry of the Eaſtern Nations. 2. On the Arts commonly called Imitative," 8vo, which in 1777 he republiſhed with the addition of ſome Latin Poems, every way worthy of their author. On the 18th June 1773, he took the degree of Maſter of Arts, and the ſame year publiſhed "The Hiſtory of the Life of Nadir Shah, King of Perſia. Extracted from an Eaſtern Manuſcript, which was tranſlated into French by order of his Majeſty the King of Denmark. With an Introduction, containing, 1. A Deſcription of Aſia according to the Oriental Geographers. 2. A ſhort Hiſtory of Perſia from the earlieſt Times to the preſent Century: And an Appendix, conſiſting of an Eſſay on Aſiatic Poetry, and the Hiſtory of the Perſian Language. To which are added Pieces relative to the French Tranſlation," 8vo. Our author having at this period determined to ſtudy the law as a profeſſion, and to relinquiſh every other purſuit, our readers will not be diſpleaſed with the following extract, relating to this reſolution, which concludes the preface to the hiſtory now under conſideration:

"To conclude; if any eſſential miſtakes be detected in this whole performance, the reader will excuſe them, when he reflects upon the great variety of dark and intricate points which are diſcuſſed in it; and if the obſcurity of the ſubject be not a ſufficient plea for the errors which may be diſcovered in the work, let it be conſidered, to uſe the words of Pope in the preface to his juvenile poems, that there are very few things in this collection which were not written under the age of five-and-twenty: moſt of them indeed were compoſed in the intervals of my leiſure in the South of France, before I had applied myſelf to a ſtudy of a very different nature, which it is now my reſolution to make the ſole object of my life. Whatever then be the fate of this production, I ſhall never be tempted to vindicate any part of it which may be thought exceptionable; but ſhall gladly reſign my own opinions, for the ſake of embracing others, which may ſeem more probable; being perſuaded, that nothing is more laudable than the love of truth, nothing more odious than the obſtinacy of perſiſting in error. Nor ſhall I eaſily be induced, when I have diſburdened myſelf of two other pieces which are now in the preſs, to begin any other work of the literary kind; but ſhall confine myſelf wholly to that branch of knowledge in which it is my chief ambition to excel. It is a painful conſideration, that the profeſſion of literature, by far the moſt laborious of any, leads to no real benefit or true glory whatſoever. Poetry, ſcience, letters, when they are not made the ſole buſineſs of life, may become its ornaments in proſperity, and its moſt pleaſing conſolation in a change of fortune; but if a man addicts himſelf entirely to learning, and hopes by that, either to raiſe a family, or to acquire, what ſo many wiſh for, and ſo few ever attain, an honourable retirement in his declining age, he will find, when it is too late, that he has miſtaken his path; that other labours, other ſtudies, are neceſſary; and that unleſs he can aſſert his own independence in active life, it will avail him little to be favoured by the learned, eſteemed by the eminent, or recommended even by kings. It is true, on the other hand, that no external advantages can make amends for the loſs of virtue and integrity, which alone give a perfect comfort to him who poſſeſſes them. Let a man, therefore, who wiſhes to enjoy, what no fortune or honour can beſtow, the bleſſing of ſelf-approbation, aſpire to the glory given to Pericles by a celebrated hiſtorian, of being acquainted with all uſeful knowledge, of expreſſing what he knows with copiouſneſs and freedom, of loving his friends and country, and of diſdaining the mean purſuits of lucre and intereſt: this is the only career on which an honeſt man ought to enter, or from which he can hope to gain any ſolid happineſs."

The next year he publiſhed *Poeſeos Aſiaticæ Commentariorum Libri Sex, cum Appendice: ſubjicitur Limon, ſeu Miſcellaneorum Liber*, 8vo; and purſuing his purpoſe of applying to the ſtudy of the law, we hear no more of him from the preſs (except the new edition of his Poems), until the year 1779. In this interval he was called to the bar, and attended Weſtminſter hall and the Oxford circuit, where he obtained but little buſineſs. He was however appointed a commiſſioner of bankrupts by Lord Bathurſt, who is ſuppoſed to have intended to exert his intereſt to procure his nomination to the bench in the Eaſt Indies.

He publiſhed in this year, "The ſpeeches of Iſeus, in cauſes concerning the law of ſucceſſion to property at Athens; with a preparatory diſcourſe, notes critical and hiſtorical, and a Commentary, 4to." In this valuable work, the talents of the ſcholar, the critic, and the lawyer, combine to elucidate a very important part of juriſprudence; for, "though deep reſearches into the legal antiquities of *Greece* and *Rome* (as he obſerves in his Commentary) are of greater uſe to ſcholars and contemplative perſons, than to lawyers and men of buſineſs; though Bracton and Lyttleton, Coke and Rolle, are the proper objects of our ſtudy; yet the ableſt advocates, and wiſeſt judges, have frequently embelliſhed their arguments with learned alluſions to antient caſes; and ſuch alluſions, it muſt be allowed, are often uſeful, always ornamental; and, when they are introduced without pedantry, never fail to pleaſe." The work was dedicated in a ſtyle of reſpectful gratitude to his patron Lord Bathurſt.

In the year 1780, we find our author a candidate to repreſent in parliament the univerſity of Oxford. He had for ſome time reſided but little in the univerſity, and therefore laboured under ſome diſadvantages; but he did not meanly court the ſupport of any man. In a paper, which was circulated on that occaſion, his friends, who were numerous, declare, that they have "neither openly ſolicited, nor intend openly to ſolicit, votes for Mr Jones within the Univerſity itſelf, becauſe he will never become the inſtrument of diſturbing the calm ſeat of the Muſes, by conſenting to any ſuch ſolicitation for himſelf or for any man whatever. His own applications have been, are, and will be, confined to thoſe only who have profeſſed a regard for him, *and who have no votes themſelves*: the Maſters of Arts in a great univerſity, whoſe prerogative is cool reaſon and impartial judgment, muſt never be placed on a level with the voters of a borough, or the freeholders of a county. Even in proceeding thus far, he does not ſet the example, but follows it; and his friends would never have printed any paper, if they had not thought themſelves juſtified by the conduct of others.

"For the firſt and the laſt time, they beg leave to ſuggeſt, that no exertions muſt be ſpared by thoſe who, either perſonally or by reputation, approve the character of Mr Jones; into which, both literary and political, as well as moral, his friends deſire and demand the ſtricteſt ſcrutiny. For his univerſity he began early to provoke, and poſſibly to incur, the diſpleaſure of great and powerful men: For his univerſity he entered the liſts with a foul-mouthed and arrogant Frenchman, who had attacked Oxford in three large volumes of miſrepreſentation and ſcurrility: For his univerſity he reſigned, for a whole year, his favourite ſtudies and purſuits, to ſave Oxford the diſcredit of not having one of her ſons ready to tranſlate a tedious Perſian manuſcript. To Oxford, in ſhort, he is known to be attached by the ſtrongeſt poſſible ties; and only regrets the neceſſity of abſenting himſelf from the place in which of all others he moſt delights, until the event of the preſent competition ſhall either convince him that he has toiled in vain as a man of letters, or ſhall confer on him the greateſt reward to which he can aſpire. The unavoidable diſadvantage of being ſo late propoſed, and the reſpectable ſupport with which he is now honoured, will ſecure him in all events from the leaſt diſgrace." The application was unſucceſsful, chiefly becauſe his own college had fixed upon another candidate, from a perſuaſion that the immediate appointment of Mr Jones to a ſeat, then vacant on the bench of judges in India, was morally certain.

The riots of that year gave occaſion to another publication of our author, entitled, "An Inquiry into the legal Mode of ſuppreſſing Riots; with a conſtitutional Plan of future Defence," 8vo; and in 1781 he publiſhed "An Eſſay on the Law of Bailments," 8vo, a very maſterly treatiſe, which did great honour to his legal abilities. In this laſt work he inculcates the neceſſity of deeply exploring the grounds of the common law; and ſpeaking of Blackſtone, (he ſays) "his commentaries are the moſt correct and beautiful outline that ever was exhibited of any human ſcience; but they alone will no more form a lawyer, than a general map of the world, how accurately and elegantly ſoever it may be delineated, will make a geographer."

In this year he likewiſe recalled his muſe in an Ode on the nuptials of Lord Viſcount Althorpe, who had been his pupil, to Miſs Lavinia Bingham. This beautiful little poem is preſerved in the European Magazine for January 1785, and we think in other periodical publications.

From many circumſtances which might be collected together, it would appear that our author at this juncture did not coincide in opinion with thoſe who had the direction of government, nor did he approve the meaſures at that period adopted.—With theſe ſentiments he ſeems to have been ſelected as a proper perſon to be introduced as a member of the Conſtitutional Society. Could he have foreſeen the degeneracy of ſuch aſſociations, there is reaſon to believe that he would have declined what he condeſcended to accept as an honour; for though an ardent friend to liberty, he was an enemy to theoretical innovation, and declares, in a letter to the ſecretary, that by the term conſtitution, he underſtands "the great ſyſtem of public, in contradiction to private and criminal law, which compriſes all thoſe articles which Blackſtone arranges, in his firſt volume, under the rights of perſons, and of which he gives a perſpicuous analyſis. Whatever then relates to the rights of perſons, either abſolute rights, as the enjoyment of liberty, ſecurity, and property, or relative, that is, in the public relations of magiſtrates and people, makes a part of that majeſtic whole, which we properly call the conſtitution. This conſtitutional or public law is partly unwritten, and grounded upon immemorial uſage, and partly written or enacted by the legiſlative power; but the unwritten, or common law, contains the true ſpirit of our conſtitution: the written has often moſt unjuſtifiably altered the form of it; the common law is the collected wiſdom of many centuries, having been uſed and approved by ſucceſſive generations; but the ſtatutes frequently contain the whims of a few leading men, and ſometimes of the mere individuals employed to draw them."

In 1782 he publiſhed "The Mahomedan Law of Succeſſion to the Property of Inteſtates, in Arabic, with a verbal Tranſlation and explanatory Notes." 4to.

At length the poſt of one of the judges in the Eaſt Indies, which had been kept vacant five years, was determined upon being filled up; and our author, on the 4th March 1783, was appointed to that ſtation, and on the 20th received the honour of knighthood. On the 8th of April he married Miſs Shipley, eldeſt daughter of the Biſhop of St Aſaph, and almoſt immediately embarked for the Indies. He had previouſly publiſhed "The Moallakat; or, Seven Arabian Poems, which were ſuſpended on the Temple at Mecca, with a Tranſlation and Arguments." 4to. To this it was intended to add a preliminary diſcourſe and notes.—The former to compriſe obſervations on the antiquity of the Arabian language and letters; on the dialects and characters of Himyar and Koraiſh, with accounts of ſome Himyarick poets; on the manners of the Arabs in the age immediately preceding that of Mahomed; on the temple at Mecca, and the Moallakat, or pieces of poetry ſuſpended on its walls or gate; laſtly, on the lives of the Seven Poets, with a critical hiſtory of their works, and the various copies or editions of them preſerved in Europe, Aſia, and Africa. The latter to contain authorities and reaſons for the tranſlation of controverted paſſages; to elucidate all the obſcure couplets, and exhibit or propoſe amendments of the text; to direct the reader's attention to particular beauties, or point out remarkable defects; and to throw light on the images, figures, and alluſions of the Arabian poets, by citations either from writers of their own country, or from ſuch of our European travellers as beſt illuſtrate the ideas and cuſtoms of Eaſtern nations. This diſcourſe and the notes have not yet appeared. At his departure for the eaſtern world, he left, in manuſcript, with his brother-in-law the Dean of St Aſaph, a little tract, entitled "The Principles of Government, in a Dialogue between a Scholar and a Peaſant." This celebrated dialogue being afterwards publiſhed by the Dean, and widely circulated by the ſociety for conſtitutional information, the Dean was proſecuted for publiſhing a libel, and, if our memory deceives us not, was found guilty.

Sir William Jones now dropt for ever all concern in party politics, and applied himſelf to purſuits more worthy of his talents. During his voyage to India, he conceived the idea of the Aſiatic Society, of which an account has been given under the title SOCIETIES (*Encycl.*), and of whoſe reſearches five volumes, replete with much curious information, are now before the public. But ardently as his mind was attached to general literature and ſcience, he was by no means inattentive to the profeſſional duties of his high ſtation. He had indeed, to uſe his own expreſſion, an “ undiſſembled fondneſs for the ſtudy of juriſprudence *;” and in the character of a judge, diſplayed the profound knowledge and irreproachable integrity, which, before his promotion, pervaded his reaſonings as a lawyer, and governed his conduct as a man. Unfortunately the intenſe ardour of application, which produced his frequent contributions to the ſtock of human knowledge, added to the unfavourable influence of the climate, greatly impaired his health. On this account, after a reſidence of about fifteen years in India, he made preparations for returning to England; but death interpoſed; and this illuſtrious ornament of ſcience and virtue was taken from the world on the 27th of April 1794, in the 48th year of his age. “ It is to the ſhame of ſcepticiſm (as one of his biographers well obſerves), to the encouragement of hope, and to the honour of genius, that this great man was a ſincere believer in the doctrines of Chriſtianity, and that he was found in his cloſet in the attitude of addreſſing his prayer to God.” We ſhall give his character as it was drawn by Sir John Shore, Baronet, (now Lord Teignmouth) in a diſcourſe delivered at a meeting of the Aſiatic Society, held on the 22d of May 1794.

“ His capacity for the acquiſition of languages has never been excelled. In Greek and Roman literature, his early proficiency was the ſubject of admiration and applauſe; and knowledge of whatever nature, once obtained by him, was ever afterwards progreſſive. The more elegant dialects of modern Europe, the French, the Spaniſh, and Italian, he ſpoke and wrote with the greateſt fluency and preciſion; and the German and Portugueſe were familiar to him. At an early period of life his application to Oriental literature commenced; he ſtudied the Hebrew with eaſe and ſucceſs; and many of the moſt learned Aſiatics have the candour to avow, that his knowledge of Arabic and Perſian was as accurate and extenſive as their own; he was alſo converſant in the Turkiſh idiom, and the Chineſe had even attracted his notice ſo far as to induce him to learn the radical characters of that language, with a view perhaps to farther improvements. It was to be expected, after his arrival in India, that he would eagerly embrace the opportunity of making himſelf maſter of the Sanſcrit; and the moſt enlightened profeſſors of the doctrines of Brahma confeſs with pride, delight, and ſurpriſe, that his knowledge of their ſacred dialect was moſt critically correct and profound. The Pandits, who were in the habit of attending him, could not, after his death, ſuppreſs their tears for his loſs, nor find terms to expreſs their admiration at the wonderful progreſs he had made in their ſciences.

“ Before the expiration of his twenty-ſecond year, he had completed his Commentaries on the Poetry of the Aſiatics, although a conſiderable time afterwards elapſed before their publication; and this work, if no other monument of his labours exiſted, would at once furniſh proofs of his conſummate ſkill in the Oriental dialects, of his proficiency in thoſe of Rome and Greece, of taſte and erudition far beyond his years, and of talents and application without example.

“ But the judgment of Sir William Jones was too diſcerning to conſider language in any other light than as the key of ſcience, and he would have deſpiſed the reputation of a mere linguiſt. Knowledge and truth were the objects of all his ſtudies, and his ambition was to be uſeful to mankind; with theſe views he extended his reſearches to all languages, nations, and times.

“ Such were the motives that induced him to propoſe to the government of India, what he juſtly denominated a work of national utility and importance, the compilation of a copious Digeſt of Hindu and Mahomedan Law, from Sanſcrit and Arabic originals, with an offer of his ſervices to ſuperintend the compilation, and with a promiſe to tranſlate it. He had foreſeen, previous to his departure from Europe, that without the aid of ſuch a work, the wiſe and benevolent intentions of the legiſlature of Great Britain, in leaving to a certain extent the natives of theſe provinces in poſſeſſion of their own laws, could not be completely fulfilled; and his experience, after a ſhort reſidence in India, confirmed what his ſagacity had anticipated, that without principles to refer to, in a language familiar to the judges of the courts, adjudications amongſt the natives muſt too often be ſubject to an uncertain and erroneous expoſition, or wilful miſinterpretation of their laws.

“ To the ſuperintendance of this work, which was immediately undertaken at his ſuggeſtion, he aſſiduouſly devoted thoſe hours which he could ſpare from his profeſſional duties. After tracing the plan of the Digeſt, he preſcribed its arrangement and mode of execution, and ſelected from the moſt learned Hindus and Mahomedans fit perſons for the taſk of compiling it: flattered by his attention, and encouraged by his applauſe, the Pandits proſecuted their labours with chearful zeal to a ſatiſfactory concluſion. The Molavees have alſo nearly finiſhed their portion of the work; but we muſt ever regret, that the promiſed tranſlation, as well as the meditated preliminary diſſertation, have been fruſtrated by that decree, which ſo often intercepts the performance of human purpoſes.

“ During the courſe of this compilation, and as auxiliary to it, he was led to ſtudy the works of Menu, reputed by the Hindus to be the oldeſt and holieſt of legiſlators; and finding them to compriſe a ſyſtem of religious and civil duties, and of law in all its branches, ſo comprehenſive and minutely exact, that it might be conſidered as the Inſtitutes of Hindu Law, he preſented a tranſlation of them to the government of Bengal. During the ſame period, deeming no labour exceſſive or ſuperfluous that tended in any reſpect to promote the welfare or happineſs of mankind, he gave the public an Engliſh verſion of the Arabic Text of the Sirajiyah or Mahomedan Law of Inheritance, with a Commentary. He had already (as has been obſerved) publiſhed in England a tranſlation of a tract on the ſame ſubject by another Mahomedan lawyer, containing, as his own words expreſs, ‘ a lively and elegant Epitome of the Law of Inheritance of Zaid.’

“ To

---

* *Law of Bailments.*

"To theſe learned and important works, ſo far out of the road of amuſement, nothing could have engaged his application but that deſire which he ever profeſſed, of rendering his knowledge uſeful to his nation, and beneficial to the inhabitants of theſe provinces.

"I ſhould ſcarcely (continues Lord Teignmouth) think it of importance to mention, that he did not diſdain the office of editor of a Sanſcrit and Perſian work, if it did not afford me an opportunity of adding, that the latter was publiſhed at his own expence, and was ſold for the benefit of inſolvent debtors. A ſimilar application was made of the produce of Sirajiyah."

But nothing exhibits the large graſp of Sir William Jones's mind in ſo ſtriking a point of view as a paper in his own hand writing, which came into Lord Teignmouth's poſſeſſion after his death. It was intitled DESIDERATA, and propoſed for inveſtigation the following ſubjects relating to the eaſtern world.

India.—1. The ancient geography of India, &c. from the Puranas. 2. A botanical deſcription of Indian plants, from the Coſhas, &c. 3. A grammar of the Sanſcrit language, from Panini, &c. 4. A dictionary of the Sanſcrit language, from the 32 original vocabularies and Niructi. 5. On the ancient muſic of the Indians. 6. On the medical ſubſtances of India, and the Indian art of medicine. 7. On the philoſophy of the ancient Indians. 8. A tranſlation of the Veda. 9. On ancient Indian geometry, aſtronomy, and algebra. 10. A tranſlation of the Puranas. 11. A tranſlation of the Mahabbara and Ramayan. 12. On the Indian theatre, &c. &c. 13. On the Indian conſtellations, with their mythology, from the Puranas. 14. The hiſtory of India before the Madomedan conqueſt, from the Sanſcrit Caſhmir Hiſtories.

Arabia.—15. The hiſtory of Arabia before Mahomed. 16. A tranſlation of the Hamaſa. 17. A tranſlation of Hariri. 18. A tranſlation of the Facahatul Khulafa. Of the Caſiah.

Perſia.—19. The hiſtory of Perſia, from authorities in Sanſcrit, Arabic, Greek, Turkiſh, Perſian ancient and modern, Firdauſi's Khroſrau nama. 20. The five poems of Nizami, tranſlated in proſe. 21. A dictionary of pure Perſian Je changire.

China.—22. A tranſlation of Shi-cing. 23. The text of Can-fu-tſu, verbally tranſlated.

Tartary.—24. A hiſtory of the Tartar nations, chiefly of the Moguls and Othmans, from the Turkiſh and Perſian.

"We are not authoriſed (ſays his Lordſhip) to conclude, that he had himſelf formed a determination to complete the works which his genius and knowledge had thus ſketched; the taſk ſeems to require a period beyond the probable duration of any human life; but we, who had the happineſs to know Sir William Jones; who were witneſſes of his indefatigable perſeverance in the purſuit of knowledge, and of his ardour to accompliſh whatever he deemed important; who ſaw the extent of his intellectual powers, his wonderful attainments in literature and ſcience, and the facility with which all his compoſitions were made—cannot doubt, if it had pleaſed Providence to protract the date of his exiſtence, that he would have ably executed much of what he had ſo extenſively planned."

We have already enumerated attainments and works which, from their diverſity and extent, ſeem far beyond the capacity of the moſt enlarged minds; but the catalogue may yet be augmented. To a proficiency in the languages of Greece, Rome, and Aſia, he added the knowledge of the philoſophy of thoſe countries, and of every thing curious and valuable that had been taught in them. The doctrines of the Academy, the Lyceum, or the Portico, were not more familiar to him than the tenets of the Vedas, the myſticiſm of the Sufis, or the religion of the ancient Perſians; and whilſt, with a kindred genius, he peruſed with rapture the heroic, lyric, or moral compoſitions of the moſt renowned poets of Greece, Rome, and Aſia, he could turn with equal delight and knowledge to the ſublime ſpeculations or mathematical calculations of Barrow and Newton. With them alſo he profeſſed his conviction of the truth of the Chriſtian religion; and he juſtly deemed it no inconſiderable advantage, that his reſearches had corroborated the multiplied evidence of Revelation, by confirming the Moſaic account of the primitive world.

In his eighth anniverſary diſcourſe to the Aſiatic Society, he thus expreſſes himſelf: "Theological inquiries are no part of my preſent ſubject; but I cannot refrain from adding, that the collection of tracts which we call, from their excellence, the Scriptures, contain, independently of a divine origin, more true ſublimity, more exquiſite beauty, purer morality, more important hiſtory, and finer ſtrains both of poetry and eloquence, than could be collected within the ſame compaſs from all other books that were ever compoſed in any age, or any idiom. The two parts, of which the Scriptures conſiſt, are connected by a chain of compoſitions, which bear no reſemblance in form or ſtyle to any that can be produced from the ſtores of Grecian, Indian, Perſian, or even Arabian learning; the antiquity of theſe compoſitions no man doubts, and the unſtrained application of them to events long ſubſequent to their publication, is a ſolid ground of belief that they were genuine predictions; and conſequently inſpired."

There were, in truth, few ſciences in which he had not acquired conſiderable proficiency; in moſt, his knowledge was profound. The theory of muſic was familiar to him; nor had he neglected to make himſelf acquainted with the intereſting diſcoveries lately made in chemiſtry; "and I have heard him (ſays Lord Teignmouth) aſſert, that his admiration of the ſtructure of the human frame had induced him to attend for a ſeaſon to a courſe of anatomical lectures, delivered by his friend the celebrated Hunter."

His laſt and favourite purſuit was the ſtudy of botany, which he originally began under the confinement of a ſevere and lingering diſorder, which with moſt minds would have proved a diſqualification from any application. It conſtituted the principal amuſement of his leiſure hours. In the arrangements of Linnæus, he diſcovered ſyſtem, truth, and ſcience, which never failed to captivate and engage his attention; and from the proofs which he has exhibited of his progreſs in botany, we may conclude that he would have extended the diſcoveries in that ſcience.

It cannot be deemed uſeleſs or ſuperfluous to inquire by what arts or method he was enabled to attain to a degree of knowledge almoſt univerſal, and apparently beyond the powers of man, during a life little exceeding 47 years.

The faculties of his mind, by nature vigorous, were improved by conſtant exerciſe; and his memory, by habitual practice, had acquired a capacity of retaining whatever had once been impreſſed upon it. To an unextinguiſhed ardour for univerſal knowledge, he joined a perſeverance in the purſuit of it which ſubdued all obſtacles; his ſtudies began with the dawn, and, during the intermiſſions of profeſſional duties, were continued throughout the day; reflection and meditation ſtrengthened and confirmed what induſtry and inveſtigation had accumulated. It was a fixed principle with him, from which he never voluntarily deviated, not to be deterred by any difficulties that were ſurmountable from proſecuting to a ſucceſsful termination what he had once deliberately undertaken.

But what appeared more particularly to have enabled him to employ his talents ſo much to his own and the public advantage, was the regular allotment of his time, and a ſcrupulous adherence to the diſtribution which he had fixed; hence all his ſtudies were purſued without interruption or confuſion. He collected information, too, from every quarter; juſtly concluding, that ſomething might be learned from the illiterate, to whom he liſtened with the utmoſt candour and complacency.

Lord Teignmouth, addreſſing himſelf to the Aſiatic Society, ſays, "Of the private and ſocial virtues of our lamented Preſident, our hearts are the beſt records. To you who knew him, it cannot be neceſſary for me to expatiate on the independence of his integrity, his humanity, probity, or benevolence, which every living creature participated; on the affability of his converſation and manners, or his modeſt, unaſſuming deportment: nor need I remark, that he was totally free from pedantry, as well as from arrogance and ſelf-ſufficiency, which ſometimes accompany and diſgrace the greateſt abilities. His preſence was the delight of every ſociety, which his converſation exhilarated and improved; and the public have not only to lament the loſs of his talents and abilities, but that of his example.

"To him, as the founder of our inſtitution, and whilſt he lived its firmeſt ſupport, our reverence is more particularly due. Inſtructed, animated, and encouraged by him, genius was called forth into exertion, and modeſt merit was excited to diſtinguiſh itſelf. Anxious for the reputation of the Society, he was indefatigable in his own endeavours to promote it, whilſt he cheerfully aſſiſted thoſe of others. In loſing him, we have not only been deprived of our brighteſt ornament, but of the guide and patron, on whoſe inſtructions, judgement, and candour, we could implicitly rely." Though theſe are the ſentiments, not only of Lord Teignmouth, but, we believe, of every man of letters, we truſt there is ſtill left in Bengal a ſufficient love of letters and of ſcience to carry on the plan which was formed by the genius of Sir William Jones.

JONESIA, is a very handſome middling-ſized ramous tree, found in gardens about Calcutta. In the Sanſcrit it is called *As'óca*, and in the Bengaleſe *Ruſſuck*; but the name Joneſia was given to it by the Aſiatic Society, who conſecrated it to the memory of their firſt preſident Sir William Jones. It is thus deſcribed by Dr Roxburgh, a member of that ſociety:

"*Calyx*, two leaved, corol, one petaled, piſtil-bearing; baſe of the tube impervious; ſtamens long, aſcending, inſerted into the margin of a glandulous nectarial ring, which crowns the mouth of the tube, the uppermoſt two of which more diſtant; ſtyle declining. *Legume* turgid. *Trunk* erect, though not very ſtraight. *Bark* dark brown, pretty ſmooth. *Branches* numerous, ſpreading in every direction, ſo as to form a moſt elegant ſhady head. *Leaves* alternate, abruptly feathered, ſeſſile, generally more than a foot long; when young pendulous and coloured. *Leaflets* oppoſite, from four to ſix pair, the lowermoſt broad lanced, the upper lanced; ſmooth, ſhining, firm, a little waved, from four to eight inches long. *Petiole* common, round, and ſmooth. *Stipule* axillary, ſolitary; in fact a proceſs from the baſe of the common petiole, as in many of the graſſes and monandriſts, &c. *Umbels* terminal and axillary; between the ſtipule and branchlet, globular, crowded, ſubſeſſile, erect. *Bracts*, a ſmall hearted one under each diviſion of the umbel. *Peduncle* and pedicles ſmooth, coloured. *Flowers* very numerous, pretty large; when they firſt expand they are of a beautiful orange colour, gradually changing to red, forming a variety of lovely ſhades; fragrant during the night. *Calyx* perianth, below two-leaved, leaflets ſmall, nearly oppoſite, coloured, hearted, bracte-like, marking the termination of the pedicel, or beginning of the tube of the corol. *Corol* one-petalled, funnel-form; tube ſlightly incurved, firm, and fleſhy, tapering towards the baſe (club funnel-ſhaped) and there impervious; border four parted; diviſion ſpreading, ſuborbicular; margins moſt ſlightly woolly: one third the length of the tube. *Nectary*, a ſtimeniferous and piſtiliferous ring crowns the mouth of the tube. *Stamens*, filaments generally ſeven; and ſeven muſt, I think, be the natural number; viz. three on each ſide, and one below, above a vacancy, as if the place of an eighth filament, and is occupied on its inſide by the piſtil; they are equal, diſtinct, aſcending, from three to four times longer than the border of the corol. *Anthers* uniform, ſmall, incumbent. *Piſtil*, germ oblong, pediceled; pedicel inſerted into the inſide of the nectary, immediately below the vacant ſpace already mentioned; ſtyle nearly as long as the ſtamens, declining; ſtigma ſimple. *Pericarp*, legume ſcimeter-formed, turgid, outſide reticulated, otherwiſe pretty ſmooth; from ſix to ten inches long, and about two broad. *Seeds* generally from four to eight, ſmooth; grey, ſize of a large cheſnut."

The Joneſia flowers at the beginning of the hot ſeaſon, and its ſeeds ripen during the rains. The plants and ſeeds were originally brought to Calcutta from the interior parts of the country, where it is indigenous. *N. B.* Many of the flowers have only the rudiment of a piſtil. In Plate XXX. A is a branchlet of the natural ſize. B, A ſingle flower a little magnified; *a a* the calyx. C, A ſection of the ſame, exhibiting four of the ſtamens, 1 1 1 1 the piſtil 2, and how far the tube is perforated. D, A ſimilar ſection of one of the abortive flowers; 3 is the abortive fiſtil. E, The ripe legume opening near the baſe, natural ſize. *Note*, The ſpace between the *b* and *c* marks the original tube of the coral. F, One of the ſeeds, natural ſize. G, The baſe of the common petiole, with its ſtipule; *a a*, the petioles of the lower pair of leaflets.

JOOTSI-SIMA, a ſmall flat iſland, which is ſeparated from Cape Nota in Japan by a channel about five leagues wide. Its circumference does not exceed two leagues; it is well wooded, of an agreeable aſpect, and well inhabited. Perouſe, who ſailed round it, remarked from the quarter-deck of his ſhip ſome conſiderable edifices between the houſes of the inhabitants; and hard

Journals, Joyſt.

hard by a ſort of caſtle, at the ſouth-weſt point of the iſland, he diſtinguiſhed ſome gibbets. He does not, however, affirm that thoſe gibbets were for the execution of criminals; for, as he obſerves, it would be ſingular enough if the Japaneſe, whoſe cuſtoms are ſo different from ours, were in this point to reſembles us ſo nearly. He repreſents the iſland as ſurrounded with dreadful breakers; at the diſtance of a league and a half from which, he had conſtantly 60 fathoms, with rocky bottom. He places the iſland (differently, according to the editor of his voyage, from all other geographers) in latitude 37° 51′ north, and in Long. 135° 20′ eaſt from Paris.

JOURNALS, the title of periodical publications. See *Encyclopædia*. The principal Britiſh Journals are: *The Hiſtory of the Works of the Learned*, begun at London in 1699. *Cenſura Temporum*, in 1708. About the ſame time there appeared two new ones; the one under the title of *Memoirs of Literature*, containing little more than an Engliſh tranſlation of ſome articles in the foreign Journals, by M. de la Roche; the other, a collection of looſe tracts, intitled, *Bibliotheca Curioſa*, or a Miſcellany. Theſe, however, with ſome others, are now no more, but are ſucceeded by the *Annual Regiſter*, which began in 1758; the *New Annual Regiſter*, begun in 1780; the *Monthly Review*, which began in the year 1749, and gives a character of all Engliſh literary publications, with the moſt conſiderable of the foreign ones: the *Critical Review*, which began in 1756, and is nearly on the ſame plan: as alſo the *London Review*, by Dr Kenrick, from 1775 to 1780; *Maty's Review*, from Feb. 1782 to Aug. 1786; the *Engliſh Review*, begun in Jan. 1783; and the *Analytical Review*, begun in May 1788, dropt in 1798, and revived in 1799, under the title of the *New Analytical Review*; but again dropt after two or three months trial: the *Britiſh Critic*, begun in 1792, and ſtill carried on with much ſpirit and ability: the *Anti-Jacobin Review and Magazine*, commenced in 1798, for the meritorious purpoſe of counteracting the pernicious tendency of French principles in politics and religion: the *New London Review*, January 1799: *A Journal of Natural Philoſophy, Chemiſtry, and the Arts*, which was begun in 1797 by Mr Nicholſon, and has been conducted in ſuch a manner, that it is one of the moſt valuable works of the kind to be found in any language: the *Philoſophical Magazine*, begun in 1798 by Mr Tilloch, and carried on upon much the ſame plan, and with much the ſame ſpirit, as Nicholſon's Journal.

Beſides theſe, we have ſeveral monthly pamphlets, called *Magazines*, which, together with a chronological ſeries of occurrences, contain letters from correſpondents, communicating extraordinary diſcoveries in nature and art, with controverſial pieces on all ſubjects. Of theſe, the principal are thoſe called the *Gentleman's Magazine*, which began with the year 1731; the *London Magazine*, which began a few months after, and has lately been diſcontinued; the *Univerſal Magazine*, which is nearly of as old a date; the *Scotch Magazine*, which began in 1739, and is ſtill continued; the *European Magazine*; and the *Monthly Magazine*, a miſcellany of much information, but not of good principles.

JOYST or Jeyst, the ſecond month of the Bengal year.

Irrational ‖ Iron.

IRRATIONAL Numbers or *Quantities*, are the ſame as *ſurds*, for which ſee Algebra, *Encycl.*

IRREDUCIBLE Case, in algebra, is uſed for that caſe of cubic equations where the root, according to Cardan's rule, appears under an impoſſible or imaginary form, and yet is real.

It is remarkable that this caſe always happens, *viz.* one root, by Cardan's rule, in an impoſſible form, whenever the equation has three real roots, and no impoſſible ones, but at no time elſe.

If we were poſſeſſed of a general rule for accurately extracting the cube root of a binomial radical quantity, it is evident we might reſolve the irreducible caſe generally, which conſiſts of two of ſuch cubic binomial roots. But the labours of the algebraiſts, from Cardan down to the preſent time, have not been able to remove this difficulty. Dr Wallis thought that he had diſcovered ſuch a rule; but, like moſt others, it is merely tentative, and can only ſucceed in certain particular circumſtances.

IRON, is by much the moſt uſeful of all the metals, as has been ſufficiently proved under the article Iron, *Encycl.* and under Chemistry in this *Supplement*. The word is again introduced here, becauſe it affords us an opportunity of laying before our readers ſome valuable obſervations by Chaptal on the uſe of the *oxyds* of iron in dyeing cotton.

"The oxyd of iron has ſuch an affinity for cotton thread, that if the latter be plunged in a ſaturated ſolution of iron in any acid whatever, it immediately aſſumes a chamoy yellow colour, more or leſs dark, according to the ſtrength of the liquors. It is both a curious and eaſy experiment, that when cotton is made to paſs through a ſolution of the ſulphat of iron, rendered turbid by the oxyd which remains ſuſpended in the liquor, it will be ſufficient to dip the cotton in the bath to catch the laſt particle of the oxyd, and to reſtore to the liquor the tranſparency it has loſt. The ſolution, then, which before had a yellowiſh appearance, becomes more or leſs green, according as it is more or leſs charged.

"The colour given to cotton by the oxyd of iron becomes darker, merely by expoſure to the air; and this colour, ſoft and agreeable when taken from the bath, becomes harſh and ochry by the progreſſive oxydation of the metal. The colour of the oxyd of iron is very faſt: it reſiſts not only the air and water, but alſo alkaline leys, and ſoap gives it ſplendour without ſenſibly diminiſhing its intenſity. It is on account of theſe properties that the oxyd of iron has been introduced into the art of dyeing, and been made a colouring principle of the utmoſt value.

"In order that the oxyd of iron may be conveniently applied to the cotton thread, it is neceſſary to begin by effecting its ſolution; and, in this caſe, acids are employed as the moſt uſeful ſolvents. Dyers almoſt everywhere make a myſtery of the acid which they employ; but it is always the acetous, the ſulphuric, the nitric, or the muriatic. Some of them aſcribe great differences to the ſolution of iron by the one or the other acid; but, in general, they give the preference to the acetous. This predilection appears to be founded much leſs on the difference of the colours that may be communicated by the one or the other ſalt, than on the different degrees of corroſive power which each exerciſes on the ſtuff. That of the ſulphat and muriat is ſo great, that if the ſtuff be not waſhed when it comes from the bath, it will certainly be burnt; whereas ſolutions by the acetous, or any other vegetable acid, are not attended with the like inconvenience.

"Iron appears to be at the ſame degree of oxydation in the different acids, ſince it produces the ſame ſhade of colour when precipitated; and any acid ſolvent may be employed indiſcriminately, provided the nature of the ſalt, and the degree of the ſaturation of the acid, be ſufficiently known; for the ſubſequent operations may be then directed according to this knowledge, and the inconveniences which attend the uſe of ſome of theſe ſalts may be prevented. This, without doubt, is a great advantage which the man of ſcience enjoys over the mere workman, who is incapable of varying his proceſs according to the nature and ſtate of the ſalts which he employs.

"1. If the ſulphat of iron, or any other martial ſalt, be diſſolved in water, and cotton be dipped in the liquid, the cotton will aſſume a chamoy colour, more or leſs dark according as the ſolution is more or leſs charged. The affinity of the cotton to the iron is ſo great, that it attracts the metal, and takes it in a great meaſure from the acid by which it was diſſolved.

"2. If the iron of a pretty ſtrong ſolution be precipitated by an alkaline liquor that ſhews five or ſix degrees (by the areometer of Baumé), the reſult will be a greeniſh blue magma. The cotton macerated in this precipitate aſſumes at firſt an unequal tint of dirty green; but mere expoſure to the air makes it in a little time turn yellow, and the ſhade is very dark.

"It is by ſuch, or almoſt ſimilar proceſſes, that dyers communicate what is called among workmen an *ochre* or *ruſt colour*. But theſe colours are attended with ſeveral inconveniences to the artiſt: 1. Strong ſhades burn or injure the cloth: 2. This colour is harſh, diſagreeable to the eye, and cannot be eaſily united with the mild colours furniſhed by vegetables."

To avoid theſe inconveniences, our author made ſeveral attempts, which led him to the following practice: He treads the cotton cold in a ſolution of the ſulphat of iron, marking three degrees; he wrings it carefully, and immediately plunges it in a ley of potaſh at two degrees, upon which he has previouſly poured to ſaturation a ſolution of the ſulphat of alumine: the colour is then brightened, and becomes infinitely more delicate, ſoft, and agreeable. The ſulphat no longer attacks the tiſſue of the ſtuff; and after the cotton has been left in the bath for four or five hours, it is taken out to be wrung, waſhen, and dried. In this manner we may obtain every ſhade that can be wiſhed, by graduating the ſtrength of the ſolutions. This ſimple proceſs, the theory of which preſents itſelf to the mind of every chemiſt, has the advantage of furniſhing a colour very agreeable, exceedingly fixed, and, above all, extremely economical. He employs it with great advantage in dyeing nankeens, as it has the property of reſiſting leys. It becomes brown, however, by the action of aſtringents.

M. Chaptal made ſeveral attempts to combine this yellow with the blue of indigo, in order to obtain a durable green; but as they were all unſucceſsful, he infers that there is not a ſufficient affinity between the blue of indigo and the oxyds of iron. He found that theſe oxyds, on the other hand, combine very eaſily with the red of madder, and produce a bright violet or plum colour, the uſe of which is as extenſive as beneficial in the cotton manufactory. But if we ſhould confine ourſelves to apply theſe two colours to cotton, without having employed a mordant capable of fixing the latter, the colour would not only remain dull and diſagreeable by the impoſſibility of brightening it, but it would ſtill be attended with the great inconvenience of not reſiſting leys. We muſt begin, then, by preparing the cotton as if to diſpoſe it for receiving the Adrianople red; and when it has been brought to the operation of galling, it is to be paſſed through a ſolution of iron, more or leſs charged, according to the nature of the violet required: it is then to be carefully waſhed, twice maddered, and brightened in a bath of ſoap.

When a real velvety rich violet is required, it is not to be paſſed through the ſolution of iron till it has been previouſly galled; the iron is then precipitated in a bluiſh oxyd, which, combined with the red of madder, gives a moſt brilliant purple, more or leſs dark according to the ſtrength of the galling and of the ferruginous ſolution. It is very difficult to obtain an equal colour by this proceſs; and in manufactories, an equal violet is conſidered as a maſter-piece of art. It is generally believed, that it is only by well-directed manipulations that it is poſſible to reſolve this problem, of ſo much importance in dyeing. But I am convinced (ſays our author), that the great cauſe of the inequality in this dye is, that the iron depoſited on the cotton receives an oxydation merely by expoſure to the air, which varies in different parts of it. The threads which are on the outſide of the hank are ſtrongly oxydated, while thoſe in the inſide, removed from the action of the air, experience no change. It thence follows, that the inſide of the hank preſents a weak ſhade, while the exterior part exhibits a violet almoſt black. The means to remedy this inconvenience is, to waſh the cotton when it is taken from the ſolution of iron, and to expoſe it to the madder moiſt. The colour will become more equal and velvety. The ſolvents of iron are almoſt the ſame for this colour as for the yellow colour already mentioned.

The following obſervation may ſerve to guide the artiſt in brightening the violet on his cotton. The red of madder and the oxyd of iron depoſited on the ſtuff determine the violet colour. This colour becomes red or blue, according as either of the principles predominates. The dyer knows by experience how difficult it is to obtain a combination which produces the tone of colour deſired, eſpecially when it is required to be very full, lively, and durable. This object, however, may be obtained, not only by varying the proportions of the two colouring principles, but alſo by varying the proceſs of brightening. The only point is to be acquainted with the two following facts; that the ſoda deſtroys the iron, while the ſoap, by ſtrong ebullition, ſeizes in preference the red of the madder. Hence it is, that the colour may be inclined to red or blue, according as you brighten with one or the other of theſe mordants. Thus, cotton taken from the madder dye, when waſhed and boiled in the brightening liquor with $\frac{3}{10}$ths of ſoap, will give a ſuperb violet; whereas you will obtain only a plum colour in treating it with ſoda.

The oxyd of iron precipitated on any ſtuff unites alſo very advantageouſly with the fawn colour furniſhed by aſtringents; and by varying the ſtrength of mordants, an infinity of ſhades may be produced. In this caſe, it is leſs a combination or ſolution of principles than the ſimple mixture or juxta-poſition of the colouring bodies on the ſtuff. By means of a boiling heat, we may combine, in a more intimate manner, the oxyd of iron with the aſtringent principle; and then it is brought to the ſtate of black oxyd, as has been obſerved by Berthollet. It is poſſible alſo to embrown theſe colours, and to give them a variety of tints, from the bright grey to the deep black, by merely paſſing the cottons impregnated with the aſtringent principle thro' a ſolution of iron. The oxyd is then precipitated itſelf by the principle which is fixed on the ſtuff.

An obſervation, which may become of the utmoſt value for the art of dyeing, is, that the moſt uſual aſtringent vegetables all furniſh a yellow colour, which has not much brilliancy, but which has ſufficient fixity to be employed with advantage. This yellow colour is brightened in the ſeries of vegetables, in proportion as the aſtringent principle is diminiſhed, and the vivacity of the colour is augmented in the ſame proportion. It is difficult, then, to obtain yellow colours which are at the ſame time durable and brilliant. Theſe two valuable qualities are to each other in an inverſe ratio; but it is poſſible to unite the colouring principles in ſuch a manner as to combine ſplendour with fixity. Green oak bark unites perfectly with yellow weed, and ſumach with green citron. It is by this mixture that we may be able to combine with the oxyd of iron vegetable colours, the ſplendour of which is equal to their durability.

Our author concludes his obſervations with cautioning the dyer againſt ſubſtituting ſumach and the bark of the alder tree or oak for gall when dyeing cotton red. "I can ſafely aſſert (ſays he), that it is impoſſible to employ theſe as ſubſtitutes, in whatever doſes they may be uſed. The colour is always much paler, poorer, and leſs fixed. I know that the caſe is not the ſame in regard to dyeing wool and ſilk, in which it may be employed with ſucceſs; and in giving an account of this difference, I think the cauſe of it may be found in the nature of the gall-nuts. 1. The acid which they excluſively contain, as Berthollet has proved, facilitates the decompoſition of the ſoap with which the cottons have been impregnated, and the oil then remains fixed in their tiſſue, and in a greater quantity, as well as in a more intimate combination. 2. The gall-nuts, which owe their development to animal bodies, retain a character of animaliſation, which they tranſmit to the vegetable ſtuff, and by theſe means augment its affinities with the colouring principle of the madder; for it is well known of what utility animal ſubſtances are to facilitate this combination. This animaliſation becomes uſeleſs in operating upon woollen or ſilk."

JUAN DE FUCA, a celebrated ſtrait on the north-weſt coaſt of America, was ſurveyed by Captain Vancouver in the Diſcovery ſloop of war, with a view to aſcertain whether it leads to any communication between the North Pacific and the North Atlantic Oceans. As they advanced within the opening of the ſtrait, their progreſs was greatly retarded by the number of inlets into which the entrance branched in every direction; and moſt of theſe were examined by the boats, which were frequently abſent from the ſhips on this ſervice for ſeveral days together. In the midſt of their labours, they were ſurpriſed by the ſight of two Spaniſh veſſels of war, employed, like themſelves, in ſurveying this inlet, the examination of which had been begun by them in the preceding year. Meaſures of mutual aſſiſtance were concerted between the captains of the two nations for the proſecution of the ſurvey, in which each agreed to communicate to the other their diſcoveries. Not one of the many arms of the inlet, nor of the channels which they explored in this broken part of the coaſt, was found to extend more than 100 miles to the eaſtward of the entrance into the ſtrait. After having ſurveyed the ſouthern coaſt, on which ſide a termination was diſcovered to every opening, by following the continued line of the ſhore, they were led to the northward, and afterward towards the north-weſt, till they came into the open ſea through a different channel from the ſtrait of Juan de Fuca, by which they had commenced this inland navigation.

Thus it appeared, that the land forming the north ſide of that ſtrait is part of an iſland, or of an archipelago, extending nearly 100 leagues in length from S. E. to N. W.; and on the ſide of this land moſt diſtant from the continent is ſituated Nootka Sound. The moſt peculiar circumſtance of this navigation is the extreme depth of water, when contraſted with the narrowneſs of the channels. The veſſels were ſometimes drifted about by the currents during the whole of a night, cloſe to the rocks, without knowing how to help themſelves, on account of the darkneſs, and the depth being much too great to afford them anchorage.

In the courſe of this ſurvey, the voyagers had frequent communications with the natives, whom they met ſometimes in canoes and ſometimes at their villages. In their tranſactions with Europeans, they are deſcribed as "well verſed in the principles of trade, which they carried on in a very fair and honourable manner." In other reſpects they were leſs honeſt. At one village 200 ſea otter ſkins were purchaſed of them by the crews of the veſſels in the courſe of a day; and they had many more to ſell in the ſame place, as alſo ſkins of bears, deer, and other animals. One party of Indians whom they met had the ſkin of a young lioneſs; and theſe ſpoke a language different from that uſed in Nootka Sound. Veniſon was ſometimes brought for ſale; and a piece of copper, not more than a foot ſquare, purchaſed one whole deer and part of another. Among other articles of traffic, two children, ſix or ſeven years of age, were offered for ſale. The commodities moſt prized by the natives were fire-arms, copper, and great coats. Beads and trinkets they would only receive as preſents, and not as articles of exchange. Many of them were poſſeſſed of fire-arms. In one part it is related, that after a chief had received ſome preſents, "he, with moſt of his companions, returned to the ſhore; and, on landing, fired ſeveral muſkets, to ſhew, in all probability, with what dexterity they could uſe theſe weapons, to which they ſeemed as familiarized as if they had been accuſtomed to fire-arms from their earlieſt infancy."

The dreſſes of theſe people, beſides ſkins, are a kind of woollen garments; the materials compoſing which are explained in the following extract;

"The dogs belonging to this tribe of Indians were numerous, and much reſembled thoſe of Pomerania, though, Juan.

though, in general, ſomewhat larger. They were all ſhorn as cloſe to the ſkin as ſheep are in England; and ſo compact were their fleeces, that large portions could be lifted up by a corner without cauſing any ſeparation. They were compoſed of a mixture of a coarſe kind of wool, with very fine long hair, capable of being ſpun into yarn. This gave Captain Vancouver reaſon to believe, that their woollen clothing might in part be compoſed of this material mixed with a finer kind of wool from ſome other animal, as their garments were all too fine to be manufactured from the coarſe coating of the dog alone."

Of other animals alive, deer only were ſeen in any abundance by our people.

The number of inhabitants computed to be in the largeſt of the villages or towns that were diſcovered, did not exceed 600. Captain Vancouver conjectured the ſmall-pox to be a diſeaſe common and very fatal among them. Many were much marked; and moſt of theſe had loſt their right eye. Their method of diſpoſing of their dead is very ſingular.

"Baſkets were found ſuſpended on high trees, each containing the ſkeleton of a young child; in ſome of which were alſo ſmall ſquare boxes filled with a kind of white paſte, reſembling (ſays our author) ſuch as I had ſeen the natives eat, ſuppoſed to be made of the ſaranne root; ſome of theſe boxes were quite full, others were nearly empty, eaten probably by the mice, ſquirrels, or birds. On the next low point ſouth of our encampment, where the gunners were airing the powder, they met with ſeveral holes in which human bodies were interred, ſlightly covered over, and in different ſtates of decay, ſome appearing to have been very recently depoſited. About half a mile to the northward of our tents, where the land is nearly level with high water mark, a few paces within the ſkirting of the wood, a canoe was found ſuſpended between two trees, in which were three human ſkeletons.

"On each point of the harbour, which, in honour of a particular friend, I called *Penn's Cove*, was a deſerted village; in one of which were found ſeveral ſepulchres, formed exactly like a centry box. Some of them were open, and contained the ſkeletons of many young children tied up in baſkets: the ſmaller bones of adults were likewiſe noticed, but not one of the limb bones could here be found; which gave riſe to an opinion, that theſe, by the living inhabitants of the neighbourhood, were appropriated to uſeful purpoſes; ſuch as pointing their arrows, ſpears, or other weapons."

However honourably theſe people have been repreſented in their conduct as traders, it appeared on ſeveral occaſions that it was unſafe to depend on their goodwill alone: and ſome inſtances occurred, of their making every preparation for an attack, from which they deſiſted only on being doubtful of the event; yet immediately on relinquiſhing their purpoſe, they would come with the greateſt confidence to trade, appearing perfectly regardleſs of what had before been in agitation. The boats, as already noticed, were frequently at a great diſtance from the ſhips; and on ſuch occaſions, when large parties of Indians have firſt ſeen them, they generally held long conferences among themſelves before they approached the boats; probably for the purpoſe of determining the mode of conduct which they judged it moſt prudent to obſerve. Captain Vancouver places the entrance of the ſtrait of Juan de Fuca in 48° 20′ N. Lat. and 124° W. Long.

Jugglers.

JUGGLERS are a kind of people whoſe profeſſion has not been often deemed either reſpectable or uſeful. Profeſſor Beckmann, however, has undertaken their defence; and in a long and learned chapter in the third volume of his *Hiſtory of Inventions*, pleads the cauſe of the practiſers of legerdemain; rope-dancers; perſons who place their bodies in poſitions apparently dangerous; and of thoſe who exhibit feats of uncommon ſtrength. All theſe men he claſſes under the general denomination of *Jugglers;* and taking it for granted (ſurely upon no good grounds) that every uſeful employment is full, he contends, that there would not be room on the earth for all its preſent inhabitants did not ſome of them practiſe the arts of *Juggling*.

"Theſe arts (ſays he) are indeed not unprofitable, for they afford a comfortable ſubſiſtence to thoſe who practiſe them; but their gain is acquired by too little labour to be hoarded up; and, in general, theſe roving people ſpend on the ſpot the fruits of their ingenuity; which is an additional reaſon why their ſtay in a place ſhould be encouraged. But farther, it often happens, that what ignorant perſons firſt employ, merely as a ſhow, for amuſement or deception, is afterwards ennobled by being applied to a more important purpoſe. The machine with which a Savoyard, by means of ſhadows, amuſed children and the populace, was by Liberkühn converted into a ſolar microſcope; and, to give one example more, the art of making ice in ſummer, or in a heated oven, enables gueſts, much to the credit of their hoſteſs, to cool the moſt expenſive diſhes. The Indian diſcovers precious ſtones, and the European, by poliſhing, gives them a luſtre.

"But, if the arts of juggling ſerved no other end than to amuſe the moſt ignorant of our citizens, it is proper that they ſhould be encouraged for the ſake of thoſe who cannot enjoy the more expenſive deceptions of an opera. They anſwer other purpoſes, however, than that of merely amuſing: they convey inſtruction in the moſt acceptable manner, and ſerve as an agreeable antidote to ſuperſtition, and to that popular belief in miracles, exorciſm, conjuration, ſorcery, and witchcraft, from which our anceſtors ſuffered ſo ſeverely."

Surely this reaſoning, as well as the cauſe in which it is brought forward, is unworthy of the learning of Beckmann. It is indeed true, that jugglers ſpend their money freely, and that their arts afford them the means of ſubſiſtence; but it is very ſeldom, as our author muſt know, that they ſubſiſt either comfortably or innocently. Is it innocent to entice the ignorant and labouring poor, by uſeleſs deceptions, to part with their hard-earned pittance to idle vagabonds? or is the life of thoſe vagabonds comfortable, when it is paſſed amid ſcenes of the moſt grovelling diſſipation? Jugglers ſpend indeed their money, for the moſt part, on the ſpot where it is gained; but they ſpend it in drunkenneſs, and other ſeducing vices, which corrupt their own morals and the morals of all with whom they aſſociate; and therefore their ſtay in a place ſhould certainly *not* be encouraged. Could it be proved that the ſolar microſcope would never have been invented, had not a Savoyard juggler contrived a ſimilar machine to amuſe children and the rabble, ſome ſtreſs might be laid on the ſervice which ſuch wretches

have

have rendered to ſcience: but where is the man that will ſuppoſe the philoſophy of Bacon and Newton to reſt upon the arts of juggling? or who conſiders the refinements of ſcience as of equal value with the morals of the people? There is, at the moment in which this article is drawing up, a fellow exhibiting, before the windows of the writer's chamber, the moſt indecent ſcenes by means of puppets, and keeping the mob in a conſtant roar. Is he innocently employed? or will any good man ſay that there is not room for him in the armies which on the Continent are fighting in the cauſe of God and humanity?

Our author endeavours to ſtrengthen his reaſoning by proving, which he does very completely, the antiquity of juggling. "The deception (ſays he) of breathing out flames, which at preſent excites, in a particular manner, the aſtoniſhment of the ignorant, is very ancient. When the ſlaves in Sicily, about a century and a half before our æra, made a formidable inſurrection, and avenged themſelves in a cruel manner for the ſeverities which they had ſuffered, there was amongſt them a Syrian named Eunus, a man of great craft and courage, who, having paſſed through many ſcenes of life, had become acquainted with a variety of arts. He pretended to have immediate communication with the gods; was the oracle and leader of his fellow ſlaves; and, as is uſual on ſuch occaſions, confirmed his divine miſſion by miracles. When, heated by enthuſiaſm, he was deſirous of inſpiring his followers with courage, he breathed flames or ſparks among them from his mouth while he was addreſſing them. We are told by hiſtorians, that for this purpoſe he pierced a nut-ſhell at both ends, and, having filled it with ſome burning ſubſtance, put it into his mouth and breathed through it.

"This deception, at preſent, is performed much better. The juggler rolls together ſome flax or hemp, ſo as to form a ball about the ſize of a walnut; ſets it on fire; and ſuffers it to burn till it is nearly conſumed; he then rolls round it, while burning, ſome more flax; and by theſe means the fire may be retained in it for a long time. When he wiſhes to exhibit, he ſlips the ball unperceived into his mouth and breathes through it; which again revives the fire, ſo that a number of weak ſparks proceed from it; and the performer ſuſtains no hurt. provided he inſpire the air not through the mouth but the noſtrils.

"For deceptions with fire the ancients employed alſo naphtha, a liquid mineral oil, which kindles when it only approaches a flame. (See NAPHTHA, *Encycl.*) Galen informs us, that a perſon excited great aſtoniſhment by extinguiſhing a candle and again lighting it, without any other proceſs than holding it immediately againſt a wall or a ſtone. The whole ſecret of this conſiſted in having previouſly rubbed over the wall or ſtone with ſulphur. But as the author, a few lines before, ſpeaks of a mixture of ſulphur and naphtha, we have reaſon to think that he alludes to the ſame here. Plutarch relates how Alexander the Great was aſtoniſhed and delighted with the ſecret effects of naphtha, which were exhibited to him at Ecbatana. The ſame author, as well as Pliny, Galen, and others, has already remarked, that the ſubſtance with which Medea deſtroyed Creuſa, the daughter of Creon, was nothing elſe than this fine oil. She ſent to the unfortunate princeſs a dreſs beſmeared with it, which burſt into flames as ſoon as ſhe approached the fire of the altar. The blood of Neſſus, in which the dreſs of Hercules, which took fire likewiſe, had been dipped, was undoubtedly naphtha alſo; and this oil muſt have been always employed when offerings caught fire in an imperceptible manner.

"In modern times, perſons who could walk over burning coals or red-hot iron, or who could hold red-hot iron in their hands, have often excited wonder. But laying aſide the deception ſometimes practiſed on the ſpectators, the whole of this ſecret conſiſts in rendering the ſkin of the ſoles of the feet and hands ſo callous and inſenſible, that the nerves under them are ſecured from all hurt, in the ſame manner as by ſhoes and gloves. Such calloſity will be produced if the ſkin is continually compreſſed, ſinged, pricked, or injured in any other manner. Thus do the fingers of the induſtrious ſempſtreſs become horny by being frequently pricked; and the caſe is the ſame with the hands of fire-workers, and the feet of thoſe who walk bare footed over ſcorching ſand.

"In the month of September 1765, when I viſited (ſays our author) the copper-works at Aweſtad, one of the workmen, for a little drink money, took ſome of the melted copper in his hand, and after ſhewing it to us, threw it againſt a wall. He then ſqueezed the fingers of his horny hand cloſe to each other; put it a few minutes under his arm-pit, to make it ſweat, as he ſaid; and, taking it again out, drew it over a ladle filled with melted copper, ſome of which he ſkimmed off, and moved his hand backwards and forwards. very quickly, by way of oſtentation. While I was viewing this performance, I remarked a ſmell like that of ſinged horn or leather, though his hand was not burnt. It is highly probable, that people who hold in their hands red hot iron, or who walk upon it, as I ſaw done at Amſterdam, but at a diſtance, make their ſkin callous before, in the like manner. This may be accompliſhed by frequently moiſtening it with ſpirit of vitriol; according to ſome the juice of certain plants will produce the ſame effect; and we are aſſured by others, that the ſkin muſt be very frequently rubbed, for a long time, with oil, by which means, indeed, leather alſo will become horny*."

Our author then proves, in a very learned manner, that all theſe tricks were of high antiquity; that the Hirpi, who lived near Rome, jumped through burning coals; that women were accuſtomed to walk over burning coals at Caſtabala in Cappadocia, near the temple dedicated to Diana; that the exhibition of balls and cups (ſee LEGERDEMAIN, *Encycl.*) is often mentioned in the works of the ancients; that in the third century, one Firmus or Firmius, who endeavoured to make himſelf emperor in Egypt, ſuffered a ſmith to forge iron on an anvil placed on his breaſt; that rope-dancers with balancing poles are mentioned by Petronius and others; and that the various feats of horſemanſhip exhibited in our circuſes paſſed, in the thirteenth century, from Egypt to the Byzantine court, and thence over all Europe.

JUNGLE, in Bengal, waſte land, or land covered with wood and brambles.

---

* *Haller, Elementa Phyſiolog.*

K.

Kaarta.

KAARTA, a kingdom in Africa, through which Mr Park paſſed in his route from the Gambia to the Niger. He deſcribes the country as conſiſting either of ſandy plains or rocky hills; but, from his account, the level part ſeems to be the moſt extenſive. The natives are negroes, of whom many, though converted to the Mahomedan faith, or rather to the ceremonial part of the Mahomedan religion, retain all their ancient ſuperſtitions, and even drink ſtrong liquors. They are called Johers or Jowers, and in Kaarta form a very numerous and powerful tribe. One of theſe men undertook to conduct our author to Kemmoo, the capital of the kingdom, and alarmed him not a little by his ſuperſtitious ceremonies.

"We had no ſooner (ſays Mr Park) got into a dark and lonely part of the firſt wood, than he made a ſign for us to ſtop, and taking hold of a hollow piece of bamboo, that hung as an amulet round his neck, whiſtled very loud, three times. I confeſs I was ſomewhat ſtartled, thinking it was a ſignal for ſome of his companions to come and attack us; but he aſſured me that it was done merely with a view to aſcertain what ſucceſs we were likely to meet with on our preſent journey. He then diſmounted, laid his ſpear acroſs the road, and having ſaid a number of ſhort prayers, concluded with three loud whiſtles; after which he liſtened for ſome time, as if in expectation of an anſwer, and receiving none, told us we might proceed without fear, for there was no danger."

White men were ſtrangers in the kingdom of Kaarta; and the appearance of our author had on ſome of the natives the effect which ignorant people, in this country, attribute to ghoſts. "I had wandered (ſays he) a little from my people, and being uncertain whether they were before or behind me, I haſtened to a riſing ground to look about me. As I was proceeding towards this eminence, two negro horſemen, armed with muſkets, came galloping from among the buſhes: on ſeeing them I made a full ſtop; the horſemen did the ſame, and all three of us ſeemed equally ſurpriſed and confounded at this interview. As I approached them their fears increaſed, and one of them, after caſting upon me a look of horror, rode off at full ſpeed; the other, in a panic of fear, put his hand over his eyes, and continued muttering prayers until his horſe, ſeemingly without the rider's knowledge, conveyed him ſlowly after his companion. About a mile to the weſtward, they fell in with my attendants, to whom they related a frightful ſtory: it ſeems their fears had dreſſed me in the flowing robes of a tremendous ſpirit; and one of them affirmed, that when I made my appearance, a cold blaſt of wind came pouring down upon him from the ſky like ſo much cold water."

At Kemmoo our traveller was graciouſly received by the king; who honeſtly told him, however, that he could not protect him, being then engaged in war with the king of BAMBARRA (ſee SEGO in this *Supplement*); but he gave him a guard to JARRA, the frontier town of the neighbouring kingdom of Ludamar. The origin and iſſue of this war between Kaarta and Bambarra, of which Mr Park gives a full account, ſhews the folly of attempting to liberate the negroes from ſlavery till civilization and Chriſtianity be introduced into Africa. Major Rennel places Kemmoo, the capital of Kaarta, in 14° 15′ N. Lat. and 7° 20′ W. Lon.

Kabobiquas.

KABOBIQUAS, a nation in ſouth Africa, who had never ſeen a white man till 1785, that they were viſited by M. Vaillant. Intimation had been given of his approach by ſome of the tribes through whoſe country he had previouſly paſſed; and every thing that had been ſaid of his colour, his fuſees, and his equipage, bore the character of the moſt enthuſiaſtic exaggeration. The curioſity of the people was wound up to the higheſt pitch; and as ſoon as they ſaw his company at a diſtance, the whole horde quitted the kraal, and ran with eagerneſs to meet him. Not being able to believe their eyes in regard to what they ſaw, they endeavoured to obtain more ſatisfaction by touching him. They felt his hair, hands, and almoſt every part of his body. His beard, above all, aſtoniſhed them to an inconceivable degree. More than thirty perſons came in ſucceſſion, and half unbuttoned his clothes. They all imagined him to be a hairy animal; and ſuppoſed, without doubt, that his body was covered with hair as long as that on his chin; but finding this not to be the caſe, they were aſtoniſhed, and confeſſed, with the openneſs of ſavages, that they had never ſeen the like in any man of their country. The little children, terrified at his appearance, hid themſelves behind their mothers. When he attempted to lay hold of any of them, in order to careſs them, they ſent forth loud cries, as a child would do in Europe who ſhould ſee a negro for the firſt time.

The grown up people, however, were ſoon reconciled to his appearance, and even the children were bribed by ſmall bits of ſugar candy. The chief of the horde ſhowed him every mark of attachment. He was a man advanced in life, and of a majeſtic figure. He wore a long mantle, which hung from his ſhoulders to the ground, and which, formed of four jackal ſkins joined together, was bordered at the ſides with that of a hyæna. His left hand wanted two joints of the little finger, which, he ſaid, were amputated in his infancy to cure him of a ſevere illneſs.

This cuſtom of ſavages, who, to relieve a man from pain, add new ſufferings to his evils, affords a vaſt field for reflection. Mr Paterſon, another African traveller, tells us, that he obſerved inſtances of the ſame practice among a horde at the mouth of Orange-river; which is not improbable. However abſurd a cuſtom may be, ſavage tribes, when they are neighbours, may borrow it from each other; but that it ſhould be common among the iſlanders of the South Sea, who, ſince their country was firſt inhabited, had never ſeen ſtrangers before Cook and Bougainville, is truly aſtoniſhing. Our author was very deſirous of interrogating minutely the people of the horde on this ſubject. He wiſhed alſo to propoſe ſome queſtions to them reſpecting other cuſtoms, which appeared ſingular; but difficulties increaſed the more he advanced into the country. The Kabobiquas ſpoke a particular language; and this dialect, though accompanied with the clapping noiſe of the Hottentots, was underſtood only by the Koraquas, who, on account of their vicinity, kept up ſome intercourſe with them. The caſe was the ſame with the language of the Koraquas, in regard to their neighbours the Nimiquas; and nothing reached our author's ear till it had paſſed through four different mouths. The conſequence was, that when he aſked any thing, the anſwer had frequently no relation to the queſtion; and for this inconveniency no remedy could be found.

The ſame deſire for trinkets to ornament their dreſs prevailed among the Kabobiquas as among the other hordes which Vaillant had viſited; and in one day he purchaſed twenty oxen for things of that kind of no value. The chief, however, had ſet his affections on a razor; and juſt when our author and he were treating about it, a ſhot was fired near them, which was inſtantly followed by the moſt frightful cries. "Ruſhing inſtantly from my tent (ſays M. Vaillant) to enquire what was the cauſe of this noiſe, I ſaw a Kabobiqua flying as faſt as he could from one of my hunters, while, at the diſtance of a hundred paces farther, three men were making the moſt lamentable clamour, and near them was a young girl lying on the ground. I made a ſignal to my hunter to approach me; but the report of the ſhot, and the howling of the three men, had already ſpread alarm throughout the horde. Some cried out treachery; others ran to their arms; and I now imagined that I was about to be maſſacred, with my whole company, and that I ſhould be obliged to arm them in my defence. My ſituation was the more critical, as neither I, nor any perſon in the kraal, knew what was the cauſe of this confuſion; and if I had known, how could I have explained it?

"Under this embarraſſment, I took the chief by the hand, and advanced with him towards the horde. Fear was painted in his countenance; tears began to drop from his eyes; and he ſpoke to me with great vivacity. He imagined, no doubt, that he was betrayed. He complained to me, and accuſed my people of perfidy; yet he readily followed me.

"As I was without arms, and preſented myſelf with the chief, I was received with confidence, and my appearance ſeemed, in ſome meaſure, to calm their perturbation. My people, who had ſeen me direct my courſe towards the kraal, haſtened thither after me, to protect me; and their number overawed the multitude. At length the whole myſtery was cleared up, and we learned what had occaſioned the tumult.

"A Kabobiqua having met one of my hunters, who was returning with his fuſee, wiſhed to examine it, and begged him to ſhew it to him. In handling it, however, he accidentally touched the trigger; it inſtantly went off; and the ſavage, frightened by the unexpected exploſion, threw down the fuſee, and ran away as faſt as he could.

"At that time, three men of the horde and a young girl happened unluckily to be ſtanding, at the diſtance of a hundred paces, in the direction of the piece. The latter received a ſingle grain of ſhot in the cheek; and the others a few grains in the legs and thighs. The author of the misfortune confirmed this explanation; tranquillity was ſoon reſtored; the ſavages depoſited their arms; and I was ſurrounded only by friends as before.

"Nothing remained but to enquire into the ſtate of the wounded, and to give them every aſſiſtance in my power. Without loſs of time, therefore, I repaired, ſtill accompanied by the chief, to the place where they were. By the way we met the young girl, who was returning from the kraal, bathed in tears. The cauſe of her uneaſineſs was a grain of lead, which had, however, penetrated ſo little, that I forced it out by only preſſing the part with my fingers. With regard to the three men, they lay rolling on the ground, howling in a moſt frightful manner, and exhibiting every ſymptom of deſpair.

"I was aſtoniſhed at their conſternation, and could not conceive how men inured to ſufferings ſhould be ſo much affected by a few ſmall punctures, the pain of which could have ſcarcely drawn tears from an infant. They at length told me the cauſe of their wailings. Theſe ſavages, accuſtomed to poiſon their arrows, imagined that I had in like manner poiſoned the lead with which they were wounded. They had, therefore, given themſelves up as loſt, and expected in a few moments to expire."

It was with great difficulty that our author could convince them that they had nothing to fear. He ſhewed them in the fleſh of his own leg a dozen of ſhots of lead; but they were not ſatisfied till one of the moſt intelligent of his Hottentots, taking from his ſhot bag a few grains of lead, and ſhewing them to the three men, immediately ſwallowed them. This concluſive argument produced the deſired effect. The cries of the wounded men inſtantly ceaſed; ſerenity again appeared in their faces; and their wounds were no more mentioned.

The Kabobiquas have neither the flat noſe nor plump cheeks of the Hottentots. Their ſkin alſo has not that baſtard colour, which, being neither black nor white, renders them odious to both races; nor do they beſmear their bodies with thoſe diſguſting fat ſubſtances, on account of which one cannot approach them without being bedaubed with their filth, or acquiring an offenſive ſmell. In ſtature they are as tall as the Caffres, and their colour is equally black. Their hair, which is exceedingly ſhort, and much curled, is ornamented with ſmall copper buttons, arranged with great art and ſymmetry. Inſtead of that apron made of a jackal's ſkin, employed by the Hottentot to cover what modeſty bids him conceal, the Kabobiquas uſe a round piece of leather, the edge of which is ornamented with a ſmall indented circle of copper, and which is divided into different compartments by rows of glaſs beads of various colours, all proceeding from the centre, and diverging towards the circumference, like the rays in our images of the ſun.

This kind of veil is made faſt to the groin by means of a girdle; but as it is only four inches in diameter, as it is deranged by the ſmalleſt movement, and as they give themſelves little uneaſineſs reſpecting ſuch accidents, it is very ill ſuited to the purpoſe for which it is applied. During the great heats, this ſmall and almoſt uſeleſs apron is the only covering on their bodies. Its being ſo readily diſplaced, enabled our author to aſcertain that they do not practice circumciſion; but it ſeemed to ſhow alſo, that, in regard to modeſty, their ideas are very different from ours.

Though they go thus almoſt entirely naked, their manners, inſtead of being licentious, are remarkably chaſte,

chaſte. No females can be more prudent or more reſerved than their women; and whether from refinement of coquetry, or the effect of prudence, they do not tattoo their faces like their huſbands and fathers. They do not even follow their example in ornamenting their hair with copper buttons; and they always go bare-legged, though moſt of them wear ſandals.

Their dreſs conſiſts of an apron that reaches only half down the thigh; a kroſs which, paſſing under the arm-pits, is tied on the breaſt; and a long mantle like that of the men. The mantle is made of ſkins not deprived of the hair; and the kroſs of tanned leather, prepared like that uſed for gloves in Europe.

With regard to glaſs beads, they wear them as bracelets. They form them alſo into necklaces, which deſcend in different rows to the pit of the ſtomach; and they ſuſpend from their girdles ſeveral ſtrings of them, which fall down their thighs below the apron.

Theſe ornaments being very durable, the habit of ſeeing them renders the women almoſt indifferent to the pleaſure of poſſeſſing them. Thoſe they procured from our author afforded at firſt great ſatisfaction, on account of their novelty. But when he ſhewed them ſciſſars and needles, they gave the preference to theſe articles; and this choice does honour to the good ſenſe of the Kabobiqua ladies. Like their chief, they ſet a higher value on utility than ornament.

Before our author's arrival among them, the Kabobiquas were acquainted with the uſe of tobacco through the means of ſome of the tribes more contiguous to the Cape. It was, however, a luxury which they could ſeldom enjoy; and ſo indifferent were they about it, that if it were not brought to them, they would not go a ſtep to procure it. This indifference, about an article which is eagerly ſought for by all the tribes of Hottentots, ſeemed to ſhew that there are traits in the character of the Kabobiquas which diſtinguiſh them from their ſouthern neighbours. The caſe was the ſame as to ſtrong liquors, on which they ſet no great value; and though there were among them ſome few individuals diſpoſed to reliſh them, the greater number abſolutely refuſed them.

" If the contents of my flaſks (ſays Vaillant) gave them little ſatisfaction, they were, however, much captivated with the flaſks themſelves. Theſe tranſparent bottles excited their admiration in the higheſt degree. They called them *ſolid water*; for, notwithſtanding the heat of the climate, theſe ſavages had ſeen ice on the ſummits of the mountains by which they are ſurrounded; and they entertained no doubt that the glaſs of my flaſks was water, which I had rendered ſolid by magic, and which I prevented their fires from melting. As it was impoſſible for me to explain this matter, I did not attempt to undeceive them: and beſides, with what advantage would it have been attended? I ſuffered them, therefore, to continue in their error, and contented myſelf with conferring on them an obligation, by giving them all the empty bottles for which I had no uſe.

" On their part, they vied with each other in ſhewing their generoſity towards me; and I muſt indeed allow, that I never ſaw a nation ſo diſintereſted. Every night they brought to my camp a conſiderable quantity of milk; and they never came to ſpend the evening with my people, without bringing ſome ſheep to regale them. I have ſeen many of them give away gratuitouſly, and without receiving any thing in return, part of their herds and their flocks; and, when I departed, there were many perſons in my caravan who poſſeſſed both ſheep and oxen, which they had received as a pure gift."

With this benevolent diſpoſition, the Kabobiquas have alſo a martial character. Their weapons are poiſoned arrows, and a lance with a long iron point, but different from the aſſagay of the Hottentots. In battle, their defenſive armour conſiſts of two bucklers; the one of a ſize ſufficient to cover the whole body of the combatant; the other much ſmaller. They are both made of ſkins exceedingly thick, and proof againſt arrows.

The courage which the Kabobiquas diſplay in combat is particularly exerciſed in their hunting excurſions, and, above all, againſt carnivorous animals. Intrepid, however, as it may be to attack the elephant and the rhinoceros, theſe ſpecies of animals are not objects of their vengeance; becauſe, living upon graſs and herbs, they have nothing to apprehend from them, either for themſelves or their cattle. But the tiger, lion, hyæna, and panther, being enemies of a different kind, they declare againſt them implacable war, and purſue them without remiſſion.

Of the ſpoils of theſe deſtructive animals they form their bucklers, girdles, ſandals, kroſſes, mantles, &c. They conſider it as a mark of honour to wear them; and they ſet a much higher value upon them than upon the ſkin of the rhinoceros or of the elephant. If they ſometimes hunt the latter, it is only as objects of food; and they employ to catch them thoſe concealed pits, which are the uſual ſnares of the Hottentots: but this method, which requires both patience and labour, is very little ſuited to a people ſo brave and enterpriſing as the Kabobiquas.

As they poſſeſs ſo bold and reſolute a character, one might be induced to believe that they are ferocious and intractable. Among all the African nations, however, which our author viſited, he never knew one that ſo much practiſed obedience and ſubordination.

The chief here is not, as in other tribes, a principal among his equals; he is a ſovereign in the midſt of his ſubjects, a maſter ſurrounded by his ſlaves. A word, a geſture, or a look, is ſufficient to procure him obedience. Whatever be his orders, they are never contradicted; and the caſe is the ſame in every particular family. What the chief is to the horde, the father is to his children. His commands are abſolute; and he exerciſes regal power at home, while he obeys elſewhere.

Though the tribe was very numerous, the wiſdom with which it was ruled, and the good order that prevailed, announced, in the man by whom it was governed, an intelligence ſuperior to that of all the ſavages our author had before ſeen; for he had not then viſited the Houzouanas. The habitation of this chief was ſuited to his ſupreme dignity. It was, indeed, a hut only, like thoſe of his ſubjects, and, like them, covered with the ſkins of animals; but it was much larger, as well as more elevated; and around it were ſix others, occupied by his family, and deſtined for them alone.

The natural dryneſs of the country inhabited by the Kabobiquas obliges them to dig wells, for their own uſe as well as for their cattle; but as the ſame cauſe often dries up theſe wells, they are then forced to remove, and to ſeek elſewhere a ſoil more abundant in ſprings; for Fiſh-River, though conſiderable in the rainy ſeaſon, is often, during the great heats, entirely deſtitute of water.

The long journeys which theſe too frequent emigrations compel them to undertake, and the intercourſe which they thence have with other nations, muſt neceſſarily inſpire them with ideas unknown to the ſettled tribes; and it would not be unnatural to ſuppoſe, that to this extenſion of ideas are they indebted for that ſuperiority of intelligence which elevates them above their neighbours.

Of the religion of the Kabobiquas, our author talks very inconſiſtently, and like a true philoſopher of the French ſchool. "Of all the African nations (ſays he), they are the only people among whom I found any idea, however confuſed a one, of the exiſtence of a Deity. I do not know whether it be from their own reflection, or the communications of other tribes, that they have acquired this ſublime knowledge, which would alone bring them near to a level with poliſhed nations; but they believe, as far as I have been able to learn from my people, that beyond the ſtars there exiſts a Supreme Being, who made and who governs all things. I muſt however obſerve, that on this ſubject their ideas are vague, barren, and unproductive. They have no conception of the future exiſtence of the ſoul, or of rewards and puniſhments in another life; in ſhort, they have neither worſhip, ſacrifices, ceremonies, nor prieſts, and are total ſtrangers to what we call religion."

This is impoſſible. A people believing in a Supreme Being, who made and who governs all things, *may* indeed be without *ſacrifices*, *ceremonies*, and *prieſts*; but ſuch a people cannot avoid *wiſhing*, that the Being who governs all things may protect them. Such a wiſh is a prayer; and ſurely he who prays is no ſtranger to religion. M. Vaillant places the country of the Kabobiquas between 23° and 25° S. Lat. and 16° 25′ and 19° 25′ Lon. eaſt from Paris.

KAJAAGA, an African kingdom, called by the French *Gallam*, is bounded on the ſouth-eaſt and ſouth by Bambouk; on the weſt, by Bondou and Foota Torra; and on the north, by the river Senegal. The air and climate (ſays Mr Park) are more pure and ſalubrious than at any of the ſettlements towards the coaſt; the face of the country is every where interſperſed with a pleaſing variety of hills and valleys; and the windings of the Senegal river, which deſcends from the rocky hills of the interior, make the ſcenery on its banks very pictureſque and beautiful.

The inhabitants are called Serawoollies, or (as the French write it) *Seracolets*. Their complexion is a jet black: they are not to be diſtinguiſhed in this reſpect from the Jaloffs.

The government is monarchical; and the regal authority, from what I experienced of it, ſeems to be ſufficiently formidable. The people themſelves, however, complain of no oppreſſion; and ſeemed all very anxious to ſupport the king in a conteſt he was going to enter into with the ſovereign of Kaſſon. The Serawoollies are habitually a trading people; they formerly carried on a great commerce with the French in gold and ſlaves, and ſtill maintain ſome traffic in ſlaves with the Britiſh factories on the Gambia. They are reckoned tolerably fair and juſt in their dealings, but are indefatigable in their exertions to acquire wealth, and they derive conſiderable profits by the ſale of ſalt and cotton cloth in diſtant countries. When a Serawoolli merchant returns home from a trading expedition, the neighbours immediately aſſemble to congratulate him upon his arrival. On theſe occaſions the traveller diſplays his wealth and liberality, by making a few preſents to his friends; but if he has been unſucceſsful, his levee is ſoon over; and every one looks upon him as a man of no underſtanding, who could perform a long journey, and (as they expreſs it) *bring back nothing but the hair upon his head*.

Their language abounds much in gutturals, and is not ſo harmonious as that ſpoken by the Foulahs: it is, however, well worth acquiring by thoſe who travel through this part of the African continent; it being very generally underſtood in the kingdoms of Kaſſon, Kaarta, Ludamar, and the northern parts of Bambara. In all theſe countries the Serawoollies are the chief traders.

Joag, the frontier town of this kingdom as you enter it from Piſania, may be ſuppoſed, on a groſs computation, to contain two thouſand inhabitants. It is ſurrounded by a high wall, in which are a number of port holes, for muſquetry to fire through in caſe of an attack. Every man's poſſeſſion is likewiſe ſurrounded by a wall; the whole forming ſo many diſtinct citadels; and amongſt a people unacquainted with the uſe of artillery, theſe walls anſwer all the purpoſes of ſtronger fortifications. To the weſtward of the town is a ſmall river, on the banks of which the natives raiſe great plenty of tobacco and onions. Mr Park was in this town plundered of half his effects by order of the king, becauſe forſooth he had neglected to pay the accuſtomed duties before he entered the kingdom; and it required a good deal of addreſs to prevent himſelf and his attendants from being made ſlaves; a ſtate to which the law, it was ſaid, condemned them for the commiſſion of this unintended crime. He was at laſt reſcued from Joag by a nephew of the king of Kaſſon. Joag is placed by Major Rennel in 14° 25′ N. Lat. and 9° 46′ W. Lon.

KAINSI is the name given by the Hottentots to a particular ſpecies of antelope, of which, according to Vaillant, no author has yet given a perfect deſcription. It is called by the Dutch *klip-ſpringer*, on account of the eaſe with which it leaps from rock to rock; and indeed of all the antelopes there is no one equal to it in agility. It is about the ſize of a kid of a year old, and of a yellowiſh grey colour; but its hair has this peculiarity, that, inſtead of being round, pliable, and firm, like that of moſt other quadrupeds, it is flat, harſh, and ſo little adherent to the ſkin, that the ſlighteſt friction makes it fall off. Nothing is more eaſy, therefore, than to deprive this animal of its hair: dead or alive it is the ſame; to rub, or even to touch the animal, is ſufficient. Another peculiarity of this ſingular hair is its being extremely fragile; ſo that if you take a tuft of it between your fingers, and twiſt it with the other hand, it will break like the barbs of a feather. This property, however, belongs not excluſively to the hair of the kainſi; for our author ſays he has obſerved it in the hair of other quadrupeds, which in the ſame manner live among the rocks.

This antelope differs from the other ſpecies alſo in the ſhape of the foot, which, inſtead of being pointed

Kainſi,
Kamtſchatka.

like theirs, is rounded at the end; and as it is always accuſtomed, both in leaping and walking, to tread with the point of the hoof, without reſting at all on the heel, it leaves a print diſtinguiſhable from that of any other antelope in Africa. Its fleſh is exquiſitely flavoured, and much ſought after, particularly by the hunters.

The chace of the kainſi is very amuſing. It is true, it is ſcarcely poſſible to hunt it down with dogs, as it ſoon eſcapes them by means of its inconceivable agility, and gets out of their reach on the point of ſome detached rock, where it will remain whole hours ſafe from all purſuit, and ſuſpended, as it were, above the abyſs. But in this ſituation it is excellently placed for the arrow or the ball of the huntſman; who is commonly certain of ſhooting it at pleaſure, though he is not always able to come at it when killed. We ſhall give our author's account of a chace of the kainſi in his own words.

"I was hunting (ſays he) one of theſe animals, when, from the nature of the place, it found itſelf ſo preſſed by my dogs, as to be on the point of being run down and taken. There were apparently no means of eſcape; ſince before it was a vaſt perpendicular rock, by which its courſe was neceſſarily ſtopped. In this wall, however, which appeared to me perfectly ſmooth, was a little ridge, projecting at moſt not above *two inches*, which the kainſi quickly perceived, and, leaping upon it, to my great aſtoniſhment kept itſelf *firm* (A). I imagined, that at any rate it muſt ſoon tumble down; and my dogs, too, ſo fully expected it, that they ran to the bottom of the rock, to be ready to catch it when it fell. To haſten its fall, I endeavoured to haraſs it, and make it loſe its equilibrium; and for this purpoſe I pelted it with ſtones. All at once, as if gueſſing my deſign, it collected its whole ſtrength, bounded over my head, and, falling a few paces from me, darted away with the utmoſt ſpeed. Notwithſtanding the rapidity of its flight, it would have been eaſy for me to have ſhot it; but its leap had ſo ſurpriſed and amuſed me, that I gave it its life." This was generous, if the ſtory be true.

KAMTSCHATKA is inhabited by a people, who are repreſented in the *Encyclopædia* as poſſeſſing almoſt every quality that can diſgrace human nature. We think it incumbent upon us to acknowledge, in this place, that a much more favourable picture of them is drawn by La Perouſe who viſited Kamtſchatka in September 1787. The Ruſſian governor made the commodore and his officers remark the promiſing appearance of ſeveral ſmall fields of potatoes, of which the ſeed had been brought from Irkoutſk a few years before; and purpoſed to adopt mild, though infallible means, of making farmers of the Ruſſians, Coſſacks, and Kamtſchadales. The ſmall-pox in 1769 ſwept away three-fourths of the individuals of the latter nation, which is now reduced to leſs than four thouſand perſons, ſcattered over the whole of the peninſula; and which will ſpeedily diſappear altogether, by means of the continual mixture of the Ruſſians and Kamtſchadales, who frequently intermarry. A mongrel race, more laborious than the Ruſſians, who are only fit for ſoldiers, and much ſtronger, and of a form leſs diſgraceful to the hand of nature, than the Kamtſchadales, will ſpring from theſe marriages, and ſucceed the ancient inhabitants. The natives have already abandoned the *yourts*, in which they uſed to burrow like badgers during the whole of the winter, and where they breathed an air ſo foul as to occaſion a number of diſorders. The moſt opulent among them now build *iſbas*, or wooden houſes, in the manner of the Ruſſians. They are preciſely of the ſame form as the cottages of our peaſants; are divided into three little rooms; and are warmed by a brick ſtove, that keeps up a degree of heat (B) inſupportable to perſons unaccuſtomed to it. The reſt paſs the winter, as well as the ſummer, in *balagans*, which are a kind of wooden pigeon-houſes, covered with thatch, and placed upon the top of poſts twelve or thirteen feet high, to which the women as well as the men climb by means of ladders that afford a footing very inſecure. But theſe latter buildings will ſoon diſappear; for the Kamtſchadales are of an imitative genius, and adopt almoſt all the cuſtoms of their conquerors. Already the women wear their hair, and are almoſt entirely dreſſed, in the manner of the Ruſſians, whoſe language prevails in all the *oſtrogs*; a fortunate circumſtance, ſince each Kamtſchadalian village ſpoke a different jargon, the inhabitants of one hamlet not underſtanding that of the next. It may be ſaid in praiſe of the Ruſſians, that though they have eſtabliſhed a deſpotic government in this rude climate, it is tempered by a mildneſs and equity that render its inconveniences unfelt. They have no reproaches of atrocity to make themſelves, like the Spaniards in Mexico and Peru. The taxes they levy on the Kamtſchadales are ſo light, that they can only be conſidered as a mark of gratitude towards the ſovereign, the produce of half a day's hunting acquitting the impoſts of a year. It is ſurpriſing to ſee in cottages, to all appearance more miſerable than thoſe of the moſt wretched hamlets in our mountainous provinces, a quantity of ſpecies in circulation, which appears the more conſiderable, becauſe it exiſts among ſo ſmall a number of inhabitants. They conſume ſo few commodities of Ruſſia and China, that the balance of trade is entirely in their favour, and that it is abſolutely ceſſary to pay them the difference in rubles. Furs at Kamtſchatka are at a much higher price than at Canton; which proves, that as yet the market of Kiatcha has not felt the advantageous effect of the new channel opened in China.

Kamtſchatka.

Our author compares Kamtſchatka, with reſpect to climate and ſoil, to the coaſt of Labrador in the vicinity of the Straits of Belle-Iſle; but the men, like the animals, are there very different. The Kamtſchadales appeared to him the ſame people as thoſe of the bay of Caſtries, upon the coaſt of Tartary. Their mildneſs and their probity are the ſame, and their perſons are very little different. They ought then no more to be compared to the Eſquimaux Indians, than the ſables of Kamtſchatka to the martins of Canada.

The Greek religion has been eſtabliſhed among the Kamtſchadales without perſecution or violence, and with extraordinary facility. The vicar of Paratounka is the ſon of a Kamtſchadale and of a Ruſſian woman. He delivers his prayers and catechiſm with a tone of feeling very

---

(A) This we think incredible.

(B) Not leſs than thirty degrees of Reaumur's thermometer.

very much to the taſte of the aborigines, who reward his cares with offerings and alms, but pay no tythes. The canons of the Greek church permitting prieſts to marry, we may conclude that the morals of the country clergymen are ſo much the better. “ I believe them, however (ſays Perouſe), to be very ignorant ; and do not ſuppoſe, that for a long time to come they will ſtand in need of greater knowledge. The daughter, the wife, and the ſiſter of the vicar, were the beſt dancers of all the women, and appeared to enjoy the beſt ſtate of health. The worthy prieſt knew that we were good Catholics, which procured us an ample aſperſion of holy water ; and he alſo made us kiſs the croſs that was carried by his clerk : theſe ceremonies were performed in the midſt of the village. His parſonage-houſe was a tent, and his altar in the open air ; but his uſual abode is Paratounka, and he only came to St Peter and St Paul's to pay us a viſit.”

The people of Kamtſchatka have inured themſelves to the extremes of heat and cold. It is well known, that their cuſtom in Europe, as well as in Aſia, is to go into vapour baths, come out covered with perſpiration, and immediately roll themſelves in the ſnow. The *oſtrog* of St Peter had two of theſe public baths, into which our author went before the fires were lighted. They conſiſt of a very low room, in the middle of which is an oven conſtructed of ſtones, without cement, and heated like thoſe intended to bake bread. Its arched roof is ſurrounded by ſeats one above another, like an amphitheatre, for thoſe who wiſh to bathe, ſo that the heat is greater or leſs according as the perſon is placed upon a higher or lower bench. Water thrown upon the top of the roof, when heated red hot by the fire underneath, is converted inſtantly into vapour, and excites the moſt profuſe perſpiration. The Kamtſchadales have borrowed this cuſtom, as well as many others, from their conquerors ; and ere long the primitive character that diſtinguiſhed them ſo ſtrongly from the Ruſſians will be entirely effaced.

Our author deſcribes the bay of Avatſcha as the fineſt, the moſt convenient, and the ſafeſt, that is to be met with in any part of the world. The entrance is narrow, and ſhips would be forced to paſs under the guns of the forts that might be eaſily erected. The bottom is mud, and excellent holding ground. Two vaſt harbours, one on the eaſtern ſide, the other on the weſtern, are capable of containing all the ſhips of the French and Engliſh navy. The rivers of Avatſcha and Paratounka fall into this bay, but they are choaked up with ſand-banks, and can only be entered at the time of high water. The village of St Peter and St Paul is ſituated upon a tongue of land, which, like a jetty made by human art, forms behind the village a little port, ſhut in like an amphitheatre, in which three or four veſſels might lie up for the winter. The entrance of this ſort of baſon is more than twenty-five toiſes wide ; and nature can afford nothing more ſafe or commodious. On its ſhore the governor propoſed to lay down the plan of a city, which ſome time or other will be the capital of Kamtſchatka, and perhaps the centre of an extenſive trade with China, Japan, the Phillippines, and America. A vaſt pond of freſh water is ſituated northward of the ſite of this projected city ; and at only three hundred toiſes diſtance run a number of ſtreamlets, the eaſy union of which would give the ground all the advantages neceſſary to a great eſtabliſhment. Of theſe advantages Mr Kaſloff underſtood the value ; “ but firſt (ſaid he a thouſand times over) we muſt have bread and hands, and our ſtock of both of them is very ſmall.” He had, however, given orders, which announced a ſpeedy union of the other *oſtrogs* to that of St Peter and St Paul, where it was his intention immediately to build a church. By obſervation, St Peter and St Paul was found to be in 53° 1′ N. Lat. and 156° 30′ E. Long. from Paris.

KANEM, is the name given by Edriſi to the kingdom of Bornou in Africa, of which the reader will find ſome account in the *Encyclopædia Britannica.* In ſome particulars, however, that account is incorrect. The kingdom of Bornou or Kanem muſt extend farther eaſt and farther north than it is there ſaid to do ; for according to the lateſt and beſt accounts, its capital ſtands in Lat. 24° 32′ Long. 22° 57′. The empire is ſaid to be very extenſive ; and if it be true, as we learn from the proceedings of the African Aſſociation, that its ſovereign is more powerful than the Emperor of Morocco, the people cannot be ſuch abſolute brutes, as we have repreſented them in the article referred to ; for the ſovereign of brutes would have no power. The truth, however is, that very little is yet known in Europe of Bornou or its inhabitants.

KANT (Immanuel), Royal Profeſſor of Morals and Metaphyſics in the Univerſity of Königſberg, is conſidered by his admirers as the greateſt philoſopher that Germany ever produced. Were we to form an eſtimate of his merits from the different views that have been given in Engliſh of his celebrated ſyſtem, we certainly ſhould not conſider him as entitled to that character ; for thoſe views are obſcured by new and uncouth terms, and are altogether wrapt up in a ſtyle which approaches nearer to jargon than to the luminous compoſition of a man who thinks with clearneſs and preciſion. We readily admit, that it is very difficult to tranſlate a novel ſyſtem of metaphyſics from one language into another ; for the tranſlator, to perform his taſk properly, muſt be not only a complete maſter of both languages, but alſo a profound metaphyſician ; and not one of the tranſlators or abridgers of the works of Kant into our language appears to us poſſeſſed of both theſe qualities. Deſpairing, from our ſcanty knowledge of the German language, of performing ourſelves what ſo many others have failed to perform, we have applied for aſſiſtance to an illuſtrious Frenchman, who has reſided many years in Germany, who is maſter of both languages, who is a profound metaphyſician, and whoſe name, were we at liberty to publiſh it, would reflect luſtre upon our Work. From him we have reaſon to expect a clear and comprehenſive view of the *Critical PHILOSOPHY*, as Kant terms his ſyſtem ; but ſhould we be diſappointed of our expectation, we ſhall, under that title, lay before our readers a *ſpecimen* of the ſyſtem from the different views of it which have been publiſhed in our own tongue.

KANTUFFA, a ſpecies of thorn peculiar to Abyſſinia, is thus deſcribed by Mr Bruce : The branches ſtand two and two upon the ſtalk ; the leaves are diſpoſed two and two likewiſe, without any ſingle one at the point, whereas the branches bearing the leaves part from the ſtalk : at the immediate joining of them are two thick thorns placed perpendicular and parallel alternate-

Kantuffa, Kaſſon.

ly; but there are alſo ſingle ones diſtributed in all the interſtices throughout the branch.

The male plant has a one-leaved perianthium, divided into five ſegments, and this falls off with the flower. The flower is compoſed of five petals, in the middle of which riſe ten ſtamina or filaments, the outer row ſhorter than thoſe of the middle, with long ſtigmata, having yellow farina upon them. The flowers grow in a branch, generally between three and four inches long, in a conical diſpoſition, that is, broader at the baſe than the point. The inſide of the leaves are a vivid green, in the outſide much lighter. It grows in form of a buſh, with a multitude of ſmall branches riſing immediately from the ground, and is generally ſeven or eight feet high. Our author ſaw it when in flower only, never when bearing fruit. It has a very ſtrong ſmell, reſembling that of the ſmall ſcented flower called mignionet, ſown in vaſes and boxes in windows, or rooms, where flowers are kept.

Our author repreſents the kantuffa as ſo very troubleſome, that it renders travelling through ſome places of Abyſſinia almoſt impoſſible. The ſoldier ſcreens himſelf from it by a goat's, a leopard's, or a lion's ſkin thrown over his ſhoulder, of which it has no hold. As his head is bare, he always cuts his hair ſhort before he goes to battle, leſt his enemy ſhould take advantage of it; but the women, wearing their hair long, and the great men, whether in the army or travelling in peace, being always clothed, it never fails to incommode them, whatever ſpecies of raiment they wear. If their cloak is fine muſlin, the leaſt motion againſt it puts it all in rags; but if it is a thick, ſoft cloth, as thoſe are with which men of rank generally travel, it buries its thorns, great and ſmall, ſo deep in it, that the wearer muſt either diſmount and appear naked, which to principal people is a great diſgrace, or elſe much time will be ſpent before he can diſengage himſelf from its thorns. In the time when one is thus employed, it rarely fails to lay hold of you by the hair, and that again brings on another operation, full as laborious, but much more painful, than the other. A proclamation is therefore iſſued, every year immediately before the king commences any march, in theſe words; "Cut down the kantuffa in the four quarters of the world; for I do not know where I am going." The wild animals, both birds and beaſts, eſpecially the Guinea fowl, know how well it is qualified to protect them. In this ſhelter, the hunter in vain could endeavour to moleſt them, were it not for a hard-haired dog, or terrier of the ſmalleſt ſize, who being defended from the thorns by the roughneſs of his coat, goes into the cover, and brings them and the partridges alive one by one to his maſter.

KASSON, a populous kingdom in North Africa, of which the capital *Kooniakary* is placed by Major Rennel in 14° 33′ N. Lat and 8° 43′ W. Lon. The king who reigned when Mr Park was in the country was extremely kind to our traveller, though his ſon plundered him unmercifully, like other rapacious chiefs of that ſavage country. From the top of a high hill, at ſome diſtance from the capital, "I had (ſays Mr Park) a moſt enchanting proſpect of the country. The number of towns and villages, and the extenſive cultivation around them, ſurpaſſed every thing I had yet ſeen in Africa. A groſs calculation may be formed of the number of inhabitants in this delightful plain, by conſidering, that the king of Kaſſon can raiſe four thouſand fighting men by the ſound of his war drum."

Kaſſon.

At Teeſee, a large unwalled town, where our author reſided for ſome days, he had an opportunity of obſerving the cuſtoms of the inhabitants, who conſiſted partly of Pagans and partly of Buſhreens, *i. e.* of negroes converted to Mahomedaniſm. Though theſe people poſſeſs both cattle and corn in abundance, rats, moles, ſquirrels, ſnakes, locuſts, &c. are eaten without ſcruple by the higheſt and loweſt. Another cuſtom, ſtill more extraordinary, is, that no woman is allowed *to eat an egg*. This prohibition, whether ariſing from ancient ſuperſtition, or from the craftineſs of ſome old Buſhreen who loved eggs himſelf, is rigidly adhered to; and nothing will more affront a woman of Teeſee than to offer her an egg. The cuſtom is the more ſingular, as the men eat eggs without ſcruple in the preſence of their wives, and Mr Park never obſerved the ſame prohibition in any other of the Mandingo countries.

Our author was preſent at a palaver held by the governor of Teeſee on a very extraordinary occaſion; of which we ſhall give his account at full length, becauſe it ſhows how free men are reduced to ſlavery in North Africa. "The caſe was this. A young man, a Kafir, of conſiderable affluence, who had recently married a young and handſome wife, applied to a very devout Buſhreen, or Muſſulman prieſt, of his acquaintance, to procure him ſaphies for his protection during the approaching war. The Buſhreen complied with the requeſt; and in order, as he pretended, to render the ſaphies more efficacious, enjoined the young man to avoid any nuptial intercourſe with his bride for the ſpace of ſix weeks. Severe as the injunction was, the Kafir ſtrictly obeyed; and without telling his wife the real cauſe, abſented himſelf from her company. In the mean time it began to be whiſpered at Teeſee, that the Buſhreen, who always performed his evening devotions at the door of the Kafir's hut, was more intimate with the young wife than he ought to be. At firſt, the good huſband was unwilling to ſuſpect the honour of his ſanctified friend, and one whole month elapſed before any jealouſy roſe in his mind; but hearing the charge repeated, he at laſt interrogated his wife on the ſubject, who frankly confeſſed that the Buſhreen had ſeduced her. Hereupon the Kafir put her into confinement, and called a palaver upon the Buſhreen's conduct. The fact was clearly proved againſt him; and he was ſentenced to be ſold into ſlavery, or to find two ſlaves for his redemption, according to the pleaſure of the complainant. The injured huſband, however, was unwilling to proceed againſt his friend to ſuch extremity, and deſired rather to have him publicly flogged before the governor's gate. This was agreed to, and the ſentence was immediately executed. The culprit was tied by the hands to a ſtrong ſtake; and a long black rod being brought forth, the executioner, after flouriſhing it round his head for ſome time, applied it with ſuch force and dexterity to the Buſhreen's back, as to make him roar until the woods reſounded with his ſcreams. The ſurrounding multitude, by their hooting and laughing, manifeſted how much they enjoyed the puniſhment of this old gallant; and it is worthy of remark, that the number of ſtripes was preciſely the ſame as are enjoined by the Moſaic law, *forty, ſave one*."

The method of converting the negro nations to the

Kaſſon.

religion of the Arabian Impoſtor is a very ſingular one; and Mr Park ſaw the whole people of Teeſee converted in an inſtant. During his reſidence in that town an embaſſy of ten people belonging to Almami Abdulkader, king of Foota Torra, a country to the weſt of Bondou, arrived at Teeſee; and deſiring Tiggity Sego the governor to call an aſſembly of the inhabitants, announced publicly their king's determination, to this effect: "That unleſs all the people of Kaſſon would embrace the Mahomedan religion, and evince their converſion by ſaying eleven public prayers, he (the king of Foota Torra) could not poſſibly ſtand neuter in the preſent conteſt, but would certainly join his arms to thoſe of Kajaaga." A meſſage of this nature, from ſo powerful a prince, could not fail to create great alarm; and the inhabitants of Teeſee, after a long conſultation, agreed to conform to his good pleaſure, humiliating as it was to them. Accordingly, one and all publicly offered up eleven prayers, which were conſidered a ſufficient teſtimony of their having renounced Paganiſm, and embraced the doctrines of the Prophet.

Our author relates a ſtory, which we cannot refuſe ourſelves the pleaſure of inſerting, becauſe it exhibits a very pleaſing picture of the affection and gratitude of the Pagan negroes. In his train was a blackſmith, who had lived ſome years on the Gambia, and who now returned to his own country *Kaſſon*. "Soon after we came in ſight of Jumbo, his native town (ſays Mr Park), his brother, who had by ſome means been appriſed of his coming, came out to meet him, accompanied by a ſinging man: he brought a horſe for the blackſmith, that he might enter his native town in a dignified manner; and he deſired each of us to put a good charge of powder into our guns. The ſinging man now led the way, followed by the two brothers; and we were preſently joined by a number of people from the town, all of whom demonſtrated great joy at ſeeing their old acquaintance the blackſmith, by the moſt extravagant jumping and ſinging. On entering the town, the ſinging man began an extempore ſong in praiſe of the blackſmith, extolling his courage in having overcome ſo many difficulties; and concluding with a ſtrict injunction to his friends to dreſs him plenty of victuals.

"When we arrived at the blackſmith's place of reſidence, we diſmounted and fired our muſkets. The meeting between him and his relations was very tender; for theſe rude children of nature, free from reſtraint, diſplay their emotions in the ſtrongeſt and moſt expreſſive manner. Amidſt theſe tranſports, the blackſmith's aged mother was led forth, leaning upon a ſtaff. Every one made way for her; and ſhe ſtretched out her hand to bid her ſon welcome. Being totally blind, ſhe ſtroked his hands, arms, and face, with great care, and ſeemed highly delighted that her latter days were bleſſed by his return, and that her ears once more heard the muſic of his voice. From this interview I was fully convinced, that whatever difference there is between the Negro and European in the conformation of the noſe and the colour of the ſkin, there is none in the genuine ſympathies and characteriſtic feelings of our common nature.

"During the tumult of theſe congratulations, I had ſeated myſelf apart, by the ſide of one of the huts, being unwilling to interrupt the flow of filial and parental tenderneſs; and the attention of the company was ſo entirely taken up with the blackſmith, that I believe none of his friends had obſerved me. When all the people preſent had ſeated themſelves, the blackſmith was deſired by his father to give them ſome account of his adventures; and ſilence being commanded, he began; and after repeatedly thanking God for the ſucceſs that had attended him, related every material occurrence that had happened to him from his leaving Kaſſon to his arrival at the Gambia; his employment and ſucceſs in thoſe parts; and the dangers he had eſcaped in returning to his native country. In the latter part of his narration, he had frequently occaſion to mention me; and after many ſtrong expreſſions concerning my kindneſs to him, he pointed to the place where I ſat, and exclaimed, *aſſille ibi ſiring*, "ſee him ſitting there." In a moment all eyes were turned upon me; I appeared like a being dropped from the clouds; every one was ſurpriſed that they had not obſerved me before; and a few women and children expreſſed great uneaſineſs at being ſo near a man of ſuch an uncommon appearance. By degrees, however, their apprehenſions ſubſided; and when the blackſmith aſſured them that I was perfectly inoffenſive, and would hurt nobody, ſome of them ventured ſo far as to examine the texture of my clothes; but many of them were ſtill very ſuſpicious; and when by accident I happened to move myſelf, or look at the young children, their mothers would ſcamper off with them with the greateſt precipitation. In a few hours, however, they all became reconciled to me." With theſe worthy people our author ſpent the greater part of two days in feaſting and merriment; the blackſmith accompanied him to the capital; and declared, that he would not leave him while he reſided there.

Kaſſon, Keate.

KEATE (George, Eſq; F. R. S.), deſcended of an ancient and honourable family, was born about the year 1729 or 1730, and received his education at Kingſton ſchool, under the Rev. Mr Woodeſon. From thence he went to Geneva, where he reſided ſome years; and during his ſtay there, became acquainted with Voltaire, with whom he continued to correſpond many years after he returned to England. After finiſhing the tour of Europe, he ſettled as a ſtudent in the Inner Temple, was called to the bar, and ſometimes attended Weſtminſter Hall; though he did not meet with encouragement enough to induce his perſeverance in his profeſſion, nor indeed does it ſeem probable that he had ſufficient application for it. His firſt literary performance was "Ancient and Modern Rome," a poem, written at Rome in the year 1755, printed in the year 1760, and received with conſiderable applauſe. The next year he publiſhed "A Short Account of the Ancient Hiſtory, Preſent Government, and Laws, of the Republic of Geneva, 8vo." This work was compiled during the author's reſidence at Geneva; is a very uſeful one; and is dedicated to Monſieur de Voltaire; to whom he ſays, "When I reflect, that it was in this Republic, whoſe government I have attempted to deſcribe, that I was firſt introduced to your acquaintance; when memory renews the hours of ſocial mirth and refined entertainment which your hoſpitality and converſation afforded me—I cannot but rejoice in this occaſion of expreſſing my gratitude; proud that, as your friendſhip diſtinguiſhed the author of theſe pages in a foreign country, your name may at home adorn his labour."

Keate.

It was at one time the intention of Voltaire to tranſlate this account into French, though he afterwards relinquiſhed the deſign.

The next year, 1762, he produced an "Epiſtle from Lady Jane Gray to Lord Guildford Dudley:" and in 1763, "The Alps," a poem; the ſubject of which comprehends all that chain of mountains known under the general name of the Alps, extending from Italy to Germany, and from France to Tyrol, by whatever denomination they are particularly diſtinguiſhed. Of all the poetical works of Mr Keate, this is intitled to the higheſt praiſe for truth of deſcription, elegance of verſification, and vigour of fancy.

Continuing to employ the preſs, in 1764 he publiſhed "Netley Abbey," which he afterwards, in 1769, enlarged and reprinted: and, in 1765, produced "The Temple Student, an Epiſtle to a Friend;" humourouſly rallying his own want of application to the ſtudy of the law, his preference of the belles lettres, and his conſequent want of ſucceſs in his profeſſion. The death of Mrs Cibber in 1766, of whoſe merits as an actreſs he entertained the higheſt opinion, gave occaſion for a poem to her memory, which celebrates her excellent performances on the ſtage, and laments the loſs the theatre would ſuſtain by her death.

In February 1769, he married Miſs Hudſon; and about the ſame time publiſhed "Ferney; an Epiſtle to M. de Voltaire" In this poem, after praiſing with energy the various beauties of his friend's poetical works, he introduces the following panegyric on Shakeſpeare:

> Yes! jealous wits may ſtill for empire ſtrive,
> Still keep the flames of critic rage alive:
> Our Shakeſpeare yet ſhall all his rights maintain,
> And crown the triumphs of Eliza's reign.
> Above controul, above each claſſic rule,
> His tut'reſs Nature, and the world his ſchool,
> On ſoaring pinions borne, to him was given
> Th' ærial range of Fancy's brighteſt heav'n;
> To bid wrapt thought o'er nobleſt heights aſpire,
> And wake each paſſion with a muſe of fire.
> Revere his genius. To the dead be juſt,
> And ſpare the laurels that o'erſhade the duſt.
> Low ſleeps the bard, *in cold obſtruction laid*,
> Nor aſks the chaplet from a rival's head.
> O'er the drear vault, Ambition's utmoſt bound,
> Unheard ſhall Fame her airy trumpet ſound!
> Unheard alike; nor grief nor tranſport raiſe
> The blaſt of cenſure, or the note of praiſe!
> As Raphael's own creation grac'd his hearſe,
> And ſham'd the pomp of oſtentatious verſe,
> Shall Shakeſpeare's honours by himſelf be paid,
> And Nature periſh ere his pictures fade.

This eulogium on Shakeſpeare, in an an epiſtle to Voltaire, who had laboured ſo long and ſo ſtrenuouſly to detract from the merit of our immortal bard, ſhews that Mr Keate had not given up his judgment to the ſage of Ferney. How the old and envious ſophiſter would reliſh his friend's conduct, may be eaſily conceived. His feelings were certainly very different from thoſe of the mayor and burgeſſes of Stratford, when, in conſequence of this panegyric on their townſman, they complimented Mr Keate with a ſtandiſh, mounted with ſilver, made out of the famous Mulberry tree planted by Shakeſpeare.

Keate.

In 1773, he publiſhed "The Monument in Arcadia," a dramatic poem, built on the picture of Pouſſin, mentioned by Abbé du Bos in his "Critical Reflections on Poetry and Painting."

In 1779, Mr Keate produced one of his moſt ſucceſsful works, intitled "Sketches from Nature; taken and coloured in a Journey to Margate," 2 vols, 12mo. This performance, allowing it to be, as it really is, an imitation of Sterne's "Sentimental Journey;" yet contains ſo many pleaſing delineations of life, ſo many ſtrokes of humour, and ſo much elegance of compoſition, that few will heſitate to give it the preference to any other of Sterne's imitators.

In 1781, he collected his poetical works in two vols, 12mo, and added ſeveral new pieces not before printed. The principal of theſe was "The Helvetiad," a fragment, written at Geneva in the year 1756. In the preface to this performance he gives the following account of it: "During a long ſtay I many years ſince made at Geneva, I viſited moſt of the principal places in Switzerland. The many ſublime ſcenes with which nature hath enriched this romantic country; the tranquillity and content with which every individual enjoys his property; and, above all, that independence of mind which is ever the reſult of liberty—animated me with ſuch veneration for the firſt authors of that freedom, whoſe figures are recorded to poſterity either by ſculpture or painting in the public parts of the towns thro' thoſe little ſtates, that my enthuſiaſm betrayed me into a deſign of writing a poem on this ſingular revolution; the argument of which I had divided into *ten cantos*, beginning the work with the oppreſſions of the Houſe of Auſtria, and cloſing it with the battle of Mongarten; by which thoſe injured people finally renounced its uſurpation, and formed among themſelves thoſe various confederacies that ended in the great union and alliance of the preſent *thirteen cantons*. When I had ſettled the whole plan of this work, I occaſionally, as I found a diſpoſition in myſelf, took up any part of the poem which at the moment moſt invited my thoughts: and enjoying at this time ſuch an intercourſe with M. de Voltaire as afforded me a conſtant acceſs to him, I acquainted him with my intention, ſhewing him the argument I had drawn out for the conduct of the whole deſign. He kept it a few days; and, in returning it, told me, that he thought the great object of the piece, the epiſodes connected with the hiſtory, together with the ſcenery of the country, preſented ſubject matter whereon to form a fine poem; "but the time (added he) which ſuch an undertaking will require, I would rather counſel you to employ on ſubjects that might more engage the public attention; for ſhould you devote yourſelf to the completion of your preſent deſign, the Swiſs would be much obliged to you, without being able to read you, and the reſt of the world care little about the matter." Feeling the force and juſtneſs of the remark, Mr Keate laid aſide his plan, and probably never reſumed it. In the ſame year, 1781, he publiſhed "An Epiſtle to Angelica Kauffman."

A few years after, he became engaged in a long and vexatious law-ſuit, in conſequence of the neglect (to ſay the leaſt of it) of an architect who profeſſed himſelf to be his friend; the particulars of which it is of no importance to detail. At the concluſion of the buſineſs, he ſhewed that his good humour had not forſaken him:

Keate. And in 1787 he gave to the public the principal circumſtances of his caſe in a performance, intitled, "The Diſtreſſed Poet, a ſerio-comic Poem, in three Cantos," 4to, with ſome pleaſantry, and without any acrimony.

His laſt work did infinite honour to his head and his heart, as well as to the liberality of the bookſeller for whom on the title-page it was ſaid to be publiſhed. In the year 1782, the Antelope packet was ſhipwrecked on the Pelew iſlands, where the commander, Captain Wilſon, and his crew lived ſome time before they could get off. On his return to England, the Captain was, for ſome reaſon or other, refuſed the command of another ſhip; and, as we have been informed, he was reduced to a ſtate much the reverſe of affluence. Theſe circumſtances being communicated to Mr Keate, who was ſtruck with admiration of the manners of the inhabitants of the Pelew iſlands (See PELEW ISLANDS, *Encycl.*), he offered to draw up, for the benefit of Captain Wilſon, a narrative of the occurrences which took place during that officer's reſidence among ſo ſingular a people. This he executed in "An Account of the Pelew Iſlands, ſituated in the Weſtern Part of the Pacific Ocean: compoſed from the Journals and Communications of Captain Henry Wilſon and ſome of his Officers, who in Auguſt 1783 were there ſhipwrecked, in the Antelope, a Packet belonging to the Honourable the Eaſt India Company," 4to; a work written with great elegance, compiled with much care, and which, if embelliſhed (as it has been inſinuated) with facts better calculated to have found a place in a novel than a genuine narrative, muſt be aſcribed to the miſinformation of thoſe who were actors in the ſcene, and muſt firſt have deceived before they obtained credit. We mention this report as it has come to us, without any attempt either to eſtabliſh or refute it. We ſhall only add, that if the charge is well founded, Mr Keate (who undertook the taſk on the moſt diſintereſted principle, and derived no advantage whatever from the work) was too ſturdy a moraliſt to have had any hand in the impoſition.—The manuſcript was offered to Mr Dodſley for 300 guineas; but he heſitated to give for it ſo large a price, when another bookſeller undertook to publiſh the work for the benefit of Mr Wilſon; and, we have reaſon to believe, paid to that gentleman, within the compaſs of a year, triple the ſum for which the manuſcript had been offered to Dodſley. Such conduct reflects honour on the London trade.

Beſides the pieces already mentioned, Mr Keate was the author of many Prologues and Epilogues, ſpoken at Mr Newcomb's ſchool at Hackney. He adapted his friend Voltaire's "Semiramis" to the ſtage; but this was ſuperſeded in 1777 at Drury Lane, by a worthleſs tranſlation of as worthleſs an author, one Captain Ayſcough; but neither this nor the author are deſerving of any further notice.

We ſhall conclude by obſerving, that Mr Keate's life paſſed without any viciſſitudes of fortune; he inherited an ample eſtate, which he did not attempt to increaſe otherwiſe than by thoſe attentions which prudence dictated in the management of it. He was hoſpitable and beneficent, and poſſeſſed the good-will of mankind in a very eminent degree. For the laſt year or two, his health viſibly declined; but on the day he died, it appeared to be ſomewhat mended. His death was ſudden, on the 27th of June 1797. He left one daughter, married in 1796 to John Henderſon, Eſq; of the Adelphi. At the time of his death, Mr Keate was a Bencher of the Temple, and a very old member of the Royal and Antiquary Societies, of both of which he had been frequently elected one of the council.

Kennicott. KENNICOTT (Dr Benjamin) was a man of ſuch eminence in the learned world, that every thing relating to him muſt be generally intereſting. In the biographical ſketch of him publiſhed in the *Encyclopædia*, we have acknowledged ourſelves unacquainted with the rank and character of his parents; but this information has been ſince ſupplied by a very candid and well-informed writer in the Monthly Magazine; and as it is accompanied with circumſtances peculiarly honourable to the Doctor, and ought therefore to be preſerved, we ſhall inſert it in this place.

"The parents of Dr Kennicott (ſays this writer) were honeſt characters: His father was the pariſh clerk of Totneſs, and once maſter of a charity ſchool in that town. At an early age young Kennicott ſucceeded to the ſame employ in the ſchool, being recommended to it by his remarkable ſobriety and premature knowledge. It was in that ſituation he wrote the verſes to the honourable Mrs Courtney, which recommended him to her notice, and that of many neighbouring gentlemen. They, with a laudable generoſity, opened a ſubſcription to ſend him to Oxford.

"He ſoon there diſtinguiſhed himſelf, as is well known. As a teſtimony of the truth of the above ſtatement, the following is a copy of an inſcription written by Dr Kennicott, and engraved on the tomb of his father and mother. The writer of this article has tranſcribed it from the original in the church-yard of Totneſs. The tomb is more elegant than perſons in their ſituation are accuſtomed to have erected, and was thought, perhaps, by the envious to be ſomewhat oſtentatious. A perſonal knowledge of the Doctor induces the writer of this article to think, that it was rather the tribute of a good and grateful mind, and of the pious reverence and love which he entertained for the authors of his being.

As Virtue ſhould be of good report,
ſacred
be this humble Monument
to the Memory of
BENJAMIN KENNICOTT, Pariſh-Clerk of Totneſs,
and ELIZABETH his Wife:
The latter
an Example of every Chriſtian Duty;
The former,
animated with the warmeſt Zeal,
regulated by the beſt good ſenſe,
and both conſtantly exerted
for the Salvation of himſelf and others.
Reader!
Soon ſhalt thou die alſo;
and as a Candidate for Immortality
ſtrike thy breaſt and ſay,
Let me live the life of the Righteous,
that my laſt end may be like his.
Trifling are the dates of Time
where the ſubject is Eternity.
Erected
by their Son, B. Kennicott, D. D.
Canon of Chriſt-Church, Oxford.

"It is ſaid, that when Dr Kennicott had taken orders, he came to officiate in his clerical capacity in his native

native town. When his father as clerk proceeded to place the ſurplice on his ſhoulders, a ſtruggle enſued between the modeſty of the ſon and the honeſt pride of the parent, who inſiſted on paying that reſpect to his ſon which he had been accuſtomed to ſhew to other clergymen: to this filial obedience was obliged to ſubmit. A circumſtance is added, that his mother had often declared ſhe ſhould never be able to ſupport the joy of hearing her ſon preach; and that on her attendance at the church for the firſt time, ſhe was ſo overcome as to be taken out in a ſtate of temporary inſenſibility."

KERMES (ſee *Coccus Ilicis*, Encycl.) has been proved by Profeſſor Beckmann to have been uſed as a dye from very remote antiquity. "All the ancient Greek and Latin writers, he ſays, agree, that kermes, called by the latter *coccum*, perhaps alſo *coccus*, and often *granum*, were found upon a low ſhrubby tree, with prickly leaves, which produced acorns, and belonged to the genus of the oak; and there is no reaſon to doubt that they mean *coccum ilicis*, and that low ever green oak, with the prickly leaves of the holly (*aquifolium*), which is called at preſent in botany *quercus ilex*. This aſſertion appears more intitled to credit, as the ancients aſſign for the native country of this tree places where it it is ſtill indigenous, and produces kermes.

"I am inclined (continues our author) to believe, that the art of employing kermes to dye a beautiful red colour was diſcovered in the Eaſt at a very early period; that it was ſoon ſo much improved as to excel even the Tyrian purple; and that it contributed to cauſe the proper purple to be at length abandoned. From the coſtly red dyes extolled ſo much by the Hebrew writers, and which, according to the opinion of learned commentators, were made from kermes, I ſhall not venture to adduce any proofs, as I am not acquainted with the Oriental languages to examine their accounts with accuracy; but I have found a paſſage in Vopiſcus, which ſeems to render my conjecture very probable. That author informs us, that the king of Perſia ſent to the Emperor Aurelian, beſides other articles of great value, ſome woollen cloth, which was of a much coſtlier and brighter purple colour than any that had been ever ſeen in the Roman empire, and, in compariſon of which, all the other purple cloth worn by the Emperor and the ladies of the court appeared dull and faded. In my opinion, this cloth, which was of a beautiful purple red colour, was not dyed with the liquor of the murex, but with kermes. This idea was indeed not likely to occur to the Romans, who were acquainted only with the purple of the murex, and who had leſs experience in the arts in general than in that of robbing and plundering, or who, at any rate, in that reſpect were inferior to the Orientals. The Roman emperors cauſed this ſuppoſed purple to be ſought for in India by the moſt experienced dyers; who, not being able to find it, returned with a vague report that the admired Perſian purple was produced by the plant ſandix. I am well aware, that ſome commentators have ſuppoſed that the ſandix was our madder. Heſychius, however, ſays, very confidently, that the *ſandix* is not a plant, but a kind of ſhrubby tree, which yields a dye like the *coccus*. The Roman dyers, perhaps prejudiced in favour of the murex, made that only the object of their ſearch; and their labour proving fruitleſs, they might have heard ſomething of kermes, or the kermes-oak, which they did not fully underſtand. Our dyers, even at preſent, believe many falſe accounts reſpecting the dye-ſtuffs which they uſe daily."

The uſe of kermes in dyeing ſeems to have been continued through every century. In the middle ages, as they are called, we meet with kermes under the name of *vermiculus* or *vermiculum*; and on that account cloth dyed with them was called *vermiculata*. Hence the French word *vermeil*, and its derivative *vermilion*, as is well known, had their extraction; the latter of which originally ſignified the red dye of kermes, but it is now uſed for any red paint, and alſo for fine pounded cinnabar.

KHAS, in Bengal, lands taken into the hands of government, oppoſed to the management of Zemindars or farmers. See ZEMINDAR in this *Supplement*.

KHALSA, in Bengal, ſometimes with the addition of *Shereefah*, the department of land and revenues; the exchequer.

KHERAJE, in Bengal, ſignifies ſtrictly the tribute paid by a conquered country: it is alſo uſed for revenue in general.

KHIDMUT, office, attendance, employment, ſervice.

KHIDMUTGAR, a waiting man.

KHISMUT, portion or diviſion.

KHOMAR, or COMAR, a Zemindar's demeſne land.

KING-POST, or KING-*Piece*, is a piece of timber ſet upright in the middle, between two principal rafters, and having ſtruts or braces going from it to the middle of each rafter. See ROOF, *Encycl.*; and CARPENTRY, *Suppl.*

KIPPIS (Andrew, D. D. F. R and A. S.), was born at Nottingham, March 28 (O. S.) 1725. His father, a reſpectable tradeſman of that town, was deſcended from the Rev. Benjamin King of Oakham, Rutlandſhire, an ejected miniſter; and his mother, Ann Ryther, was the grand-daughter of the Rev. John Ryther, who was ejected from the church of Fernby, in the county of York. In the year 1730, he loſt his father, and went to reſide with his grandfather, Andrew Kippis of Seaford in Lincolnſhire. He received his claſſical education at the grammar ſchool in that town; but what contributed moſt to his future eminence, was the friendſhip of the Rev. Mr Merrival, who was equalled by few of his contemporaries in various branches of learning, particularly in his acquaintance with the claſſics, his knowledge of ancient and modern hiſtory, and his refined taſte in the belles lettres. Dr Kippis frequently ſaid, that it was impoſſible for him to expreſs his obligations to this friend of his youth. In 1741 he removed to Northampton, and commenced his academical ſtudies under Dr Doddridge. After a reſidence of five years at the academy, he was invited by ſeveral congregations to become their miniſter. Though he was preſſed to ſettle at Dorcheſter, and had been choſen their miniſter, he gave the preference to an invitation from Boſton in Lincolnſhire, where he went to reſide in September 1746. Here he continued four years; and in November 1750, accepted the paſtoral charge of a congregation at Dorking in Surry. The congregation meeting in Princes-ſtreet Weſtminſter, having been without a miniſter about two years, he was choſen, in June 1753, to ſucceed the Rev. Dr Obadiah Hughes. On the 21ſt of September

ber following, he married, at Boſton, Miſs Elizabeth Bott, one of the daughters of Mr Iſaac Bott, a merchant of that place; and in the month of October fixed his reſidence in Weſtminſter. In June 1767, he received the degree of D. D. from the univerſity of Edinburgh, on the unſolicited recommendation of the late learned Profeſſor Robertſon. He was elected a member of the Society of Antiquaries on the 19th of March 1778; and on the 17th of June 1779, he was choſen a Fellow of the Royal Society. In both Societies he had the honour of being in the council two years.

Dr Kippis was eminently diſtinguiſhed for the virtues and accompliſhments which form the chief ornaments of private life. With a ſuavity of manners and urbanity of behaviour peculiarly attractive, he united that knowledge of men and books which rendered his converſation uncommonly entertaining and inſtructive to the circle of his acquaintance and friends. As a miniſter, he was not leſs eminent for his profound acquaintance with every branch of theology than for the happy manner in which he applied it to the improvement of thoſe who attended his miniſtry. His ſermons were remarkable for perſpicuity, elegance, and energy; and his elocution was unaffected and very impreſſive, particularly at the cloſe of his diſcourſes. But the ſuperior powers and vigour of mind which he derived from nature, and which he had cultivated with unremitting diligence and peculiar ſucceſs, were not to be confined to the narrow limits of private life and the duties of the paſtoral charge, however important; they were deſigned for more extenſive and important ſervices to his country and to mankind. The intereſts of literature, ſcience, and religion, have received from the exertion of his talents as a writer the moſt eſſential advantages. His firſt efforts in literature were made in the Gentleman's Magazine, a periodical publication called the Library, and the Monthly Review; to each of which he contributed many important articles, eſpecially in the hiſtorical and philological departments of the laſt. He was the author of three important tracts, viz "A Vindication of the Proteſtant Diſſenting Miniſters, &c." "Obſervations on the late Conteſts in the Royal Society;" and "Conſiderations on the Treaty with America, &c." His improved edition of Dr Doddridge's Lectures is a work of great value; and "The Hiſtory of Knowledge, Learning, and Taſte, in Great Britain," prefixed to the New Annual Regiſter, merits, and has received, the approbation of the public. He publiſhed at different times ſeveral ſingle ſermons; among which, that on the death of his friend the Rev. Mr Laugher, is intitled to very high praiſe. The greater part of theſe he republiſhed, with other practical diſcourſes, in the year 1794: but the work which, next to the ſtudies immediately connected with his office as a Chriſtian miniſter, engaged his principal attention, and by which he has long been diſtinguiſhed, is, the improved edition of the "*Biographia Britannica.*" In this great national publication, the comprehenſiveneſs and powers of his mind, the correctneſs of his judgment, the vaſt extent of his information, his indefatigable reſearches and unremitting aſſiduity, his peculiar talent of appreciating the merits, and analyzing the labours of the moſt eminent writers, and his unſhaken integrity, unbiaſſed fidelity, and impartial deciſion on the characters of the philoſopher, ſtateſman, poet, ſcholar, and divine, are ſtrongly diſplayed, and univerſally acknowledged. His ſtyle, formed on the models of Sir William Temple and the claſſical Addiſon, is remarkable for its perſpicuity, elegance, and purity; and gives a peculiar luſtre to the rich ſtores of knowledge treaſured in the volumes now publiſhed. This work has given him a high rank among the literati of his country, and will carry down his name with diſtinguiſhed reputation to poſterity. He died on the 8th October 1795.

KOL-QUALL, the Abyſſinian name of a tree, which ſome botaniſts have ſuppoſed to be the EUPHORBIA *Officinarum* of Linnæus. Mr Bruce, who gives the only deſcription of the Kol quall that we have ſeen, is of a different opinion: for which he aſſigns two reaſons; the firſt is, that the flower, which he ſays is roſaceous, is compoſed of ſeveral petals, and is not companiform; and the ſecond, that it produces no ſort of gum, either ſpontaneouſly or upon inciſion. We muſt acknowledge, that we entertain ſome doubts whether our author was at due pains to aſcertain this fact; and theſe doubts are ſuggeſted by his own hiſtory of the tree. His deſcription is not very perſpicuous, and therefore, leſt we ſhould miſrepreſent his meaning, we ſhall give it in his own words:

"The firſt thing that preſented itſelf was the firſt ſhoot of this extraordinary tree. It was a ſingle ſtalk, about ſix inches meaſured acroſs, in eight diviſions, regularly and beautifully ſcolloped and rounded at the top, joining in the centre at three feet and a half high. Upon the outſide of theſe ſcollops were a ſort of eyes or ſmall knots, out of every one of which came five horns, four on the ſides and one in the centre, ſcarce half an inch long, fragil, and of no reſiſtance, but exceedingly ſharp and pointed. Its next proceſs is to put out a branch from the firſt or ſecond ſcollop near the top, others ſucceed from all directions; and this ſtalk, which is ſoft and ſucculent, of the conſiſtence of the aloe, turns by degrees hard and ligneous, and after a few years, by multiplying its branches, aſſumes the form of a tree, the lower part of which is wood, the upper part, which is ſucculent, has no leaves; theſe are ſupplied by the fluted, ſcolloped, ſerrated, thorny ſides of its branches. Upon the upper extremity of theſe branches grow its flowers, which are of a golden colour, roſaceous, and formed of five round or almoſt oval petala; this is ſucceeded by a triangular fruit, firſt of a light green with a ſlight caſt of red, then turning to a deep crimſon, with ſtreaks of white both at top and bottom. In the inſide it is divided into three cells, with a ſeed in each of them; the cells are of a greeniſh white, the ſeed round, and with no degree of humidity or moiſture about it; yet the green leaves contain a quantity of bluiſh watery milk almoſt incredible.

"Upon cutting two of the fineſt branches of a tree in its full vigour, a quantity of this iſſued out, which I cannot compute to be leſs than four Engliſh gallons; and this was ſo exceedingly cauſtic, that though I waſhed the ſabre that cut it immediately, the ſtain has not yet left it.

"When the tree grows old, the branches wither, and, in place of milk, the inſide appears to be full of powder, which is ſo pungent, that the ſmall duſt which I drew upon ſtriking a withered branch, ſeemed to

Koona, Koraquas

threaten to make me ſneeze to death, and the touching of the milk with my fingers excoriated them as if ſcalded with boiling water; yet I everywhere obſerved the wood-pecker piercing the rotten branches with its beak, and eating the inſects, without any impreſſion upon its olfactory nerves.”

If what is milk in a young tree be a dry powder in one that is old, is it not probable that the milk might by evaporation be reduced to the conſiſtence of gum, and that the kol quall may be at moſt but a variety of the *euphorbia officinarum?* From our author's obſervation, the kol quall appeared to thrive beſt on poor, ſandy, ſtony earth, at no great diſtance from the ſea. The Abyſſinians employ the milky juice in tanning to take off the hair from the ſkins, and they make no other uſe whatever of the tree.

KOONA, a ſpecies of ECHITES (for which ſee *Encycl.*), very common in the woods of North Africa. It is a ſhrub, of which the leaves, when boiled with a ſmall quantity of water, yield a thick black juice, into which the negroes dip a cotton thread. This thread they faſten round the iron of their arrows, in ſuch a manner that it is almoſt impoſſible to extract the arrow when it has ſunk beyond the barbs, without leaving the iron and the poiſoned thread in the wound. The poiſon of the koona is ſaid to be very deadly.—*Park's Travels.*

KORAQUAS, a tribe of Hottentots inhabiting a diſtrict of South Africa, which M. Vaillant places on the confines of the Nimiqua country (See NIMIQUAS, *Suppl.*). When our author viſited them, the whole tribe was aſſembled for the election of a chief: and not agreeing among themſelves, ſome blood had been ſhed, and much more would have been ſhed, had they not unanimouſly made choice of him. When he firſt joined them, the whole horde paid attention to nothing but their quarrel. To ſee their warmth, one might have ſuppoſed that their election was a matter of importance to the whole world, and that the fate of mankind was about to depend on their chief. All ſpoke at the ſame time; each endeavoured to drown his neighbour's voice by his own; their eyes ſparkled with fury; and amidſt this confuſion, while they threatened each other in turns, the noiſe they made became truly dreadful.

Unarmed, and without any precaution, though ſurrounded by this enraged multitude, our author walked calmly along in the midſt of them; and when he reached the kraal, he ordered his tent to be immediately formed, as if he had been ſurrounded by friends and relations. This appearance, raiſed ſuddenly, and as if by magic, before the eyes of the horde, with his fuſees, horſes, and tent, objects which were all new to them, filled them with admiration. Men, women, and children, motionleſs, and with their mouths wide open, all ſtood looking at them with profound ſilence. Anger, hatred, and every violent paſſion, ſeemed by their countenances to be extinguiſhed, and to have given place to more tranquil emotions, to ignorant ſurpriſe, and ſtupid aſtoniſhment. Infancy is naturally curious; it is ſtruck with every thing it ſees; and the ſavage, in this reſpect, is only a grown-up child. As theſe ſavages ſeemed to wiſh that he would permit them to examine more cloſely whatever excited their admiration, he readily condeſcended to gratify their deſire. They approached, ſurveyed, and handled every thing. But the principal object of general curioſity was his perſon. They ſeemed as if they would never be ſatisfied with looking at his dreſs. They pulled off his hat, that they might the better examine his hair and his beard, which were long. They even half unbuttoned his clothes; and ſurpriſed to ſee his ſkin white, each felt it, as if deſirous to aſcertain that what they ſaw was real.

Koraquas.

This comedy continued till the evening; and at length, when the moment of ſeparation arrived, M. Vaillant cauſed to be hinted to the whole company, that if, two hours after ſun-riſe next morning, they ſhould not be agreed reſpecting the choice of a chief, he would immediately leave them. He added, however, that if, on the other hand, they came and preſented to him a chief, elected by general conſent, he would then load them all with preſents, and beſtow on him a diſtinction which would raiſe him above all his equals, and render the horde one of the moſt celebrated in the whole country. “But what was my ſurpriſe (ſays he) when I learned the ſame evening, that on my head the burden of the crown was depoſed!” He acquieſced, however; aſſuring them, that if they would promiſe to be obedient, he would give them the only chief worthy of ruling them, and of making them happy.

By his interpreters he had learned, that the choice of the majority leaned towards one Haripa, a man about 40 years of age; tall, well made, exceedingly ſtrong, and conſequently formed by nature for ruling the feeble multitude. He therefore named Haripa chief; and the people appearing to approve of his choice, he commanded ſilence, and cauſing the new monarch to approach, placed on his head, with great ſolemnity, a Dutch grenadier cap, of which the copperplate on the front was ornamented with the arms of Holland. This ſymbol, *viz.* a lion rampant, having in one of his fore-paws ſeven arrows, and in the other a naked ſabre, could not fail to pleaſe the ſavages, as it exhibited a repreſentation of the weapons peculiar to them, and of the moſt formidable animal of their country. They teſtified their admiration in the moſt expreſſive manner; and imagined that, ſuperior to kings, the white man during the night had by magic made this crown, merely to adorn their chief, and to afford them pleaſure. Vaillant then affixed to the ſkin, which formed Haripa's dreſs, ſeveral rows of glaſs beads; gave him a girdle made of a ſtring of very large ones; ornamented his arms with tin bracelets, and ſuſpended from his neck a ſmall padlock, ſhaped like a butterfly, the key of which had been loſt. Such padlocks, made in the form of animals of every kind, are very common at the Cape. They come from China; and are brought to Africa by the captains of the Company's ſhips which trade in the Indian ſeas.

During the ceremony of inſtallation, the whole horde, dumb and motionleſs through admiration, ſeemed loſt in ecſtacy. Haripa himſelf, though highly gratified, did not dare to make the leaſt movement, and obſerved a gravity altogether riſible. When the inauguration was finiſhed, and he was completely dreſſed, our author preſented him with a mirror, that he might enjoy the ſatiſfaction of ſurveying his own figure. He then ſhewed him to the people, who expreſſed their joy by ſhouts and applauſes without end.

“Ye honeſt hearts (ſays M. Vaillant), who peruſe this account, behold what it coſt me to reſtore peace among

among

among a whole tribe, and to prevent them from deſtroying each other!" From this moment concord was re-eſtabliſhed; univerſal joy prevailed through the horde; and they inſtantly began their dancings, which continued for three days and three nights without intermiſſion. They killed for this feſtival ſeveral fat ſheep, and even two oxen; an extraordinary and truly aſtoniſhing magnificence among a people who, when they barter one of their daughters for a cow, think they have made an excellent bargain.

Our author, wiſhing to purchaſe ſome oxen for his waggons, bought them at the price of a nail the ox; and thoſe who had the good fortune to make ſuch an exchange were highly ſatisfied with their bargain. Nails and ſmall bits of iron were indeed of real value to them, to point the arrows and aſſageys with which they ſhot the antelopes that abound in their country, and conſtitute much of their food. Like other ſavages, the Koraquas were ready to pilfer, and appropriate to their own uſe whatever they found pleaſing, or ſuited to their purpoſes. They attempted to carry away ſome of our author's effects, even before his face; and to prevent their rapacity, he was obliged either to watch over, or to depoſit them in ſome place of ſafety.

The Koraquas are much taller than the Hottentots of the colonies, though they appeared evidently to be deſcended from the ſame race, having the ſame language and cuſtoms with their neighbours the NIMIQUAS (ſee that article), who are certainly of Hottentot extraction.

As the exceſſive dryneſs of the country renders ſprings very rare, the Koraquas would be unable to inhabit it, had they not found the means of remedying this ſcarcity of water. For this purpoſe they dig in the earth a kind of ciſterns or rather wells, to which they deſcend gradually by ſteps; and theſe people are the only African nation among whom our author ever found the ſame mark of induſtry.

As their wells always contain little water, and as none is to be loſt, they take care to ſecure it even from the birds, by cloſing up the mouth of the hole with ſtones and the branches of trees; ſo that, unleſs one knows the ſpot, it is impoſſible to find it. They go down into it every day, to fetch up as much water as may be neceſſary for the conſumption of their people and cattle. They draw it in a kind of veſſels made of hollowed wood, and pour it into the ſkins of buffaloes or giraffes, placed in a concave form on the ground to hold it; but they diſtribute it with the utmoſt parſimony, and never draw more than they abſolutely have occaſion for.

Notwithſtanding this ſtrict economy, the wells often become dry; and in that caſe the horde is obliged to remove to ſome other place. Among all the weſtern tribes, therefore, there are none who lead ſo wandering a life as the Koraquas: the conſequence of which is, that, as they often change their abode, and acquire new neighbours, they muſt, in ſome meaſure, adopt the cuſtoms of the nations near which they fix their reſidence. Some tribes of them greaſe themſelves like the Hottentots; while others tattoo their face, breaſt, and arms, after the manner of the Caffres. It is, however, to be remarked, that the ſame colour is not employed by all the Koraquas; each has his own, according as caprice may direct him in his choice, and it generally varies every day; which renders, as one may ſay, the inhabitants of the ſame horde ſtrangers to each other, and gives them a motley appearance, as if they were dreſſed for a maſquerade.

KRISHNA or CRISNA, is an eaſtern river of conſiderable magnitude, which is very little known in Europe. We have the following account of it, and its tributary waters, and the countries through which it flows, in Mr Pennant's View of Hinduſtan:

"From Gangapatam, on the northern mouth of the Pennar, the land runs due north as far as Mottapilli, when it forms a ſtrong curve toward the eaſt; the point of which is one ſide of the great river Criſna, in about lat. 15° 43′. Its Delta, which winds round as far as Maſulipatam, is not conſiderable. This river annually overflows a vaſt tract of country, like the Indus on the weſtern ſide of this empire, and like all the other great rivers on this extenſive coaſt. The Criſna riſes from the foot of the weſtern Ghauts, and not more than 45 miles from Severndrug, on the weſtern coaſt. There is another branch to the eaſt, that riſes ſtill more northerly. On that ſide is Sattara, a ſtrong fortreſs, the capital of the Mahratta ſtate in the time of the rajahs of Sivaji's race. It was taken by him in 1673, and found to be the depoſitory of immenſe treaſure; at that time it belonged to the king of Vijapur: it was afterwards uſed by the Mahrattas as the lodgment of their riches, and alſo as a retreat for the more defenceleſs inhabitants of Puna, and other open towns, in time of potent invaſions.

"The river continues deſcending to the eaſt. In latitude 17° is Meritch, a ſtrong fortreſs, with a Jaghirdar territory, conquered from its owner by Hyder. In lat. 16° 45′, a ſmall river diſcharges itſelf into the Criſna from the north. It would not be worth mentioning, but that Pannela, a fortreſs of vaſt ſtrength, was made by Sumbuji, the profligate ſon of Sivaji, his reſidence juſt before his ſurpriſal in 1689, betrayed by Cablis Khan, the vile inſtrument of his pleaſures, corrupted by Aurengzebe. His extravagant love of women brought on him ruin. Informed by Cablis that a Hindu of rank and great beauty was on the road to be delivered by her parents to her huſband, according to the cuſtom of the Hindus, he inſtantly put himſelf at the head of a ſmall body of horſe to carry off the prize, and ordered Cablis to follow at a diſtance for his protection, in caſe of accidents in that hoſtile time. The traitor had given notice to Aurengzebe of this expedition, who, ſending a body of cavalry, ſurpriſed Sumbuji juſt as he had diſperſed the nuptial proceſſion.

"Into the north ſide of the Criſna, in lat. 16° 20′, falls the great river Bima, after a courſe of 350 miles. It riſes at the head of the weſtern Ghauts, parallel to Chaul in the Concan, and not above 50 miles from the ſea. It deſcends rapidly towards the ſouth-eaſt. In lat. 17° 40′ it receives a ſmall river from the weſt, on the ſouthern banks of which ſtands Vijapur, the capital of the famous kingdom of the ſame name, now poſſeſſed by the Mahrattas, but once governed by its own monarchs, till conquered by Aurengzebe in 1686. It was of great extent, and reached to the weſtern ſea, where it poſſeſſed the ports of Dabul, Vingorla, and Carapatan.

"The capital Vijapur is ſome leagues in circuit, ſeated in a fine but naked country, well watered. It makes a ſingular appearance from an adjacent eminence, filled with numbers of ſmall domes, and one of a majeſtic ſize.

ſize. It was once a city of great ſplendour, and filled with palaces, moſques, mauſoleums, and public and private buildings of great magnificence; many of them are fallen to ruin, and give melancholy proofs of its former ſplendour. I ſhall not attempt to detail them. The palaces of the kings, and accommodations for their attendants, were within a vaſt fort, ſurrounded with a ditch 100 yards wide; the depth appeared to be great, but is now filled with rubbiſh: within the fort is the citadel. Tavernier ſays, that the great ditch was filled with crocodiles, by way of garriſon, to prevent all acceſs by water. Lieutenant Moor has his doubts about this, imagining that there never was any water in this foſs. That ſuch garriſons have exiſted I doubt not. I have read in Purchas, that in Pegu the foſſes of fortified places were ſtocked with thoſe tremendous animals, not only to keep out enemies, but to prevent deſertion. This practice has certainly been of great antiquity in ſome parts of India: Pliny mentions it as uſed in a fair city of the Horatæ, a people I cannot trace.

“ The Criſna, above and below its conflux with the Bima, is fordable; and a few miles below its channel is 600 yards wide, made horrid with the number and rudeneſs of the variouſly formed rocks, which are never covered but in the rainy ſeaſon.

“ The Tungbuddra is another vaſt branch of the Criſna. It falls into it in lat. 16° 25′, and originates extremely ſouth, from a doubtful fountain. Towards its lower part it divides into three or four ſmall branches, which riſe remote from each other; the moſt ſouthern is the Curga Naïr's country; the moſt northern from the head of the Ghauts oppoſite to Onor, and ſcarcely 20 miles from the ſea. What muſt give this river great celebrity, is its having had on its banks, in lat. 15° 22′, the ſplendid city of Vijanagar. Feriſhta ſays, that it was founded in 1344 by Belaldeo king of the Carnatic, which in thoſe days included the whole peninſula. It was viſited by Cæſar Frederick a Venetian traveller, in 1565, and found deſerted and ruinous, having been ſacked by four confederated Mahomedan princes two years before, on which its monarch had retired to Penuconda. Frederick ſays that its circumference was 24 miles. Mr Rennel has given us a view of its preſent ſtate from Lieutenant Emitt, who viſited it in 1792.

“ The ruins of Vijanagar are in the little Sircar of Anagundi, which does not extend above 20 miles around this vaſt city. It is very ſingular, that that little Sircar is now poſſeſſed by a lineal deſcendant of Rama Rajah, the laſt great monarch of Vijanagar, and its attendant nations Canarine and Malabar, united 700 years before under the rule of Criſna Deva. Tippu wiſhed to reſerve this little tract to himſelf, for the ſatisfaction of generouſly reſtoring to the deſcendant the ſmall relique of the great empire of his anceſtors. He is denied the title of Rajah, inſtead of which he has the diminutive Raïl beſtowed on him. This is ſuitable to his revenues, which do not exceed two lacs of rupees, or 25,000 *per annum*, with the empty regality of a mint at Anagundi.” In the remainder of its courſe the Criſna offers nothing remarkable.

KUARA, is a beautiful tree, which grows in the ſouth and ſouth-weſt parts of Abyſſinia. With the ebony it is almoſt the only wood of the province of Kuara, of which it bears the name; but Mr Bruce aſſures us, that it is very frequent in all the countries where there is gold. “ It is (ſays he) what naturaliſts call *a Corallodendron*, probably from the colour of its flowers or of its fruit, both equal in colour to coral. Its fruit is a red bean, with a black ſpot in the middle of it, which is incloſed in a round capſula or covering, of a woody nature, very tough and hard. This bean ſeems to have been in the earlieſt ages uſed for a weight of gold among the Shangalla, and, where that metal is found, all over Africa; and by repeated experiments, I have found that, from the time of its being gathered, it varies very little in weight, and may perhaps have been the very beſt choice that therefore could have been made between the collectors and buyers of gold.

“ I have ſaid this tree is called kuara, which ſignifies the ſun. The bean is called *carat*, from which is derived the manner of eſteeming gold as ſo many carats fine. From the gold country in Africa it paſſed to India, and there came to be the weight of precious ſtones, eſpecially diamonds; ſo that to this day in India we hear it commonly ſpoken of gold or diamonds, that they are of ſo many carats fine or weight. I have ſeen theſe beans likewiſe from the Weſt-Indian iſlands. They are juſt the ſame ſize, but, as far as I know, are not yet applied to any uſe there.”

This is a very different account of the origin of the term CARAT from what we have given in the *Encyclopædia*; but the reader will judge for himſelf between the two.

KUMI, the name of an iſland between Japan and China, of which Perouſe writes in the following terms: “ On the 5th of May, at one o'clock in the morning, we made an iſland, which bore north-north eaſt of us; we paſſed the reſt of the night, ſtanding off and on, under an eaſy ſail, and at day-break I ſhaped my courſe ſo as to run along the weſt coaſt of this iſland, at the diſtance of half a league. We ſounded ſeveral times without finding bottom. We were ſoon ſatisfied that this iſland was inhabited, for we ſaw fires in ſeveral places, and herds of oxen grazing on the ſea-ſhore. When we had doubled its weſt point, which is the moſt beautiful and beſt inhabited ſide, ſeveral canoes put off from the ſhore in order to obſerve us. They ſeemed to be extremely in fear of us; their curioſity cauſed them to advance within muſket ſhot, and their diſtruſt made them immediately flee away with ſpeed. Our ſhouts, geſtures, ſigns of peace, and the ſight of ſome ſtuffs, at length determined two of the canoes to come alongſide of us. I made each of them a preſent of a piece of nankeen and ſome medals. It was evident that theſe iſlanders had not left the coaſt with any intention of trafficking with us, for they had nothing to offer in exchange for our preſents; they only faſtened to a rope a bucket of freſh water, making ſigns to us, that they ſtill thought themſelves in our debt, but that they were going aſhore to fetch proviſion, which they expreſſed by putting their hand into their mouth. Before coming alongſide the frigate, they placed their hands upon their breaſt, and raiſed their arms towards the ſky: theſe geſtures were repeated by us, and then they reſolved to come on board; but it was with a want of confidence, which was ſtrongly expreſſed in their countenance during the whole time. They nevertheleſs invited us to approach the land, giving us to underſtand, that we ſhould there want for nothing. Theſe iſlanders

Kumi, Kuriles.

are neither Japaneſe nor Chineſe, but, ſituate between theſe two empires, they ſeem to partake of both people. Their covering was a ſhirt and a pair of cotton drawers Their hair, tucked up on the crown of the head, was rolled round a needle, which ſeemed to us to be gold : each of them had a dagger, the handle of which was gold alſo. Their canoes were made out of hollowed trees, and they managed them very indifferently. I could have wiſhed to land upon this iſland, but as we had brought the ſhip to, in order to wait for theſe canoes, and as the current ſet to the northward with extreme rapidity, we had drifted a great way to leeward, and our efforts to reach it would perhaps have been in vain : beſides, we had not a moment to loſe, and it was of the higheſt importance to us to get out of the Japan ſeas before the month of June ; a period of ſtorms and hurricanes, which render theſe ſeas the moſt dangerous in the whole world.

"It is clear, that veſſels which might be in want would readily provide themſelves with proviſion, wood, and water, in this iſland, and perhaps even carry on a little trade ; but as it is not more than three or four leagues in circumference, there is no great probability that its population exceeds four or five hundred perſons; and a few gold needles are not of themſelves a proof of wealth." Our author, by obſervation, found the latitude of Kumi to be 24° 33′ north ; its longitude 120° 56′ eaſt from Paris.

KURILES, are a cluſter of iſlands, of which ſome account has been given under the word Kuril, in the *Encyclopædia*. In addition to that article, the following particulars are worthy of notice : Of the 21 iſlands belonging to Ruſſia, which are diſtinguiſhed from each other, not by names, but by numbers, four only are inhabited, viz. thoſe which are called the firſt, the ſecond, the thirteenth, and the fourteenth. The laſt two may indeed be counted only as one, becauſe the inhabitants all paſs the winter upon N° 14, and return to N° 13 to paſs the ſummer months. The others are entirely uninhabited, the iſlanders only landing there occaſionally from their canoes for the ſake of hunting foxes and otters. Several of theſe laſt mentioned iſlands are no better than large rocks, and there is not a tree on any one of them. The currents are very violent between the iſlands, particularly at the entrance of the channels, ſeveral of which are blocked up by rocks on a level with the ſea. The population of the four inhabited iſlands amounts at moſt to 1400 ſouls. The inhabitants are very hairy, wear long beards, and live entirely upon ſeals, fiſh, and the produce of the chace. When viſited by M. Perouſe, they had juſt been exempted for ten years from the tribute uſually paid to Ruſſia, becauſe the number of otters on their iſlands is very much diminiſhed. Theſe poor people are good, hoſpitable, and docile, and have all embraced the Chriſtian religion. The more ſouthern and independant iſlanders ſometimes paſs in canoes the channels that ſeparate them from the Ruſſian Kuriles, in order to give ſome of the commodities of Japan in exchange for peltries.

L.

Labdaſſeba, Laboratory.

LABDASSEBA, a tribe of ſavage Arabs who inhabit the deſart of Sahara in Africa. They are the moſt powerful of all thoſe tribes except the Ouadelims ; and they reſemble theſe ſo much in every thing, that we ſhall give an account of the manners of both under the title Ouadelims, and of their country under that of Sahara.

LABORATORY, is an apparatus ſo neceſſary to the chemiſt, that every contrivance to render it more convenient, or to leſſen the expence of it, muſt contribute greatly to the advancement of ſcience. The abilities of *Morveau* alias *Guyton*, and the ſucceſs with which he has proſecuted the ſtudy of chemiſtry, are well known ; and therefore his different methods of ſaving time and expence in making chemical experiments muſt be worthy of the notice of younger chemiſts.

In the ſecond volume of the Memoirs of the Ancient Academy of Dijon, we have a deſcription by him of a box containing a kind of portable laboratory, compoſed of a lamp with three wicks, diſpoſed in the figure of an equilateral triangle, to form an internal current of air, with ſupports for the different veſſels of digeſtion, diſtillation, evaporation, &c. He made a ſolution of ſilver with common aqua fortis and the metal in an alloyed ſtate, which anſwered very well as a re-agent, without having occaſion for any other utenſils but this box and apothecary's phials, which are every where to be found.

Laboratory.

This apparatus, however, was confined in its application, and he ſoon thought of improving it. He conſtructed a lamp, on the principles of Argand, with three concentric circular wicks, each having an interior and exterior current of air. The effect ſurpaſſed his expectations with regard to the intenſity of the heat ; but it was difficult to prevent the deſtruction of the hard ſolder round the wicks ; and the glaſs retorts were frequently melted at the bottom, and disfigured. It was attended with other inconveniences, and the quantity of oil conſumed was great.

A ſhort time afterwards, it occurred him to ſubſtitute, inſtead of the glaſs chimney of Argand's lamp, a cylinder of copper with an indented part or ledge a few millimetres (ſee Revolution, *Encycl.* n° 183.) above the flame, to perform the office of the indented chimney of glaſs, and by that means to render it practicable to raiſe the wick to a certain height without ſmoaking. This cylinder has three branches like a chaffing-diſh. By this apparatus two or three decilitres of water (about half an Engliſh wine pint) may be brought to boil in a copper or glaſs veſſel in about ſix or ſeven minutes. It has ſerved for a number of operations ; but it was not till after he had obſerved the degree of heat obtained from the lamp in its ordinary ſtate, and particularly ſince he had ſubſtituted inſtead of the metallic tube a chimney of glaſs cut off at the length of three centimetres (rather more than one Engliſh inch) above the contraction, that he perceived all the advantages it was capable of affording; and that by means of a moveable ſupport for the reception of the different veſſels, which may be fixed at pleaſure by a thumb-ſcrew, this lamp furnace, at the ſame time that it gives light, and conſequently without any additional expence, may with facility be uſed for almoſt every one of the operations of chemiſtry; ſuch as digeſtions, ſolutions, cryſtallizations, concentrations; the rectification of acids; diſtillations on the ſand-bath, or by the naked fire; incinerations of the moſt refractory reſidues; analyſes with the pneumatic apparatus, or of minerals by the ſaline fuſion, &c. "I have not (ſays he) hitherto met with any exception but for complete vitrifications and cupellations; for even the diſtillations to dryneſs may be performed with ſome precautions, ſuch as that of transferring the matter into a ſmall retort blown by the enameller's lamp, and placing its bottom on a little ſand-bath in a thin metallic diſh." The ſupport here mentioned is ſimply a copper ring eight centimetres (3,15 inch.) in diameter, which is raiſed or lowered by ſliding on a ſtem of the ſame metal. Nothing more was required but to adapt it to the ſquare iron ſtem which paſſes through the reſervoir of the lamp. The connection is made by a piece of wood, in order that leſs of the heat might be diſperſed. As the lamp itſelf is capable of being moved on its ſtem, it is eaſy to bring it nearer or remove it at pleaſure from the veſſels, which remain fixed; a circumſtance which, independent of the elevation or depreſſion of the wick, affords the means of heating the retorts by degrees, of moderating or ſuppreſſing the fire inſtantly, or of maintaining it for ſeveral hours at a conſtant or determinate intenſity, from the almoſt inſenſible evaporation of cryſtallizable ſolutions to the ebullition of acids; properties never poſſeſſed by the athanor, of which chemiſts have boaſted ſo much. The advantage of theſe will be properly valued by thoſe operators who know that the moſt experienced and the moſt attentive chemiſts meet with frequent accidents, by which both their veſſels and the products of their operations are loſt for want of power in the management of the fire."

For the analyſis of ſtones, ſuch as the cryſtals of tin, the ſhortened chimney of glaſs is to be uſed; and the proceſs is to be begun by placing the mixture in a capſule of platina or ſilver $2\frac{3}{4}$ inches in diameter. This capſule is to be placed on the ſupport, and the heat regulated in ſuch a manner, that ebullition ſhall take place without throwing any portion of the matter out of the veſſel. As ſoon as its contents are perfectly dry, they are to be transferred into a very thin crucible of platina, of which the weight is about $252\frac{1}{2}$ grains Engliſh, and its diameter one inch and three-fourths. This crucible reſts on a ſmall ſupport of iron-wire, which ſerves to contract the ring; and the wick being at its greateſt elevation, with the ring lowered to the diſtance of $9\frac{3}{4}$ inches from the upper rim of the chimney, Guyton produced, in leſs than twenty minutes, the ſaline fuſion to ſuch a degree, that from the commencement of the operation the decompoſition proceeded as far as to 0.70 of the mineral. The ſame apparatus, that is to ſay, with the ſhortened chimney, ſerves for oxidations, incinerations, torrefactions, and diſtillations to dryneſs.

In ſuch operations as require a leſs heat, he leaves the lamp with its large chimney abſolutely in the ſame ſtate as when it is uſed for illumination; and by raiſing and lowering either the ring which ſupports the veſſel, or the body of the lamp if the veſſels be fixed in communication with others, he graduates the heat at pleaſure. Vinegar diſtils without interruption at $2\frac{1}{3}$ inches Engliſh from the upper termination of the chimney, that is to ſay, $7\frac{1}{2}$ inches Engliſh from the flame. Water is made to boil in eight minutes, at the ſame height, in a glaſs veſſel containing one wine pint Engliſh, and is uniformly maintained at the diſtance of $8\frac{2}{3}$ inches from the flame.

"I muſt not in this place (ſays our author) omit to mention a ſlight obſervation which this proceſs has afforded, becauſe it may lead to uſeful applications, and tends to point out one great advantage of this method of operating; namely, that an infinity of circumſtances may be perceived, which might not even be ſuſpected when the whole proceſs is carried on within a furnace. I have remarked, as did likewiſe ſeveral of my colleagues who were then preſent, that a column of bubbles conſtantly roſe from a fixed point of the retort on one ſide of the bottom. We were of opinion, that ſome particle of matter was in that place incorporated with the glaſs, which had a different capacity for heat from that of the reſt of the glaſs. In order to verify this conjecture, I endeavoured the following day to diſtil the ſame quantity of the ſame water in the ſame retort, after having introduced a button of cupelled ſilver, weighing nine decigrammes ($20\frac{1}{2}$ grains). At the commencement of the operation there was a ſmall ſtream of bubbles from the ſame point as before; but a ſhort time afterwards, and during the whole remaining time of operating, the largeſt and moſt inceſſant ſtream of bubbles roſe from the circumference of the button, which was often diſplaced by the motion; and in proportion to the time the product of the diſtillation was ſenſibly greater. Whence we may conclude, that metallic wires or rods, diſtributed through a maſs of water required to be kept in a ſtate of ebullition, and placed a little below its ſurface, would produce, without any greater expence of fuel, nearly the ſame effect as thoſe cylinders filled with ignited matter which are made to paſs through the boilers."

We have related this fact in Guyton's own words, or at leaſt in a faithful tranſlation of them; and we are far from calling it in queſtion, for it is a fact which has been often obſerved; but we think his inference from it too haſtily drawn. It is not conceivable that heat can be more rapidly conveyed through a maſs of liquid by the conducting power of metal, than by a free circulation; but we agree with what ſeems to be Mr Nicholſon's opinion *, that the thin ſtratum of water beneath the button becomes more ſuddenly and violently elaſtic than elſewhere, and therefore riſes regularly to the ſurface. The whole of this phenomenon the reader will find explained in our article STEAM (*Encycl.*), n° 10. But this is a digreſſion.

We return therefore to Guyton's laboratory, of which the reader will form a diſtinct notion from plate XXXIII. where fig. 1. repreſents the whole apparatus ready mounted for diſtillation, with the tube of ſafety and a pneumatic receiver. A is the body or reſervoir of the uſual lamp of Argand, with its ſhade and glaſs chimney. The lamp may be raiſed or lowered at pleaſure by means of the thumb ſcrew B, and the wick riſes and

---

* *Journal*, Auguſt 1798, note, page 212.

and falls by the motion of the ſmall toothed wheel placed over the waſte cup. This conſtruction is moſt convenient, becauſe it affords the facility of altering the poſition of the flame with regard to the veſſels, which remain fixed; and the troubleſome management of bended wires above the flame for the ſupport of the veſſels is avoided, at the ſame time that the flame itſelf can be brought nearer to the matter on which it is intended to act. D, a ſupport conſiſting of a round ſtem of braſs, formed of two pieces which ſcrew together at about two thirds of its height. Upon this the circular ring E, the arm F, and the nut G ſlide, and are fixable each by its reſpective thumb-ſcrew. The arm alſo carries a moveable piece H, which ſerves to ſuſpend the veſſels in a convenient ſituation, or to ſecure their poſition. The whole ſupport is attached to the ſquare iron ſtem of the lamp by a piece of hard wood I, which may be fixed at any required ſituation by its ſcrew. K repreſents a ſtand for the receivers. Its moveable tablet L is fixed at any required elevation by the wooden ſcrew M. The piece which forms the foot of this ſtand is fixed on the board N; but its relative poſition with regard to the lamp may be changed by ſliding the foot of the latter between the pieces OO. P, another ſtand for the pneumatic trough. It is raiſed or lowered, and fixed to its place, by a ſtrong wooden ſcrew, Q. R is a tube of ſafety, or reverſed ſyphon, which ſerves, in a great meaſure, to prevent the bad effects of having the veſſels either perfectly cloſed, or perfectly open. Suppoſe the upper bell-ſhaped veſſel to be nearly of the ſame magnitude as the bulb at the lower end of the tube, and that a quantity of water, or other ſuitable fluid, ſomewhat leſs than the contents of that veſſel, be poured into the apparatus: In this ſituation, if the elaſticity of the contents of the veſſels be leſs than that of the external air, the fluid will deſcend into the bulb, and atmoſpheric air will follow and paſs through the fluid into the veſſels: but, on the contrary, if the elaſticity of the contents be greater, the fluid will be either ſuſtained in the tube, or driven into the bell-ſhaped veſſel; and if the force be ſtrong enough, the gaſeous matter will paſs through the fluid, and in part eſcape.

Fig. 2. Shews the lamp furnace diſpoſed to produce the ſaline fuſion; the chimney of glaſs ſhortened; the ſupport D turned down; the capſule of platina or ſilver S placed on the ring very near the flame.

Fig. 3. The ſame part of the apparatus, in which, inſtead of the capſule, a very thin and ſmall crucible of platina T is ſubſtituted, and reſts upon a triangle of iron wire placed on the ring.

Fig 4. Exhibits the plan of this laſt diſpoſition.

LACERTA, in aſtronomy. See ASTRONOMY, nº 406. *Encycl.*

LACMUS, a dye ſtuff prepared by the Dutch from the LICHEN ROCELLA, which ſee in this *Supplement*.

LACSHA, the Indian name of the lac inſect, which has been deſcribed in the *Encyclopædia* under the title COCCUS, *Species* 5. Since that article was publiſhed, a deſcription of that inſect, which is more to be depended upon, has been given to the world in the ſecond volume of the Aſiatic Reſearches. It is by Mr Roxburgh, ſurgeon on the Madras eſtabliſhment, and was communicated to the Society by Dr James Anderſon phyſician at Fort St George, who obſerves, that Mr Roxburgh's diſcovery will bring the lacſha as a genus into the claſs *Hemiptera* of Linnæus.

"Some pieces of very freſh-looking lac (ſays Mr Roxburgh) adhering to ſmall branches of mimoſa cinerea, were brought me from the mountains on the 20th of November 1789. I kept them carefully, and to-day, the 4th of December, fourteen days from the time they came from the hills, myriads of exceedingly minute animals were obſerved creeping about the lac and branches it adhered to, and more ſtill iſſuing from ſmall holes over the ſurface of the cells: other ſmall and perforated excreſcences were obſerved with a glaſs amongſt the perforations, from which the minute inſects iſſued, regularly two to each hole, and crowned with ſome very fine white hairs. When the hairs were rubbed off, two white ſpots appeared. The animals, when ſingle, ran about pretty briſkly, but in general they were ſo numerous as to be crowded over one another. The body is oblong, tapering moſt towards the tail, below plain, above convex, with a double, or flat margin: laterally on the back part of the thorax are two ſmall tubercles, which may be the eyes: the body behind the thorax is croſſed with twelve rings: legs ſix; feelers (antennæ) half the length of the body, jointed, hairy, each ending in two hairs as long as the antennæ: rump, a white point between two terminal hairs, which are as long as the body of the animal. The mouth I could not ſee. On opening the cells, the ſubſtance that they were formed of cannot be better deſcribed, with reſpect to appearance, than by ſaying it is like the tranſparent amber that beads are made of: the external covering of the cells may be about half a line thick, is remarkably ſtrong, and able to reſiſt injuries: the partitions are much thinner: the cells are in general irregular ſquares, pentagons and hexagons, about an eighth of an inch in diameter, and one quarter deep: they have no communication with each other. All thoſe I opened during the time the animals were iſſuing, contained in one half, a ſmall bag filled with a thick red jelly-like liquor, replete with what I take to be eggs: theſe bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which paſs through perforations in the external coat of the cells, forming the fore-mentioned excreſcences, and ending in ſome very fine hairs. The other half of the cells have a diſtinct opening, and contain a white ſubſtance, like ſome few filaments of cotton rolled together, and numbers of the inſects themſelves ready to make their exit. Several of the ſame inſects I obſerved to have drawn up their legs, and to lie flat: they did not move on being touched, nor did they ſhew any ſigns of life with the greateſt irritation.

" *December* 5. The ſame minute hexapedes continue iſſuing from their cells in numbers: they are more lively, of a deepened red colour, and fewer of the motionleſs ſort. To-day I ſaw the mouth: it is a flattened point about the middle of the breaſt, which the little animal projects on being compreſſed.

" *December* 6. The male inſects I have found to-day: a few of them are conſtantly running among the females moſt actively: as yet they are ſcarce more, I imagine, than one to 5000 females, but twice their ſize. The head is obtuſe; eyes black, very large; antennæ clavated, feathered, about ⅔ds the length of the body: below the middle an articulation, ſuch as thoſe in the legs: colour between the eyes a beautiful ſhining green: neck very ſhort: body oval, brown: abdomen oblong, the length of body and head: legs ſix: wings membranaceous, four, longer than the body, fixed to the ſides of the

the thorax, narrow at their inſertions, growing broader for ⅔ds of their length, then rounded; the anterior pair is twice the ſize of the poſterior: a ſtrong fibre runs along their anterior margins: they lie flat, like the wings of a common fly when it walks or reſts: no hairs from the rump: it ſprings moſt actively to a conſiderable diſtance on being touched: mouth in the under part of the head: maxillæ tranſverſe. To-day the female inſects continue iſſuing in great numbers, and move about as on the 4th.

"*December* 7. The ſmall red inſects ſtill more numerous, and move about as before: winged inſects, ſtill very few, continue active. There have been freſh leaves and bits of the branches of both *Mimoſa Cinerea* and *Corinda* put into the wide mouthed bottle with them: they walk over them indifferently, without ſhewing any preference, or inclination to work or copulate. I opened a cell whence I thought the winged flies had come, and found ſeveral, eight or ten, more in it, ſtruggling to ſhake off their incumbrances: they were in one of thoſe utriculi mentioned on the 4th, which ends in two mouths, ſhut up with fine white hairs, but one of them was open for the exit of the flies; the other would no doubt have opened in due time: this utriculus I found now perfectly dry, and divided into cells by exceeding thin partitions. I imagine, before any of the flies made their eſcape, it might have contained about twenty. In theſe minute cells with the living flies, or whence they had made their eſcape, were ſmall dry dark coloured compreſſed grains, which may be the dried excrements of the flies."

LAMANON (Robert Paul), of the academy at Turin, correſpondent of the Academy of Sciences at Paris, and member of the Muſeum in the ſame city, was born at Salon in Provence, in 1752, of an old and reſpectable family. Being a younger ſon, he was deſtined for the church, and ſent to Paris to complete his theological ſtudies; but getting acquainted with the philoſophers (as they called themſelves), he ſoon loſt all reliſh for the ſtudy of theology, and devoted himſelf to the phyſical ſciences, eſpecially thoſe of chemiſtry and mineralogy. Into the church, however, he got, and roſe to the dignity of canon; but by the death of his father and elder brother, having acquired the right of directing his own future exertions, he haſtened to quit a profeſſion, towards which he felt no partiality.

A prelate, then in high favour at court, hearing of Lamanon's intention of quitting his office of canon, offered him a conſiderable ſum, to induce him to reſign in favour of one of his dependents. The chapter of Arles, replied our young eccleſiaſtic, did not ſell me my benefice, I ſhall therefore reſtore it in the ſame manner that I received it. This conduct was certainly meritorious; and his eulogiſt *Ponce* mentions another trait of his character, which ſets him in a very amiable point of view; he refuſed to accept of his paternal inheritance, otherwiſe than as an equal ſharer with his brothers and ſiſters.

Thus liberated from the trammels of his former profeſſion, Lamanon applied himſelf with uncommon ardour to ſtudy. Eager to raiſe the awful veil that conceals from our eyes the ſecrets of nature; perſuaded, that even the greateſt genius only amuſes itſelf with falſe ſyſtems in the ſilence of a cabinet; convinced of the neceſſity of much and various obſervation, and of ſurpriſing Nature, as it were, in the very fact, in order to penetrate into the ſublimity of her operations;—our young philoſopher travelled through Provence and Dauphine, and ſcaled the Alps and Pyrenees. At the ſight of theſe vaſt natural laboratories the bent of his mind burſt forth inſtantaneouſly: he climbed to the ſummit of rocks, and explored the abyſs of caverns, weighed the air, analyſed ſpecimens, and, in his ardent fancy, having attained the ſecrets of creation, he formed a new ſyſtem of the world. On his return home, he applied with additional intereſt to the ſtudy of meteorology, mineralogy, natural philoſophy, and the other branches of the hiſtory of nature.

Whilſt he was meditating a viſit to Paris for the purpoſe, as his eulogiſt expreſſes himſelf, of converſing with the luminaries of ſcience, the inhabitants of the commune of Salon, having loſt a cauſe againſt their lord, unanimouſly elected Lamanon, with whoſe integrity and abilities they were well acquainted, to go and ſolicit of the council the repeal of an unjuſt decree that had been obtained by partiality. The reply of the young philoſopher on this occaſion is an additional proof of his uncommon diſintereſtedneſs. "As I intend (ſaid he) to go to Paris on buſineſs of my own, I cannot think of accepting your offer of 24 livres daily pay: a twelfth of this ſum will cover the extraordinary expences of the journeys that I ſhall be obliged to make to Verſailles on your account." He had the ſatisfaction of complete ſucceſs in the buſineſs thus undertaken.

Having ſatisfied his curioſity in Paris, he went over to England. During the paſſage, though much incommoded by ſea ſickneſs, and in imminent hazard of being overwhelmed by the tumbling waves of a very ſtormy ſea, he cauſed himſelf to be tied to the main-maſt, in order to contemplate at leiſure ſo grand and fearful a ſpectacle. The burſts of thunder, the howling of the wind, the brilliancy of the lightning, the glancing of the ſpray which covered him every moment, theſe objects, ſo terrible to an ordinary man, threw him into a kind of mental intoxication, and he has often declared, that this day was the moſt exquiſite of his whole life.

Convinced that the friendſhip of an eminent man elevates the ſoul, excites generous emulation, and becomes an additional ſtimulus to one whoſe delight is ſtudy, and whoſe moſt preſſing want is an object on which to place his affection, Lamanon anxiouſly endeavoured to merit the regard of CONDORCET, ſo well known by his talents, his impieties, his rebellion, and his misfortunes. This academician, juſtly conſidering that an apoſtate prieſt would be ready to join the conſpiracy of the philoſophiſts againſt the altar and the throne, received Lamanon with diſtinction, and at length admitted him to his moſt intimate friendſhip.

During the three ſucceſſive years that Lamanon ſpent at Paris, he followed with care the track of thoſe learned ſocieties, of which he had been elected a member. He became at this period, together with Count de Gebelin, and ſome other philoſophers and artiſts, one of the founders of the Muſeum, the greater part of the members of which are now reunited in the open ſociety of ſciences, letters, and arts, at Paris. Among the different papers of his that were read at various meetings of theſe ſocieties, Ponce mentions with particular approbation what he calls *a notice* of Adam de Crapone, an eminent hydraulic engineer; a memoir on the Cretins; a memoir on the theory of the winds; a treatiſe on the alteration in the courſe of rivers, particularly the Rhone; and another on an enormous bone belonging to to ſome cetaceous fiſh, that was dug up at Paris in laying the foundations of a houſe in the *rue Dauphine*. We have not ſeen theſe memoirs; but as their author was the friend of Condorcet, and fancied that he had attained the ſecrets of creation, we can eaſily conceive their tendency.

Having reſolved again to reviſit Switzerland and Italy, Lamanon firſt went to Turin, where he allied himſelf to the learned of that country. During his ſtay there, the brilliant novelty diſcovered by Montgolfier was occupying the attention of all the philoſophers of Europe. Lamanon, deſirous of making ſome experiments of this kind himſelf, aſcended in a balloon from the city of Turin; but not perceiving in this diſcovery, which had at firſt highly intereſted him, an object of public utility; not foreſeeing, that one day, on the plains of Fleurus, it would be the cauſe of rallying and eſtabliſhing victory under the ſtandards of France, he returned to his favourite occupations. Purſuing his route from Piedmont, he viſited Italy, and returned by Switzerland, where he explored the Alps and aſcended the ſummit of Mont Blanc: thence returning, loaden with the ſpoils of the countries which he had traverſed, to Provence, he employed himſelf in the arrangement of the intereſting fruits of his journey.

Of the ſcrupulous exactneſs of his obſervations, his eulogiſt gives the following inſtance: "Being convinced that the plain of Crau, divided by the channel of the Durance, had formerly been a lake, he wiſhed to be abſolutely aſſured of it. For this purpoſe he collected a ſpecimen of each of the ſtones that are to be found in this vaſt plain; the number of theſe he found to amount to nineteen; then tracing the courſe of the river towards its head, near the frontiers of Savoy, he obſerved, that above each junction of the tributary ſtreams with the Durance, the variety of pebbles diminiſhed. Afterwards aſcending the current of each of theſe ſmaller ſtreams, he diſcovered on their banks the original rock of every pebble that overſpreads the plain of Crau; thus inconteſtably proving, that this plain was anciently a lake formed by the waters of the Durance, and the ſtreams that fall into it. If all philoſophers (ſays our author) would conduct their examinations with equal preciſion, certain hypotheſes, more brilliant than ſolid, would not find ſo many admirers; the charm of imagination, and the graces of ſtyle, would not ſo often encroach upon the impreſcriptible rights of nature and truth."

To citizen Ponce this appears a demonſtration of Lamanon's theory; but we cannot ſay that it does ſo to us. It may be a kind of proof, though not a demonſtration, that in ſome convulſion of nature, ſtones had been rolled from the rock, and the plain of Crau, for a time, overflowed by the Durance; but it ſurely furniſhes no evidence of that plain's having ever been *a permanent lake*. It *may* have been ſo; but ſuch inveſtigations as this will not guard philoſophers againſt the deluſions of favourite hypotheſes.

It was at the time when Lamanon was preparing for the preſs his great work on the *Theory of the Earth*, that the French government conceived the vaſt project of completing the diſcoveries of Captain Cook: the academy of ſciences was entruſted with the care of ſelecting men capable of rectifying our notions of the ſouthern hemiſphere, of improving hydrography, and advancing the progreſs of natural hiſtory. Condorcet, not knowing any one better qualified for this laſt department than Lamanon, wrote to him an invitation to ſhare the danger and glory of this great enterprize. He accepted with eager tranſport a propoſal that fulfilled his higheſt expectations, haſtened to Paris, refuſed in a conference with the miniſter the ſalary that was offered, took a haſty leave of his friends, and departed for Breſt.

On the 1ſt of Auguſt 1785, the armament ſet ſail under the orders of La Perouſe, an experienced commander, whoſe patriotiſm and ſcientific zeal were equal to his courage and good ſenſe, and who had already merited the public confidence. The philoſophers of all Europe were in expectation of thoſe uſeful diſcoveries, the probable fruit of the zeal and talents employed in the expedition. The beginning of the voyage was proſperous. After various delays, and a multitude of obſervations, the two veſſels arrived at the iſland of Maouna, one of the ſouthern Archipelago. The impatient Lamanon, eager to aſſure himſelf of the truth of the publiſhed accounts of that country, debarked with Langle, the ſecond in command. At the moment of their return, the natives, in hopes of booty, which had been excited by the number of preſents that they had received, ſeized upon the boats, and attacked the party. The French were obliged to have recourſe to arms for ſelf defence, and a deſperate combat enſued. Lamanon, Langle, and ten of the two boats crews, fell a ſacrifice to the fury of theſe barbarians.

Thus periſhed Lamanon, a young man ardent in the purſuits of ſcience, to a high degree diſintereſted, and a zealot in what he thought the cauſe of liberty. He refuſed the ſalary which was allotted to him when he was appointed to this unfortunate expedition; for "if I do not feel ſatisfied (ſaid he) on board the veſſel; if my inclination or curioſity lead me to quit the ſhip,—I ſhould be unhappy if any power in the world had acquired the right of preventing me."

According to M. Ponce, Lamanon ſeemed born to bring about a revolution in ſcience: the depth of his ideas, the energy of his character, the ſagacity of his mind, united to that lively curioſity that can draw inſtruction out of any thing, and leaves nothing unexplored, would have led him to the moſt valuable diſcoveries. In perſon he was tall; and to great vivacity and expreſſion of feature added prodigious ſtrength and activity; in a word, Nature formed him with ſuch care, as if ſhe had intended him for one of thoſe few who are deſtined to great exploits. His ſtyle was nervous, often poetical, without loſing ſight of propriety, and the language of ſentiment might frequently be diſcovered in the midſt of ſtrong and ſtriking expreſſions; and if he wanted the exquiſitely dazzling poliſh of diction, he was eminently gifted with the preciſion of logical reaſoning, which commands attention and enforces perſuaſion.

LAMP (ſee *Encycl.*) is an inſtrument compriſing three articles which demand our attention, *viz.* the oil, the wick, and the ſupply of air. It is required that the oil ſhould be readily inflammable, without containing any fetid ſubſtance which may prove offenſive, or mucilage, or other matter, to obſtruct the channels of the wick. Mr Nicholſon ſays *, that he knows of no proceſs by which oils can be meliorated for this purpoſe, except that of waſhing with water containing acid or alkali. Either of theſe is ſaid to render the mucilage of animal oils more ſoluble in water; but acid is to be preferred, becauſe

---

* *Journal*, vol. i. n° 2.

because it is leſs diſpoſed to combine with the oil itſelf. Perhaps oil might be deprived of all fetid ſmell in burning, by being made to paſs through Collier's filtering apparatus, deſcribed under the word FILTER in this *Suppl.*

The office of the wick appears to be chiefly, if not ſolely, to convey the oil by capillary attraction to the place of combuſtion. As the oil is conſumed and flies off, other oil ſucceeds, and in this way a continued current of oil and maintenance of the flame are effected. But as the wicks of lamps are commonly formed of combuſtible matter, it appears to be of ſome conſequence what the nature and ſtructure of this material may be. It is certain that the flame afforded by a wick of ruſh differs very conſiderably from that afforded by cotton; though perhaps this difference may, in a great meaſure, depend on the relative dimenſions of each. And if we may judge from the different odour in blowing out a candle of each ſort, there is ſome reaſon to ſuſpect that the decompoſition of the oil is not effected preciſely in the ſame manner in each. We have alſo ſome obſcure accounts of prepared wicks for lamps, which are ſtated to poſſeſs the property of facilitating the combuſtion of very impure oils, ſo that they ſhall burn for many hours without ſmoke or ſmell.

The economical wicks of M. Leger, concerning which a report was preſented to the Academy at Paris in 17[illegible]2 by Condorcet, Lavoiſier, and De Milly, were compoſed of cotton of different ſizes and forms, namely, round and flat, according to the uſe they were intended to ſerve. They were covered with a fat ſubſtance, of a ſmell not diſagreeable, but feebly aromatic. From the trials of theſe commiſſaries it was aſcertained: 1. That they afforded a clearer flame, with leſs undulation. 2. That they conſumed ſomewhat leſs oil; and, 3. That they poſſeſſed the remarkable property of affording neither ſmell nor ſmoke, however common the oil made uſe of. When uſing a lamp with a flat wick, we have ourſelves found a piece of clean cotton ſtocking anſwer the purpoſe better than the cotton wicks which are ſold in the ſhops.

The acceſs of air is of the laſt importance in every proceſs of combuſtion. When a lamp is fitted up with a very ſlender wick, the flame is ſmall, and of a brilliant white colour: if the wick be larger, the combuſtion is leſs perfect, and the flame is brown: a ſtill larger wick not only exhibits a brown flame, but the lower internal part appears dark, and is occupied by a portion of volatiliſed matter, which does not become ignited until it has aſcended towards the point. When the wick is either very large or very long, part of this matter eſcapes combuſtion, and ſhews itſelf in the form of coal or ſmoke. The different intenſity of the ignition of flame, according to the greater or leſs ſupply of air, is remarkably ſeen by placing a lamp with a ſmall wick beneath a ſhade of glaſs not perfectly cloſed below, and more or leſs covered above. While the current of air through the glaſs ſhade is perfectly free, the flame is white; but in proportion as the aperture above is diminiſhed, the flame becomes brown, long, wavering, and ſmoky; it inſtantly recovers its original whiteneſs when the opening is again enlarged. The inconvenience of a thick wick has been long ſince obſerved, and attempts made to remove it; in ſome inſtances, by ſubſtituting a number of ſmall wicks inſtead of a larger; and in others, by making the wick flat inſtead of cylindrical. The moſt ſcientific improvement of this kind, though perhaps leſs ſimple than the ordinary purpoſes of life demand, is the well known lamp of Argand, deſcribed in the *Encyclopædia.*

Much has been ſaid of this lamp, and great praiſe laviſhed on the inventor. It cannot indeed be denied that it was a very pretty invention, nor have we the ſlighteſt wiſh to detract from the merit of M. Argand; but truth compels us to ſay, that the ſame thought had occurred to others as early as to him, and that lamps had been conſtructed on his principles long before he had publiſhed an account of his lamp to the world (A).

Many ingenious men have endeavoured to determine the moſt economical method of lighting up large halls and workhouſes by means of different lamps and candles; and when the expence of tallow and oil is conſidered, it will be admitted that they could not employ their time in a manner more beneficial to the poor and the induſtrious. Among others, Count Rumford and M. Haſſenfratz have turned their attention to this ſubject; and the reſults of their inveſtigations are worthy of notice. To the Count, a method occurred for meaſuring the relative quantities of light emitted by lamps of different conſtructions, which is at once ſimple and accurate. It is as follows:

Let the two burning lamps, or other lights to be compared, be called A and B; and let them be placed at equal heights upon two light tables, or moveable ſtands, in a darkened room; let a ſheet of clean white paper be equally ſpread out, and faſtened upon the wainſcot, or ſide of the room, at the ſame height from the floor as the lights; and let the lights be placed overagainſt this ſheet of paper, at the diſtance of ſix or eight feet from it, and ſix or eight feet from each other, in ſuch a manner, that a line drawn from the centre of the paper, perpendicular to its ſurface, ſhall biſect the angle formed by lines drawn from the lights to that centre; in which caſe, conſidering the ſheet of paper as a plane ſpeculum, the one light will be preciſely in the line of reflection of the other.

This may be eaſily performed, by actually laying a piece of a looking-glaſs, ſix or eight inches ſquare, flat upon the paper, in the middle of it; and obſerving, by means of it, the real lines of reflection of the lights from that plane, removing it afterwards, as ſoon as the lights are properly arranged. When this is done, a ſmall cylinder of wood, about $\frac{1}{4}$th of an inch in diameter, and ſix inches long, muſt be held in a vertical poſition, about two or three inches before the centre of the ſheet of paper, and in ſuch a manner, that the two ſhadows of the cylinder, correſponding to the two lights, may be diſtinctly ſeen upon the paper.

If theſe ſhadows ſhould be found to be of unequal denſities, which will almoſt always be the caſe, then that light whoſe correſponding ſhadow is the denſeſt muſt be removed farther off, or the other muſt be brought nearer to the paper, till the denſities of the ſhadows appear to be exactly equal; or, in other words, till the denſities of the rays from the two lights are equal *at the ſurface of the paper;* when, the diſtances of the lights from

---

(A) One of theſe was employed in the college of Glaſgow, by the lecturer on chemiſtry, ſo long ago as 1766.

from the centre of the paper being meaſured, the ſquares of thoſe diſtances will be to each other as the real intenſities of the lights in queſtion at their ſources.

If, for example, the weaker light being placed at the diſtance of four feet from the centre of the paper, it ſhould be found neceſſary, in order that the ſhadows may be of the ſame denſity, to remove the ſtronger light to the diſtance of eight feet from that centre, in that caſe, the real intenſity of the ſtronger light will be to that of the weaker as 8^2 to 4^2; or as 64 to 16; or 4 to 1; and ſo for any other diſtances.

It is well known, that when any quality proceeds from a centre in ſtraight lines in all directions, like the light emitted by a luminous body, its intenſity at any given diſtance from that centre will be as the ſquare of that diſtance inverſely; and hence it is clear, that the intenſities of the lights in queſtion, at their ſources, muſt be to each other as the ſquares of their diſtances from that given point *where their rays uniting are found to be of equal denſity*. For, putting $x =$ the intenſity of B, if P repreſents the point where the rays from A and from B meeting are found to be of equal denſity or ſtrength, and if the diſtance of A from P be $= m$, and the diſtance of B from the ſame point P $= n$; then, as the intenſity of the light of A at P is $= \frac{x}{m^2}$, and the intenſity of the light of B at the ſame place $= \frac{y}{n^2}$, and as it is $\frac{x}{m^2} = \frac{y}{n^2}$ by the ſuppoſition, it will be $x : y :: m^2 : n^2$.

That the ſhadows being of equal denſity at any given point, the intenſities of the illuminating rays muſt of neceſſity be equal at that point alſo, is hence evident, that the total abſence of light being perfect blackneſs, and the ſhadow correſponding to one of the lights in queſtion being deeper or fainter, according as it is more or leſs enlightened by the other, when the ſhadows are equal, the intenſities of the illuminating rays muſt be equal likewiſe.

In removing the lights, in order to bring the ſhadows to be of the ſame denſity, care muſt be taken to recede from, or advance towards, the centre of the paper in a ſtraight line, ſo that the one light may always be found exactly in the line of reflection of the other; otherwiſe the rays from the different lights falling upon the paper, and conſequently upon the ſhadows, at different angles, will render the experiment fallacious.

When the intenſity of one ſtrong light is compared with the intenſities of ſeveral ſmaller lights taken together, the ſmaller lights ſhould be placed in a line perpendicular to a line drawn to the centre of the paper, and as near to each other as poſſible; and it is likewiſe neceſſary to place them at a greater diſtance from the paper than when only ſingle lights are compared.

In all caſes, it is abſolutely neceſſary to take the greateſt care that the lights compared be properly trimmed, and that they burn clear and equally, otherwiſe the reſults of the experiments will be extremely irregular and inconcluſive. It is aſtoniſhing what a difference there is in the quantities of light emitted by the ſame candle, when it burns with its greateſt brilliancy, and when it has grown dim for want of ſnuffing. But as this diminution of light is progreſſive, and as the eye inſenſibly conforms to the quantity of light actually preſent, it is not always taken notice of by the ſpectators; it is nevertheleſs very conſiderable, in fact, as will be apparent to any one who will take the trouble to make the experiment; and ſo great is the fluctuation in the quantity of light emitted by burning bodies, lamps, or candles, in all caſes, even under the moſt favourable circumſtances, that this is the ſource of the greateſt difficulties which our author met with in determining the relative intenſities of lights by the method here propoſed.

To aſcertain by this method the comparative denſities, or intenſities, of the light of the moon and of that of a candle, the moon's direct rays muſt be received upon a plane white ſurface, at an angle of incidence of about 60°, and the candle placed in the line of the reflection of the moon's rays from this ſurface; when the ſhadows of the cylinder, correſponding to the moon's light and to that of the candle, being brought to be of equal denſity, by removing the candle farther off, or bringing it nearer to the centre of the white plane, as the occaſion may require, the intenſity of the moon's light will be equal to that of the candle *at the given diſtance of the candle from the plane*.

To aſcertain the intenſity of the light of the heavens, by day or by night, this light muſt be let into a darkened room through a long tube blackened on the inſide, when its intenſity may be compared with that of a candle or lamp by the method above deſcribed.

The Count, however, has contrived an apparatus for aſcertaining the intenſity of the ſun's light, compared with the light emitted by any artificial illuminator, with much greater accuracy than it can be done by this ſimple method. That apparatus we ſhall deſcribe under the title PHOTOMETER in this *Supplement*; and in the mean time we proceed to lay before our readers the reſults of his experiments as they relate to economy in the production of artificial light.

1
Of the relative quantities of oil conſumed, and of light emitted, by an Argand's lamp, and by a lamp on the common conſtruction, with a riband wick.

The brilliancy of Argand's lamp is not only unrivalled, but the invention is in the higheſt degree ingenious, and the inſtrument uſeful for many purpoſes; but ſtill, to judge of its real merits as an illuminator, it was neceſſary to know whether it gives more light than another lamp *in proportion to the oil conſumed*. This point he determined in the following manner:

Having placed an Argand's lamp, well trimmed, and burning with its greateſt brilliancy, before his *photometer*, and over againſt it a very excellent common lamp, with a riband wick about an inch wide, and which burnt with a clear, bright flame, without the leaſt appearance of ſmoke, he found the intenſities of the light emitted by the two lamps to be to each other as 17956 to 9063; the denſities of the ſhadows being equal when, the Argand's being placed at the diſtance of 134 inches, the common lamp was placed at the diſtance of 95,2 inches, from the field of the photometer.

Both lamps having been very exactly weighed when they were lighted, they were now (without being removed from their places before the photometer) cauſed to burn with the ſame brilliancy juſt 30 minutes; they were then extinguiſhed and weighed again, and were found to have conſumed of oil, the Argand's lamp $\frac{253}{8192}$, and the common lamp $\frac{161}{8192}$, of a Bavarian pound.

Now, as the quantity of light produced by the Argand's gand's lamp, in this experiment, is to the quantity produced by the common lamp as 17956 to 9063, or as 187 to 100, while the quantity of oil conſumed by the former is to that conſumed by the latter only in the ratio of 253 to 163, or as 155 to 100, it is evident that the quantity of light produced by the combuſtion of a given quantity of oil in an Argand's lamp is greater than that produced by burning the ſame quantity in a common lamp, in the ratio of 187 to 155, or as 100 to 85.

The ſaving, therefore, of oil which ariſes from making uſe of an Argand's lamp inſtead of a common lamp, in the production of light, is evident; and it appears, from this experiment, that that ſaving cannot amount to leſs than fifteen *per cent.* How far the advantage of this ſaving may, under certain circumſtances, be counterbalanced by inconveniences that may attend the making uſe of this improved lamp, our author does not pretend to determine.

2
Of the relative quantities of light emitted by an Argand's lamp and by a common wax candle.

The Count made a conſiderable number of experiments to determine the relative quantities of light emitted by an Argand's lamp and a common wax candle; and the general reſult of them is, that a common Argand's lamp, burning with its uſual brightneſs, gives about as much light as nine good wax-candles; but the ſizes and qualities of candles are ſo various, and the light produced by the ſame candle ſo fluctuating, that it is very difficult to aſcertain, with any kind of preciſion, what a common wax-candle is, or how much light it ought to give. He once found that his Argand's lamp, when it was burning with its greateſt brilliancy, gave twelve times as much light as a good wax candle $\frac{3}{4}$ths of an inch in diameter, but never more.

3
Of the fluctuations of the light emitted by candles.

To determine to what the ordinary variations in the quantity of light emitted by a common wax-candle might amount, he took ſuch a candle, and, lighting it, placed it before the photometer, and over againſt it an Argand's lamp, which was burning with a very ſteady flame; and meaſuring the intenſity of the light emitted by the candle from time to time, during an hour, the candle being occaſionally ſnuffed when it appeared to ſtand in need of it, its light was found to vary from 100 to about 60. The light of a wax-candle of an inferior quality was ſtill more unequal; but even this was but trifling, compared to the inequalities of the light of a tallow-candle.

An ordinary tallow-candle, of rather an inferior quality, having been juſt ſnuffed, and burning with its greateſt brilliancy, its light was as 100; in eleven minutes it was but 39; after eight minutes more had elapſed, its light was reduced to 23; and in ten minutes more, or twenty-nine minutes after it had been laſt ſnuffed, its light was reduced to 16. Upon being again ſnuffed, it recovered its original brilliancy, 100.

4
Of the relative quantities of bees-wax, tallow, olive-oil, rape-oil, and linſeed-oil, conſumed in the production of light.

In order to aſcertain the relative quantities of bees wax and of olive-oil conſumed, in the production of light, the Count proceeded in the following manner: Having provided an end of a wax-candle of the beſt quality, ,68 of an inch in diameter, and about four inches in length, and a lamp with five ſmall wicks, which he had found upon trial to give the ſame quantity of light as the candle, he weighed very exactly the candle and the lamp filled with oil, and then, placing them at equal diſtances (forty inches) before the field of the photometer, he lighted them both at the ſame time; and, after having cauſed them to burn with preciſely the ſame degree of brightneſs *juſt one complete hour*, he extinguiſhed them both. and, weighing them a ſecond time, he found that 100 parts of wax and 129 parts of oil had been conſumed.

Hence it appears, that the conſumption of bees wax is to the conſumption of olive-oil, in the production of the ſame given quantity of light, as 100 is to 129.

In this experiment no circumſtance was neglected that could tend to render the reſult of it concluſive; care was taken to ſnuff the candle very often with a pair of ſharp ſciſſars, in order to make it burn conſtantly with the ſame degree of brilliancy; and the light of the lamp was, during the whole time, kept in the moſt exact equilibrium with the light of the candle, which was eaſily done by occaſionally drawing out, a little more or leſs, one or more of its five equal wicks. Theſe wicks, which were placed in a right line, perpendicular to a line drawn from the middle wick to the middle of the field of the photometer, were about $\frac{1}{10}$th of an inch in diameter each, and $\frac{1}{4}$th of an inch from each other; and, when they were lighted, their flames united into one broad, thin, and very clear, white flame, without the leaſt appearance of ſmoke.

In order to aſcertain the relative conſumption of olive-oil and rape-oil, in the production of light, two lamps, like that juſt deſcribed, were made uſe of; and, the experiment being made with all poſſible care, the conſumption of olive-oil appeared to be to that of rape-oil, in the production of the ſame quantity of light, as 129 is to 125.

The experiment being afterwards repeated with olive-oil and very pure linſeed-oil, the conſumption of olive-oil appeared to be to that of linſeed-oil as 129 to 120.

The experiment being twice made with olive oil and with a tallow candle; once when the candle, by being often ſnuffed, was made to burn conſtantly with the greateſt poſſible brilliancy, and once when it was ſuffered to burn the whole time with a very dim light, owing to the want of ſnuffing; the reſults of theſe experiments were very remarkable.

When the candle burnt with a clear, bright flame, the conſumption of the olive oil was to the conſumption of the tallow as 129 is to 101: but when the candle burnt with a dim light, the conſumption of the olive-oil was to the conſumption of the tallow as 129 is to 229. So that it appeared, from this laſt experiment, that the tallow, inſtead of being nearly as productive of light in its combuſtion as bees wax, as it appeared to be when the candle was kept conſtantly well ſnuffed, was now, when the candle was ſuffered to burn with a dim light, by far leſs ſo than oil.

But this is not all; what is ſtill more extraordinary is, that the very ſame candle, burning with a long wick, and a dim light, actually conſumed *more tallow* than when, being properly ſnuffed, it burnt with a clear, bright flame, and gave near *three times as much light.*

To be enabled to judge of the relative quantities of light actually produced by the candle in the two experiments, it will ſuffice to know, that in order to counterbalance this light at the field of the *photometer*, it required, in the former experiment, the conſumption of 141 parts, but in the latter only the conſumption of 64 parts, of olive-oil. But in the former experiment 110, and

and in the latter 114, parts of tallow were actually found to be conſumed. Theſe parts were 8192ths of a Bavarian pound.

From the reſults of all the foregoing experiments, it appears that the relative expence of the undermentioned inflammable ſubſtances, in the production of light, is as follows:

		Equal Parts in Weight.
Bees wax.	A good wax-candle, kept well ſnuffed, and burning with a clear, bright flame, - - -	100
Tallow.	A good tallow candle, kept well ſnuffed, and burning with a bright flame, - - - - -	101
	The ſame tallow-candle, burning very dim for want of ſnuffing,	229
Olive-oil.	Burnt in an Argand's lamp, - -	110
	The ſame burnt in a common lamp, with a clear, bright flame, without ſmoke, - - - - -	129
Rape-oil.	Burnt in the ſame manner, - - -	125
Linſeed-oil.	Likewiſe burnt in the ſame manner, - - - - - - -	120

With the foregoing table, and the prices current of the therein mentioned articles, the relative prices of light produced by thoſe different materials may very readily be computed.

In the year 1795, Mr J. H. Haſſenfratz was employed by the French government to make a ſeries of experiments to determine the moſt economical method of procuring light from the different combuſtible ſubſtances uſually employed for that purpoſe. The materials of his experiments were, wax, ſpermaceti, and tallow candles, fiſh-oil, oil of coleſeed, and of poppy ſeeds. In uſing theſe oils, both the Argand and common lamps were employed. The wicks of the latter were round, containing thirty-ſix cotton threads. The tallow and ſpermaceti candles were mould, ſix to the pound. The wax candles five to the pound. Mr Haſſenfratz uſed the ſame method with Count Rumford for determining the comparative intenſity of the lights.

Count Rumford, as we have ſeen, uſed the Argand lamp as a ſtandard for compariſon; but as the intenſity of its light varies according to the height of the wick, Mr Haſſenfratz preferred a wax-candle, making uſe of it ſoon after it was lighted. When two luminous bodies, of different intenſities, are put in compariſon with each other, the ſhadows are of two colours. That from the weakeſt light is blue, and from the ſtrongeſt, red. When the lights of two different combuſtible bodies are compared, they are either red or blue in a compound ratio of the colour and intenſity. Thus in comparing the ſhadows from different luminous bodies, they will be red or blue reſpectively, in the following order:

Light of the ſun.
——- of the moon.
——- of Argand lamps.
——- of tallow-candles.
——- of wax ditto.
——- of ſpermaceti ditto.
——- of common lamps.

That is to ſay, when a body is illuminated by the ſun and by any other luminous ſubſtance, the ſhadow of the former is red, and of the latter, blue. In like manner, the ſhadow from an Argand lamp is red, when placed by that of a tallow-candle, which is blue.

The following table will ſhew, according to Mr Haſſenfratz, the proportional diſtance that different luminous bodies ſhould be placed at to produce an equally intenſe ſhadow from the ſame object. The ſecond column gives the proportional intenſity of each light, which is known to be in proportion to the ſquares of the diſtances of luminous bodies giving the ſame depth of ſhadow. The third column ſhews the quantity of combuſtible matter conſumed in the hour by each mode of giving light, which Mr Haſſenfratz calculates from the average of many repeated experiments.

		Diſtance.	Intenſity.	Quantity conſumed per hour	Quantity required for equal intenſities.
Argand lamps with	Oil of poppy ſeed	10	10.000	23	23
	— of fiſhes	10	10.000	23.77	23.77
	— of cole-ſeed	9.246	8.549	14.18	16.59
Common lamps with	Oil of cole-ſeed	6.774	4.588	8.81	19.2
	— of fiſhes	6.524	4.550	9.14	20.06
	— of poppy-ſeed	5.917	3.501	7.03	20.14
Spermaceti candle		5.917	3.501	9.23	26.37
Old tallow-candle		5.473	2.995	7.54	25.17
New ditto		5.473	2.995	8.23	27.48
Wax candle		4.275	1.827	9.54	53

The relative quantity of combuſtible matter required to produce *equal* lights at equal diſtances, may be obtained by a ſimple rule of proportion from the above data. Thus, if a given intenſity of light, expreſſed by 3.501, has been produced by a conſumption of 9.23 of ſpermaceti in the hour, the ſame luminous body will produce a light of 10.000, by conſuming in the ſame time a quantity of ſpermaceti $= \frac{10.000 \times 9.23}{3.501} = 26.37.$— Therefore we may add to the table a fourth column, expreſſing the quantity of combuſtible which each body muſt conſume to produce a light of 10.000.

From what has been laid down, it will alſo appear that the number of lights required to produce a given light, will be as follows: To produce a light equal to 100 Argand lamps, burning poppy-ſeed oil, it will require

100 Argand lamps with fiſh-oil.
117 Ditto do. with cole ſeed oil
218 Common lamps with cole-ſeed oil
219 Ditto do. with fiſh oil
285 Ditto do. with poppy-ſeed oil
285 Spermaceti candles
333 Tallow ditto
546 Wax ditto.

Mr Haſſenfratz next takes notice of the comparative price of theſe articles; by which he finds, that in Paris the moſt expenſive light is that produced from wax-candles; and the moſt *economical*, that from oil of cole-ſeed, burned in Argand lamps.

The chief difference between the Argand and common lamp is, that in the latter much of the oil is volatilized without combuſtion, and hence the unpleaſant ſmell which it produces; whereas in the former, the heat is ſo great at the top of the wick, that all the oil is decompoſed in paſſing through, the diſpoſition of the wick allowing the free acceſs of air to aſſiſt combuſtion. It ſhould therefore follow, that the Argand lamp conſumes leſs fuel to produce a given light than the common lamp, and this, as we have ſeen, is the opinion of Count Rumford. Yet (Mr Haſſenfratz obſerves) there are two circumſtances that prevent the full effect of the complete combuſtion in the Argand lamp. The one is, that the glaſs cylinder abſorbs a part of the rays of light as they paſs through; the other, that the column of light proceeding from the inner ſurface of the wick, is, in part, loſt, by being obliged to paſs through that from the outer ſurface. Count Rumford allows the firſt cauſe of diminution of light, and eſtimates it at .1854, but not the latter. The author of this memoir, in repeating Count Rumford's experiments, aſſerts, that when two candles are placed ſo that the light of the one is obliged to paſs through that of the other, the ſum of the light ſo produced is not ſo ſtrong as when they are placed ſide by ſide; for in the firſt caſe, a part of the hindmoſt light is abſorbed by the foremoſt.

LANCASHIRE. In the account which we have given of that county in the *Encyclopædia*, an obliging correſpondent has pointed out to us ſome miſtakes. He aſſures us, that the ſea coaſt, where we underſtood the atmoſphere to be loaded with ſuch exhalations as produce malignant and intermitting fevers, is remarkably healthy; and he ſpeaks from experience, having lived on that coaſt for forty years. He aſſures us likewiſe, that the Duke of Bridgewater's inland navigation was begun ſoon after, if not before, the year 1736, and that he (the writer), ſo early as 1764, was one of a party who ſailed up the ſough or edit a conſiderable way to ſee how the coals were worked. The ſame correſpondent has pointed out a few miſtakes in our account of

LANCASTER, the capital of the county. "That town (he ſays) carries on no trade whatever with North America, but a very conſiderable one with Jamaica and the other Weſt India iſlands, in veſſels of from 100 to 500 tons burthen. It exports to theſe iſlands all ſuch Britiſh manufactures as they have occaſion for, Iriſh linens, and ſalted proviſions of all kinds, ſuch as Iriſh beef, pork, butter, &c. It trades alſo to the Baltic, Portugal, Hamburgh, &c. to a large amount; and ſome of its ſhips with their cargoes have of late been worth from L. 60 to L. 80,000 ſterling. It has, however, no communication by water with the rivers Merſey, Dee, &c. as we have ſaid; the canal reaching as yet no farther than to near Preſton in Lancaſhire." The communication with theſe rivers is indeed intended to be completed; but whether the ſcheme be practicable is, according to our correſpondent, very uncertain.

LANTERN (See *Encycl.*). Sir George Staunton informs us, that of the Chineſe lanterns, ſome were ſuch as we have deſcribed, *viz.* compoſed of thin ſilk gauze, painted or wrought in needle-work with figures of birds, inſects, flowers, or fruit, and ſtretched on neat frames of wood. Others, however, were very different, being entirely made of horn. Theſe were ſo thin and tranſparent, that they were taken at firſt for glaſs; a material to which, for this purpoſe, the horn is preferred by the Chineſe, as cheaper, lighter, leſs liable to accident, and, in caſe of accident, more eaſily repaired; many of them were about two feet in the diameter, and in the form of a cylinder, with the ends rounded off, and the edges meeting in the point to which the ſuſpending cords were tied. Each lantern conſiſted of an uniform piece of horn, the joints, or ſeams, being rendered inviſible by an art found out by the Chineſe; among whom, the vaſt number of ſuch lanterns uſed in their dwelling houſes and temples, as well as on the occaſions of their feſtivals and proceſſions, have led to many trials for improving their conſtruction. The horns generally employed are thoſe of ſheep and goats. The uſual method of managing them, according to the information obtained upon the ſpot, is to bend them by immerſion in boiling water, after which they are cut open and flattened; they then eaſily ſcale, or are ſeparated into two or three thin laminæ or plates. In order that theſe plates ſhould be made to join, they are expoſed to the penetrating effect of ſteam, by which they are rendered almoſt perfectly ſoft. In this ſtate the edges of the pieces to be joined are carefully ſcraped and ſlanted off, ſo as that the pieces overlapping each other ſhall not together exceed the thickneſs of the plate in any other part. By applying the edges, thus prepared, immediately to each other, and preſſing them with pincers, they intimately adhere, and incorporating, form one ſubſtance, ſimilar in every reſpect to the other parts; and thus uniform pieces of horn may be prepared to almoſt any extent. It is a contrivance little known elſewhere, however ſimple the proceſs appears to be; and perhaps ſome minute precautions are omitted in the general deſcription, which may be eſſential to its complete ſucceſs.

Such lanterns as theſe would be very proper for military ſtore houſes; and Rochon of *the National Inſtitute* was employed, ſince the commencement of the preſent war, to make them, if he could, for the marine ſtorehouſes of France. While he was thus engaged, however, it occurred to him, that he might ſupply the preſſing wants of the navy without horn, merely by filling up the interſtices of wire-cloth with fine tranſparent glue. In carrying this thought into execution, he at firſt tinned the iron wires of the ſieve cloth he made uſe of; but afterwards found it more convenient, in every reſpect, to give it a ſlight coating of oil paint to preſerve it from ruſt. The glue he made uſe of was afforded by boiling the clippings of parchment with the air-bladders and membranes of ſea fiſh; materials which he uſed, not from any notion that they were preferable to iſinglaſs, but becauſe they were the cheapeſt he could procure. He added the juice of garlic and cyder to his compoſition, in ſuch proportions as he found to communicate great tenacity, and ſomewhat more of tranſparence than it would have poſſeſſed without them. Into this tranſparent and very pure glue or ſize he plunged his wire cloth, which came out with its interſtices filled with the compound. It is requiſite that the ſize ſhould poſſeſs a determinate heat and conſiſtence, concerning which experience alone muſt guide the operator.

When this prepared wire cloth is fixed in the lantern, it muſt be defended from moiſture by a coating of pure drying linſeed oil; but even in this ſtate it is not fit to be expoſed to the weather. The eaſe with which theſe lanterns are repaired in caſe of accident, by a ſlight coating of glue, is pointed out as a great advantage by the inventor; who likewiſe informs us, that they were uſed in the expedition to Ireland as ſignal lanterns, though contrary to his wiſhes.

LAPIS Fungifer, a ſpecies of earth found near Rome, Naples, and Florence, of which the following account is taken from the *New Tranſactions of the Royal Academy of Sciences at Stockholm* for the year 1797: Near Naples the lapis fungifer is found in the chalk-hills like a white ſtalactites, intermixed with a great many fine roots of ſhrubs; and near Florence there is a ſpecies of it, conſiſting of hardened turf, which is dug up near volcanoes. The author made experiments with a piece procured from Italy, and found that 100 parts contain from 45 to 46 ſiliceous earth, 23 argillaceous earth, 7 calcareous earth, and 20 calx of iron, with ſome white magneſia and vegetable alkali. It is well known, that when this friable ſpecies of ſtone is preſerved in cellars and moiſtened with water, it produces abundance of eatable muſhrooms, which in Italy are highly eſteemed and brought to the firſt tables. Hence the origin of its name.

LARDIZABALA, a new genus of plants belonging to the *diœcia hexandria* of Linnæus. It is a native of Chili, and is thus deſcribed in Perouſe's Voyage, from drawings ſent to France by La Martiniere. The leaves are alternate, on footſtalks inflated at their baſe. Each leaf is bi-ternate, that is to ſay, it is divided into three leaflets, each of which is again ſubdivided into three oval ſharp-pointed folioles, which, when young, are entire, but afterwards become obſcurely lobed. The flowers, diſpoſed in ſimple and pendent cluſters, grow towards the top of the ſtem and of the branches in the axillæ of the leaves. The plant is diœcius. At the baſe of each cluſter of bloſſoms are two ſmall, rounded, oval, floral leaves.

Plate XXX.

Male Flower.—*Calyx* formed of ſix expanding leaves, oblong-oval, and obtuſe, of which the three outermoſt are the largeſt. *Corolla* compoſed of ſix ſharp lanceolated petals, oppoſite to, and ſhorter than, the leaves of the calyx. A cylinder riſes from the centre of the flower of the length of the petals, terminated by ſix oblong bilocular anthers, which open from below.

Female Flower.—*Calyx*, ſimilar to that of the male flower, but larger. *Corolla* inſerted beneath the piſtil compoſed of ſix petals, rarely entire, but generally bifid or trifid at their ſummit: ſhorter than the leaves of the calyx. *Stamina* ſix, having the ſame inſertion as the corolla; filaments diſtinct, broad, very ſhort, ſurrounding the piſtil; *anthers*, ſix, upright, oblong, acuminated, barren. *Seed bud*, cells, from three to ſix, oblong, gibbous on the outſide, of nearly the length of the corolla; ſtyles none; ſtigmata, ſitting, oblong, permanent. *Berries*, equal in number to the cells, oblong, acuminated (divided into ſix cells, containing ſeveral angular ſeeds. *Flora Peruviana*).

The general character of the lardizabala evidently places this new genus among the family of the *meniſpermæ*, to which it is related by its climbing ſtalk, its bunches of diœcious flowers, by its ſix petals, ſtamina, and leaves of its calyx, by its piſtil, compoſed of from three to ſix cells, which contain as many ſeeds. It differs from the known genera of this order only in its fruit, which, inſtead of being monoſpermous, contains ſeveral ſeeds. This character, which requires the introduction of a new ſection into the *meniſpermæ*, ſtrengthens the relation of this family to the next order of the *anonæ*. In fact, the greater part of the genera of the anonæ, as they have in the ſame flower ſeveral fruits, with numerous ſeeds, differ in this particular from all the genera of the meniſpermæ; and by placing between them the lardizabala, we eſtabliſh a natural tranſition. In order to confirm theſe reſemblances, it only remains to examine the inſide of the fruit, and particularly the ſtructure of the ſeeds. Thoſe of the meniſpermæ are reniform, at leaſt on the inſide, incloſed in a hinged pericarpium, and containing in their upper part a very ſmall dicotyledonus embryo. The characters that we have given of the lardizabala render probable a ſimilar ſtructure in its ſeeds.

LARMIER, in architecture, a flat ſquare member of the cornice below the cimaſium, and jets out fartheſt; being ſo called from its uſe, which is to diſperſe the water, and cauſe it to fall at a diſtance from the wall, drop by drop, or, as it were, by tears; *larme* in French ſignifying a tear.

LATUS Primarium, a right line drawn through the vertex of the ſection of a cone, within the ſame, and parallel to the baſe.

Latus Rectum. See *Conic Section*, Encycl.

Latus Tranſverſum of the hyperbola, is the right line between the vertices of the two oppoſite ſections, or that part of their common axis lying between the two oppoſite cones.

LAVA. In addition to the obſervations of Sir William Hamilton, Bergmann, Formes, and Dalmieu, on the compoſition of different lavas, which have been given in the *Encyclopædia*, we cannot refuſe ourſelves the pleaſure of noticing, in this place, thoſe of Sir James Hall. From a number of well-deviſed experiments, Sir James thinks himſelf warranted to conclude, that lava and whinſtone are intrinſically the ſame ſubſtance; and that their apparent differences ariſe wholly from the circumſtances under which they have paſſed from a liquid to a ſolid ſtate. The lavas, it is well known, have been cooled rapidly in the open air, and the whins (according to Dr Hutton's theory, which Sir James ſeems willing to adopt) ſlowly in the bowels of the earth.

Though we are far from adopting that theory in all its parts, to which we think inſuperable objections may be made (ſee Earth, *Encycl.* nº 120), we admit, that the experiments of Sir James Hall go far to eſtabliſh the identity of lava and whinſtone. Theſe experiments were made upon ſeven different ſpecies of whinſtone and ſix lavas, of which four were broken from the currents of Etna and Veſuvius by Sir James himſelf. Each of the original whinſtones was reduced, by fuſion and ſubſequent rapid cooling, to a ſtate of perfect glaſs. This glaſs, being again placed in the furnace, was ſubjected to a ſecond fuſion. The heat, being then reduced to a temperature generally about 28° of Wedgewood, was maintained ſtationary for ſome hours; when the crucible was either immediately removed, or allowed to cool with the furnace. The conſequence was, that in every caſe the ſubſtance had loſt the character of glaſs, and by cryſtallization had aſſumed in all reſpects that of an original whinſtone. It muſt be owned, that in moſt caſes the new production did not exactly reſemble the particular original from which it was formed, ed, but ſome other original of the ſame claſs; owing to accidental varieties in the mode of refrigeration, and to chemical changes which unavoidably took place during the proceſs. In the caſe, however, of the rock of Edinburgh caſtle, and of that of the baſaltic columns of Staffa, the artificial ſubſtances bear a complete reſemblance to their originals, both in colour and texture.

The lavas were now treated in the ſame way, and were each, by fuſion and rapid cooling, reduced, as the whinſtones had been, to glaſs. This glaſs, when fuſed again and cooled ſlowly, yielded the ſame kind of cryſtallized, ſtony, or earthy maſſes, completely reſembling an original whin or lava.

Although the internal ſtructure of lava was thus accounted for, yet Sir James was embarraſſed with the ſtate of its external ſurface; which, though cooled in contact with the open air, is ſeldom or never vitreous, holding an intermediate ſtation between glaſs and ſtone; but this difficulty was removed by a circumſtance which took place in the courſe of theſe experiments. It was found, that a ſmall piece of glaſs of any of the lavas, or of ſeveral of the whins, being introduced into a muffle, the temperature of which was at any point between the 20th and the 22d degree of Wedgewood's ſcale, the glaſs became quite ſoft in the ſpace of one minute; but, being allowed to remain till the end of a ſecond minute, it was found to have become hard throughout in conſequence of a rapid cryſtallization, to have loſt its character of glaſs, and to have become by 12 or 14 degrees more infuſible, being unaffected by any heat under 30, though the glaſs had been fuſible at 18° or at 16°. This accounted for the ſcoria on the ſurface of lavas; for the ſubſtance even at the ſurface, being in contact with the flowing ſtream, and ſurrounded with heated air, could not cool with exceſſive rapidity: and the experiment ſhews, that ſhould any part of the maſs, in deſcending heat, employ more than one or two minutes in cooling from 22 to 20, it would infallibly loſe its vitreous character.

Independently of any alluſion to ſyſtem or to general theory, Sir James Hall flatters himſelf that theſe experiments may be of ſome importance, by ſimplifying the hiſtory of volcanoes; and, above all, by ſuperſeding ſome very extraordinary, and, he conceives, unphiloſophical opinions advanced with regard to volcanic heat, which has been ſtated as poſſeſſing very little intenſity, and as acting by ſome occult and inconceivable influence, or with the help of ſome inviſible agent, ſo as to produce liquidity without fuſion. Theſe ſuppoſitions, which have been maintained ſeriouſly by ſome of the moſt celebrated naturaliſts in Europe, have originated from the difficulty of accounting for the ſtony character of lavas when compared with that of glaſs, which they aſſume in conſequence of fuſion in our furnaces. But now he hopes we may be relieved from the neceſſity of ſuch violent efforts of imagination, ſince the phenomena have been fully accounted for by the ſimple, though unnoticed, principle of refrigeration, and have been repeated again and again with eaſe and certainty in a ſmall chamber furnace.

LAVOISIER (Antoine Laurent), was born in Paris on the 26th of Auguſt 1743. His father, who directed his education, was opulent, and ſpared no coſt for his improvement. The youth ſhewed a decided taſte for the phyſical ſciences. In 1764, government having propoſed an extraordinary premium for the beſt and cheapeſt mode of lighting the ſtreets of a large city, Lavoiſier obtained the gold medal; and his memoir, full of nice inveſtigation, was printed by the Academy. Into that body he was received on the 13th May 1768, in ſpite of a formidable oppoſition; and to its ſervice he ever after devoted his labours, and became one of its moſt uſeful aſſociates and coadjutors.

His attention was ſucceſſively occupied with every branch of phyſical and mathematical ſcience. The pretended converſion of water into earth, the analyſis of gypſum in the neighbourhood of Paris, the cryſtallization of ſalts, the effects produced by the *grande de loupe* of the garden of the Infanta, the project of bringing water from l'Yvette to Paris, the congelation of water, and the phenomena of thunder and the aurora borealis—all occupied his attention.

Journeys, undertaken in concert with Guettard into every diſtrict of France, enabled him to procure numberleſs materials towards a deſcription of the lithological and mineralogical empire; theſe he arranged into a kind of chart, which wanted little of being completed. They ſerved alſo as a foundation for a more laborious work of his on the revolutions of the globe, and the formation of *Couches de la Terre;* a work of which two beautiful ſketches are to be ſeen in the Memoirs of the French Academy for 1772 and 1787. All the fortune and all the time of Lavoiſier were devoted to the culture of the ſciences; nor did he ſeem to have a preponderating inclination for any one in particular, until an event, ſuch as ſeldom occurs in the annals of the human mind, decided his choice, and attached him thenceforth excluſively to chemiſtry—a purſuit which has ſince rendered his name immortal.

The important diſcovery of gaſes was juſt announced to the philoſophical world. Black, Prieſtley, Scheele, Cavendiſh, and Macbride, had opened to phyſiologiſts a ſort of new creation; they had commenced a new era in the annals of genius, which was to become equally memorable with thoſe of the compaſs, printing, electricity, &c.

It was about the year 1770 that Lavoiſier, ſtruck with the importance and grandeur of this diſcovery, turned his attention to this inexhauſtible fountain of truths, and inſtantly perceived, by a kind of inſtinct, the glorious career which lay before him, and the influence which this new ſcience would neceſſarily have over the whole train of phyſical reſearches. Of thoſe who had preceded him, the moſt indefatigable experimenter was Prieſtley: but facts the moſt brilliant remained frequently unproductive in his hands; on every occaſion he was ready to frame ſome crude hypotheſis, which as haſtily he abandoned. Lavoiſier was imbued with the true ſpirit of inductive philoſophy; his obſervations, eminently preciſe and luminous, always pointed to general views. In 1774, he publiſhed his chemical opuſcules, which contained a very neat hiſtory of all that had been done with reſpect to gaſes, and concluded with the author's capital experiments, by which it was proved, that metals, in calcination, derive their augmentation of weight from the abſorption of air. Soon afterward, he ſhewed, in oppoſition to Prieſtley, that nitrous acid is compoſed of air; a remark, of which the importance appeared in the ſequel. His ingenuity as a chemiſt was now ſo well known, that in 1776 Turgot employed him to inſpect the manufacture of gun-powder. He introduced ſome valuable improvements, and, ſuppreſſing the odious viſits in queſt of the materials of ſaltpetre, he yet quintupled its produce. The gun powder would now carry 120 toiſes, when formerly it would not reach 90. This ſuperiority was indeed acknowledged in the laſt war.

It had been alleged, that by frequent diſtillation water is converted into earth. This queſtion Lavoiſier reſolved in 1778, having ſhewn that the earthy ſediment was owing to the continual eroſion of the internal ſurface of the retort. In that ſame year he made a more intereſting diſcovery; namely, that the reſpirable portion of the atmoſphere is a conſtituent principle of all acids, and which he therefore denominated *oxygen;* a moſt important fact, and the firſt great ſtep towards the new chemiſtry; which the compoſition of water, aſcertained in 1783, triumphantly completed.

Lavoiſier poſſeſſed deciſive advantages over his contemporaries; he ſtudied a geometrical accuracy of inveſtigation; and his wealth enabled him to make experiments on a large ſcale, and to uſe inſtruments of the moſt perfect conſtruction. He was able to hold in his houſe, twice every week, aſſemblies, to which he invited every literary character that was moſt celebrated in geometrical, phyſical, and chemical, ſtudies; in theſe inſtructive *converſationes,* diſcuſſions, not unlike ſuch as preceded the firſt eſtabliſhment of academies, regularly took place. Here the opinions of the moſt eminent literati in Europe were canvaſſed; paſſages the moſt ſtriking and novel, out of foreign writers, were recited and animadverted on; and theories were compared with experiments. Here learned men of all nations found eaſy admiſſion; Prieſtley, Fontana, Blagden, Ingenhouſz, Landriani, Jacquin, Watt, Bolton, and other illuſtrious phyſiologiſts and chemiſts of England, Germany, and Italy, found themſelves mixed in the ſame company with La Place, La Grange, Borda, Couſin, Meunier, Vandermonde, Monge, Morveau, and Berthollet. Happy hours paſſed in theſe learned interviews, wherein no ſubject was left uninveſtigated that could poſſibly contribute to the progreſs of the ſciences, and the amelioration and happineſs of man. One of the greateſt benefits reſulting from theſe aſſemblages, and the influence of which was ſoon afterwards felt in the academy itſelf, and conſequently in all the phyſical and chemical works that have been publiſhed for the laſt twenty years in France, was the agreement eſtabliſhed in the methods of reaſoning between the natural philoſophers and the geometricians. The preciſion, the ſeverity of ſtyle, the philoſophical method of the latter, was inſenſibly tranſfuſed into the minds of the former; the philoſophers became diſciplined in the tactics of the geometricians, and were gradually moulded into their reſemblance.

It was in the aſſemblage of theſe talents that Lavoiſier embelliſhed and improved his own. When any new reſult from ſome important experiment preſented itſelf, a reſult which threatened to influence the whole theory of the ſcience, or which contradicted theories till then adopted, he repeated it before this ſelect ſociety. Many times ſucceſſively he invited the ſevereſt objections of his critical friends; and it was not till after he had ſurmounted their objections, to the conviction and entire perſuaſion of the ſociety; it was not till after he had removed from it all myſtery and obſcurity, that he ventured to announce to the world any diſcovery of his own.

At length he combined his philoſophical views into a conſiſtent body, which he publiſhed in 1789, under the title of *Elements of Chemiſtry;* a book which is a moſt beautiful model of ſcientific compoſition, clear, logical, and elegant. It would be foreign to our purpoſe to attempt an expoſition of the principles, or to expatiate on the merits, of this celebrated ſyſtem; which, within the ſpace of a very few years, has been almoſt univerſally adopted, and which, if not the genuine interpretation of nature, approaches as near to it as the preſent ſtate of knowledge will permit. See CHEMISTRY in this *Supplement.*

The laſt, but not the leaſt uſeful, of Lavoiſier's philoſophical reſearches, on the Perſpiration of Animals, was read to the Academy on the 4th May 1791, and of which part was publiſhed in the volume for 1790. He found, by ſome delicate experiments, made in conjunction with Seguin, that a man in 24 hours perſpires 45 ounces; that he conſumes 33 ounces of vital air; that he diſcharges from the lungs 8 cubic feet of carbonic acid gas, of which one-third is carbon and two-thirds are oxygen; that the weight of water diſcharged from the lungs amounts to 23 ounces, of which 3 are hydrogen and 20 oxygen, excluſive of 6 ounces of water already formed, loſt in pulmonary perſpiration. Theſe diſcoveries were directed to the improvement of medicine.

We have mentioned the aſſiſtance which Lavoiſier received while he was digeſting his new ſyſtem of chemiſtry; but we muſt add, that to him pertains excluſively the honour of a founder. His own genius was his ſole conductor, and the talents of his aſſociates were chiefly uſeful in illuſtrating diſcoveries he himſelf had made; he firſt traced the plan of the revolution he had been a long time conceiving; and his colleagues had only to purſue and execute his ideas.

In the twenty volumes of the Academy of Sciences, from 1772 to 1793, are 40 memoirs of Lavoiſier, replete with all the grand phenomena of the ſcience; the doctrine of combuſtion, general and particular; the nature and analyſis of atmoſpherical air; the formation and fixation of elaſtic fluids; the properties of the matter of heat; the compoſition of acids; the augmentation of the ponderoſity of burnt bodies; the decompoſition and recompoſition of water; the diſſolution of metals; vegetation, fermentation, and animalization. For more than 15 years conſecutive, Lavoiſier purſued, with unſhaken conſtancy, the route he had marked out for himſelf, without making a ſingle falſe ſtep, or ſuffering his ardour to be damped by the numerous and increaſing obſtacles which conſtantly beſet him.

Many were the ſervices rendered by Lavoiſier, in a public and private capacity, to manufactures, to the ſciences, and to artiſts. He was treaſurer to the Academy after Buffon and Tillet, and introduced economy and order into the accounts. He was alſo a member of the Board of Conſultation, and took an active ſhare in whatever was going forwards. When the new ſyſtem of meaſures was agitated, and it was propoſed to determine a degree of the meridian, he made accurate experiments on the expanſion of metals, and conſtructed a metalline thermometer. By the National Convention he was conſulted on the means of improving the manufacture of aſſignats, and of increaſing the difficulties of forging them.

Like a good citizen, Lavoiſier turned his thoughts to political economy. Between the years 1778 and 1785, he allotted 240 *arpents* in the Vendômois to experimental agriculture, and increaſed the uſual produce by one-half. In 1791, he was invited by the Conſtituent Aſſembly to digeſt a plan for ſimplifying the collection of the taxes. This gave occaſion to an excellent report, afterwards printed with the title of *Territorial Riches of France*. At this time, alſo, he was appointed commiſſioner of the national treaſury, in which he effected ſome beneficial reforms.

During the horrors of the Robeſpierrean dictatorſhip, Lavoiſier told La Lande that he foreſaw he ſhould be ſtripped of his property, but that he would work for his bread. The profeſſion of apothecary would have ſuited him the beſt. But his doom was already fixed. On the 8th of May 1794, confounded with 28 farmers general, he ſuffered on the ſcaffold, merely becauſe he was rich!

Lavoiſier was tall, and of a graceful, ſprightly appearance. He was mild, ſociable, obliging, and extremely active; and in his manners he was unaffectedly plain and ſimple. Many young men, not bleſſed with the gifts of fortune, but incited by their genius to woo the ſciences, have confeſſed their obligations to him for pecuniary aid; many, alſo, were the unfortunate whom he relieved in ſilence, and without the oſtentation of virtue. In the communes of the department of the *Loir* and *Char*, where he poſſeſſed conſiderable eſtates, he would frequently viſit the cottages of indigence and diſtreſs; and long will his memory be cheriſhed there. But his reputation, influence, virtues, and wealth, gave him a great preponderance, which unfortunately provoked the jealouſy of a crew of homicides, who made a ſport of ſacrificing the lives of the beſt of men to a ſanguinary idol.

This great and good man married, in 1771, Marie-Anni Pierette Paulze, daughter of a farmer general; a woman whoſe wit and accompliſhments conſtituted the charm of his life; who aſſiſted him in his labours, and even engraved the figures of his laſt work.

LEAD. See that article (*Encycl.*), and CHEMISTRY-*Index* in this *Supplement*. It is well known, that lead generally contains a portion of ſilver, and ſometimes of gold; and that there are occaſions, particularly in aſſaying, when it is of importance to have it freed from theſe metals. For accompliſhing theſe purpoſes different proceſſes have been propoſed; but the following by Pet. Jac. Hjelm, as it is the leaſt expenſive, promiſes to be the moſt uſeful:

LITHARGE (ſee *Encycl.*) was the ſubſtance on which this chemiſt made his experiments, and his principal object was to free it from all mixture of ſilver. This was accompliſhed in the following manner: He placed a crucible, in which half a pound of litharge found good room, and which was fitted with a cloſe cover, in a wind-furnace filled with dead coals. He then put into the crucible a mixture of four ounces of potaſh and the ſame quantity of powder of flint. When the whole was well melted by ſtrengthening the draught, and making the coals glow, he took off the cover, and laid hold of the crucible with a pair of tongs, in order to take it out, and to ſuffer this very fuſible glaſs to cover the inſide of the crucible, to ſecure it from the glaſs of the lead which he meant to melt in it. The ſuperfluous glaſs was poured out; the crucible again placed on its foot, and half a pound of litharge thrown into it with a ſhovel. The cover was placed upon it while the litharge was melting; and when it was thoroughly glowing and fluid, charcoal duſt was ſifted into the uncovered crucible through a ſieve, ſo that the ſurface of the litharge was completely covered with it. This immediately produced an efferveſcence, and the riſing of bubbles, by means of the ſeparation of the air occaſioned by the reduction of the lead. During this proceſs, the cover was put on, and a few coals thrown into the furnace: when theſe were burnt, every thing in the crucible was quiet, and the melted maſs was poured into a warm conical mould. The crucible was then again filled with half a pound of the ſame kind of litharge, and put into the furnace, and charcoal duſt was ſeveral times ſifted over the melted ſurface, till it was well covered before the maſs was thrown out, a ſufficient ſpace being every time left for the efferveſcence. The firſt maſs had, in the mean time, become cool, and, on examination, contained four ounces of lead at the bottom, and litharge at the top. When this litharge was reduced with potaſhes and wine ſtone, the lead thence obtained, which weighed 23 ounces, was found to contain leſs than one-half grain of ſilver in the pound. In the ſecond maſs there was found ſomewhat more than ſix ounces of lead, which contained all the ſilver that had been before mixed with the litharge, becauſe in the lead which had been reduced from the litharge in the above manner, there were no perceptible traces of ſilver. This lead was then melted over a ſlow fire, and caſt into bars, which were rolled ſmooth, and formed into maſſes of a known weight, to be uſed for aſſaying gold and ſilver, and for other purpoſes of the ſame kind. All theſe meltings were made in one crucible, which, according to every appearance, remained unhurt. If the ſame experiments were made with red lead, the like reſult would infallibly follow.

With the ſame view of obtaining lead free from ſilver, he melted, in the like manner, half a pound of white lead, which produced half an ounce of lead When the litharge ſtanding over it was revived, the lead obtained was ſtill found to contain too much ſilver. He therefore precipitated another half pound of white lead by charcoal powder, after the lead that fell from it had been ſeparated; and then it produced, by reviving, a maſs of lead without any mixture of ſilver.

LEDYARD (—— ——), the celebrated, though unfortunate, traveller, was a native of North America, but of what province we have not learned. We are equally ignorant of the year of his birth, and the rank of his parents; but have no reaſon to think that they were opulent. From his early youth he diſplayed a ſtrong propenſity to viſit unknown and ſavage countries; and to gratify that propenſity, he lived for ſeveral years with the American Indians, whoſe manners and habits he ſeemed in ſome degree to have acquired. Afterwards he ſailed round the world with Captain Cook in the humble ſtation of a corporal of marines; and on his return, he determined to traverſe the vaſt continent of America, from the Pacific to the Atlantic Ocean.

This deſign being fruſtrated by his not obtaining a paſſage to Nootka Sound, he determined to travel over land to Kamſchatka. With this view he went over to Oſtend, with only ten guineas in his pocket, and proceeded by the way of Denmark and the Sound to the capital of Sweden, and endeavoured to croſs the Gulph of Bothnia on the ice; but finding, when he came to the middle, that the water was not frozen, he walked round the gulph to Peterſburgh. Here he found himſelf without ſtockings or ſhoes; but procured relief from the Portugueſe ambaſſador, and obtained leave to proceed with a detachment of ſtores to Yakutz. He made this journey of ſix thouſand miles, and there met Mr Billengs, an Engliſhman, whom he had known on board Captain Cook's ſhip. From thence he went to Oczakow, on the coaſt of the Kamſchatka Sea; but being too late to embark that year, returned to Yakutz to winter. Here he was, on ſome ſuſpicion, ſeized, conveyed on a ſledge through Northern Tartary, and left on the frontiers of the Poliſh dominions. In the midſt of poverty, rags, and diſeaſe, he however reached Koningſburg, where he found friends that enabled him to reach England.

On his arrival in London, he waited on Sir Joſeph Banks, on whoſe credit he had, in his diſtreſs, received at different times 25 guineas. Sir Joſeph communicated to him the views of the African Aſſociation, and pointed out the route in which they wiſhed Africa to be explored. On his engaging at once in the enterpriſe, Sir Joſeph aſked him when he would be able to ſet out. "To-morrow morning," replied Ledyard, without heſitation. At this interview the preſident of the Royal Society declares, that he was ſtruck with the figure of the man, the breadth of his cheſt, the openneſs of his countenance, and the rolling of his eye. Though ſcarcely exceeding the middle ſize, his figure indicated great ſtrength and activity. Deſpiſing the accidental diſtinctions of ſociety, he ſeemed to regard no man as his ſuperior; but his manners, though coarſe, were not diſagreeable. His uncultivated genius was original and comprehenſive. From the native energy of his mind, he was adventurous, curious, and unappalled by dangers; while the ſtrength of his judgment united caution with energy. The track pointed out to him was from Cairo to Senaar, and thence weſtward in the latitude and ſuppoſed direction of the Niger.

He was not ignorant, that the taſk aſſigned him was arduous and big with danger; but inſtead of ſhrinking from it, he ſaid, on the day of his departure, "I am accuſtomed to hardſhips; I have known both hunger and nakedneſs to the utmoſt extremity of human ſuffering; I have known what it is to have food given me as charity to a madman; and I have at times been obliged to ſhelter myſelf under the miſeries of that character to avoid a heavier calamity. My diſtreſſes have been greater than I ever owned, or ever will own to any man. Such evils are terrible to bear, but they never yet had power to turn me from my purpoſe. If I live, I will faithfully perform, in its utmoſt extent, my engagement to the Society: and if I periſh in the attempt, my honour will be ſafe; for death cancels all bonds."

After receiving his inſtructions and letters of recommendation, this intrepid traveller ſailed from London on the 30th of June 1788; and in 36 days arrived at Alexandria. Proceeding to Cairo, where he arrived Auguſt the 17th, he viſited the ſlave markets, and converſed with the travelling merchants of the caravans. Theſe ſources of information, generally neglected by travellers, enabled him to obtain, at a very ſmall expence, more correct information concerning the African nations and their trade, the poſition of places, the nature of the country, the manner of travelling, &c. than could have been eaſily obtained by any other method. He thus learned, that the Arabs of the deſert have an invincible attachment to liberty, though it is ſingular that they have no word to expreſs liberty in their language. The Mahomedans of Africa are a trading, ſuperſtitious, and warlike ſet of vagabonds. He ſaw near 200 black ſlaves expoſed to ſale, who had been brought from the interior parts of Africa; their appearance ſavage, but not like priſoners of war; they had head ornaments, and their hair plaited in detached plaits of great length. Another parcel, which had come from Darfoor, were moſtly women; and the beads, and ſome other ornaments which they wore, were Venetian. They were well formed, quite black, had the true Guinea face, and curled hair. Mr Ledyard was informed, that the king of Senaar was a merchant, and concerned in the caravans; that 20,000 negro ſlaves are imported into Egypt annually. Among ſome Senaar ſlaves, he ſaw three of a bright olive colour, but their heads uncommonly formed, the forehead the narroweſt, longeſt, and moſt protuberant he ever ſaw.

The Senaar caravan is the moſt rich; that of Darfoor is not equally ſo, though it trades with almoſt the ſame commodities. Beſides ſlaves, theſe are gum, elephants teeth, camels, and oſtrich-feathers; for which are received in exchange trinkets, ſoap, antimony, red linen, razors, ſciſſars, mirrors, and beads. Wangara, to which the caravans alſo trade, was repreſented to Mr Ledyard as a kingdom producing much gold; but the king ſeems to intermeddle with commerce as well as the potentate of Senaar; for in order to deceive ſtrangers, and prevent them from gueſſing at the extent of his riches, he was reported to vary continually the gold uſed in barter, which it is his province to regulate, and of which he iſſues at one time a great quantity, and at others little or none. A caravan goes from Cairo to Fezzan, which they call a journey of fifty days; and as the caravans travel about 20 miles a day, the diſtance muſt be about 1000 miles; from Fezzan to Tombuctoo is 1800 miles; from Cairo to Senaar about 600 miles.

Such was the information which Mr Ledyard derived from the merchants of the caravans in Egypt; but when he was about to verify it by his own obſervations, and had announced to the Aſſociation that his next diſpatch would be dated from Senaar, he was ſeized with a bilious complaint, which fruſtrated the ſkill of the moſt eminent phyſicians, and put a period to his travels and his life at Cairo. It is needleſs to ſay how much his death was regretted, or how well he was qualified for the arduous enterpriſe in which he had engaged. The perſon who, with ſuch ſcanty funds, could penetrate the frozen regions of Tartary, ſubſiſt among their churliſh inhabitants, and ingratiate himſelf with the ferocious Moors of Egypt, could hardly have failed to obtain a kind reception from the gentle and hoſpitable Negro, had no untoward circumſtance intervened. At Senaar, indeed, his riſk would have been great; and Mr Bruce was decidedly of opinion, that a man ſo poorly attended as Mr Ledyard, could never have made his eſcape from that treacherous and ferocious people.

The obſervations of this accurate obſerver on the female character, though they have been repeatedly quoted in other works, are well intitled to a place here; and with them we ſhall conclude this ſketch of his life: "I have always (ſays he) remarked, that women in all countries are civil and obliging, tender and humane; that they are ever inclined to be gay and cheerful, timorous and modeſt; and that they do not heſitate, like man, to perform a generous action. Not haughty, not arrogant, not ſupercilious; they are full of courteſy, and fond of ſociety; more liable, in general, to err than man; but in general alſo more virtuous, and performing more good actions than he. To a woman, whether civilized or ſavage, I never addreſſed myſelf, in the language of decency and friendſhip, without receiving a decent and friendly anſwer. With man it has often been otherwiſe. In wandering over the barren plains of inhoſpitable Denmark, through honeſt Sweden, and frozen Lapland, rude and churliſh Finland, unprincipled Ruſſia, and the wide ſpread regions of the wandering Tartar; if hungry, dry, cold, wet, or ſick, the women have ever been friendly to me, and uniformly ſo. And to add to this virtue (ſo worthy the appellation of benevolence), theſe actions have been performed in ſo free and kind a manner, that if I was dry, I drank the ſweeteſt draught; and if hungry, I eat the coarſeſt morſel with a double reliſh." For a fuller account of *Ledyard*, ſee *The Tranſactions of the African Aſſociation*, or *A View of the Late Diſcoveries in Africa.*

Hyperbolic LEGS, are the ends of a curve line that partakes of the nature of the hyperbola, or having aſymptots.

LEMINGTON Priors, is a village two miles eaſt of the town of Warwick, famous for its mineral waters. One ſalt ſpring, which riſes near the church yard, has been long known, as well as another which riſes in the bed of the river; but the moſt remarkable ſpring was diſcovered in the year 1790. The waters of both ſprings have been analyzed with great accuracy by William Lambe, M. A. late Fellow of St John's colledge, Cambridge, who has given us the following ſynoptical table of the ſubſtances contained in them:

Gaſeous Fluids contained in a Wine gallon in Cubic Inches.

	WATER OF THE NEW SPRING.	WATER OF THE OLD SPRING.
Hepatic gas -	*Too ſmall to be meaſured.*	*Too ſmall to be meaſured.*
Azotic gas -	3.5	3
Carbonic acid gas	.5	—

Solid contents of a Wine-gallon in Grains.

	WATER OF THE NEW SPRING.	WATER OF THE OLD SPRING.
Carbonat of iron	·75	
Oxyds of iron and mangaueſe -	—	*Too ſmall to be weighed.*
Oxygenated muriat of iron and manganeſe - -	*Unknown, but very ſmall.*	*Unknown, but very ſmall.*
Sulphur - - -	*Unknown, but very ſmall.*	—
Muriat of magneſia	11.5	58
Muriat of ſoda	430	330
Sulphat of ſoda	152	62
Sulphat of lime	112	146

In the courſe of his experiments, for which we muſt refer to the original memoir, in Tranſactions of the Mancheſter Society, Mr Lambe thinks he diſcovered the origin of the *muriatic acid.* He found a coincidence, very unexpected, between the hepatiſed ſolution of iron and the oxygenated muriat of iron. "I had almoſt concluded (ſays he), from the reſemblance between the properties of this ſalt and the phenomena of the water, that the water contains this very ſalt. Now, I conclude, that they contain a matter, be it what it may, produced by the action of hepatic gas on iron. But they are the very ſame facts which form the baſis, upon which each ſeparate inference is built. Does it not follow, then, as a neceſſary conſequence, that the hepatiſed ſolution itſelf contains a muriat of iron highly oxygenated, and that therefore *in this proceſs muriatic acid is generated?* This concluſion ſeemed authoriſed by reaſon, and experiment has confirmed it."

LEMNISCATE, the name of a curve in the form of the figure of 8.

LEMON juice, is an article of ſuch harmleſs luxury, and in ſome caſes of ſuch real utility, that many of our readers will be pleaſed to know a ſimple method by which they may obtain it in great purity. In the article Chemistry (*Suppl.*), nº 476, we have ſhewn from Scheele and Dizé, how to obtain the citric acid perfectly pure, and in the form of cryſtals; but here we mean nothing more than to ſhew how it may be completely ſeparated from that ſlimy ſubſtance with which it is always mixed in the lemon, without allowing it time to ſpoil or to acquire any diſagreeable taſte during the ſeparation. This we are enabled to do by M. Brugnatelli, who, in the 2d volume of the *Annali di Chimia*, informs us, that he expreſſed in the common manner the juice of perfectly ripe lemons, and ſtrained it through a piece of linen. In half an hour he ſtrained it again, to free it from a little ſlimy matter which had ſettled at the bottom of the veſſel. He then added to the juice a certain quantity of the ſtrongeſt ſpirit of wine, and preſerved the mixture for ſome days in a well-corked bottle. During that time there was a conſiderable depoſit, which to all appearance was of a ſlimy nature, and which he ſeparated by filtering paper. If the fluid was too thick to paſs through the filter, he diluted it again with ſpirit of wine. After this operation, the depoſit remained on the paper, which was entirely covered with it; and he obtained, in the veſſel placed below, the pureſt acid of lemons combined with ſpirit of wine.

If it be required to obtain the acid perfectly pure, nothing is neceſſary but to ſeparate from it the ſpirit of wine, which can be beſt effected by evaporation. The acid of the lemons aſſumes, after it has been freed from the ſpirit of wine and the moiſture combined with it, a yellowiſh colour, and becomes ſo ſtrong, that by its taſte it might be conſidered as a mineral acid.

It is not neceſſary to evaporate the ſpirit of wine in a cloſe veſſel, if the experiment is made only on a ſmall ſcale; nor is there any danger that in open veſſels any of the acid will be loſt, as it is too fixed to be volatiliſed by the ſame degree of heat at which ſpirit of wine evaporates. This acid has peculiar properties, which deſerve farther examination.

LENSES (ſee Lens and Dioptrics, *Encycl.*), are either blown or ground.

Blown Lenses are uſed only in the ſingle microſcope; and

and the uſual method of making them has been to draw out a fine thread of the ſoft white glaſs called *cryſtal*, and to convert the extremity of this into a ſpherule by melting it at the flame of a candle. But this glaſs contains lead, which is diſpoſed to become opake by partial reduction, unleſs the management be very carefully attended to. We are informed, however, by Mr Nicholſon, that the hard glaſs uſed for windows ſeldom fails to afford excellent ſpherules. This glaſs is of a clear bright green colour when ſeen edgewiſe. A thin piece was cut from the edge of a pane of glaſs leſs than one-tenth of an inch broad. This was held perpendicularly by the upper end, and the flame of a candle was directed upon it by the blow-pipe at the diſtance of about an inch from the lower end. The glaſs became ſoft, and the lower piece deſcended by its own weight to the diſtance of about two feet, where it remained ſuſpended by a thin thread of glaſs about one five-hundredth of an inch in diameter. A part of this thread was applied endwiſe to the lower blue part of the flame of the candle without the uſe of the blow-pipe. The extremity immediately became white-hot, and formed a globule. The glaſs was then gradually and regularly thruſt towards the flame, but never into it, until the globule was ſufficiently large. A number of theſe were made; and being afterwards examined, by viewing their focal images with a deep magnifier, proved very bright, perfect, and round. This, as the ingenious author obſerves, may prove an acceptable piece of information to thoſe eminent men (and there are many ſuch), whoſe narrow circumſtances, or remote ſituations, are obliged to have recourſe to their own ſkill and ingenuity for experimental implements.

Ground LENSES, are ſuch as are ground or rubbed into the deſired ſhape, and then poliſhed. Different ſhapes have been propoſed for lenſes; but in the article OPTICS, nº 251 (*Encycl.*), it has been ſhewn that, after all, the ſpherical is the moſt practically uſeful. By many of the methods of grinding, however, the artificer, with his utmoſt care, can only produce an approximation to a truly ſpherical figure; and, indeed, gentlemen have, for the moſt part, nothing to depend on for the ſphericity of the lenſes of their teleſcopes, but the care and integrity of the workmen. In the 41ſt volume of the Tranſactions of the Royal Society of London, a machine is deſcribed by Mr Samuel Jenkins, which, as it is contrived to turn a ſphere at one and the ſame time on two axes, cutting each other at right angles, will produce the ſegment of a true ſphere merely by turning round the wheels, and that without any care or ſkill in the workmen. The following deſcription of this machine will enable our readers fully to comprehend its conſtruction, and the mode of uſing it: A is a globe covered with cement, in which are fixed the pieces of glaſs to be ground. This globe is faſtened to the axis, and turns with the wheel B. C is the braſs cup which poliſhes the glaſs: this is faſtened to the axis, and turns with the wheel D. The motion of the cup C, therefore, is at right angles with the motion of the globe A; whence it follows demonſtrably, that the pieces of glaſs ground by this double motion muſt be formed into the ſegments of ſpheres.

Plate XXXII.

LEO X. is a pontiff to whom learning, and art, and ſcience, are ſo deeply indebted, that not to give a ſketch of his life and character, in a Work of this kind, would be an unpardonable omiſſion. A character of him is indeed given in the *Encyclopædia*; but it is ſo far from the truth, that it is difficult to conceive the prejudices under which he muſt have laboured by whom ſuch a libel was drawn up.

Leo, whoſe name, before his elevation to the pontificate, was *Giovanni de Medici*, was the ſecond ſon of Lorenzo de Medici, juſtly ſtyled the Magnificent. In the life of that great man publiſhed in this *Supplement*, the reader will ſee by what means, and for what purpoſe, he got Giovanni raiſed to the dignity of cardinal at ſo early a period of life; and in the elegant work of Roſcoe, to which we there refer, he will find ſuch inſtructions of Lorenzo to the cardinal as muſt have made a deep impreſſion on his youthful mind.

Speaking of his promotion, Lorenzo ſays, "The firſt thing that I would ſuggeſt to you, is, that you ought to be grateful to God, and continually to recollect that it is not through your merits, your prudence, or your ſolicitude, that this event has taken place, but through his favour, which you can repay only by a *pious*, *chaſte*, and *exemplary life*; and that your obligations to the performance of theſe duties are ſo much the greater, as in your *early years* you have given ſome *reaſonable expectation* that your riper age may produce ſuch fruits. It would indeed be highly diſgraceful, and as contrary to your duty as to my *hopes*, if at a time when others diſplay a greater ſhare of reaſon, and adopt a better mode of life, you ſhould forget the *precepts of your youth*, and forſake the path in which you have *hitherto trodden*."—"I well know (continues Lorenzo), that as you are now to reſide at Rome, that ſink of all iniquity, the difficulty of conducting yourſelf by theſe admonitions will be increaſed. The influence of example is itſelf prevalent; but you will probably meet with thoſe, who will particularly endeavour to corrupt and incite you to vice; becauſe, as you yourſelf may perceive, your early attainment of ſo great a dignity is not obſerved without envy, and thoſe who could not prevent your receiving that honour, will ſecretly endeavour to diminiſh it, by inducing you to forfeit the good eſtimation of the public."—"You are not unacquainted with the great importance of the character which you have to ſuſtain; for you well know, that all the Chriſtian world would proſper if the cardinals were what they ought to be; becauſe in ſuch a caſe there would always be a good pope, upon which the tranquillity of Chriſtendom ſo materially depends."

As this was a confidential letter from Lorenzo to his ſon, the firſt of theſe extracts furniſhes very ſufficient evidence, that Giovanni had been at leaſt a well behaved boy, diligent in his ſtudies, and regular in his conduct; and without ſuppoſing him remarkably religious, the admonitions of ſuch a father, aided by his own ambition and love of letters, would ſurely guard him againſt ſuch groſs licentiouſneſs as that of which he is accuſed in the *Encyclopædia*. How much he revered his father, is apparent from the letter which he wrote to his brother immediately after Lorenzo's death. "What a father (ſays he) have we loſt! How indulgent to his children! Wonder not, then, that I grieve, that I lament, that I find no reſt. Yet, my brother, I have ſome conſolation in reflecting that I have thee, whom I ſhall always regard in the place of a father." Surely this is not the language of a groſs ſenſualiſt, or of one who could ſoon forget the ſalutary admonitions of ſuch a parent as Lorenzo de Medici. But it is needleſs to infer the decency of his character by ſuch reaſonings as theſe. The ſtory publiſhed in the *Encyclopædia*, of the manner in which the Cardinal de Medici obtained the tiara, cannot poſſibly be true. The reader, who ſhall turn to the article Pope in that Work, will find that the conclave, when fitted up for an election, is ſo large a place, that we may ſafely affirm, that had the cardinal's ulcer diſcharged matter ſo fetid as to *poiſon all the cells*, the aſſertion of the phyſicians would have been verified, and that in the then ſtate of the healing art, the new pope could not have ſurvived a month. Let it be remembered, too, that Leo, at his acceſſion, was not 30, but 37 years of age, and that he had long ruled in Florence with ſovereign ſway by the ſame means which had upheld the authority of his father. The follies of youth, therefore, had he ever been remarkable for ſuch follies, muſt have been over with him; and in ſuch a ſtate as Florence he could not have maintained the authority of Lorenzo, without exhibiting not only Lorenzo's liberality, but likewiſe his decency of manners.

The next charge brought againſt Leo in the *Encyclopædia* is, that he publiſhed general indulgences throughout Europe; and this is ſo expreſſed as to lead the ill-informed reader to ſuppoſe, either that no ſuch indulgences had ever been publiſhed by any of his predeceſſors, or that there was ſomething peculiarly ſcandalous in Leo's mode of publiſhing them. Both ſuppoſitions, however, are erroneous. The hiſtorian of the council of Trent, who certainly was not partial to the court of Rome, or to the diſpenſing power of the pope, has ſhewn, that the practice of raiſing money by the publication of indulgences, had prevailed ever ſince the year 1100; that many former popes had raiſed money in this manner for purpoſes much leſs laudable than thoſe which Leo had in his eye; and that the real cauſe of Luther's attack upon Leo's indulgences was, that they were preached through Saxony by the Dominican friars; whereas the preaching of former indulgences had been committed to the hermits of St Auguſtine, the order to which Luther himſelf belonged!

Leo is likewiſe accuſed in the *Encyclopædia* of being a profeſſed infidel, and of having called Chriſtianity "a fable very profitable for him and his predeceſſors." But of the truth of this accuſation there ſeems not to be the ſhadow of evidence. Leo had too much ſenſe to utter expreſſions of this kind, even had he been an unbeliever in his heart; for he could not poſſibly expect that his indulgences and pardons would be purchaſed, had he declared in ſuch ſtrong terms that they were of no value. Father Paul indeed ſays, that he was not a deep divine, or ſo pious as ſome of his predeceſſors; but he affirms, that he *adorned the papacy* with many admirable qualities; that he was learned, affable, liberal, *good;* that he delighted in healing differences, and that his equal had not, for many years, filled the chair of St Peter. Surely this is not the character of a profane infidel!

Leo has been charged with raiſing his own family to grandeur at the expence of juſtice; and of dealing treacherouſly, in order to effect this purpoſe, both with the emperor and with the French king. But the charge is either falſe or greatly exaggerated. He loſt no opportunity indeed of aggrandizing his relations, well knowing, that in order to ſecure to them any laſting benefit, it was neceſſary that they ſhould be powerful enough to defend themſelves, after his death, from the rapacious aims of ſucceeding pontiffs; but, in proſecuting this plan, he was ſo far from acting tyrannically or injuriouſly to others, that during his pontificate, the papal dominions enjoyed a degree of tranquillity ſuperior to any other Italian ſtate. During the conteſts that took place between the emperor and the French king, ſo far from acting treacherouſly, he diſtinguiſhed himſelf by his moderation, his vigilance, and his political addreſs; on which account he is juſtly celebrated by an eminent hiſtorian of our own *, as "the only prince of the age who obſerved the motions of the two contending monarchs with a prudent attention, or who diſcovered a proper ſolicitude for the public ſafety."

We truſt that no zealous Proteſtant will think we have employed our time ill, in vindicating the character of this ſplendid pontiff; for good learning, and, of courſe, true religion, are more indebted to Leo X. than to any other individual of the age in which he lived, his father Lorenzo alone excepted.

Leo Minor, the *Little Lion*, a conſtellation of the northern hemiſphere, and one of the new ones that were formed out of what were left by the ancients, under the name of *Stellæ Informes*, or unformed ſtars. See Astronomy, n° 406, *Encycl.*

LESLIE (Charles), was a man ſo eminent for his learning, his talents, and his piety, that a fuller account of him than that which is given in the *Encyclopædia* muſt be acceptable to our Chriſtian readers. He was the ſecond ſon of Dr John Leſlie biſhop of Clogher in Ireland, who was deſcended from an ancient family in the north of Scotland, and being an admirable ſcholar, roſe to the dignity of biſhop of Orkney in his own country, whence he was tranſlated, in 1633, to Raphoe in Ireland, and afterwards, in 1661, to the ſee of Clogher.

Our author was born in Ireland, but in what year we have not learned. A ludicrous ſtory goes indeed of his having been begotten in priſon, and of his father having ſaid that he hoped he would in conſequence become the greateſt ſcourge of the covenanters that Great Britain or Ireland had ever ſeen. This ſtory, with all its circumſtances as told to us, can hardly be true; but we think it could not have been fabricated, had not Charles Leſlie been born within a year of Cromwell's conqueſt of Ireland, when the good biſhop, having ſuſtained a ſiege in his caſtle of Raphoe againſt that arch rebel, was ſome time kept in cloſe confinement.

We are equally ignorant of the ſchool where he was educated as of the year of his birth; but we know that he had his academical education in Trinity College, Dublin, where he took the degree of maſter of arts. In the year 1671, he loſt his father, when he came over to England, and, entering himſelf in the temple, ſtudied law for ſome years, but afterwards relinquiſhed it for the ſtudy of divinity. In 1680, he was admitted into holy orders; and, in 1687, was made chancellor of Connor.

About this period he rendered himſelf particularly obnoxious to the Popiſh party in Ireland, by his zealous oppoſition to them, which was thus called forth. Roger Boyle, biſhop of Clogher, dying in 1687, Patrick Tyrrel was made titular Popiſh biſhop, and had the revenues of the ſee aſſigned him by king James. He ſet

Biographical Dictionary.

---

* Dr Robertſon.

up a convent of friars in Monaghan: and, fixing his habitation there, held a public viſitation of his clergy with great ſolemnity; when, ſome ſubtle logicians attending him, he was ſo inſolent as to challenge the Proteſtant clergy to a public diſputation. Leſlie undertook the taſk, and performed it to the ſatisfaction of the Proteſtants; though it happened, as it generally does at ſuch conteſts, that both ſides claimed the victory. He afterwards held another public diſputation with two celebrated Popiſh divines, in the church of Tynan, in the dioceſe of Armagh, before a very numerous aſſembly of perſons of both religions; the iſſue of which was, that Mr John Stewart, a Popiſh gentleman, ſolemnly renounced the errors of the church of Rome.

As the Papiſts had got poſſeſſion of an Epiſcopal ſee, they engroſſed other offices too; and a Popiſh high-ſheriff was appointed for the county of Monaghan. This proceeding alarmed the gentlemen in that county; who, depending much on Leſlie's knowledge as a juſtice of peace, repaired to him, then confined, by the gout, to his houſe. He told them, that it would be as illegal in them to permit the ſheriff to act as it would be in him to attempt it. But they inſiſting that he ſhould appear himſelf on the bench at the next quarter-ſeſſions, and all promiſing to ſtand by him, he was carried thither with much difficulty and in great pain. When the ſheriff appeared, and was taking his place, he was aſked whether he was legally qualified; to which he anſwered pertly, "That he was of the king's own religion, and it was his majeſty's will that he ſhould be ſheriff." Leſlie replied, "That they were not inquiring into his majeſty's religion, but whether he (the pretended ſheriff) had qualified himſelf according to law, for acting as a proper officer; that the law was the king's will, and nothing elſe to be deemed ſuch; that his ſubjects had no other way of knowing his will, but as it is revealed to them in his laws: and it muſt always be thought to continue ſo, till the contrary is notifed to them in the ſame authentic manner." Upon this, the bench unanimouſly agreed to commit the pretended ſheriff, for his intruſion and arrogant contempt of the court. Leſlie alſo committed ſome officers of that tumultuous army which the Lord Tyrconnel raiſed for robbing the country.

In this ſpirited conduct Leſlie acted like a ſound divine and an upright magiſtrate; but though he thought himſelf authoriſed to reſiſt the illegal mandates of his ſovereign, like many other great and good men, he diſtinguiſhed between active and paſſive obedience, and felt not himſelf at liberty to transfer his allegiance from that ſovereign to another. Refuſing therefore to take the oaths to king William and queen Mary, he was deprived of all his preferments; and in 1689 he removed with his family to England, where he publiſhed the following works, beſides thoſe already noticed in the *Encyclopædia*: 1. Anſwer to Archbiſhop King's State of the Proteſtants in Ireland. 2. Caſſandra, concerning the new Aſſociations, &c. 1703, 4to. 3. Rehearſals; at firſt a weekly paper, publiſhed afterwards twice a-week in a half-ſheet, by way of dialogue on the affairs of the times; begun in 1704, and continued for ſix or ſeven years. 4. The Wolf ſtripped of his Shepherd's Clothing, in Anſwer to Moderation a Virtue, 1704, 4to. The pamphlet it anſwers was written by James Owen. 5. The Biſhop of Sarum's [Burnet's] proper Defence, from a Speech ſaid to be ſpoken by him againſt occaſional conformity, 1704, 4to. 6. The new Aſſociation of thoſe called Moderate Churchmen, &c. occaſioned by a pamphlet, intitled, The Danger of Prieſtcraft, 1705, 4to. 7. The new Aſſociation, part 2d, 1705, 4to. 8. The Principles of Diſſenters concerning Toleration and occaſional Conformity, 1705, 4to. 9. A Warning for the Church of England, 1706, 4to. Some have doubted whether theſe two pieces were his. 10. The good old Cauſe, or Lying in Truth; being a ſecond Defence of the Biſhop of Sarum from a ſecond Speech, &c. 1710. For this a warrant was iſſued out againſt Leſlie. 11. A Letter to the Biſhop of Sarum, in Anſwer to his Sermon after the Queen's Death, in Defence of the Revolution, 1715. 12. Salt for the Leech. 13. The Anatomy of a Jacobite. 14. Gallienus redivivus. 15. Delenda Carthago. 16 A Letter to Mr William Molyneux, on his Caſe of Ireland's being bound by the Engliſh Acts of Parliament. 17. A Letter to Julian Johnſon. 18. Several Tracts againſt Dr Higden and Mr Hoadly. 19 A Diſcourſe, ſhewing who they are that are now qualified to adminiſter Baptiſm. 20. The Hiſtory of Sin and Hereſy, &c. 1698, 8vo. 21. The Truth of Chriſtianity demonſtrated, in a Dialogue between a Chriſtian and a Deiſt, 1711, 8vo.—Againſt the Papiſts: 22. Of private Judgment and Authority in Matters of Faith. 23. The Caſe ſtated between the Church of Rome and the Church of England, &c. 1713. 24. The true notion of the Catholic Church, in Anſwer to the Biſhop of Meaux's Letter to Mr Nelſon, &c.

Beſides theſe, he publiſhed the four following tracts: 25. A Sermon preached in Cheſter, againſt Marriages in different Communions, 1702, 8vo. This ſermon occaſioned Mr Dodwell's diſcourſe upon the ſame ſubject. 26. A Diſſertation concerning the Uſe and Authority of Eccleſiaſtical Hiſtory. 27. The Caſe of the Regal and the Pontificate. 28. A Supplement, in Anſwer to a Book, intitled, The regal Supremacy in Eccleſiaſtical Affairs aſſerted, &c. Theſe two laſt pieces were occaſioned by the diſpute about the rights of convocation, between Wake, &c. on one ſide, and Atterbury and his friends, among whom was Leſlie, on the other.

It is ſaid by the authors of the Biographical Dictionary, that, in conſequence of a publication of his, intitled, "The hereditary right of the crown of England aſſerted," he was under the neceſſity of leaving the kingdom; and that he repaired to the Pretender at *Bar le duc*, where he was allowed to officiate, in a private chapel, after the rites of the church of England; and where he endeavoured, though in vain, to convert the Pretender to the Proteſtant religion.

That he repaired to *Bar le duc*, and endeavoured to convert to the church of England him whom he conſidered as the rightful ſovereign of England, is indeed true; but we have reaſon to believe that this was not in conſequence of his being obliged to leave the kingdom. There is, in the firſt place, ſome grounds to believe, that "The hereditary right of the crown of England aſſerted" was not written by him; and there is ſtill in exiſtence undoubted evidence, that, in conſequence of his great fame as a polemic, he was ſent to *Bar le duc* for the expreſs purpoſe of endeavouring to convert the ſon of James II. by ſome gentlemen of fortune in England, who wiſhed to ſee that prince on the throne of his anceſtors. The writer of this article had the honour, 16 or 17 years ago, to be known to the granddaughter of one of thoſe gentlemen—a lady of the ſtricteſt veracity; and from her he received many anecdotes of Leſlie and his aſſociates, which, as he did not then foreſee that he ſhould have the preſent occaſion for them, he has ſuffered to ſlip from his memory. That lady is ſtill alive, and we have reaſon to believe is in poſſeſſion of many letters by Leſlie, written in confidence to her grandfather, both from *Bar le duc* and from St Germains; and by the account which ſhe gave of theſe letters, Leſlie appears to have conſidered his prince as a weak and incorrigible bigot, though, in every thing but religion, an amiable and accompliſhed man. This may have been his genuine character; for we all know that it was the character of his father; but it is not of him that we are writing.

Mr Leſlie having remained abroad from the year 1709 till 1721, returned that year to England, reſolving, whatever the conſequences might be, to die in his own country. Some of his friends acquainting lord Sunderland with his purpoſes, implored his protection for the good old man, which his lordſhip readily and generouſly promiſed. Mr Leſlie had no ſooner arrived in London, than a member of the houſe of commons officiouſly waited on lord Sunderland with the news, but met with ſuch a reception from his lordſhip as the malice of his errand deſerved. Our author then went over to Ireland, where he died April 13. 1722. at his own houſe at Glaſlough in the county of Monaghan.

His character may be ſummed up in a few words. Conſummate learning, attended by the loweſt humility, the ſtricteſt piety without the leaſt tincture of moroſeneſs, a converſation to the laſt degree lively and ſpirited, yet to the laſt degree innocent, made him the delight of mankind, and leaves what Dr Hickes ſays of him unqueſtionable, that he made more converts to a ſound faith and holy life than any other man of our times.

A charge, however, has been lately brought againſt him of ſuch a nature, as, if well founded, muſt detract not only from his literary fame, but alſo from his integrity. "The ſhort and eaſy Method with the Deiſts" is unqueſtionably his moſt valuable, and apparently his moſt original work; yet this tract is publiſhed in French among the works of the Abbé St Real, who died in 1692; and therefore it has been ſaid, that unleſs it was publiſhed in Engliſh prior to that period, Charles Leſlie muſt be conſidered as a ſhameleſs plagiary.

The Engliſh work was certainly not publiſhed prior to the death of Abbé St Real; for the firſt edition bears date July 17th 1697; and yet many reaſons conſpire to convince us, that our countryman was no plagiary. There is indeed a ſtriking ſimilarity between the Engliſh and the French works; but this is no complete proof that the one was copied from the other. The article PHILOLOGY in the *Encyclypædia Britannica*, of which Dr Doig is the author, was publiſhed the very ſame week with Dr Vincent's diſſertation on the Greek verb. It was therefore impoſſible that either of theſe learned men, who were till then ſtrangers to each others names, could have ſtolen aught from the other; and yet Dr Vincent's derivation of the Greek verb bears as ſtriking a reſemblance to Dr Doig's as the Abbé St Real's work does to Charles Leſlie's. In the article MIRACLE (*Encycl.*), the credibility of the goſpel miracles is eſtabliſhed by an argument, which the author certainly borrowed from no man, and which the late principal Campbell conſidered as original; yet within half a year of the publication of that article, the credibility of the goſpel-miracles was treated in the very ſame manner by F. SAYERS, M. D. though there is in his diſſertation complete internal evidence that he had not ſeen the article in the *Encyclopædia*. Not many months ago, the author of this ſketch reviewed, in one of the journals, the work of a friend, which was at the ſame time reviewed in another journal, that at this moment he has never ſeen. Yet he has been told by a friend, who is much verſant in that kind of reading, and knows nothing of his concern with either review, that the book in queſtion muſt, in both journals, have been reviewed by the ſame hand; becauſe in both the ſame character is given of it in almoſt the very ſame words!

After theſe inſtances of apparent plagiariſm, which we know to be *only* apparent, has any man a right to ſay that Charles Leſlie and the Abbé St Real might not have have treated their ſubject in the way that they have done, without either borrowing from the other? The coincidence of arrangement and reaſoning in the two works is indeed very ſurpriſing; but it is by no means ſo ſurpriſing as the coincidence of etymological deductions which appears in the works of the Doctors Doig and Vincent. The divines reaſon from the acknowledged laws of human thought; the reaſonings of the grammarians, with all due deference to their ſuperior learning, we cannot help conſidering as ſometimes fanciful.

But this is not all that we have to urge on the ſubject. If there be plagiariſm in the caſe, and the identity of titles looks very like it, it is infinitely more probable that the editor of St Real's works ſtole from Leſlie, than that Leſlie ſtole from St Real, unleſs it can be proved that the works of the Abbé, and this work in particular, were publiſhed before the year 1697. At that period, the Engliſh language was very little read or underſtood on the continent; whilſt in Britain the French language was, by *ſcholars*, as generally underſtood as at preſent. Hence it is, that ſo many Frenchmen, and indeed foreigners of different nations, thought themſelves ſafe in pilfering ſcience from the Britiſh philoſophers *; whilſt there is not, that we know, one well authenticated inſtance of a Britiſh philoſopher appropriating to himſelf the diſcoveries of a foreigner. If, then, ſuch men as LEIBNITZ, John BERNOULLI, and DES CARTES, truſting to the improbability of detection, condeſcended to pilfer the diſcoveries of HOOKE, NEWTON, and HARRIOT, is it improbable that the editor of the works of St Real would claim to his friend a celebrated tract, of which he knew the real author to be obnoxious to the government of his own country, and therefore not likely to have powerful friends to maintain his right?

But farther, Burnet, biſhop of Sarum, was an excellent ſcholar, and well read, as every one knows, in the works of foreign divines. Is it conceivable, that this prelate, when ſmarting under the laſh of Leſlie, would have let ſlip ſo good an opportunity of covering with diſgrace his moſt formidable antagoniſt, had he known that antagoniſt to be guilty of plagiariſm from the writings of the Abbé St Real? Let it be granted, however,

---

* See *Quantity* (Encycl.), *Aſtronomy*, *Dynamics*, *Impulſion*, and *Harriot*, in this Suppl.

however, that Burnet was a ſtranger to theſe writings and to this plagiariſm; it can hardly be ſuppoſed that *Le Clarc* was a ſtranger to them likewiſe. Yet this author, when, for reaſons beſt known to himſelf, he choſe (1706) to depreciate the argument of *the ſhort method*, and to traduce its author as ignorant of ancient hiſtory, and as having brought forward his four marks for no other purpoſe than to put the deceitful traditions of Popery on the ſame footing with the moſt authentic doctrines of the goſpel, does not ſo much as inſinuate that he borrowed theſe marks from a Popiſh abbé, though ſuch a charge, could he have eſtabliſhed it, would have ſerved his purpoſe more than all his rude railings and invective. But there was no room for ſuch a charge. In the ſecond volume of the works of St Real, publiſhed in 1757, there is indeed a tract entitled *Methode Courte et Aiſée pour combattre les Deiſtes;* and there can be little doubt but that the publiſher wiſhed it to be conſidered as the work of his countryman. Unfortunately, however, for his deſign, a catalogue of the Abbé's works is given in the firſt volume; and in that catalogue the *Methode Courte et Aiſée* is not mentioned.

We have dwelt thus long on *The Short and Eaſy Method with the Deiſts*, becauſe it is one of the ableſt works that ever was written in proof of the Divine origin of the Jewiſh and Chriſtian Scriptures; a work of which the merit is acknowledged by Lord Bolingbroke, and which, as has been obſerved elſewhere (ſee THEOLOGY, nº 16. *Encycl.*) Dr Conyers Middleton confeſſes to be unanſwerable. If by men of ſcience we be thought to have ſpent our time well in vindicating the rights of our illuſtrious philoſophers Hooke and Newton, to diſcoveries which have been unjuſtly claimed by the philoſophers of Germany and France; we will not ſurely by the friends of Chriſtianity be thought to have employed our time ill in vindicating Leſlie's claim to this deciſive argument in ſupport of our holy religion.

LEVER, the firſt of the mechanical powers, for the properties of which ſee MECHANICS; and for a demonſtration of its fundamental property, ſee STEEL YARD, both in the *Encyclopædia*.

LICENSER of BOOKS (ſee LIBERTY *of the Preſs*, *Encycl*), has been an officer in almoſt every civilized nation, till the end of the laſt century that the office was aboliſhed in Great Britain. Profeſſor Beckmann, with his uſual induſtry *, has proved that ſuch an office was eſtabliſhed not only in the Roman Empire, but even in the republic, and in the free ſtates of ancient Greece. At Athens, the works of Protagoras were prohibited; and all the copies of them which could be collected were burnt by the public crier. At Rome, the writings of Numa, which had been found in his grave, were, by order of the ſenate, condemned to the fire, becauſe they were contrary to the religion which he had introduced. As the populace at Rome were, in times of public calamity, more addicted to ſuperſtition than ſeemed proper to the government, an order was iſſued, that all ſuperſtitious and aſtrological books ſhould be delivered into the hands of the prætor. This order was often repeated; and the emperor Auguſtus cauſed more than twenty thouſand of theſe books to be burnt at one time. Under the ſame emperor the ſatirical works of Labienus were condemned to the fire, which was the firſt inſtance of this nature; and it is related as ſomething ſingular, that, a few years after, the writings of the perſon who had been the cauſe of the order for that purpoſe ſhared the like fate, and were alſo publicly burnt. When Cremutius Cordus, in his hiſtory, called C. Caſſius the laſt of the Romans, the ſenate, in order to flatter Tiberius, cauſed the book to be burnt; but a number of copies were ſaved by being concealed. Antiochus Epiphanes cauſed the books of the Jews to be burnt; and in the firſt centuries of our æra the books of the Chriſtians were treated with equal ſeverity, of which Arnobius bitterly complains. We are told by Euſebius, that Diocleſian cauſed the ſacred Scriptures to be burnt. After the ſpreading of the Chriſtian religion the clergy exerciſed, againſt books that were either unfavourable or diſagreeable to them, the ſame ſeverity which they had cenſured in the heathens as fooliſh and prejudicial to their own cauſe.

Soon after the invention of printing, laws began to be made for ſubjecting books to examination; a regulation propoſed even by Plato; and which has been wiſhed for by many ſince. Our author gives a great deal of curious information on this important ſubject, which our limits do not permit us to repeat; but it is apparent from his work, that the liberty of the preſs is but a modern privilege; and that it has not been enjoyed completely in any country but this happy iſland.

LICHEN (ſee *Encycl.*), is a genus of plants, of which the moſt valuable ſpecies ſeems to be the LICHEN ROCELLA, or *Argol*. As that ſpecies has not been noticed in the article referred to, the following account of it from Profeſſor Beckmann will be acceptable to many of our readers:

It is found in abundance in ſome of the iſlands near the African coaſt, particularly in the Canaries, and in ſeveral of the iſlands in the Archipelago. It grows upright, partly in ſingle, partly in double ſtems, which are about two inches in height. When it is old, theſe ſtems are crowned with a button ſometimes round, and ſometimes of a flat form, which Tournefort, very properly, compares to the excreſcences on the arms of the ſepia. Its colour is ſometimes a light, and ſometimes a dark grey. Of this moſs, with lime, urine, and alkaline ſalts, is formed a dark red paſte, which in commerce has the ſame name, and which is much uſed in dyeing. That well-known ſubſtance called lacmus is alſo made of it.

Theophraſtus, Dioſcorides, and their tranſcriber Pliny, give the name of *Phycos thalaſſion*, or *pontion*, to this plant, which, notwithſtanding its name, is not a ſea weed but a moſs; as it grew on the rocks of different iſlands, and particularly on thoſe of Crete or Candia. It had, in their time, been long uſed for dyeing wool, and the colour it gave when freſh was ſo beautiful, that it excelled the ancient purple, which was not red, as many ſuppoſe, but violet. Pliny tells us, that with this moſs dyers gave the ground or firſt tint to thoſe cloths which they intended to dye with the coſtly purple. When it was firſt employed as a dye by the moderns, is not ſo certain, though the Profeſſor has proved, we think completely, that it muſt have been at leaſt as early as the beginning of the 14th century.

"Among the oldeſt and principal Florentine families (ſays he), is that known under the name of the

---

* *Hiſtory of Inventions*, vol 3.

Oricellarii or Rucellarii, Ruſcellai or Rucellai, ſeveral of whom have diſtinguiſhed themſelves as ſtateſmen and men of letters. This family are deſcended from a German nobleman, named Ferro or Frederigo, who lived in the beginning of the twelfth century. One of his deſcendants, in the year 1300, carried on a great trade in the Levant, by which he acquired conſiderable riches, and returning at length to Florence, with his fortune, firſt made known in Europe the art of dyeing with argol. It is ſaid, that a little before his return from the Levant, happening to make water on a rock covered with this moſs, he obſerved, that the plant, which was there called *reſpio*, or *reſpo*, and in Spain *orciglia*, acquired by the urine a purple, or, as others ſay, a red colour. He therefore tried ſeveral experiments; and when he had brought to perfection the art of dyeing wool with this plant, he made it known at Florence, where he alone practiſed it for a conſiderable time, to the great benefit of the ſtate. From this uſeful invention, the family received the name of Oricellarii, from which, at laſt, was formed Rucellai." The Profeſſor, however, does not believe that this Florentine diſcovered the dye by means of the above-mentioned accident, but that he learned the art in the Levant, and on his return taught it to his countrymen.

"Our dyers do not purchaſe raw argol, but a paſte made of it, which the French call *orſeille en pâte*. The preparation of it was for a long time kept a ſecret by the Florentines. The perſon who, as far as I know, made it firſt known was Roſetti; who, as he himſelf tells us, carried on the trade of dyer at Florence. Some information was afterwards publiſhed concerning it by Imperati * and Micheli the botaniſt †. In later times this art has been much practiſed in France, England, and Holland. Many druggiſts, inſtead of keeping this paſte in a moiſt ſtate with urine, as they ought, ſuffer it to dry, in order to ſave a little dirty work. It then has the appearance of a dark violet-coloured earth, with here and there ſome white ſpots in it.

"The Dutch (continues our author), who have found out better methods than other nations of manufacturing many commodities, ſo as to render them cheaper, and thereby to hurt the trade of their neighbours, are the inventors alſo of lacmus, a preparation of argol, called *orſeille en pierre*, which has greatly leſſened the uſe of that *en pâte*, as it is more eaſily tranſported and preſerved, and fitter for uſe; and as it is beſides, if not cheaper, at leaſt not dearer. This art conſiſts, undoubtedly, in mixing with that commodity ſome leſs valuable ſubſtance, which either improves or does not much impair its quality, and which, at the ſame time, increaſes its weight (A). Thus do they pound cinnabar and ſmalt finer than other nations, and yet ſell both theſe articles cheaper. Thus do they ſift cochineal, and ſell it cheaper than what is unſifted.

"It was for a long time believed, that the Dutch prepared their lacmus from thoſe linen rags which in the ſouth of France are dipped in the juice of the *croton tinctorium*; but at preſent, it is almoſt certainly known, that *orſeille en pâte* is the principal ingredient in *orſeille en pierre* that is in lacmus; and for this curious information we are indebted to Ferber. But whence ariſes the ſmell of the lacmus, which appears ſo like that of the Florentine iris?" Some of the latter may, perhaps, be mixed with it; for our author thinks, that he has obſerved in it ſmall indiſſoluble particles, which may have been bits of the roots. The addition of this ſubſtance can be of no uſe to improve the dye; but it may increaſe the weight, and give the lack more body; and perhaps it may be employed to render imperceptible ſome unpleaſant ſmell, for which purpoſe the roots of that plant are uſed on many other occaſions.

LIGHT, it has been obſerved in the article CHEMISTRY, n° 319. (*Suppl.*), conſiſts of rays differently flexible. This was eſtabliſhed by ſome well deviſed experiments made by Henry Brougham, Eſq; of which it may be proper to give an account here.

In the firſt experiment, he darkened his chamber in the uſual way, and let a beam of the ſun's light into it through the hole of a metal plate fixed in the ſhutter of the window, $\frac{1}{30}$th of an inch in diameter. At the hole within the room he placed a priſm of glaſs, of which the refracting angle was 45 degrees, and which was everywhere covered with black paper, except a ſmall part on each ſide; and through this part the light was refracted ſo as to form a diſtinct ſpectrum on a chart at ſix feet diſtance from the window. In the rays, at two feet from the priſm, he placed a black unpoliſhed pin, of which the diameter was $\frac{1}{10}$th of an inch, parallel to the chart, and in a vertical poſition. The ſhadow of the pin was found in the ſpectrum; and this ſhadow had a conſiderable penumbra, which was broadeſt and moſt diſtinct in the violet part, narroweſt and moſt confuſed in the red, and of an intermediate thickneſs and diſtinctneſs in the intermediate colours. The penumbra was bounded by curvilinear ſides, convex towards the axis to which they approached as to an aſymptote, ſo as to be neareſt to it in the place of the leaſt refrangible rays. By moving the priſm on its axis, and cauſing the colours to aſcend and deſcend on any bodies that were uſed inſtead of the pin, the red, wherever they fell, made the leaſt, and the violet the greateſt, ſhadow.

In the next experiment, a ſcreen was ſubſtituted in the place of the pin; and this ſcreen had a large hole, on which was a braſs plate, pierced with a ſmall hole $\frac{1}{32}$d of an inch in diameter. While an aſſiſtant moved the priſm ſlowly on its axis, the author obſerved the round image made by the different rays paſſing through the hole to the chart; that made by the red was greateſt, that of the violet leaſt, and that of each intermediate rays was of an intermediate ſize. When the ſharp blade of a knife was held at the back of the hole, "ſo as to produce the fringes mentioned by Grimaldo and Newton, theſe fringes in the red were broadeſt and moſt moved inwards to the ſhadow, and moſt dilated when the knife was moved over the hole; and the hole itſelf on the chart was more dilated during the motion when illuminated by the red than when illuminated by any other of the rays, and leaſt of all when illuminated by the violet."

From theſe two experiments, the author infers "that the rays of the ſun's light differ in degree of flexibility, and

* Lib. xxvii c. 9.

† *Nova Plantarum genera Florenciæ*, 1729.

(A) As dry lacmus is much cheaper than moiſt, it may be readily ſuppoſed that it is adulterated with ſand and other ſubſtances. *Valentini Hiſtoria ſimplicium.* Francf. ad Moen. 1716. fol. p. 152.

and that thoſe which are leaſt *refrangible* are *moſt inflexible*." From other experiments, he concludes, that the *moſt inflexible* rays are alſo *moſt deflexible*. In the ſequel of his paper, he aſcertains the proportion which the angle of *inflection* bears to that of *deflection* at equal incidences, and the proportion which the different *flexibilities* of the different rays bear to one another. We ſhall give an account of ſome other experiments made by him, and of the inferences drawn from them, under the word REFLEXITY, to which a reference has already been made.

LIMBERS, in artillery, a ſort of advanced train, joined to the carriage of a cannon on a march. It is compoſed of two ſhafts, wide enough to receive a horſe between them, called the *fillet horſe:* theſe ſhafts are joined by two bars of wood, and a bolt of iron at one end, and mounted on a pair of rather ſmall wheels. Upon the axle-tree riſes a ſtrong iron ſpike, which is put into a hole in the hinder part of the train of the gun-carriage, to draw it by. But when a gun is in action, the limbers are taken off, and run out behind it.

LIMIT OF A PLANET, has been ſometimes uſed for its greateſt heliocentric latitude.

LIMITED Problem, denotes a problem that has but one ſolution, or ſome determinate number of ſolutions: as to deſcribe a circle through three given points that do not lie in a right line, which is limited to one ſolution only; to divide a parallelogram into two equal parts by a line parallel to one ſide, which admits of two ſolutions, according as the line is parallel to the length or breadth of the parallelogram; or to divide a triangle in any ratio by a line parallel to one ſide, which is limited to three ſolutions, as the line may be parallel to any of the three ſides.

LOCAL PROBLEM, is one that is capable of an infinite number of different ſolutions; becauſe the point, which is to ſolve the problem, may be indifferently taken within a certain extent; as ſuppoſe any where in ſuch a line, within ſuch a plane figure, &c. which is called a *geometrical Locus*.

A local problem is *ſimple*, when the point ſought is in a right line; *plane*, when the point ſought is in the circumference of a circle; *ſolid*, when it is in the circumference of a conic ſection; or *ſurſolid*, when the point is in the perimeter of a line of a higher kind.

LOCI, the plural of

LOCUS, a line by which a local or indeterminate problem is ſolved; or a line of which any point may equally ſolve an indeterminate problem. See ALGEBRA, *Encycl.*

LOGISTIC CURVE, the ſame with *LOGARITHMIC Curve*, for which ſee *Encycl.*

LOGISTICS, or *LOGISTICAL Arithmetic*, a name ſometimes employed for the arithmetic of ſexageſimal fractions, uſed in aſtronomical computations.

The ſame term has been uſed for the rules of computations in algebra, and in other ſpecies of arithmetic: witneſs the logiſtics of Vieta and other writers.

Shakerly, in his *Tabulæ Britannicæ*, has a table of logarithms adapted to ſexageſimal fractions, and which he calls Logiſtical Logarithms; and the expeditious arithmetic, obtained by means of them, he calls Logiſtical Arithmetic.

LIBYAN LOTUS has been deſcribed (*Encycl.*) under the title RHAMNUS; but the following additional particulars from Mr Park will be acceptable to our botanical readers:

The lotus is very common in all the countries which our author viſited, and he had an opportunity to make a drawing of a branch in flower, of which an engraving is publiſhed in his travels, that with his permiſſion we have copied (ſee Plate XXX.). The lotus produces fruit which the negroes call *tomberongs*. Theſe are ſmall farinaceous berries, of a yellow colour and delicious taſte. They are much eſteemed by the natives, who convert them into a ſort of bread, by expoſing them for ſome days to the ſun, and afterwards pounding them gently in a wooden mortar, until the farinaceous part of the berry is ſeparated from the ſtone. This meal is then mixed with a little water, and formed into cakes; which, when dried in the ſun, reſemble in colour and flavour the ſweeteſt gingerbread. The ſtones are afterwards put into a veſſel of water, and ſhaken about ſo as to ſeparate the meal which may ſtill adhere to them: this communicates a ſweet and agreeable taſte to the water, and with the addition of a little pounded millet, forms a pleaſant gruel called *fondi*, which is the common breakfaſt in many parts of Ludamar, during the months of February and March. The fruit is collected by ſpreading a cloth upon the ground, and beating the branches with a ſtick. Our author thinks there can be little doubt of this being the lotus mentioned by Pliny, as the food of the Lybian Lotophagi. An army may very well have been fed with the bread made of the meal of the fruit, as is ſaid by Pliny to have been done in Lybia; and as the taſte of the bread is ſweet and agreeable, it is not likely that the ſoldiers would complain of it.

LOWANG, a Chineſe iſland of ſome extent in the neighbourhood of the CHUSAN-Iſles, which ſee in this *Supplement*. Some of the gentlemen belonging to the Britiſh embaſſy went aſhore on Lowang, which they deſcribed as naked both of trees and of cattle. They examined particularly a ſmall level plain recovered from the ſea, which was kept out by an embankment of earth, at leaſt thirty feet thick. The quantity of ground gained by it ſeemed ſcarcely to be worth the labour that it muſt have coſt. The plain was indeed cultivated with the utmoſt care, and laid out chiefly in rice-plats, ſupplied with water collected from the adjacent hills into little channels, through which it was conveyed to every part of thoſe plantations. It was manured, inſtead of the dung of animals, with matters more offenſive to the human ſenſes, and which are not very generally applied to the purpoſes of agriculture in England. Earthen veſſels were ſunk into the ground for the reception of ſuch manure; and for containing liquids of an analogous nature, in which the grain was ſteeped previouſly to its being ſown; an operation which is ſuppoſed to haſten the growth of the future plant, as well as to prevent any injury from inſects in its tender ſtate.

The party fell in with a peaſant who, though ſtruck with their appearance, was not ſo feared by it as to ſhun them. He was dreſſed in looſe garments of blue cotton, a ſtraw hat upon his head faſtened by a ſtring under his chin, and half boots upon his legs. He ſeemed to enter into the ſpirit of curioſity, naturally animating travellers, and readily led them towards an adjoining village.

village. Paſſing by a ſmall farm houſe, they were invited into it by the tenant, who, together with his ſon, obſerved them with aſtoniſhed eyes. The houſe was built of wood, the uprights of the natural form of the timber. No ceiling concealed the inſide of the roof, which was put together ſtrongly, and covered with the ſtraw of rice. The floor was of earth beaten hard, and the partitions between the rooms conſiſted of mats hanging from the beams. Two ſpinning wheels for cotton were ſeen in the outer room; but the ſeats for the ſpinners were empty. They had probably been filled by females, who retired on the approach of ſtrangers; while they remained, none of that ſex appeared. Round the houſe were planted cluſters of bamboo, and of that ſpecies of palm, of which each leaf reſembles the form of a fan; and, uſed as ſuch, becomes an article of merchandize.

LOXODROMIC Curve, or *Spiral*, is the ſame as the rhumb line, or path of a ſhip ſailing always on the ſame courſe in an oblique direction, or making always the ſame angle with every meridian. It is a ſpecies of logarithmic ſpiral, deſcribed on the ſurface of the ſphere, having the meridians for its radii.

LOXODROMICS, the art or method of oblique ſailing, by the loxodromic or rhumb line.

LUCIOLE, a name given in the *Annales de Chimie* to the Lampyris *Italica* (See Lampyris, *Encycl.*). According to Dr Carradori, the light of the luciole does not depend on the influence of any external cauſe, but merely on the will of thoſe inſects. While they fly about at freedom, their ſhining is very regular; but when they are once in our power, they ſhine very irregularly, or do not ſhine at all. When they are moleſted, they emit a frequent light, which appears to be a mark of their reſentment. When placed on their backs, they ſhine almoſt without interruption, making continual efforts to turn themſelves from that poſition. In the daytime it is neceſſary to torment them in order to make them ſhine; and thence it follows, that the day to them is the ſeaſon of repoſe. The luciole emit light at pleaſure from every point of their bellies, which proves that they can move all the parts of their viſcera independently of each other. They can alſo render their phoſphoreſcence more or leſs vivid, and continue it as long as they pleaſe.

A ſlight compreſſion deprives the luciole of their power of ceaſing to ſhine. The author is inclined to believe, that the movement by which they conceal their light is executed by drawing back their phoſphoric ſubſtance into a particular membrane or tunic. He ſuppoſes alſo, that the ſparkling conſiſts in a trembling or oſcillation of the phoſphoric maſs. He is of opinion, that there is no emanation of a phoſphoric ſubſtance, and that the whole phenomenon takes place in the interior part of the luminous viſcera. When the ſhining is at its greateſt degree of height, it is ſo ſtrong that a perſon may by it eaſily diſtinguiſh the hours on the ſmalleſt watch, and the letters of any type whatever.

The phoſphoric part of the luciole does not extend farther than to the extreme rings of the belly. It is there incloſed in a covering compoſed of two portions of membranes, one of which forms the upper, and the other the lower, part of the belly, and which are joined together. Behind this receptacle is placed the phoſphorus, which reſembles a paſte, having the ſmell of garlic, and very little taſte. The phoſphoric matter iſſues from a ſort of bag on the ſlighteſt preſſure; when ſqueezed out, this matter loſes its ſplendour in a few hours, and is converted into a white dry ſubſtance. A portion of the phoſphoric belly put into oil, ſhone only with a feeble light, and was ſoon extinguiſhed. In water, a like portion ſhone with the ſame vivacity as in the air, and for a much longer time. The author thence concludes, that the phoſphoreſcence of the luciole is not the effect of ſlow inflammation, nor of the fixation of azotic gas, as the oil in which they ſhine does not contain a ſingle air-bubble: beſides, the phoſphorus of theſe inſects ſhines in a barometrical vacuum. The obſervation made by Foſter, that the luciole diffuſed a more vivid light in oxygen gas than in atmoſpheric air, does not, according to Carradori, depend upon a combuſtion more animated by the inſpiration of this gas, but on the animals feeling themſelves, while in that gas, in a better condition. "Whence, then, ariſes (ſays the author) the phoſphoric light of the luciole? I am of opinion (adds he), that the light is peculiar and innate in theſe inſects, as ſeveral other productions are peculiar to other animals. As ſome animals have the faculty of accumulating the electric fluid, and of keeping it condenſed in particular organs, to diffuſe it afterwards at pleaſure, there may be other animals endowed with the faculty of keeping in a condenſed ſtate the fluid which conſtitutes light. It is poſſible, that by a peculiar organization they may have the power of extracting the light which enters into the compoſition of their food, and of tranſmitting it to the reſervoir deſtined for that purpoſe, which they have in their abdomen. It is not even impoſſible that they may have the power to extract from the atmoſpheric air the luminous fluid, as other animals have the power of extracting from the ſame air, by a chemical proceſs, the fluid of heat."

Carradori diſcovered, that the phoſphoreſcence of the luciole is a property independent of the life of theſe animals, and that it is chiefly owing to the ſoft ſtate of the phoſphoric ſubſtance. Its light is ſuſpended by drying, and it is again revived by ſoftening it in water; but only after a certain time of deſiccation. Reaumur, Beccaria, and Spallanzani, obſerved the ſame thing in regard to the *pholades* and the *meduſa*.

By plunging the luciole alternately into lukewarm and cold water, they ſhine with vivacity in the former, but their light becomes extinct in the latter; which, according to the author, depends on the alternate agreeable and diſagreeable ſenſation which they experience. In warm water their light diſappears gradually. Dr Carradori tried on the luciole and their phoſphorus the action of different ſaline and ſpirituous liquors, in which they exhibited the ſame appearances as other phoſphoric animals. Theſe laſt experiments prove that the phoſphoric matter of the luciole is only ſoluble in water.

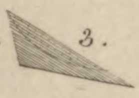
LUDAMAR, a Mooriſh kingdom in the interior of Africa, of which the capital Benorm is placed by Major Rennel in 15° N. Lat. and 6° 50′ W. Long. It has for its northern boundary the great deſert (ſee Sahara in this *Supplement*), and is deſcribed by Mr Park as little better than a deſert itſelf. Our traveller was taken captive on the confines of this kingdom, and carried to the camp of the king, where he was ſubjected to

PLATE. XXX.

Fig. 1.

Fig. 2.

Fig. 3.



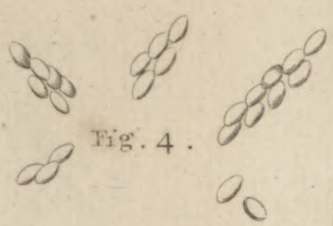


Fig. 4.

JONESIA.

Fig. 5.

Fig. 6.

MALE LARDIZABALA.

INDIAN SPIKENARD.

LOTUS.

D Lizars Sculpt

Fig. 7.

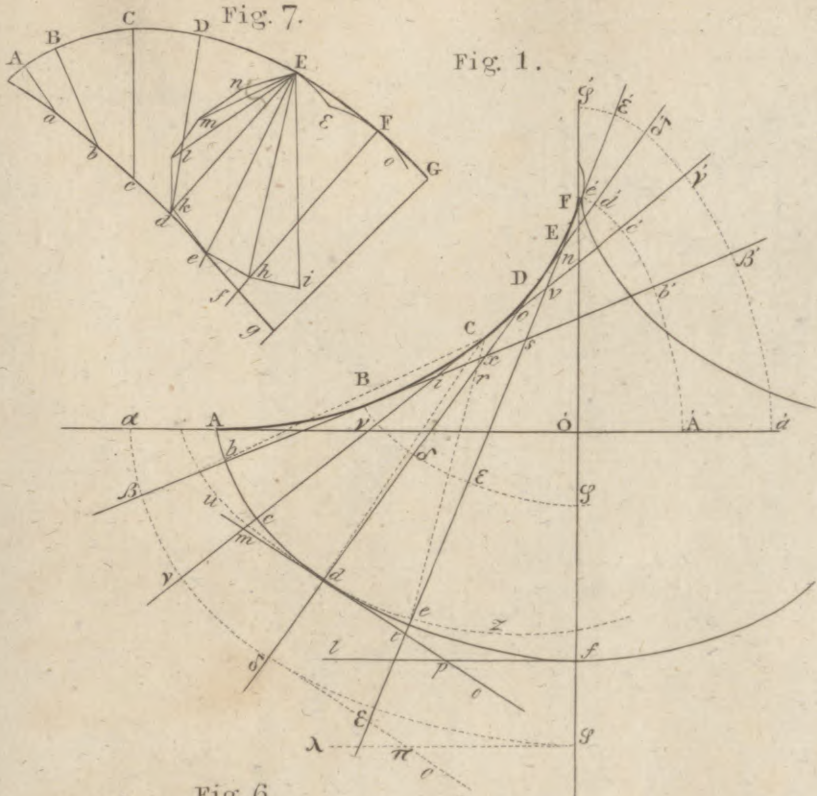


Fig. 1.

Fig. 3.

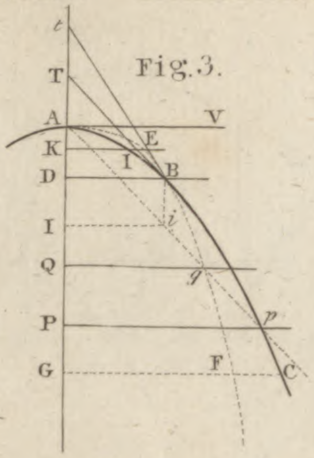


Fig. 2.

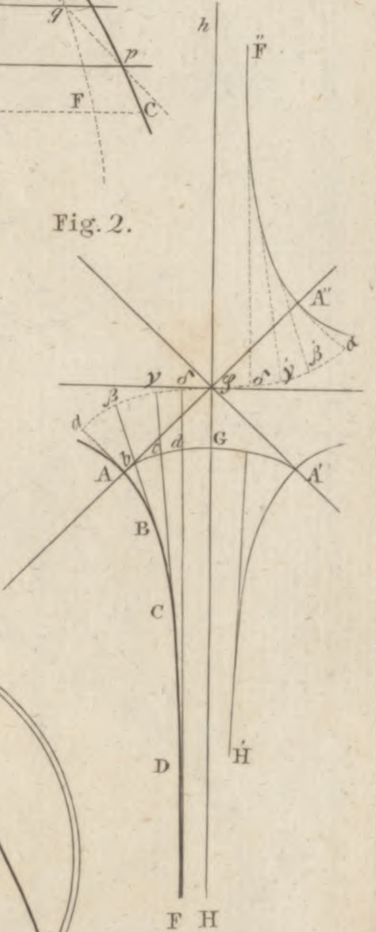


Fig. 6.

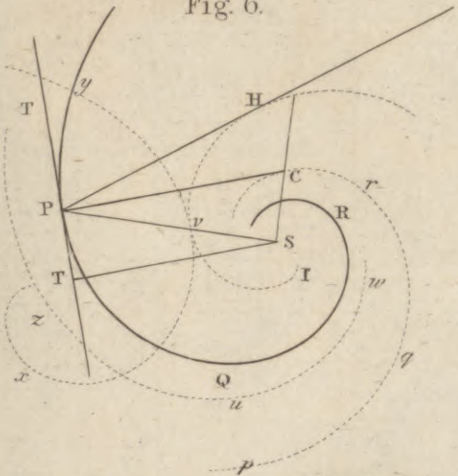


Fig. 4.

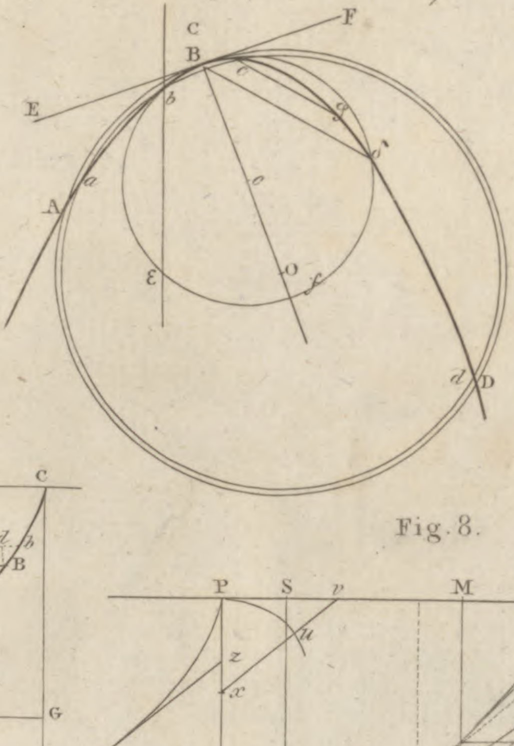


Fig. 5.

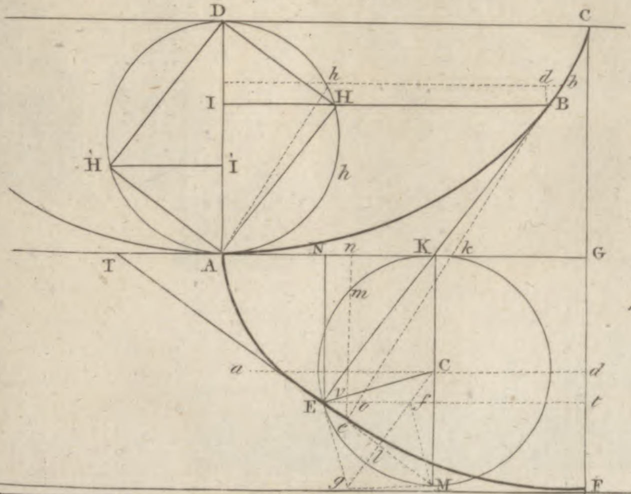
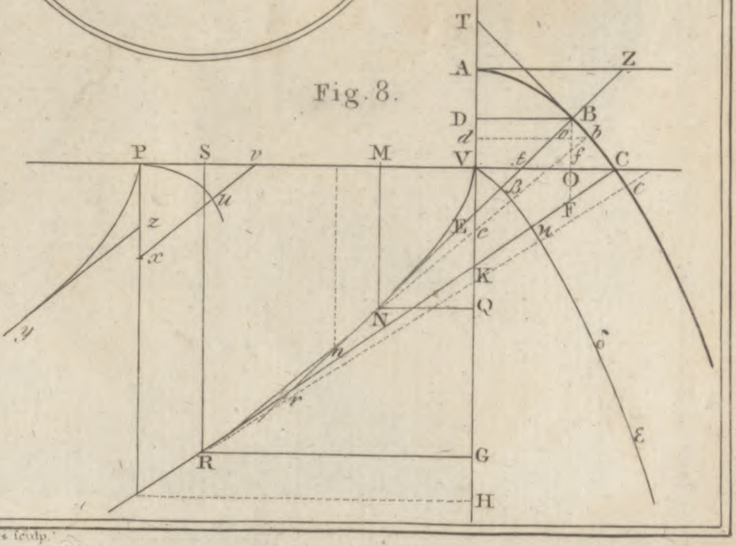


Fig. 8.



D. Lizars sculp.

PLATE XXXII.

Fig. 9.

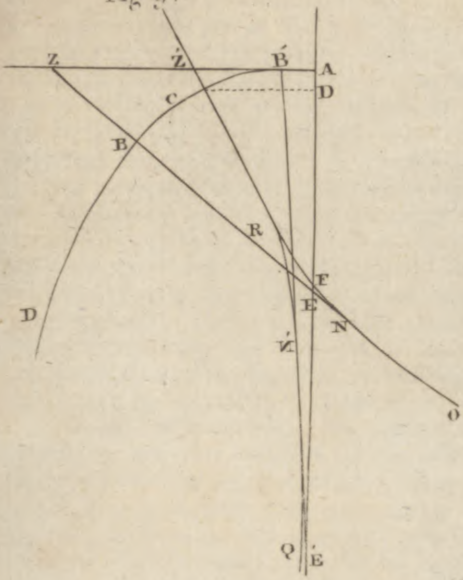


Fig. 10.

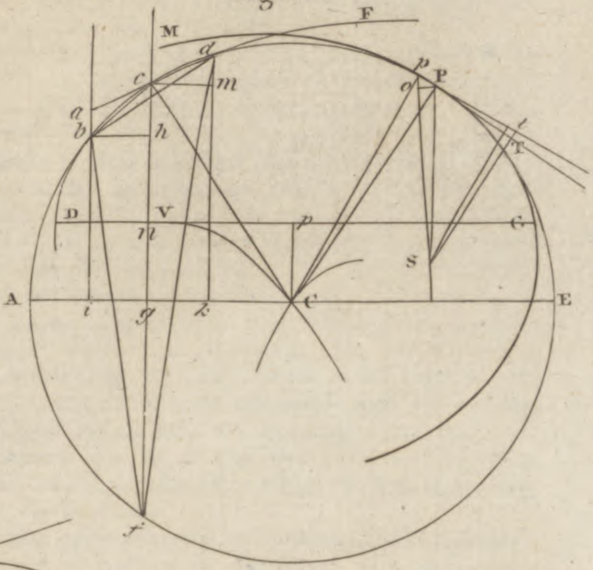


Fig. 12.

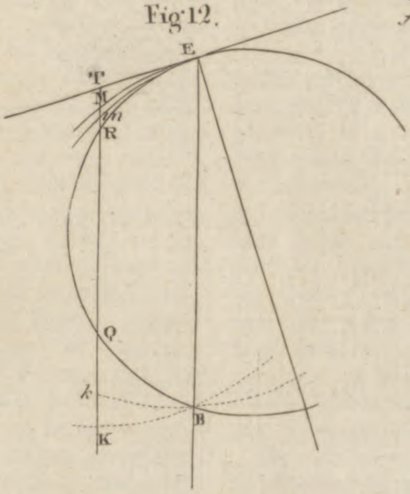


Fig. 13.

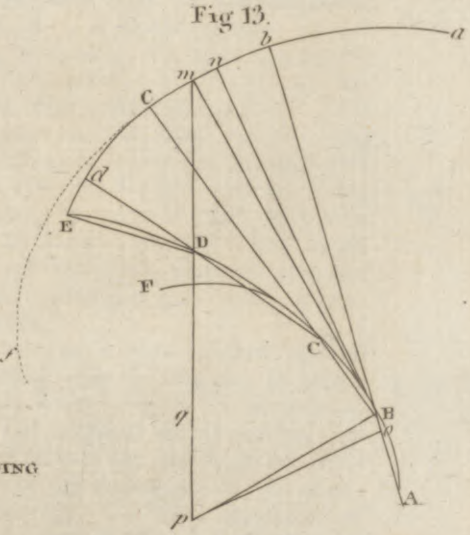
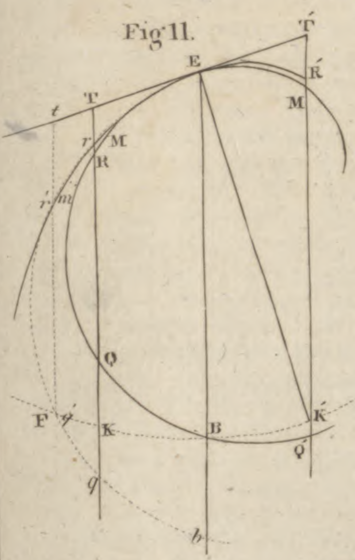
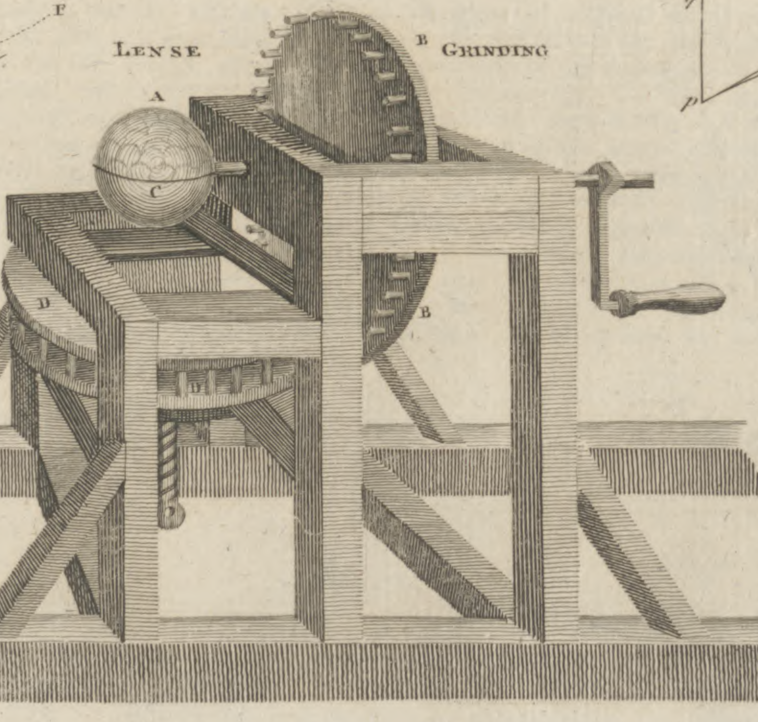


Fig. 11.



LENSE GRINDING



ONISCUS.

Fig. 1.

ONISCUS.

Fig. 2.

D. Lizars ſculp.

to the crueleſt indignities that the malice of bigotted Moors could invent. He was not ſuffered to travel beyond the camp; though he moved as it moved, and of courſe ſaw a conſiderable part of the country, and had an opportunity of obſerving the manners of the people. “The Moors of Ludamar ſubſiſt chiefly on the fleſh of their cattle; and are always in the extreme of either gluttony or abſtinence. In conſequence of the frequent and ſevere faſts which their religion enjoins, and the toilſome journeys which they ſometimes undertake acroſs the deſert, they are enabled to bear both hunger and thirſt with ſurpriſing fortitude; but whenever opportunities occur of ſatisfying their appetite, they generally devour more at one meal than would ſerve an European for three. They pay but little attention to agriculture; purchaſing their corn, cotton cloth, and other neceſſaries, from the Negroes, in exchange for ſalt, which they dig from the pits in the Great Deſert.

“The natural barrenneſs of the country is ſuch, that it furniſhes but few materials for manufacture. The Moors, however, contrive to weave a ſtrong cloth, with which they cover their tents; the thread is ſpun by their women from the hair of goats: and they prepare the hides of their cattle ſo as to furniſh ſaddles, bridles, pouches, and other articles of leather. They are likewiſe ſufficiently ſkilful to convert the native iron, which they procure from the Negroes, into ſpears and knives, and alſo into pots for boiling their food; but their ſabres and other weapons, as well as their fire-arms and ammunition, they purchaſe from the Europeans, in exchange for the Negro ſlaves which they obtain in their predatory excurſions. Their chief commerce of this kind is with the French traders on the Senegal river.”

The Moors of this country have ſingular ideas of feminine perfection. The gracefulneſs of figure and motion, and a countenance enlivened by expreſſion, are by no means eſſential points in their ſtandard; with them corpulence and beauty appear to be terms nearly ſynonymous. A woman, of even moderate pretenſions, muſt be one who cannot walk without a ſlave under each arm to ſupport her; and a perfect beauty is a load for a camel. In conſequence of this prevalent taſte for unwieldineſs of bulk, the Mooriſh ladies take great pains to acquire it early in life; and for this purpoſe many of the young girls are compelled by their mothers to devour an immenſe quantity of food, and drink a large bowl of camel's milk every morning. It is of no importance whether the girl has an appetite or not, the meat and the drink muſt be ſwallowed; and obedience is frequently enforced by blows. This ſingular practice, inſtead of producing indigeſtion and diſeaſe, ſoon covers the young lady with that degree of plumpneſs, which, in the eye of a Moor, is perfection itſelf.

“Although the wealth of the Moors conſiſts chiefly in their numerous herds of cattle; yet, as the paſtoral life does not afford full employment, the majority of the people are perfectly idle, and ſpend the day in trifling converſation about their horſes, or in laying ſchemes of depredation on the Negro villages.

“The uſual place of rendezvous for the indolent is the king's tent, where great liberty of ſpeech ſeems to be exerciſed by the company towards each other. While in ſpeaking of their chief, they expreſs but one opinion. In praiſe of their ſovereign, they are unanimous. Songs are compoſed in his honour, which the company frequently ſing in concert; but they are ſo loaded with groſs adulation, that no man but a Mooriſh deſpot could hear them without bluſhing. The king is diſtinguiſhed by the fineneſs of his dreſs, which is compoſed of blue cotton cloth brought from Tombuctoo, or white linen or muſlin from Morocco. He has likewiſe a larger tent than any other perſon, with a white cloth over it; but in his uſual intercourſe with his ſubjects, all diſtinctions of rank are frequently forgotten. He ſometimes eats out of the ſame bowl with his camel driver, and repoſes himſelf, during the heat of the day, upon the ſame bed.

“The military ſtrength of Ludamar conſiſts in cavalry. They are well mounted, and appear to be very expert in ſkirmiſhing and attacking by ſurpriſe. Every ſoldier furniſhes his own horſe, and finds his accoutrements, conſiſting of a large ſabre, a double barrelled gun, a ſmall red leather bag for holding his balls, and a powder horn flung over the ſhoulder. He has no pay, nor any remuneration but what ariſes from plunder. This body is not very numerous; for when Ali the king made war upon Bambara, our author was informed that his whole force did not exceed 2000 cavalry. They conſtitute, however, by what he could learn, but a very ſmall proportion of his Mooriſh ſubjects. The horſes are very beautiful, and ſo highly eſteemed, that the Negro princes will ſometimes give from twelve to fourteen ſlaves for one horſe.”

Cut off from all intercourſe with civilized nations, and boaſting an advantage over the Negroes, by poſſeſſing, though in a very limited degree, the knowledge of letters, the Moors of Ludamar are at once the vaineſt and proudeſt, and perhaps the moſt bigotted, ferocious, and intolerant of all the nations on the earth; combining in their character the blind ſuperſtition of the Negro with the ſavage cruelty and treachery of the Arab. It was with the utmoſt difficulty that our author made his eſcape from this inhoſpitable people.

LUPUS, the *Wolf*, a ſouthern conſtellation, joined to the Centaur, containing together 19 ſtars in Ptolomy's catalogue, but 24 in the Britannic catalogue.

LYNX, a conſtellation of the northern hemiſphere, compoſed by Hevelius out of the unformed ſtars. In his catalogue it conſiſts of 19 ſtars, but in the Britannic 44.

M.

MACHINERY.

THE denomination *Machine* is now vulgarly given to a great variety of ſubjects, which have very little analogy by which they can be claſſed with propriety under any one name. We ſay a travelling machine, a bathing machine, a copying machine, a threſhing machine, an electrical machine, &c. &c. The only circumſtance in which all theſe agree ſeem to be, that their conſtruction is more complex and artificial than the utenſils, tools, or inſtruments which offer themſelves to the firſt thoughts of uncultivated people. They are more artificial than the common cart, the bathing tub, or the flail. In the language of ancient Athens and Rome, the term was applied to every tool by which hard labour of any kind was performed; but in the language of modern Europe, it ſeems reſtricted either to ſuch tools or inſtruments as are employed for executing ſome philoſophical purpoſe, or of which the conſtruction employs the ſimple mechanical powers in a conſpicuous manner, in which their operation and energy engage the attention. An electrical machine, a centrifugal machine, are of the firſt claſs; a threſhing machine, a fire machine, are of the other claſs. It is nearly ſynonymous, in our language, with ENGINE; a term altogether modern, and in ſome meaſure honourable, being beſtowed only, or chiefly, on contrivances for executing work in which ingenuity and mechanical ſkill are manifeſt. Perhaps, indeed, the term *engine* is limited, by careful writers, to machines of conſiderable magnitude, or at leaſt of conſiderable art and contrivance. We ſay, with propriety, ſteam engine, fire-engine, plating-engine, boring-engine; and a dividing machine, a copying machine, &c. Either of theſe terms, *machine* or *engine*, are applied with impropriety to contrivances in which ſome piece of work is not executed on materials which are then ſaid to be manufactured. A travelling or bathing machine is ſurely a vulgariſm. A machine or engine is therefore a TOOL; but of complicated conſtruction, peculiarly fitted for expediting labour, or for performing it according to certain invariable principles: And we ſhould add, that the dependence of its efficacy on mechanical principles muſt be apparent, and even conſpicuous. The contrivance and erection of ſuch works conſtitute the profeſſion of the engineer; a profeſſion which ought by no means to be confounded with that of the mechanic, the artiſan, or manufacturer. It is one of the *artes liberales*; as deſerving of the title as medicine, ſurgery, architecture, painting, or ſculpture. Nay, whether we conſider the importance of it to this flouriſhing nation, or the ſcience that is neceſſary for giving eminence to the profeſſor, it is very doubtful whether it ſhould not take place of the three laſt named, and go *pari paſſu* with ſurgery and medicine. The inconſiderate reader, who peruſes *Cicero de Oratore* with ſatisfaction, is apt to ſmile at Vitruvius, who requires in his architect nearly the ſame accompliſhments which Cicero requires in his orator. He has not recollected, or perhaps did not know, that the profeſſion of an architect in the Auguſtan age was the moſt reſpectable of all thoſe which were not eſſentially connected with the management of ſtate affairs. It appears that the architects were all Greeks, or the pupils of Greeks, altogether different from the members of the *Collegium Murariorum*, the corporation of builders and maſons. The architecture of temples, ſtadiums, circuſes, amphitheatres, ſeems to have been monopoliſed, by ſtate authority, by a ſociety which had long ſubſiſted in Aſia, connected by certain myſterious bonds, both civil and religious. We find it in Syria; and we learn that it was brought thither from Perſia in very ancient times. From thence it ſpread into Ionia, where it became a very eminent and powerful aſſociation, under the particular protection of Bacchus, to whom the members had erected a magnificent temple at Teos, with a vaſt eſtabliſhment of prieſts and prieſteſſes, conſiſting of perſons of the firſt rank in the ſtate. They were the ſole builders of temples and ſtadiums throughout all Greece and the Leſſer Aſia; and the contractors for the machinery that was employed in the theatres, and in the great temples, for the celebration of the high myſteries of paganiſm. By the imperfect accounts which remain of the Eleuſinian and other myſteries, it appears, that this machinery muſt have been immenſe and wonderful, and muſt have required a great deal of mechanical ſkill. This indeed appears, in the moſt convincing manner, to any perſon who reflects on the magnificent ſtructures which they erected, which excite to this day the wonder of the world, not only on account of their magnificence and incomparable elegance, but alſo on account of the mechanical knowledge that ſeems indiſpenſably neceſſary for their erection. This will ever remain a myſtery. There are no traces of ſuch knowledge to be found in the writings of antiquity. Even Vitruvius, writing expreſsly on the ſubject, has given us nothing but what is in the loweſt degree of elementary knowledge.

This aſſociation of the Dyoniſiacs undoubtedly kept their mechanical ſcience a profound ſecret from the uninitiated, the profane. They were the engineers of antiquity, and Vitruvius was perhaps not one of the initiated. He ſpeaks of Myro and other Greek architects in terms of reſpect which border on veneration. Perhaps the modern aſſociation of free maſons is a remain of this antient fraternity, continued to our times by the company of builders, who erected the cathedrals and great conventual churches. No one who conſiders their works with ſcientific attention, can doubt of their being deeply verſed in the principles of mechanics, and even its more refined branches. They appear to have carried the art of vault-roofing almoſt to its acmé of perfection; far outſtripping their Grecian inſtructors in their knowledge of this moſt delicate branch of their art.

It were greatly to be wiſhed that ſome ſuch inſtitution did yet exiſt, where men might be induced by the moſt powerful motives to accompliſh themſelves in the knowledge neceſſary for attaining eminence in their profeſſion.

We have been informed (and we thought our authority good), that our gracious Sovereign has ſignified his intention of patroniſing an inſtitution of this kind. We heard, that it was propoſed to inſtitute degrees ſimilar to our univerſity degrees, and proceeding on ſimilar conditions of a regular education or ſtanding, which would enſure the *opportunities* of information, and alſo on an examination of the proficiency of the candidate. This examination, being conducted by perſons eminent in the profeſſion, perhaps ſtill exerciſing it, would probably be ſerious, becauſe the ſucceſsful candidate would immediately become a rival practitioner. Such an inſtitution would undoubtedly prevent many groſs impoſitions by unlettered mill-wrights and pump-makers, who now ſeldom appear under any name but that of engineer, although they are frequently ignorant even of the elements of mechanical ſcience, and are totally unacquainted with the higher mathematics; without which it is abſolutely impoſſible for them to contrive a machine well ſuited to the intended purpoſe, or to ſay with any tolerable preciſion what will be the performance of the engine they have erected. Yet theſe are queſtions ſuſceptible of accurate ſolution, becauſe they depend on the unalterable laws of matter and motion.

All who have a juſt view of the unſpeakable advantages which this highly favoured land poſſeſſes in the ſuperiority and activity of its manufactures, and who know how much of this ſuperiority ſhould be aſcribed to the great improvements which have been made in practical mechanics within theſe laſt thirty years, will join us in wiſhing ſucceſs to ſome ſuch inſtitution as that now mentioned.

We were naturally led to theſe reflections when we turned our thoughts to machinery in general, and obſerved what is done in this country by the native energy of its inhabitants, unaſſiſted by ſuch ſcientific inſtructions as they might have expected from the pupils of a Newton, their countryman, under the patronage of the beſt of Sovereigns, eminently knowing in theſe things, and ever ready to encourage thoſe ſciences and arts which have ſo highly contributed to the national proſperity. What might not be reaſonably expected from Britiſh activity, if thoſe among ourſelves who have knowledge and leiſure had been at the ſame pains with the members of the foreign academies to cultivate the Newtonian philoſophy, and particularly the more refined branches of mechanics, and to deduce from their ſpeculations maxims of conſtruction fitted to our ſituation as a great manufacturing nation? But ſuch knowledge is not attainable by thoſe who are acquainted only with the imperfect elements contained in the publications read by the bulk of our practitioners. Much to this purpoſe has been done on the continent by the moſt eminent mathematicians; but from want of individual energy, or perhaps of general ſecurity and protection, the patriotic labours of thoſe gentlemen have not done the ſervice to their country which might have been reaſonably expected. Indeed, their diſſertations have generally been ſo compoſed, that only the learned could ſee their value. They ſeem addreſſed only, or chiefly, to ſuch; but it is to thoſe authors that our countrymen generally have recourſe for information concerning every thing in their profeſſion that riſes above mere elementary knowledge. The books in our language which profeſs to be ſyſtems of mechanics rarely go beyond this: they contain only the principles of equilibrium. Theſe are abſolutely neceſſary for the knowledge of machines; but they are very far indeed from giving what may be called a practical knowledge of *working machinery*. This is never in a ſtate of equilibrium. The machine muſt move in order to work. There muſt be a ſuperiority of impelling power, beyond what is merely ſufficient for balancing the reſiſtance or contrary action of the work to be performed. The reader may turn to the article STATICS in the *Encyclopædia Britannica*, and he will there ſee ſome farther obſervations on this head. And in the article MECHANICS he will find a pretty ample detail of all the uſual doctrines, and a deſcription of a conſiderable variety of machines or engines, accompanied by ſuch obſervations as are neceſſary for tracing the propagation or tranſmiſſion of preſſure from that part of the machine to which the natural power is applied to the working part of the machine. Along with theſe two articles, it will be proper to read with peculiar attention the article ROTATION.

By far the greateſt number of our moſt ſerviceable engines conſiſt chiefly of parts which have a motion of rotation round fixed axes, and derive all their energy from levers virtually contained in them. And theſe acting parts are alſo material, requiring force to move them, over and above what is neceſſary for producing the acting force at the working part of the machine. The modifications which this circumſtance frequently makes of the whole motions of the machine, are indicated in the article ROTATION in an elementary way; and the propoſitions there inveſtigated will be found almoſt continually involved in the complete theory of the operation of a machine. Laſtly, it will be proper to conſider attentively the propoſitions contained in the article *STRENGTH of Materials*, that we may combine them with thoſe which relate wholly to the working of the machine; becauſe it is from this combination only that we diſcover the ſtrains which are excited at the various points of ſupport, and of communication, and in every member of the machine. We ſuppoſe all theſe things already underſtood.

1
The chief queſtion in mechanics.

Our object at preſent is to point out the principles which enable us to aſcertain what will be the preciſe motion of a machine of given conſtruction, when actuated by a natural power of known intenſity, applied to a given point of the machine, while it is employed to overcome a known reſiſtance acting at another point. To abbreviate language, we ſhall call that the IMPELLED POINT of the machine to which the preſſure of the moving power is immediately applied; and we may call that the WORKING POINT, where the reſiſtance ariſing from the work to be performed immediately acts.

To conſider this important ſubject, even in its chief varieties, requires much more room than can be allowed in an undertaking like ours, and therefore we muſt content ourſelves with a very limited view; but at the ſame time, ſuch a view as ſhall give ſufficient indication of the principles which ſhould direct the practical reader in every important caſe. We ſhall conſider thoſe machines

which

which perform their motions round fixed axes; theſe being by far the moſt numerous and important, becauſe they involve in their conſtruction and operations all the leading principles.

2 The proper meaſure of mechanical power exerted.

That we may proceed ſecurely, it is neceſſary to have a preciſe and adequate notion of moving force, as applied to machinery, and of its meaſures. We think this peculiarly neceſſary. Different notions have been entertained on this ſubject by Mr Leibnitz, Des Cartes, and other eminent mechanicians of the laſt century; and their ſucceſſors have not yet come to an agreement. Nay, ſome of the moſt eminent practitioners of the preſent times (for we muſt include Mr Smeaton in the number) have given meaſures of mechanical power in machinery which we think inaccurate, and tending to erroneous concluſions and maxims.

We take for the meaſure (as it is the effect) of exerted mechanical power the quantity of motion which it produces by its uniform exertion during ſome given time. We ſay *uniform exertion*, not becauſe this uniformity is neceſſary, but only becauſe, if any variation of the exertion has taken place, it muſt be known, in order to judge of the power. This would needleſsly complicate the calculations; but in whatever way the exertion may have varied, the whole accumulated exertion is ſtill accurately meaſured by the quantity of motion exiſting at the end of the exertion. The reader muſt perceive that this is the ſame thing that is expreſſed in the article Dynamics of this *Supplement*, n° 90. by the area of the figure whoſe abſciſſa or axis repreſents the time of exertion; and the ordinates are as the preſſures in the different inſtants of that time, the whole being multiplied by the number of particles (that is, by the quantity of matter), becauſe that figure repreſents the quantity of motion generated in one particle of matter only. All this is abundantly clear to perſons converſant in theſe diſquiſitions; but we wiſh to carry along with us the diſtinct conceptions of that uſeful claſs of readers whoſe profeſſion engages them in the conſtruction and employment of machines, and to whom ſuch diſcuſſions are not ſo familiar. We muſt endeavour therefore to juſtify our choice of this meaſure by appealing to familiar facts.

If a man, by preſſing uniformly on a maſs of matter for five ſeconds, generates in it the velocity of eight feet per ſecond, we obtain an exact notion of the proportion of this exertion to the mechanical exertion of gravity, when we ſay that the man's exerted force has been preciſely one-twentieth part of the action of gravity on it; for we know that the weight of that body (or, more properly, its heavineſs) would, in five ſeconds, have given it the velocity of 160 feet per ſecond, by acting on it during its fall. But let us attend more cloſely to what we mean by ſaying that the exerted force is one-twentieth of the exertion of gravity. The only notion we have of the exertion of gravity is what we call the weight of the body—the preſſure which we feel it make on our hand. To ſay that this is 20 pounds weight, does not explain it; becauſe this is only the action of gravity on another piece of matter. Both preſſures are the ſame. But if the body weighs 20 pounds, it will draw out the rod of a ſteelyard to the mark 20. The rod is ſo divided, that the 20th part of this preſſure will draw it out to 1. Now the fact is, that if the man preſſes on the maſs of 20 pounds weight with a ſpring ſteelyard during five ſeconds, and if during that time the rod of the ſteelyard was always at the mark 1, the body will have acquired the velocity of eight feet per ſecond. This is an acknowledged fact. Therefore we were right in ſaying, that the man's exertion is one-twentieth of the exertion of gravity. And ſince we believe the weight of bodies to be proportional to their quantity of matter, all matter being equally heavy, we may ſay, that the man's exertion was equal to the action of gravity on a quantity of matter whoſe weight is one pound. We expreſs it much more familiarly, by ſaying, that the man exerted on it the preſſure of one pound of matter, or the force of one pound.

In this manner, the motion communicated to a maſs of matter, by acting on it during ſome time, informs us with accuracy of the real mechanical force or preſſure which has been exerted. This is judged to be double when twice the velocity has been generated in the ſame maſs, or where the ſame velocity has been generated in twice the maſs; becauſe we know, that a double preſſure would have done either the one or the other.

But farther: We know that this preſſure is the exertion; we have no other notion of our own force; and our notion of gravity, of elaſticity, or any other natural force, is the ſame. We alſo know that the continuance of this exertion fatigues and exhauſts our ſtrength as completely as the moſt violent motion. A dead pull, as it is called, of a horſe, at a poſt fixed in the ground, is a uſual trial of his ſtrength. No man can hold out his arm horizontally for much more than a quarter of an hour; and the exertion of the laſt minutes gives the moſt diſtreſſing fatigue, and diſables the ſhoulder from action for a conſiderable time after. This is therefore an expenditure of mechanical power, in the ſtrict primitive ſenſe of the word. Of this expenditure we have an exact and adequate effect and meaſure in the quantity of motion produced; that is, in the product of the quantity of matter by the velocity generated in it by this exertion. And it muſt be particularly noticed, that this meaſure is applicable even to caſes where no motion is produced by the exertion; that is, if we know that the exertion which is juſt unable to ſtart a block of ſtone lying on a ſmooth ſtone pavement, but would ſtart it, if increaſed by the ſmalleſt addition; and if we know that this would generate in a ſecond 32 feet of velocity in 100 pounds of matter—we are certain that it was a preſſure equal to the weight of this 100 pounds. It is a good meaſure, though not immediate, and may be uſed without danger of miſtake when we have no other.

3 Mr Smeaton's meaſure

The celebrated engineer Mr Smeaton, in his excellent diſſertation on the power of water and wind to drive machinery, and alſo in two other diſſertations, all publiſhed in the Philoſophical Tranſactions, and afterwards in a little volume, has employed another meaſure, both of the expenditure of mechanical power, and of the mechanical effect produced. He ſays, that the weight of a body, multiplied by the height thro' which it deſcends, while driving a machine, is the only proper meaſure of the power expended; and that the weight, multiplied by the height through which it is uniformly raiſed, is the only proper meaſure of the effect produced. And he produces a large train of accurate experiments

riments to prove that a certain weight, deſcending through a certain ſpace, always produces the ſame effect, whether it has deſcended ſwiftly or ſlowly, employing little or much time.

Had this eminent engineer propoſed this as a popular meaſure, of eaſy comprehenſion and remembrance, and as well accommodated to the uſes of thoſe engaged in the conſtruction of machines, when reſtricted to a certain claſs of caſes, it might have anſwered very good purpoſes; but the author is at pains to recommend it to the philoſophers as a neceſſary correction of their theories, which he ſays tend to miſlead the artiſts. His own reaſonings terminate in the ſame concluſion with Mr Leibnitz's, namely, that the power of producing a mechanical effect, and the effect produced, are proportional to the ſquare of the velocity. The deference juſtly due to Mr Smeaton's authority, and the influence of his name among thoſe who are likely to make the moſt uſe of his inſtructions, render it neceſſary for us to examine this matter with ſome attention.

Mr Smeaton was led to the adoption of this meaſure by his profeſſional habits. Raiſing a weight to a height is, in one ſhape or another, the general taſk of the machines he was employed to erect; and we may add, the opportunities of expending the mechanical powers of nature which are in our command, are generally in this proportion. A certain daily ſupply of water, coming from a certain height, is our beſt opportunity, and may very properly be ſaid to be expended.

4
xamined,

This being the general caſe, the meaſure was obvious, and natural, and good. The power and effect were of the ſame kind, and *muſt* be meaſures of each other; at leaſt, in thoſe circumſtances in which they were ſet in oppoſition Yet even here Mr Smeaton was obliged to make a reſtriction of his meaſures: "The height thro' which a body *ſlowly and equably* deſcended, or to which it was raiſed." And why was this limitation neceſſary? "Becauſe in rapid or accelerated motions, the inertia of bodies occaſioned ſome variation *." But this is too vague language for philoſophical diſquiſition. Beſides, what is meant by this variation? What is the ſtandard from which the unreſtricted meaſure varies? This ſtandard, whatever it is, is the true meaſure, and it was needleſs to adopt any other. Now, the ſtandard from which Mr Smeaton eſtimates the deviation, is the very meaſure which we wiſh to employ, namely, the quantity of motion produced. Strictly ſpeaking, even this is not the immediate meaſure. The immediate meaſure is that faculty which we call preſſure. This is the intermedium perceivable in all productions of motion; and it is alſo the intermedium of mechanical effect, even when motion is not produced; as when the weight of a body bends a ſpring, or the elaſticity of a body ſupports another preſſure. How it operates in all or any of theſe caſes, we know not; but we know that all theſe meaſures of preſſure agree with each other. A double quantity of motion will bend a ſpring doubly ſtrong, will raiſe a double weight, will withſtand any double preſſure, &c. &c. In ſhort, preſſure is the immediate agent in every mechanical phenomenon. It penetrates bodies, overcoming their tenacity; it overcomes friction; it balances preſſure; it produces motion. Mr Smeaton's meaſure is only nearly true, in any caſe, and in all caſes it is far from being exact in the firſt inſtants of the motion, during its acceleration or retardation.

Page 7.

We have already noticed the complete expenditure of animal power by continued preſſure, even when motion is not produced: the only difficulty is to connect this in a meaſurable way with the power which the ſame exertion has of generating motion in a body.

When a man ſupports a weight for a ſingle inſtant, he certainly balances the preſſure or action of gravity on that body; and he continues this action as long as he continues to ſupport it: and we know that if this body were at the end of a horizontal arm turning round a vertical axis, the ſame effort which the man exerted in merely carrying the weight, if now exerted on the body, by puſhing it horizontally round the axis, will generate in it the ſame velocity which gravity would generate by its falling freely. On this authority therefore we ſay, that the whole accumulated action of a man, when he has juſt carried a body whoſe weight is 30 pounds for one minute, is equal to the whole exertion of gravity on it during that minute; and if employed, not to counteract gravity, but to generate motion, would generate, during that minute, the ſame motion that gravity would, that is, 60 × 32 feet velocity per ſecond, in a maſs of 30 pounds. There would be 30 pounds of matter moving with the velocity of 1920 feet per ſecond. We would expreſs this production or effect by 30 × 1920, or by 57600, as the meaſure of the man's exertion during the minute.

But, according to Mr Smeaton, there is no expenditure of power, nor any production of mechanical effect, in thus carrying 30 pounds for a minute; there is no product of a weight by a height through which it is equably raiſed; yet ſuch exertion will completely exhauſt a man's ſtrength if the body be heavy enough. Here then is a caſe to which Mr Smeaton's meaſure does not readily apply; and this caſe is important, including all the actions of animals at a dead pull.

But let us conſider more narrowly what a man really does when he performs what Mr Smeaton allows to be the production of a meaſurable mechanical effect. Suppoſe this weight of 30 pounds hanging by a cord which paſſes over a pulley, and that a man, taking this cord over his ſhoulder, turns his back to the pulley, and walks away from it. We know, that a man of ordinary force will walk along, raiſing this weight, at the rate of about 60 yards in a minute, or a yard every ſecond, and that he can continue to do this for eight or ten hours from day to day; and that this is all that he can do without fatigue. Here are 30 pounds raiſed uniformly 180 feet in a minute; and Mr Smeaton would expreſs this by 30 × 180, or 5400, and would call this the meaſure of the mechanical effect, and alſo of the expenditure of power. This is very different from our meaſure 57600.

5
And found to be inaccurate.

But this is not an accurate and complete account of the man's *action* on the weight, and of the whole effect produced. To be convinced of this, ſuppoſe that a man A has been thus employed, while another B, walking along ſide of him at the ſame rate, ſuddenly takes the rope out of his hand, frees him of the taſk, and *continues* to raiſe the weight without the ſmalleſt change on its velocity of aſcent. What is the action of B, and whether is it the ſame with that of A or not? It is acknowledged by all, that the exertion of B againſt the load is preciſely equal to 30 pounds. If he holds the rope by a ſpring ſteelyard, it will ſtand conſtantly at the mark 30. B exerts the ſame action on the load as when

when he ſimply ſupports it from falling back into the pit. It was moving with the velocity of three feet per ſecond when he took hold of the rope, and it would continue to move with that velocity if any thing could annihilate or counteract its gravity. If therefore there was no action when a perſon merely carried it, there is none at preſent when it is riſing 180 feet in a minute. The man does indeed work more than on that occaſion, but not againſt the load: his additional work is walking, the motion of his own body, as a thing previouſly neceſſary that he may continue to ſupport the load, that he may continue his mechanical effort as it follows him. It appears to yield to him: but it is not to *his* efforts that it yields; its weight completely balances thoſe efforts, and is balanced by them. It was to a *greater* effort of the man A that it yielded. It was then lying on the ground. He pulled at the cord, gradually perhaps increaſing his pull till it was juſt equal to its weight. When this obtains, the load no longer preſſes on the ground, but is completely carried by the rope. But it does not move by this effort of 30 pounds; but let him exert a force of 31 pounds, and continue this for three ſeconds. He will put it in motion; will accelerate that motion; and at the end of three ſeconds the load is riſing with the velocity of three feet per ſecond. The man feels that this is as much ſpeed as he can continue in his walk; he therefore ſlackens his pull, reducing his action to 30 pounds, and with this action he walks on. All this would be diſtinctly perceived by means of a ſteelyard. The rod would be pulled out beyond 30, till the load acquired the uniform velocity intended, and after this it would be obſerved to ſhrink back to 30.

More is done therefore than appears by Mr Smeaton's meaſure. Indeed, all that appears in it is the exertion neceſſary for *continuing* a motion already produced, but which would be immediately extinguiſhed by a contrary power, which muſt therefore be counteracted. This meaſure will not apply to numberleſs caſes of the employment of machines, where there is no ſuch oppoſing power, and where, notwithſtanding, mechanical power muſt be expended, even according to Mr Smeaton's meaſurement. Such are corn mills, boring mills, and many others.

How then comes it that Mr Smeaton's valuable experiments concur ſo exactly in ſhewing that the ſame quantity of water deſcending from the ſame height, always produces the ſame effect (as he meaſured it), whatever be the velocity? In the firſt place, all his experiments are caſes where the power expended and the work performed are of the ſame kind: A heavy body deſcends, and by its preponderancy raiſes another heavy body. But even this would not enſure the preciſe agreement obſerved in his experiments, if Mr Smeaton were not careful to exclude from his calculations all that motion where there is any acceleration, and all the expenditure of water during the acceleration, and to admit only thoſe motions that are ſenſibly uniform. In moderate velocities, the additional preſſure required for the firſt acceleration is but an inſignificant part of the whole; and to take theſe accelerated motions into the account, would have embarraſſed the calculations, and perhaps confuſed many of the readers. We ſee, in the inſtance now given, that the addition of one pound continued for three ſeconds only, was all that was neceſſary.

Mr Smeaton's meaſurement is therefore abundantly exact for practice; and being accommodated to the circumſtances moſt likely to engage the attention, is very proper for the inſtruction of the numerous practitioners in all manufacturing countries who are employed for ordinary erections: but it is improperly propoſed as an article eſſential to a juſt theory of mechanics, and therefore it was proper to notice it in this place. Beſides, there frequently occur moſt important caſes, in which the motion of a machine is, of neceſſity, deſultory, alternately accelerated, and retarded. We ſhould not derive all the advantages in our power from the firſt mover, if we did not attend particularly, and chiefly, to the *accelerating* forces. And in every caſe, the improvement, or the proper employment of the machine, is not attained, if we are not able to diſcriminate between the two parts of the mechanical exertion; one of them, by which the motion is produced and accelerated to a certain degree; and the other, by which that motion is continued. We muſt be able to appreciate what part of the effect belongs to each.—But it is now time to proceed to the important queſtion,

What will be the preciſe motion of a machine of given conſtruction, actuated by a power of known intenſity and manner of acting, and oppoſed by a known reſiſtance?

6
Things to be conſidered in a machine at work.

In the ſolution of this queſtion, much depends on the nature of both power and reſiſtance. In the ſtatical conſideration of machines, no attention is paid to any differences. The intenſity of the preſſures is all that it is neceſſary to regard, in order to ſtate the proportion of preſſure which will be exerted in the various parts of the machine. The preſſures at the impelled and working points, combined with the proportions of the machine, neceſſarily determine all the reſt. Preſſure being the ſole cauſe of all mechanical action among bodies, any preſſure may be ſubſtituted for another that is equal to it; and the preſſure which is moſt familiar, or of eaſieſt conſideration, may be uſed as the repreſentative of all others. This has occaſioned the mechanical writers to make uſe of the preſſure of gravity as the ſtandard of compariſon, and to repreſent all powers and reſiſtances by weights. However proper this may be in their hands, it has hurt the progreſs of the ſcience. It has rendered the uſual elementary treatiſes of mechanics very imperfect, by limiting the experiments and illuſtrations to ſuch as can be ſo repreſented with facility. This has limited them to the ſtate of equilibrium (in which condition a working machine is never found), becauſe illuſtrations by experiment out of this ſtate are neither obvious nor eaſy. It has alſo prevented the ſtudents of mechanics from accompliſhing themſelves with the mathematical knowledge required for a ſucceſsful proſecution of the ſtudy. The moſt elementary geometry is ſufficient for a thorough underſtanding of equilibrium, or the doctrines of ſtatics; but true mechanics, the knowledge of machines as inſtruments by which work is performed, requires more refined mathematics, and is inacceſſible without it.

Had not Newton or others improved mathematics by the invention of the infiniteſimal analyſis and calculus, we muſt have reſted contented with the diſcoveries (really great) of Galileo and Huyghens. But Newton,

ton, *ſuâ matheſi facem præferente*, opened a boundleſs field of inveſtigation, and has not only given a magnificent and brilliant ſpecimen of the diſcoveries to be made in it, but has alſo traced out the particular paths in which we are to find the ſolution of all queſtions of practical mechanics. This he has done by ſhewing another ſpecies of equilibrium, indicated, not by the ceſſation of all motion, but by the uniformity of motion; by the ceſſation of all acceleration or retardation. As the extinction of motion by the action of oppoſite forces is aſſumed by us as the indication of the perfect equality of thoſe forces; ſo the extinction of acceleration ſhould be received as the indication of ſomething equal and oppoſite to the force which was known to have cauſed the acceleration; and therefore as the indication of an equilibrium between oppoſite forces, or elſe of the ceſſation of all force.

7 Mechanical quilibrium. This new view of things was the ſource of all our diſtinct notions of mechanical forces, and gave us our only unexceptionable marks and meaſures of them. The 39th propoſition of the firſt book of Newton's Principles of Natural Philoſophy, and its corollaries, contain almoſt the whole doctrine of active mechanical nature, and are peculiarly applicable to our preſent purpoſe, becauſe they enable us to comprehend in this *mechanical equilibrium* (ſo different from the *ſtatical)* every circumſtance in which thoſe preſſures which are exerted by natural powers differ from each other, and vary in their action on the impelled and working points of a machine. Indeed, when we recollect that the operations of our machines are the ſame on board a ſhip as on ſhore, and that all our machines are moving with the ground on which they ſtand, we muſt acknowledge, that even ordinary ſtatics is only an imperfect view of an equilibrium among things which are in motion; and this ſhould have taught us that, even in thoſe caſes where nothing like equilibrium appears, an equilibrium may ſtill be uſefully traced.

8 Diſtinctions nuſt be nade in the ature of he powers pplied to vorking nachines. In the ſtatical conſideration of machines, the *quantity* of preſſure is all that we need attend to. But in the mechanical diſcuſſion of their *operations*, we muſt attend to their diſtinctions in kind: and it will by no means be ſufficient to repreſent them all by weights; for their diſtinction in kind is accompanied by great differences in their manner of acting on the machine. Some natural powers, in order to continue their action on the impelled point of the machine, muſt at the ſame time put into motion a quantity of matter external to the machine, in which theſe powers reſide; and this muſt be made to follow the impelled point in its motion, and not only follow, but continue to preſs it forward; or, this matter, thus continually put into motion, muſt be ſucceſſively applied to different points of the machine, which become impelled points in their turn. This is the caſe with a weight, with the action of a ſpring, the action of animals, the action of a ſtream of water or wind, and many other powers. A part of the natural mechanical powers muſt therefore be employed in producing this external motion. This is ſometimes a very conſiderable part of the whole natural power. In ſome caſes it is the whole of it. This obtains in the action of a deſcending weight, lying on the end of a lever and preſſing it down, or hanging by a chord attached to the machine.

There is alſo an important diſtinction in the manner in which this external motion is kept up. In a weight employed as the moving power, the actuating preſſure ſeems to reſide in the matter itſelf; and all that is neceſſary for continuing this preſſure is merely to continue the connection of it with the machine. But in the action of animals it may be very different: A man puſhing at a capſtan bar, muſt firſt of all walk as faſt as the bar moves round, and this requires the expenditure of his muſcular force. But this alone will not render his action an effective power: He muſt alſo *preſs forward* the capſtan bar with as much force as he has remaining over and above what he expends in walking at that rate. The proportion of theſe two expenditures may be very different in different circumſtances; and in the judicious ſelection of ſuch circumſtances as make the firſt of theſe as inconſiderable as poſſible, lies much of the ſkill and ſagacity of the engineer. In the common operation of thraſhing corn, much more than half of the man's power is expended in giving the neceſſary motion to his own body, and only the remainder is employed in urging forward the ſwiple with a momentum ſufficient for ſhaking off the ripe grains from the ſtalk. We had ſufficient proof of this, by taking off the ſwiple of the flail, and putting the ſame weight of lead on the end of the ſtaff, and then cauſing the hind to perform the uſual motions of thraſhing with all the rapidity that he could continue during the ordinary hours of work. We never could find a man who could make three motions in the ſame time that he could make two in the uſual manner, ſo as to continue this for half an hour. Hence we muſt conclude, that half (ſome will ſay two-thirds) of a thraſher's power is expended in merely moving his own body. Such modes of animal action will therefore be avoided by a judicious engineer; but to be avoided, their inconvenience muſt be underſtood. More of this will occur hereafter.—In other caſes, we are almoſt (never wholly) free from this unprofitable expenditure of power. Thus, in the ſteam engine, the operation requires that the external air follow the piſton down the cylinder, in order to continue its preſſure. But the force neceſſary for ſending in this rare fluid into the cylinder with the neceſſary velocity, is ſuch an inſignificant part of the whole force which is at our command, that it would be ridiculous affectation in any engineer to take it into account; and this is one great ground of preference to this natural power. The ſame thing may be ſaid of the action of a ſtrong and light ſpring, which is therefore another very eligible firſt mover for machinery. The ancient artilleriſts had diſcovered this, and employed it in their warlike engines.

We muſt alſo attend to the nature of the reſiſtance which the work to be performed oppoſes to the motion of our machine. Sometimes the work oppoſes, not a ſimple obſtruction, but a real reſiſtance or reaction, which, if applied alone to the machine, would cauſe it to move the contrary way. This always obtains in caſes where a heavy body is to be raiſed, where a ſpring is to be compreſſed, and in ſome other caſes. Very often, however, there is no ſuch contrary action. A flour mill, a ſaw mill, a boring mill, and many ſuch engines, exhibit no reaction of this kind. But although ſuch machines, when at reſt or not impelled by the firſt mover, ſuſtain no preſſure in the oppoſite direction, yet they will not acquire any motion whatever, unleſs they be impelled by a power of a certain determinate intenſity. Thus in a ſaw mill, a certain force muſt be impreſſed on the teeth of the ſaw, that the cohеſion of the fibres of the timber may be overcome. This requires that a certain force, determined by the proportions of the machine, be impreſſed on the impelled point. If this, and no more, be applied there, a force will be excited at the teeth of the ſaw, which will *balance* the cohеſion of the wood, but will not *overcome* it. The machine will continue at reſt, and no work will be performed. Any addition of force at the impelled point, will occaſion an addition to the force excited in the teeth of the ſaw. The cohеſion will be overcome, the machine will move, and work will be performed. It is only this *addition* to the impelling power that gives motion to the machine; the reſt being expended merely in balancing the cohеſion of the woody fibres. While therefore the machine is in motion, performing work, we muſt conſider it as actuated by a force impreſſed on the impelled point by the natural power, and by another acting at the working point, furniſhed by or derived from the reſiſtance of the work.

Again: It not unfrequently happens, that there is not even any ſuch reſiſtance or obſtruction excited at the working point of the machine; the whole reſiſtance (if we can with propriety give it that name) ariſes from the neceſſity of giving motion to a quantity of inert and inactive matter. This happens in urging round a heavy fly, as in the coining preſs, in the punching engine, in drawing a body along a horizontal plane without friction, and a few ſimilar caſes. Here the ſmalleſt force whatever, applied at the impelled point, will begin motion in the machine; and the *whole* force ſo applied is conſumed in this ſervice. Such caſes are rare, as the ultimate performance of a machine; but occaſionally, and for a farther purpoſe, they frequently occur; and it is neceſſary to conſider them, becauſe there are many of the moſt important applications of machinery where a very conſiderable part of the force is expended in this part of the general taſk.

Such are the chief circumſtances of diſtinction among the mechanical powers of nature which muſt be attended to, in order to know the motion and performance of a machine. Theſe never occur in the ſtatical conſideration of the machine, but here they are of chief importance.

9
The inertia of the machine itſelf muſt alſo be conſidered,

But farther: The action of the moving power is transferred to the working point through the parts of a machine, which are material, inert, and heavy. Or, to deſcribe it more accurately, before the neceſſary force can be excited at the working point of the machine, the various connecting forces muſt be exerted in the different parts of the machine; and in order that the working point may follow out the impreſſion already made, all the connecting parts or limbs of the machine muſt *be moved*, in different directions, and with different velocities. Force is neceſſary for thus changing the ſtate of all this matter, and frequently a very conſiderable force. Time muſt alſo elapſe before all this can be accompliſhed. This often conſumes, and really waſtes, a great part of the impelling power. Thus, in a crane worked by men walking in a wheel, it acquires motion by ſlow degrees; becauſe, in order to give ſufficient room for the action of the number of men or cattle that are neceſſary, a very capacious wheel muſt be employed, containing a great quantity of inert matter. All of this muſt be put in motion by a very moderate preponderance of the men. It accelerates ſlowly, and the load is raiſed. When it has attained the required height, all this matter, now in conſiderable motion, muſt be ſtopped. This cannot be done in an inſtant with a jolt, which would be very inconvenient, and even hurtful; it is therefore brought to reſt gradually. This alſo conſumes time; nay, the wheel muſt get a motion in the contrary direction, that the load may be lowered into the cart or lighter. This can only be accompliſhed by degrees. Then the tackle muſt be lowered down again for another load, which alſo muſt be done gradually. All this waſtes a great deal both of time and of force, and renders a walking wheel a very improper form for the firſt mover of a crane, or any machine whoſe uſe requires ſuch frequent changes of motion. The ſame thing obtains, although in a lower degree, in the ſteam engine, where the great beam and pump rods, ſometimes weighing very many tons, muſt be made to acquire a very briſk motion in oppoſite directions twice in every working ſtroke. It obtains, in a greater or a leſs degree, in all engines which have a reciprocating motion in any of their parts. Pump mills are of neceſſity ſubjected to this inconvenience. In the famous engine at Marly, about $\frac{19}{20}$ of the whole moving power of ſome of the water wheels is employed in giving a reciprocating motion to a ſet of rods and chains, which extend from the wheels to a ciſtern about three-fourths of a mile diſtant, where they work a ſet of pumps. This engine is, by ſuch injudicious conſtruction, a monument of magnificence, and the ſtruggle of ignorance with the unchangeable laws of Nature. In machines, all the parts of which continue the direction of their motions unchanged, the inertia of a great maſs of matter does no harm; but, on the contrary, contributes to the ſteadineſs of the motion, in ſpite of ſmall inequalities of power or reſiſtance, or unavoidable irregularities of force in the interior parts. But in all reciprocations, it is highly prejudicial to the performance; and therefore conſtructions which admit ſuch reciprocation without neceſſity, are avoided by all intelligent engineers. The mere copying artiſt, indeed, who derives all his knowledge from the common treatiſes of mechanics, will never ſuſpect ſuch imperfections, becauſe they do not occur in the ſtatical conſideration of machines.

10
And its friction.

Laſtly, no machine can move without a mutual rubbing of its parts, at all points of communication; ſuch as the teeth of wheelwork, the wipers and lifts, and the gudgeons of its different axes. In many machines, the ultimate taſk performed by the working point, is either friction, or very much reſembles it. This is the caſe in poliſhing mills, grinding mills, nay in boring mills, ſaw mills, and others. A knowledge of friction, in all its varieties, ſeems therefore abſolutely neceſſary, even for a moderate acquaintance with the principles of machinery. This is a very abſtruſe ſubject; and although a good deal of attention has been paid to it by ſome ingenious men, we do not think that a great deal has been added to our knowledge of it; nor do the experiments which have been made ſeem to us well calculated to lead us to a diſtinct knowledge of its nature and modifications. It has been conſidered chiefly with a view to diminiſh it as much as poſſible in the communicating parts

parts of machinery, and to obtain ſome general rules for aſcertaining the quantity of what unavoidably remains. Mr Amontons, of the Royal Academy of Sciences at Paris, gave us, about the beginning of this century, the chief information that we have on the ſubject. He diſcovered, that the obſtruction which it gave to motion was very nearly proportional to the force by which the rubbing ſurfaces are preſſed together. Thus he found, that a ſmooth oaken board, laid on another ſmooth board of the ſame wood, requires a force nearly equal to one third of what preſſes the ſurfaces together. Different ſubſtances required different proportions.

11 Meaſure of it by Amontons. He alſo found, that neither the extent of the rubbing ſurfaces, nor the velocity of the motion, made any conſiderable variation on the obſtruction to motion. Theſe were curious and unexpected reſults. Subſequent obſervations have made ſeveral corrections neceſſary in all theſe propoſitions. This ſubject will be more particularly conſidered in another place; but ſince the deviations from Mr Amontons's rule are not very conſiderable, at leaſt in the caſes which occur in this general conſideration of machines, we ſhall make uſe of it in the mean time. It gives us a very eaſy method of eſtimating the effect of friction on machines. It is a certain proportion of the mutual preſſure of the rubbing ſurfaces, and therefore muſt vary in the ſame proportion with this preſſure. Now, we learn from the principles of ſtatics, that whatever preſſures are exerted on the impelled and working point of the machine, all the preſſures on its different parts have the ſame conſtant proportion to theſe, and vary as theſe vary: Therefore the whole friction of the machine varies in the ſame proportion. But farther, ſince it is found that the friction does not ſenſibly change with the velocity, the force which is juſt ſufficient to overcome the friction, and put the loaded machine in motion, muſt be very nearly the ſame with the force expended in overcoming the friction while the machine is moving with any velocity whatever, and performing work. Therefore if we deduct from the force which juſt puts the loaded machine in motion that part of it which balances the reaction of the impelled point occaſioned by the reſiſtance of the work, or which balances the reſiſtance of the work, the remainder is the part of the impelling power which is employed in overcoming the friction. If indeed the actual reſiſting preſſure of the work varies with the velocity of the working point, all the preſſures, and all the frictions in the different communicating parts of the machine, vary in the ſame proportion. But the law of this variation of working reſiſtance being known, the friction is again aſcertained.

We can now ſtate the dynamical equilibrium of forces in the working machine in two ways. We may either conſider the efficient impelling power as diminiſhed by all that portion which is expended in overcoming the friction, and which only prepares the machine for performing work, or we may conſider the impelling power as entire, and the work as increaſed by the friction of the machine; that is, we may ſuppoſe the machine without friction, and that it is loaded with a quantity of additional reſiſtance acting at the working point. Either of theſe methods will give the ſame reſult, and each has its advantages. We took the laſt method in the ſlight view which we took of this ſubject in the *Encycl.* art. ROTATION, nº 64. and ſhall therefore uſe it here.

Suppoſing now this previous knowledge of all theſe variable circumſtances which affect the motion of machines of the rotative kind, ſo that, for any momentary poſition of it while performing work, we know what are the preciſe preſſures acting at the impelled and working points, and the conſtruction of the machine, on which depend the friction, and the momentum of its inertia (expreſſed in the article ROTATION by $\int p r^2$); we are now in a condition to determine its motion, or at leaſt its momentary acceleration, competent to that poſition. Therefore,

12 Compoſition of the formula expreſſing the performance of a machine. Let there be a rotative machine, ſo conſtructed, that while it is performing work, the velocity of its impelled point is to that of its working point as m to n. It is eaſy to demonſtrate, from the common principles of ſtatics, that if a ſimple wheel and axle be ſubſtituted for it, having the radius of the wheel to that of the axle in the ſame proportion of m to n, and having the ſame momentum of friction and inertia, and actuated by the ſame preſſures at the impelled and working points, then the velocities of theſe points will be preciſely the ſame as in the given machine.

Let p repreſent the intenſity (which may be meaſured by pounds weight) of the preſſure exerted in the moment at the impelled point; and r expreſs the preſſure exerted at the working point by the reſiſtance oppoſed by the work that is then performing. This may ariſe from the weight of a body to be raiſed, from the coheſion of timber to be ſawed, &c. Any of theſe reſiſtances may alſo be meaſured by pounds weight; becauſe we know, that a certain number of pounds hung on the ſaw of a ſaw mill, will juſt overcome this coheſion, or overcome it with any degree of ſuperiority. Therefore the impelling power p, and the reſiſtance r, however differing in kind, may be compared as mere preſſures.

Let x repreſent the quantity of inert matter which muſt be urged by the impelling power p, with the ſame velocity as the impelled point, in order that this preſſure p may really continue to be exerted on that point. Thus, if the impelling power is a quantity of water in the bucket of an overſhot wheel, acting by its weight, this weight cannot impel the wheel except by impelling the water. In this way, x may be conſidered as repreſenting the inertia of the impelling power, while p repreſents its preſſure on the machine. In like manner, let y repreſent the quantity of external inert matter which is really moved with the velocity of the working point in the execution of the taſk performed by the machine.

Whatever be the momentum of the inertia of the machine, we can always aſcertain what quantity of matter, attached to the impelled point, or the working point of the wheel and axle, will require the ſame force to give the wheel the ſame angular motion; that is, which ſhall have the ſame momentum of inertia. Let the quantity a, attached to the working point, give this momentum of inertia $a n^2$.

Laſtly, ſuppoſing that the wheel and axle have no friction, let f be ſuch a reſiſtance, that if applied to the working point, it ſhall give the ſame obſtruction as the friction of the machine, or require the ſame force at the impelled point to overcome it.

13 Angular motion of the machine.

Theſe things being thus eſtabliſhed, the angular velocity of the wheel and axle, that is, the number of turns, or the portion of a turn, which it will make in a given time, will be proportional to the fraction $\frac{pm - \overline{r+f}\,n}{xm^2 + \overline{a+y}\,n^2}$. (I.)—See ROTATION, n° 64, &c. *Encycl.*

Since the whole turns together, the velocities of the different points are as their diſtances from the axis, and may be expreſſed by multiplying the common angular velocity by theſe diſtances. Therefore the above formulæ, multiplied by *m* or *n*, will give the velocity of the impelled or of the working point. Therefore,

14 Velocity of the impelled point.

$$\text{Velocity of impelled point} = \frac{pm^2 - \overline{r+f}\,mn}{xm^2 + \overline{a+y}\,n^2}. \text{ (II.)}$$

15 Velocity of the working point.

$$\text{Velocity of working point} = \frac{pmn - \overline{r+f}\,n^2}{xm^2 + \overline{a+y}\,n^2}. \text{ (III.)}$$

In order to obtain a clear conception of theſe velocities, we muſt compare them with motions with which we are well acquainted. The propoſition being univerſally true, we may take a caſe where gravity is the ſole power and reſiſtance; where, for example, *p* and *r* are the weights of the water in the bucket of a wheel, and in the tub that is raiſed by it. In this caſe, $p = x$, and $r = y$. We may alſo, for greater ſimplicity, ſuppoſe the machine without inertia and friction. The velocity of *p* is now $\frac{pm^2 - rmn}{pm^2 + rn^2}$.

16 Abſolute meaſure of them.

Let *g* be the velocity which gravity generates in a ſecond. Then it will generate the velocity $g\dot{t}$ in the moment $\dot{t}$. Let $\dot{v}$ be the velocity generated during this moment in *p*, connected as it is with the wheel and axle, and with *r*. This connection produces a change of condition $= g\dot{t} - \dot{v}$. For, had it fallen freely, it would have acquired the velocity $g\dot{t}$, whereas it only acquires the velocity $\dot{v}$. In like manner, had *r* fallen freely, it would have acquired the velocity $g\dot{t}$. But, inſtead of this, it is raiſed with the velocity $\frac{n}{m}\dot{v}$. The change on it is therefore $= g\dot{t} + \frac{n}{m}\dot{v}$. Theſe changes of mechanical condition ariſe from their connection with the corporeal machine Their preſſures on it bring into action its connecting forces, and each of the two external forces is in immediate equilibrium with the force exerted by the other. The force excited at the impelled point, by *r* acting at the working point, may be called the momentum or energy of *r*. Theſe energies are preciſely competent to the production of the changes which they really produce, and muſt therefore be conceived as having the ſame proportions. They are therefore equal and oppoſite, by the general laws *obſerved* in all actions of tangible matter; that is, they are ſuch as balance each other. Thus, and only thus, the remaining motions are what we obſerve them to be.

$$\text{That is, } p \times \overline{g\dot{t} - \dot{v}} \times m = r \times \overline{gt + \frac{n}{m}\dot{v}} \times n$$

$$\text{Or } pmg\dot{t} - pm\dot{v} = rng\dot{t} + r\frac{n^2}{m}\dot{v}$$

$$\text{Or } pm^2g\dot{t} - pm^2\dot{v} = rmng\dot{t} + rn^2\dot{v}$$

$$\text{Or } \overline{pm^2 - rmn} \times g\dot{t} = \overline{pm^2 + rn^2} \times \dot{v}$$

That is, $pm^2 + rn^2 : pm^2 - rmn = g\dot{t} : \dot{v}$

That is, *the denominator of the fraction, expreſſing the velocity of the impelled point, is to the numerator as the velocity which a heavy body would acquire in the moment* $\dot{t}$, *by falling freely, is to the velocity which the impelled point acquires in that moment.* The ſame thing is true of the velocity of the working point.

This reaſoning ſuffers no change from the more complicated nature of the general propoſition. Here the impelling power is ſtill *p*, but the matter to be accelerated by it at the working point is $a + y$, while its reaction, diminiſhing the impelling power, is only *r*. We have only to conſider, in this caſe, the velocity with which $a + y$ would fall freely when impelled, not by $a + y$, but only by *r*. The reſult would be the ſame; $g\dot{t}$ would ſtill be to $\dot{v}$ as the denominator of the ſame fraction to its numerator.

Thus have we diſcovered the momentary acceleration of our machine. It is evident, that if the preſſures *p* and *r*, and the friction and inertia of the machine, and the external matter, continue the ſame, the acceleration will continue the ſame; the motion of rotation will be uniformly accelerated, and $pm^2 + \overline{a+y}\,n^2$ will be to $pm^2 - \overline{r+f}\,mn$ as the ſpace *s*, through which a heavy body would fall in any given time *t*, is to the ſpace through which the impelled point will really have moved in the ſame time. In like manner, the ſpace through which the working point moves in the ſame time is $= \frac{pmn - \overline{r+f}\,n^2}{pm^2 + \overline{a+y}\,n^2}s$.

Thus are the motions of the working machine determined. We may illuſtrate it by a very ſimple example. Suppoſe a weight *p* of five pounds, deſcending from a pulley, and dragging up another weight *r* of three pounds on the other ſide. *m* and *n* are equal, and each may be called 1. The formula becomes $\frac{p-r}{p+r}s$, or $\frac{5-3}{5+3}s$, or $\frac{2}{8}$, $= \frac{1}{4}s$. Therefore, in a ſecond, the weight *p* will deſcend $\frac{1}{4}$th of 16 feet, or 4 feet; and will acquire the velocity of 8 feet per ſecond.

17 Performance of the machine.

Having obtained a knowledge of the velocity of every point of the machine, we can eaſily aſcertain its performance. This depends on a combination of the quantity of reſiſtance that is overcome at the working point, and the velocity with which it is overcome. Thus, in raiſing water, it depends on the quantity (proportional to the weight) of water in the bucket or pump, and the velocity with which it is lifted up. This will be had by multiplying the third formula by *r*, or by $rg\dot{t}$, or by *r s*. Therefore we obtain this expreſſion,

$$\text{Work done} = \frac{pmrn - \overline{r+f}\,rn^2}{pm^2 + \overline{a+y}\,n^2}g\dot{t}. \text{ (IV.)}$$

Such is the general expreſſion of the momentary performance of the machine, including every circumſtance which can affect it. But a variation of thoſe circumſtances produces great changes in the reſults. Theſe muſt be diſtinctly noticed.

Cor. 1. If $pmrn$ be equal to $\overline{r+f}\,rn^2$, there will be no work done, becauſe the numerator of the fraction is annihilated. There is then no unbalanced force, and the

the natural power is only able to balance the preſſure propagated from the working point to the impelled point.

2. In like manner, if $n = o$, no work is done altho' the machine turns round. The working point has no motion. For the ſame reaſon, if m be infinitely great, although there is a great prevalence of impelling momentum, there will not be any ſenſible performance during a finite time. For the velocity which p can impreſs is a finite quantity, and the impelled point cannot move faſter than x would be moved by it if detached from the machine. Now when the infinitely remote impelled point is moved through any finite ſpace, the motion of the working point muſt be infinitely leſs, or nothing, and no work will be done.

Remark. We ſee that there are two values of n, viz. v, and $m \times \frac{p}{r}$, which give no performance. But in all other proportions of m and n ſome work is done. Therefore, as we gradually vary the proportion of m to n, we obtain a ſeries of values expreſſing the performance, which muſt gradually increaſe from nothing, and then decreaſe to nothing. There muſt therefore be ſome proportion of m to n, depending on the proportion of p to $\overline{r+f}$, and of x to $\overline{a+y}$, which will give the greateſt poſſible value of the performance. And, on the other hand, if the proportion of m to n be already determined by the conſtruction of the machine already erected, there muſt be ſome proportion of p to $\overline{r+f}$, and of x to $a+y$, by which the greateſt performance of the machine may be enſured. It is evident, that the determination of theſe two proportions is of the utmoſt importance to the improvement of machines. The well informed reader will pardon us for endeavouring to make this appear more forcibly to thoſe who are leſs inſtructed, by means of ſome very ſimple examples of the firſt principle.

Suppoſe that we have a ſtream of water affording three tons per minute, and that we want to drain a pit which receives one ton per minute, and that this is to be done by a wheel and axle? We wiſh to know the beſt proportion of their diameters m and n. Let m be taken $= 6$; and ſuppoſe,

1. That $n = 5$.

Then $\frac{p\,m\,r\,n - r^2 n^2}{p\,m^2 + r\,n^2} = \frac{3.6.1.5 - 1.25}{3.36 + 1.36}, = \frac{65}{133}, = 0,4887$

2. Let n be $= 6$. The formula is $= 0,5$.

3. Let $n = 7$. The formula is $= 0,49045$. Hence we find, that the performance is greater when n is 6, than when it is either 5 or 7.

As an example of the ſecond principle, ſuppoſe the machine a ſimple pulley, and let p be 10.

1. Let r be $= 3$. The formula is $\frac{10 \times 3 - 9}{10 + 3}, = \frac{21}{13}, = 1,6154$.

2. Let r be $= 4$. The formula is $= \frac{10 \times 4 - 16}{10 + 4}, = \frac{24}{14}, = 1,7143$.

3. Let r be $= 5$. The formula is $= \frac{10 \times 5 - 25}{10 + 5}, = \frac{25}{15}, = 1,6666$. Here it appears, that more work is done when r is 4 than when it is 5 or 3.

It muſt therefore be allowed to be one of the moſt important problems in practical mechanics to determine that conſtruction by which a given power ſhall overcome a given reſiſtance with the greateſt advantage, and the proportion of work which ſhould be given to a machine already conſtructed ſo as to gain a ſimilar end.

18 Proportion of the machine which gives the greateſt work.

I. The general determination of the firſt queſtion has but little difficulty. We muſt conſider n as the variable magnitude in the formula $\frac{p\,m\,r\,n - \overline{r+f}\,r\,n^2}{p\,m^2 + \overline{a+y}\,n^2}$, which expreſſes the work done; and find its value when the formula is a maximum. Taking this method, we ſhall find that the formula IV. is a maximum when n is

$$= m\,\frac{\sqrt{x^2(r+f)^2 + p^2 x(a+y)} - x(r+f)}{p(a+y)}.$$

This expreſſion of the performance, in its beſt ſtate, appears pretty complex; but it becomes much more ſimple in all the particular applications of it, as the circumſtances of the caſe occur in practice.

We have obtained a value of n expreſſed in parts of m If we ſubſtitute this for n in the third formula, we obtain the greateſt velocity with which the reſiſtance r, connected with the inertia y, can be overcome by the power p, connected with the inertia x, by the intervention of a machine, whoſe momentum of inertia and friction are $a\,n^2$ and $f\,n$. This is $= \frac{r+f}{2\,\overline{a+y}} \times \left(\sqrt{\frac{p^2\,\overline{a+y}}{\overline{r+f}^2\,x} + 1} - 1\right) g\,t$. This expreſſes the velocity of the working point in feet per ſecond, and therefore the actual performance of the machine.

But the proper proportion of m to n, aſcertained by this proceſs, varies exceedingly, according to the nature both of the impelling power, and of the work to be performed by the machine.

1. It frequently happens that the work exerts no contrary ſtrain on the machine, and conſiſts merely in impelling a body which reſiſts only by its inertia. This is the caſe in urging round a millſtone or a heavy fly; in urging a body along a horizontal plane, &c. In this caſe r does not enter into the formula, which now becomes $m \times \frac{\sqrt{x^2 f^2 + p^2 x(a+y)} - x\,f}{p(a+y)}$. If the friction be inſignificant we may take $n = m\sqrt{\frac{p^2 x(a+y)}{p^2(a+y)^2}} = m\sqrt{\frac{x}{a+y}}$. The velocity of the working point is nearly $= \frac{p}{2\sqrt{x\,\overline{a+y}}}$. In this caſe, it will be found that the velocity acquired at the end of a given time will be nearly in the proportion of the power applied to the machine.

2. On the other hand, and more frequently, the inertia of the external matter which muſt be moved in performing the work need not be regarded. Thus, in the grinding of grain, ſawing of timber, boring of cylinders, &c. the quantity of motion communicated to the flour, to the ſaw duſt, &c. is too inſignificant to be taken into the account. In this caſe, y vaniſhes from the formula, which becomes extremely ſimple when the friction and inertia of the machine are inconſiderable. We

ſhall not be far from the truth if we make m to n as $2r$ to p, or $n = m \times \frac{p}{2r+f}$. In this caſe, the velocity of the working point is $\frac{p^2}{4x(r+f)+\frac{ap^2}{4(r+f)}}$.

But it is rare that machines of this kind have a ſmall inertia. They are generally very ponderous and powerful; and the force which is neceſſary for generating even a very moderate motion in the unloaded machine (that is, unloaded with any work), bears a great proportion to the force neceſſary for overcoming the reſiſtance oppoſed by the work. The formula muſt therefore be uſed in all the terms, becauſe a is joined with y. It would have been ſimpler in this particular, had a been joined with x in the expreſſion of the angular velocity.

3. In ſome caſes we need not attend to the inertia of the power, as in the ſteam engine. In this caſe, if taken ſtrictly, n appears to have no value, becauſe x is a factor of every term of the numerator. But the formula gives this general indication, that the more inſignificant the inertia of the moving power is ſuppoſed, the larger ſhould m be in proportion to n; provided always, that the impelling power is not, by its nature, greatly diminiſhed, by giving ſo great a velocity to the impelled point. This circumſtance will be particularly conſidered afterwards.

4. If the inertia of the power and the reſiſtance be proportional to their preſſures, as when the impelling power is water lying in the buckets of an overſhot wheel, and the work is the raiſing of water, minerals, or other heavy body, acting *only* by its weight; then p and r may be ſubſtituted for x and y, and the formula expreſſing the value of n, when the performance is a maximum, becomes

$$n = m\frac{\sqrt{p^2\times\overline{r+f}^2+p^3\times\overline{a+r}}-p\times\overline{r+f}}{p\times\overline{a+r}}.$$

If, in this caſe, the inertia and friction of the machine may be diſregarded, as may often be done in pulleys, we have

$$n = m\sqrt{\frac{p}{r}+1}-1.$$

If we make m the unit of the radii, and r the unit of force, we have

$$n = \sqrt{p+1}-1, \text{ in parts of } m = 1.$$

Or, making $p = 1$, we have $n = \sqrt{\frac{1}{r}+1}-1$.

Theſe very ſimple expreſſions are of conſiderable uſe, even in caſes where the inertia of the machine is very conſiderable, provided that it have no reciprocating motions. A ſimple wheel and axle, or a train of good wheelwork, have very moderate friction. The general reſults, therefore, which even very unlettered readers can deduce from theſe ſimple formulæ, will give notions that are uſeful in the caſes which they cannot ſo thoroughly comprehend. Some ſervice of this kind may be derived from the following little table of the beſt proportions of m to n, correſponding to the proportions of the power furniſhed to the engineer, and the reſiſtance which muſt be overcome by it. The quantity r is always $= 10$, and $m = 1$.

p	n	p	n
1	0,0488	10	0,4142
2	0,0954	20	0,7321
3	0,1402	30	1,
4	0,1832	40	1,2362
5	0,2246	50	1,4495
6	0,2649	60	1,6457
7	0,3038	70	1,8284
8	0,3416	80	2,
9	0,3784	90	2,1623
10	0,4142	100	2,3166

This muſt ſuffice for a very general view of the firſt problem.

19 Beſt proportion of the power and work.

II. The next queſtion is not leſs momentous, namely, to determine for a machine of a given conſtruction that proportion of the reſiſtance at the working point to the impelling power which will enſure the greateſt performance of the machine; that is, the proportion of m to n being given, to find the beſt proportion of p to r.

This is a much more complicated problem than the other; for here we have to attend to the variations both of the preſſures p and r, and alſo of the external matters x and y, which are generally connected with them. It will not be ſufficient therefore to treat the queſtion by the uſual fluxionary proceſs for determining the maximum, in which r is conſidered as the only varying quantity. We muſt, in this curſory diſcuſſion, reſt ſatisfied with a comprehenſion of the circumſtances which moſt generally prevail in practice.

It muſt either happen, that when r changes, there is no change (that is, of moment) in the maſs of external matter which muſt be moved in performing the work, or that there is alſo a change in this circumſtance. If no change happens, the denominator of the fourth formula, expreſſing the performance, remains the ſame; and then the formula attains a maximum when the numerator $prmn - \overline{r+f}\,rn^2$ is a maximum. Alſo, we may include f without complicating the proceſs, by the conſideration, that f is always in nearly the ſame ratio to r; and therefore $r+f$ may be conſidered as a certain multiple of r, ſuch as br. We may therefore omit f in the fluxionary equations for obtaining the maximum, and then, in computing the performance, divide the whole by b. Thus if the whole friction be $\frac{1}{20}$th of the reſiſting preſſure r, we have $r+f = \frac{21}{20}$ of r, and $b = \frac{21}{20}$. Having aſcertained the beſt value for r, we put this in its place in the fourth formula, and take $\frac{20}{21}$ of this for the performance. This will never differ much from the truth.

This proceſs gives us $pmn = 2n^2r$, and $r = \frac{pmn}{2n^2}$, $= \frac{pm}{2n}$; and if we farther ſimplify the proceſs, by making $p = 1$, and $m = 1$, we have $r = \frac{1}{2n}$; a moſt ſimple expreſſion, directing us to make the reſiſtance one half of what would balance the impelling power by the intervention of the machine.

This will evidently apply to many very important caſes,

caſes, namely, to all thoſe in which the matter put in motion by the working point is but trifling.

But it alſo happens in many important caſes, that the change is at leaſt equally conſiderable in the inertia of the work. In this caſe it is very difficult to obtain a general ſolution. But we can hardly imagine ſuch a change, without ſuppoſing that the inertia of the work varies in the ſame proportion as the preſſure excited by it at the working point of the machine; for ſince r continues the ſame in kind, it can rarely change but by a proportional change of the matter with which it is connected. Yet ſome very important caſes occur where this does not happen. Such is a machine which forces water along a long main pipe. The reſiſtance to motion and the quantity of water do not follow nearly the ſame ratio. But in the caſes in which this ratio is obſerved, we may repreſent y by any multiple $b\,r$ of r, which the caſe in hand gives us; b being a number, integer, or fractional. In the farther treatment of this caſe, we think it more convenient to free r from all other combinations; and inſtead of ſuppoſing the force f (which we made equivalent with the friction of the machine) to be applied at the working point, we may apply it at the impelled point, making the effective power $q = p - f$. For the ſame reaſons, inſtead of making the momentum of the machine's inertia $= a\,n^2$, we may make it $a\,m^2$, and make $a + x = z$. Now, ſuppoſing q, or $p - f$, $= 1$, and alſo $m = 1$, our formula expreſſing the performance becomes $\frac{r\,n - r^2\,n^2}{z + b\,r\,n^2}$. This is a maximum when

$$r = \frac{\sqrt{z^2 + z\,b\,n} - z}{b\,n^2}.$$

Cor. 1. If the inertia of the work is always equal to its preſſure, as when the work conſiſts wholly in raiſing a weight, ſuch as drawing water, &c. then $b = 1$, and the formula for the maximum performance becomes

$$r = \frac{\sqrt{z\,n + z^2} - z}{n^2}.$$

2. If the inertia of the impelling power is alſo the ſame with its preſſure, and if we may neglect the inertia and friction of the machine, the formula becomes

$$r = \frac{\sqrt{n + 1} - 1}{n^2}.$$

Example. Let the machine be a common pulley, ſo that the radii m and n are equal, and therefore $n = 1$. Then, $r = \frac{\sqrt{1 + 1} - 1}{1}, = \sqrt{2} - 1, = 0{,}4142$, &c. more than $\frac{2}{5}$ths of what would balance it.

Here follows a ſeries of the beſt values of r, correſponding to different values of n. m and p are each $= 1$. The numbers in the laſt column have the ſame proportion to 1 which r has to the reſiſtance which will balance p.

$n = \frac{1}{4}$	$r =$ 1,8885	0,4724 to 1
$\frac{1}{3}$	1,3928	0,4639
$\frac{1}{2}$	0,8986	0,4493
1	0,4142	0,4142
2	0,1830	0,3660
3	0,1111	0,3333
4	0,0772	0,3088

From what has now been eſtabliſhed, we ſee with ſufficient evidence the importance of the higher mathematics to the ſcience of mechanics. If the velocities of the impelled and working points of an engine are not properly adjuſted to the preſſures, the inertia, and the friction of the machine, we do not derive all the advantages which we might from our ſituation. Hence alſo we learn the falſity of the maxim which has been received as well founded, that the augmentation of intenſity of any force, by applying it to the long arm of a lever, is always fully compenſated by a loſs of time; or, as it is uſually expreſſed, "what we gain by a machine in force we loſe in time." If the proportion of m to n is well choſen, we ſhall find that the work done, when it reſiſts by its inertia only, increaſes nearly in the proportion of the power employed; whereas when the inertia of the work is but a ſmall part of the reſiſtance, it increaſes nearly in the duplicate ratio of the power employed.

General but erroneous maxim.

It was remarked, in the ſetting out in the preſent problem, that the formulæ do not immediately expreſs the velocity of any point of the machine, but its momentary acceleration. But this is enough for our purpoſe; becauſe, when the momentary acceleration is a maximum, the velocity acquired, and the ſpace deſcribed, in any given time, is alſo a maximum. We alſo ſhewed how the real velocities, and the ſpaces deſcribed, may be aſcertained in known meaſures. We may ſay in general, that if g repreſent the preſſure of gravity on any maſs of matter w, then $\frac{g}{w}$ is to $\frac{p\,m\,n - \overline{r + f}\,n}{a\,m^2 + a + y\,n^2}$ as 16 feet to the ſpace deſcribed in a ſecond by the working point in a ſecond, or as 32 feet per ſecond is to the velocity acquired in that time.

20
Cauſes why machines do not continually accelerate.

A remark now remains to be made, which is of the greateſt conſequence, and gives an unexpected turn to the whole of the preceding doctrines. It appears, from all that has been ſaid, that the motion of a machine muſt be uniformly accelerated, and that any point will deſcribe ſpaces proportional to the ſquares of the times; for while the preſſures, friction, and momentum of inertia remain the ſame, the momentary acceleration muſt alſo be invariable. But this ſeems contrary to all experience. Such machines as are properly conſtructed, and work without jolts, are obſerved to quicken their pace for a few ſeconds after ſtarting; but all of them, in a very moderate time, acquire a motion that is ſenſibly uniform. Is our theory erroneous, or what are the circumſtances which remain to be conſidered, in order to make it agree with obſervation? The ſcience of machines is imperfect, till we have explained the cauſes of this deviation from the theory of uniform acceleration.

Theſe cauſes are various.

1. Increa of friction

1. In ſome caſes, every increaſe of velocity of the machine produces an increaſe of friction in all its communicating parts. By theſe means, the accelerating force, which is $p\,m - \overline{r + f\,n}$, or $\overline{p - f}\,m - r\,n$, is diminiſhed, and conſequently the acceleration is diminiſhed. But it ſeldom happens that friction takes away or employs the whole accelerating force. We are not yet well inſtructed in the nature of friction. Moſt of the kinds of friction which obtain in the communicating parts of machines, are ſuch as do not ſenſibly increaſe by an increaſe of velocity; ſome of them really diminiſh. Yet even the moſt accurately conſtructed machines, unloaded with work, attain a motion that is ſenſibly uniform. If we take off the pallets from a pendulum

dulum clock, and allow it to run down amain, it accelerates for a while, but in a very moderate time it acquires an uniform motion. So does a common kitchen jack. Theſe two machines ſeem to bid the faireſt of any for an uniformly accelerated motion; for their impelling power acts with the utmoſt uniformity. There is ſomething yet unexplained in the nature of friction, which takes away ſome of this acceleration.

2. Reſiſtance of air. But the chief cauſe of its ceſſation in theſe two inſtances, and others *of very rapid motion*, is the reſiſtance of the air. This ariſes from the motion which is communicated to the air diſplaced by the ſwift moving parts of the machine. At firſt it is very ſmall; but it increaſes nearly in the duplicate ratio of the velocity (ſee *Reſiſtance of Fluids*, Encycl.) Thus r increaſes continually; and, in a certain ſtate of motion, $\overline{r + f n}$ becomes equal to $p m$. Whenever this happens, the accelerating power is at an end. The acceleration alſo ceaſes; and the machine is in a ſtate of dynamical equilibrium; not at reſt, but moving uniformly, and performing work.

3. Increaſe of reſiſtance very imperfectly known. Still, however, this is not one of the general cauſes of the uniform motion attained by working engines. Rarely is the motion of their parts ſo rapid, as to occaſion any great reſiſtance from the air. But in the moſt frequent employments of machines, every increaſe of velocity is accompanied by an increaſe of reſiſtance from the work performed. This occurs at once to the imagination; and few perſons think of inquiring farther for a reaſon. But there is perhaps no part of mechanics that is more imperfectly underſtood, even in our preſent improved ſtate of mechanical ſcience. In many kinds of work, it is very difficult to ſtate what increaſe of labour is required in order to perform the work with twice or thrice the ſpeed. In grinding corn, for inſtance, we are almoſt entirely ignorant of this matter. It is very certain, that twice the force is not neceſſary for making the mill grind twice as faſt, nor even for making it grind twice as much grain equally well. It is not eaſy to bring this operation under mathematical treatment; but we have conſidered it with ſome attention, and we imagine that a very great improvement may ſtill be made in the conſtruction of griſt mills, founded on the law of variation of the reſiſtance to the operation of grinding, and a ſcientific adjuſtment of m to n, in conſequence of our knowledge of this law. We may make a ſimilar obſervation on many other kinds of work performed by machines. In none of thoſe works where the inertia of the work is inconſiderable, are we well acquainted with the real mechanical proceſs in performing it. This is the caſe in ſawing mills, boring mills, rolling mills, ſlitting mills, and many others, where the work conſiſts in overcoming the ſtrong coheſion of a ſmall quantity of matter. In ſawing timber (which is the moſt eaſily underſtood of all theſe operations), if the ſaw move with a double velocity, it is very difficult to ſay how much the actual reſiſting preſſure on the teeth of the ſaw is increaſed. Twice the number of fibres are neceſſarily torn aſunder during the ſame time, becauſe the ſame number are torn by one deſcent of the ſaw, and it makes that ſtroke in half the time. But it is very uncertain whether the reſiſtance is double on this account; becauſe if each fibre be ſuppoſed to have the ſame tenacity in both caſes, it reſiſts with this tenacity only for half the time. The parts of bodies reſiſt a ſimilar change of condition in different manners; and there is another difference in their reſiſtance of different changes—the reſiſtance of red hot iron under the roller may vary at a very different rate from that of its reſiſtance to the cutting tool. The reſiſtance of the ſpindles of a cotton mill, ariſing partly from friction, partly from the inertia of the heaped bobins, and partly from the reſiſtance of the air, is ſtill more complicated, and it may be difficult to learn its law. The only caſe in which we can judge with ſome preciſion is, when the inertia of matter, or a conſtant preſſure like that of gravity, conſtitutes the chief reſiſtance. Thus in a mill employed to raiſe water by a chain of buckets, the reſiſtance proceeds from the inertia only of the water. The buckets are moving with a certain velocity, and the loweſt of them takes hold of a quantity of water lying at reſt in the pit, and drags it into motion with its acquired velocity. The force required for generating this motion on the quieſcent water muſt be double or triple, when the velocity that muſt be given to it is ſo. This abſorbs the overplus of the impelling power, by which that power exceeds what is neceſſary for balancing the weight of the water contained in all the aſcending buckets. This is a certain determinate quantity which does not change; for in the ſame inſtant that a new bucket of water is forced into motion below, and its weight added to that of the aſcending buckets, an equal bucket is emptied of its water at top. The aſcending buckets require only to be balanced, and they then *continue* to aſcend, with any velocity already acquired. While the machine moves ſlow, the motion impreſſed on the new bucket of water is not ſufficient to abſorb all the overplus of impelling power. The quantity not abſorbed accelerates the machine, and the next bucket muſt produce more motion in the water which it takes up. This conſumes more of the overplus. This goes on till no overplus of power is left, and the machine accelerates no more. The complete performance of the machine now is, that "a certain quantity of water, formerly at reſt, is now moving with a certain velocity." Our engineers conſider it differently; "as a certain *weight* of water lifted up." But while the machine is thus moving uniformly, it is really not doing ſo much as before; that is, it is not exerting ſuch great preſſures as before the motion was rendered uniform: for at that time there was a preſſure at the working point equal to the weight of all the water in the aſcending buckets; and alſo an overplus of preſſure, by which the whole was accelerated. In the ſtate of uniform motion, the preſſure is no more than juſt balances the weight of the aſcending chain. We ſhall learn by and bye how the preſſures have been diminiſhing, although the mill has been accelerating; a thing that ſeems a paradox.

In this inſtance, then, we ſee clearly, why a machine muſt attain a uniform motion. A pumping machine gives us the ſame opportunity, but in a manner ſo different as to require explanation. The piſton may be ſuppoſed at the very ſurface of the pit water, and the impelling power may be leſs than will ſupport a column in the pipe as high as can be raiſed by the preſſure of the atmoſphere. Suppoſe the impelling power to be the water lying in the buckets of an overſhot wheel.

Let this water be laid into the buckets by a very ſmall ſtream. It will fill the buckets very ſlowly; and as this gives them a preponderance, the mill loſes its balance, the wheel begins to move, and the piſton to riſe, and the water to follow it. The water may be delivered on the wheel drop by drop; the piſton will riſe by inſenſible degrees, always ſtanding ſtill again as ſoon as the atmoſpheric preſſure on it juſt balances the water on the wheel. The water in the riſing pipe is always a balance to the preſſure of the atmoſphere on the ciſtern; therefore the preſſure of the atmoſphere on the piſton (which is the r in our formula) is equal to the weight of this water. Our pump-makers therefore (calling themſelves engineers) ſay, that the weight of water in the pipe balances the water on the wheel. It does not balance it, nor is it raiſed by the wheel, but by the atmoſphere; but it ſerves us at preſent for a meaſure of the power of the wheel. At laſt, all the buckets of the wheel are full, and the water is (for example) 25 feet high in the pipe. Now let the ſtream of water run its full quantity. It will only run over from bucket to bucket, and run off at the bottom of the wheel; but the mill will not move, and no work will be performed. (N. B. We are here excluding all impulſe or ſtroke on the buckets, and ſuppoſing the water to act only by its weight.) But now let all be emptied again, and let the water be delivered on the wheel in its full quantity at the firſt. The wheel will immediately acquire a preponderancy, which will *greatly* exceed the firſt ſmall preſſure of the atmoſphere on the piſton. It will therefore accelerate the piſton, overcoming the preſſure of the air with great velocity. The piſton riſes faſt; the water follows it, by the preſſure of the atmoſphere; and when it attains the former utmoſt height, it attains it with a conſiderable velocity. If allowed to run off there, it will *continue* to run off with that velocity; becauſe there is the ſame quantity of water preſſing round the wheel as before, and therefore enough to balance the preſſure of the atmoſphere on the piſton. The preſſure of the ſame atmoſphere on the water in the ciſtern, raiſed the water in the pipe with this velocity; therefore it will continue to do ſo, and the mill will deliver water by the pump with this velocity, although there is no more preſſure acting on it than before, when the water ran to waſte, doing no work whatever.

This mode of action is extremely different from the former example. The mill is not acting againſt the inertia y of the water to be moved, but againſt the preſſure r of the atmoſphere on the piſton. The preſſure of the ſame atmoſphere on the ciſtern is employed againſt the inertia of the water in the pipe; and the uſe of the mill is to *give occaſion*, by raiſing the piſton, to the exertion of this atmoſpherical preſſure, which is the real raiſer of the water. The maxim of conſtrnction, and the proper adjuſtment of m to n in this caſe, are different from the former; and we ſhould run the riſk of making an imperfect engine were we to confound them.

We muſt mention another caſe of a pumping mill, ſeemingly the ſame with this, but eſſentially different. Suppoſe the pipe of this pump to reach 30 feet below the ſurface of the pit water, and that the piſton is at the very bottom of it. Suppoſe alſo, that the wheel buckets, when filled with water, only enable it to *ſupport* 25 feet of water in the riſing pipe. Let the water be delivered into the wheel drop by drop. The wheel will gradually preponderate; the piſton will gradually riſe, lifting the water above it, ſuſtaining a preſſure of water which gradually increaſes. At laſt, the water in the pump is 25 feet higher than that in the ciſtern; the wheel is full and running to waſte; but no work is performed. Let all be emptied, and now let the water come to the wheel in its full ſtream, but without impulſe. The piſton will lift the water briſkly, bring it to 25 feet high with a conſiderable velocity, and the mill will now raiſe it with this velocity. In this example, the mill is the immediate agent in raiſing the water; but, in this caſe alſo, its ultimate office is not overcoming inertia, but overcoming preſſure. It was the overplus of power only that was employed in overcoming inertia, while accelerating the water in the riſing pipe, in order to give it the neceſſary velocity for a continued diſcharge.

These and ſimilar examples ſhew the great difference between the ſtatical and dynamical equilibrium of machines, and the neceſſity of a ſcientific attention by all who wiſh to improve practical mechanics. Without this, and even a pretty refined attention, we cannot ſee the connection between a copious ſupply of water to the bucket wheel and a plentiful diſcharge by the pump. We believe, that the greateſt part of thoſe employed in erecting machines conceive it as owing to the greater weight of water impelling the wheel with greater force; but we ſee that there is no difference in the preſſures on the mill at reſt, and the mill doing its work ſteadily and uniformly, with any velocity, however great. Without keeping the notions of that part of the impelling power which ſupports diſtinct from that of the part which accelerates, we ſhall never have a clear conception of the operation of machines, or of mechanical power in general. We cannot derive all the advantages of our natural powers, without knowing how our machine employs the preſſure excited by it at the working point; that is, without perceiving in what caſes it is oppoſed to inertia, and in what to the mechanical properties of tangible matter. This only can inform us at what rate the reſiſtance varies by a change of velocity; and when it happens that this augmentation, neceſſarily accompanied by an augmentation of all the frictions, and the reſiſtance of the air, is in equilibrio with the whole of the impelling power, and all acceleration is at an end. 21.

22
The chief cauſe is a real diminution of power.

Laſtly, another chief cauſe of the finally uniform motion of machines is, that, in moſt caſes, an increaſe of velocity produces a real diminution of impelling power. We hardly know any exception to this beſides the employment of *one* deſcending weight as a power or firſt mover. Moſt of the powers which we employ reſide in bodies external to the machine; and theſe bodies muſt be put in motion, and continued in that motion, in order to continue their preſſure on the impelled point. Frequently a great part of the power is employed in giving this neceſſary motion to the external matter, and the remainder only is employed in preſſing forward the machine. We mentioned a remarkable inſtance of this in the operation of thraſhing. Now, the power thus employed muſt increaſe in proportion to the motion required; that is, in proportion to the velocity of the impelled

pelled point; what remains, urging forward the machine, is therefore diminiſhed. The acceleration is therefore diminiſhed, and may ceaſe. At *laſt* the actual preſſure is ſo much diminiſhed, that it is no more than what is neceſſary for overcoming the increaſed reſiſtance of the work, the increaſed friction. The machine therefore accelerates no more, but moves uniformly.

This cauſe very general.

This cauſe of the diminution of power by an increaſe of velocity, obtains in all caſes where the ſtrength of animals, of ſprings, the force of fired gunpowder, &c. is exerted. In ſome caſes, the viſible effect is not very conſiderable; as in the employment of a ſtrong ſpring, the force of gunpowder, and a few others. In the action of animals, this defalcation of power is very great when the velocity is conſiderable. Nay, even in the action of gravity, although it acts as ſtrongly on a body in rapid motion as on one at reſt, yet when gravity is not the immediate agent, but acts by the intervention of a body in which it reſides, the neceſſity of previouſly moving this body frequently diminiſhes the acceleration which it would otherwiſe produce. Thus, in an overſhot wheel, if the water be delivered into the bucket with a velocity (eſtimated in the direction of the part of the wheel into which it is delivered) leſs than that of the rim of the wheel, it muſt retard the motion; for it muſt be immediately dragged into that motion; that is, part of the accelerating overplus, already acting on the wheel, muſt be employed in accelerating this new bucket of water, and this muſt leſſen the general acceleration of the machine. Hence we learn, that the water muſt be delivered on the wheel with a velocity that is at leaſt not leſs than that of the wheel's motion.

It obtains in all machines actuated by impulſion,

The caſe in which we ſee this diminution of power on machines moſt diſtinctly is, when water or wind, acting by impulſe alone, is our moving power. Since the mutual impulſes of bodies depend entirely on their relative motions (ſee IMPULSION, *Suppl.*), it follows, that when the velocity of the impelled point is augmented, the impulſion, or effective preſſure, muſt be diminiſhed. Nay, this velocity may be ſo increaſed, that there ſhall be no relative motion, and therefore no impulſion. If the floats of an underſhot wheel be moving with the velocity of the ſtream, they remain conjoined in their progreſs, but without any mutual action. Therefore, when an underſhot wheel is ſet into a running water, the firſt impulſions are ſtrong, and accelerate the wheel. This diminiſhes the next impulſion and acceleration: but the wheel is ſtill impelled and accelerated; leſs and leſs in every ſucceeding moment, as it moves faſter; by and bye, the acceleration becomes inſenſible, and the wheel appears to attain a motion which is perfectly uniform. This requires a very long time, or rather it is never attained, and we only cannot diſcern the very ſmall additions which are ſtill made to the velocity. All this happens generally after a very moderate time, by reaſon of various other obſtructions.

Or by the force of animals.

Animal action is ſubject to the ſame variation. We know, that there is a certain rate at which a horſe can run, exhauſting or employing his whole ſtrength. If he be made to drag any the ſmalleſt load after him, he muſt employ part of his force on it, and his ſpeed will be checked. The more he is loaded with a draught, the ſlower he will run, ſtill employing all his ſtrength. The draught may be increaſed till he is reduced to a trot, to a walk, nay, till he is unable to draw it. Now, juſt inverting this proceſs, we ſee, that there is a certain ſtrain which will ſufficiently tire the horſe without ſtirring from the ſpot, but which he could continue to exert for hours. This is greater than the load that he can juſt crawl along with, employing his ſtrength as much as would be prudent to continue from day to day. And, in like manner, every leſſer draught has a correſponding rate, at which the horſe, employing his whole working ſtrength, can continue to draw at during the working hours of a day. At ſetting out, he pulls harder, and accelerates it.* Following his pull, he walks faſter, and therefore pulls leſs (becauſe we are ſtill ſuppoſing him to employ his whole working ſtrength). At laſt he attains that ſpeed which occupies his whole ſtrength in merely continuing the pull. Other animals act in a ſimilar manner; and it becomes a general rule, that the preſſure actually exerted on the impelled point of a machine diminiſhes as its velocity increaſes.

23 We muſt diſtinguiſh between the power expended and the power employed.

From the concurrence of ſo many facts, we perceive that we muſt be careful to diſtinguiſh between the quantity of power expended, and the quantity that is uſefully employed, which muſt be meaſured ſolely by the preſſure exerted on the machine. When a weight of five pounds is employed to drag up a weight of three pounds by means of a thread over a pulley, it deſcends, with a motion uniformly accelerated, four feet in the firſt ſecond. Mr Smeaton would call this an expenditure of a mechanical power 20. The weight three pounds is raiſed four feet. Mr Smeaton would call this a mechanical effect 12. Therefore the effect produced is not adequate to the power expended. But the fact is, that the preſſure, ſtrain, or mechanical power really exerted in this experiment, is neither five nor three pounds; the five pound weight would have fallen 16 feet, but it falls only 4. A force has therefore acted on it ſufficient to make it deſcribe 12 feet in a ſecond, with a uniformly accelerated motion; for it has counteracted ſo much of its weight. The thread was ſtrained with a force equal to $3\frac{3}{4}$ pounds, or $\frac{3}{4}$ths of 5 pounds. In like manner, the three pound weight would have fallen 16 feet; but it was raiſed 4 feet. Here was a change preciſely equal to the other. A force of $3\frac{3}{4}$ pounds, acting on a maſs whoſe matter is only 3, will, in a ſecond, cauſe it to deſcribe 20 feet with a uniformly accelerated motion. Now, 5 × 12, and 3 × 20, give the ſame product 60. And thus we ſee, that the quantity of motion extinguiſhed or produced, and not the product of the weight and height, is the true unequivocal meaſure of mechanical power really expended, or the mechanical effect really produced; and that theſe two are always equal and oppoſite. At the ſame time, Mr Smeaton's theorem merits the attention of engineers; becauſe it generally meaſures the opportunities that we have for procuring the exertion of power. In ſome ſenſe Mr Smeaton may ſay, that the quantity of water multiplied by the height from which it deſcends in working our machines, is the meaſure of the power expended; becauſe we muſt raiſe this quantity to the dam again, in order to have the ſame uſe of it. It is expended, but not employed; for the water, at leaving the wheel, is ſtill able to do ſomething.

24 It requires but little conſideration to be ſenſible, that the

the preceding account of the ceſſation of accelerated motion in our principal machines, muſt introduce different maxims of conſtruction from thoſe which were expreſsly adapted to this acceleration; or rather, which proceeded on the erroneous ſuppoſition of the conſtancy of the impelling power and the reſiſtance. The examination of this point has brought into view the fundamental principle of working machines, namely, the perfect equilibrium which takes place between the impelling power and the ſimultaneous reſiſtance. It may be expreſſed thus:

irſt prin iple of working machines.

The force required for preſerving a machine in uniform motion, with any velocity whatever, is that which is neceſſary for balancing the reſiſtance then actually exerted on the working point of the machine. We ſaw this diſtinctly in the inſtance of the two weights acting againſt each other by the intervention of a thread over a fixed pulley. It is equally true of every caſe of acting machinery: for if the force at the impelled point be greater than what balances the reſiſtance acting at the ſame point, it muſt accelerate that point, and therefore accelerate the whole machine; and if the impelling force be leſs than this, the machine muſt immediately retard in its motion. When the machine has once acquired this degree of motion, every part of it will continue in its preſent ſtate of motion, if only the two external forces are in equilibrio, but not otherwiſe. But when the preſſure of the external power on the impelled point balances the reſiſtance oppoſed by that point, it is, in fact, maintaining the equilibrium with the external power acting at the working point; for this is the only way that external forces can be ſet in oppoſition to each other by the intervention of a body. The external forces are not in immediate equilibrio with each other, but each is in equilibrio with the force exerted by the point on which it acts This force excited by the point is a modification of the connecting forces of the body, all of which are brought into action by means of the actions of the external forces, and each is accompanied by a force preciſely equal and oppoſite to it. Now, the principles of ſtatics teach us the proportions of the external preſſures which are thus ſet in equilibrium by the intervention of a body; and therefore teach us what proportion of power and reſiſtance will keep a machine of a given conſtruction in a ſtate of uniform motion

This propoſition appears paradoxical, and contrary to common obſervation; for we find, that, in order to make a mill go faſter, we muſt either diminiſh the reſiſtance, or we muſt employ more men, or more water, or water moving with greater velocity, &c. But this ariſes from ſome of the cauſes already mentioned. Either the reſiſtance of the work is greater when the machine is made to move faſter, or the impulſion of the power is diminiſhed, or both theſe changes obtain. Friction and reſiſtance of air alſo come in for their ſhare, &c. The actual preſſure of a given quantity of the external power is diminiſhed, and therefore more of it muſt be employed. When a weight is *uniformly* raiſed by a machine, the preſſure exerted on it by the working point is preciſely equal to its weight, whatever be the velocity with which it riſes. But, even in this ſimpleſt caſe, more natural power muſt be expended in order to raiſe it faſter; becauſe either more natural power muſt be employed to accelerate the external matter which is to preſs forward the impelled point, or the relative motion of the preſſing matter will be diminiſhed.

It is well known, that, in the employment of the mechanic powers, whether in their ſtate of greateſt ſimplicity, or any how combined in a complicated machine, if the machine be put in motion, the velocities of the extreme points (which we have called the *impelled* and *working* points) are inverſely proportional to the forces which are in equilibrio when applied to theſe points in the direction of their motion. This is an inductive propoſition, and has been uſed as the foundation of ſyſtems of mechanics. It is unneceſſary to take up time in proving what is ſo familiarly known; conſequently, the products of the preſſures at theſe points by the velocities of the motions are equal; that is, the product of the preſſure actually exerted at the impelled point of a machine working uniformly, multiplied by the velocity of that point, is equal to the product of the reſiſtance actually exerted at the working point, multiplied by the velocity of that point, that is, by the velocity with which the reſiſtance is overcome,

$$p\,m = r\,n.$$

Now, the product of the reſiſtance, by the velocity with which it is overcome, is evidently the meaſure of the performance of the machine, or the work done. The product of the actual preſſure on the impelled point, by the velocity of that point, may be called the MOMENTUM OF IMPULSE.

Hence we deduce this propoſition:

25 Second principle. Momentum of impulſe and the performance of the machine are equal.

In all working machines which have acquired a uniform motion, the performance of the machine is equal to the momentum of impulſe (A).

(A) The truth of this propoſition has been long perceived in every particular inſtance that happened to engage the attention; but we do not recollect any mechanician before Mr Euler conſidering it as a general truth, expreſſing in a few words a mechanical law. This celebrated mathematician undertook, about the year 1735 or 1736, a general and ſyſtematic view of machines, in order to found a complete theory immediately conducive to the improvement of practical mechanics. In 1743 he publiſhed the firſt propoſitions of this uſeful theory in the 10th volume of the *Comment. Petropolitani*, containing the excellent dynamical theorems of which we have given the ſubſtance. In the 3d volume of the *Comment. Novi Petropol.* he proſecuted the ſubject a little farther; and in the 8th volume, he entered on what we are now engaged in, and formally announces this fundamental propoſition, calling theſe two products the *momentum of impulſe*, and the *momentum of effect*. It is much to be regretted, that this conſummate mathematician did not continue theſe uſeful labours; his ardent mind being carried away by more abſtruſe ſpeculations in all the moſt refined departments of mathematics and philoſophy. No man in Europe could have proſecuted the ſubject with more judgment and ſucceſs.—See alſo *Mem. Acad. Berlin*, 1747 and 1752.

This is a propoſition of the utmoſt importance in the ſcience of machines, and leads to the fundamental maxim of their conſtruction. Since the performance of a machine is equal to the momentum of impulſe, it increaſes and diminiſhes along with it, and is a maximum when the momentum of impuſe is a maximum; therefore, the fundamental maxim in the conſtruction of a machine is to faſhion it in ſuch a manner, that the momentum of impulſe ſhall be a maximum, or that the product of the preſſure actually exerted on the impelled point of the machine by the velocity with which it moves may be as great as poſſible. Then are we certain that the product of the reſiſtance, by the velocity of the working point, is as great as poſſible, provided that we take care that none of the impulſe be needleſsly waſted by the way by injudicious communications of motion, by friction, by unbalanced loads, and by reciprocal motions, which irrecoverably waſte the impelling power. This maxim holds good, whether the reſiſtance remains conſtantly the ſame, or varies by any law whatever.

26 Important deſiderata for practice. But much remains to be done for the improvement of mechanical ſcience before we can avail ourſelves of this maxim, and apply it with ſucceſs. The chief thing, and to this we ſhould give the moſt unremitting attention, is, to learn the changes which obtain in the actual preſſure exerted by thoſe natural powers which we can command; the changes of actual preſſure produced by a change of the velocity of the impelled point of the machine. Theſe depend on the ſpecific natures of thoſe powers, and are different in almoſt every different caſe. Nothing will more contribute to the improvement of practical mechanics than a ſeries of experiments, well contrived, and accurately made, for diſcovering thoſe laws of variation, in the caſes of thoſe powers which are moſt frequently employed. Such experiments, however, would be coſtly, beyond the abilities of an individual; therefore, it were greatly to be wiſhed that public aid were given to ſome perſons of ſkill in the ſcience to inſtitute a regular train of experiments of this kind. An experimental machine might be conſtructed, to be wrought either by men or by cattle. This ſhould be loaded with ſome kind of work which can be very accurately meaſured, and the load varied at pleaſure. When loaded to a certain degree, the men or cattle ſhould be made to work at the rate which they can continue from day to day. The number of turns made in an hour, multiplied by the load, will give the performance correſponding to the velocities; and thus will be diſcovered the moſt advantageous rate of motion. The ſame machine ſhould alſo be fitted for grinding, for ſawing, boring, &c. and ſimilar experiments will diſcover the relation between the velocities with which theſe operations are performed, and the reſiſtances which they exert. The laws of friction may be inveſtigated by the ſame machine. It ſhould alſo be fitted with a walking wheel, and the trial ſhould be made of the ſlope and the velocity of walking which gives the greateſt momentum of impulſe. It is not unreaſonable to expect great advantages from ſuch a train of experiments.

27 A ſubſtitute for them. Till this be done, we muſt content ourſelves with eſtabliſhing the above, in the moſt general terms, applicable to any caſe in which the law of the variation of force may hereafter be diſcovered.

There is a certain velocity of the impelled point of a machine which puts an end to the action of the moving power. Thus, if the floats of an underſhot wheel be moving with the velocity of the ſtream, no impulſe is made on them. If the arm of a gin or capſtan be moving with that velocity with which a horſe or a man can juſt move, ſo as to continue at that ſpeed from day to day, employing all his working ſtrength, but not fatiguing himſelf; in this ſtate of motion, the animal can exert no preſſure on the machine. This may be called the EXTINGUISHING VELOCITY, and we may expreſs it by the ſymbol e. Let f be that degree of force or preſſure which the animal can exert at a dead pull or thruſt, as it is called. We do not mean the utmoſt ſtrain of which the animal is capable, but that which it can continue unremittingly during the working hours of a day, fully employing, but not fatiguing itſelf. And let p be the preſſure which it actually exerts on the impelled point of a machine, moving with the velocity m. Let $e - m$ be called the RELATIVE VELOCITY, and let it be expreſſed by v. And let it be ſuppoſed, that it has been diſcovered, by any means whatever, that the actual preſſure varies in the proportion of v^q, or $\overline{e-m}^q$. This ſuppoſition gives us $e^q : v^q = f : p$, and $p = f \times \frac{v^q}{e^q}$. For the machine muſt be at reſt, in order that the agent may be able to exert the force f on its impelled point. But when the machine is at reſt, what we have named the relative velocity is e, the whole of the extinguiſhing velocity.

The momentum of impulſe is $p\,m$, that is $\frac{v^q}{e^q} f\,m$, or $f \times \frac{v^q}{e^q} \times \overline{e-v}$ (becauſe $m = e - v$). Therefore $f \times \frac{v^q}{e^q} \times \overline{e-v}$ muſt be made a maximum. But f and e^q are two quantities which ſuffer no change. Therefore the momentum of impulſe will be a maximum when $v^q \times \overline{e-v}$ is a maximum. Now $v^q \times \overline{e-v} = v^q e - v^q v, = v^q e - v^{q+1}$. The fluxion of this is $q e v^{q-1} \dot{v} - \overline{q+1}\, v^q \dot{v}$. This being ſuppoſed $= c$, we have the equation

$$q e v^{q-1} = \overline{q+1}\, v^q$$

$$\text{And } q e = \overline{q+1}\, v$$

$$\text{Therefore } v = \frac{q e}{q+1}$$

And m, which is $= e - v$, becomes $\frac{e}{q+1}$. Therefore we muſt order matters ſo, that the velocity of the impelled point of the machine may be $= \frac{e}{q+1}$. Now p is $= f \frac{v^q}{e^q}$, and therefore $= f \times \frac{q^q}{\overline{q+1}^q}$. And $p\,m$, $= f \frac{q^q}{\overline{q+1}^q} m, = f \frac{q^q}{\overline{q+1}^q} \times \frac{e}{q+1}, = f \times \frac{q^q e}{\overline{q+1}^{q+1}}, =$ the momentum of impulſe, and therefore $=$ the momentum of effect, or the performance of the machine, when in its beſt ſtate.

28 Example underſhot mills by Mr Parent. Thus may the maxim of conſtruction be ſaid to be brought to a ſtate of great ſimplicity, and of moſt eaſy recollection. A particular caſe of this maxim has been long known, having been pointed out by Mr Parent. Since the action of bodies depends on their relative velocity,

locity, the impulſe of fluids muſt be as the ſquare of the relative velocity. From which Mr Parent deduced, that the moſt advantageous velocity of the floats of an underſhot wheel is one-third of that of the ſtream. This maxim is evidently included in our general propoſition; for in this caſe, the index q of that function of the relative velocity v, which is proportional to the impulſe, is $= 2$. Therefore we have the maximum when $v = \frac{2e}{2+1}, = \frac{2}{3}e$, and $m = \frac{1}{3}e$. e, the extinguiſhing velocity, is evidently the velocity of the ſtream. Our propoſition alſo gives us the preciſe value of the performance. The impulſe of the ſtream on the float at reſt being ſuppoſed $= f$, its impulſe on the float moving with the velocity $\frac{2}{3}e$ muſt be $= \frac{4}{9}f$. This is the meaſure of the actual preſſure p. This being multiplied by m, or by $\frac{1}{3}e$, gives $\frac{4}{27}f$. Now f is conſidered as equal to the weight of a column of water, having the ſurface of the floatboard for its baſe, and the depth of the ſluice under the ſurface of the reſervoir (or, more accurately, the fall required for generating the velocity of the ſtream) for its height. Hence it has been concluded, that the utmoſt performance of an underſhot wheel is to raiſe $\frac{4}{27}$ of the water which impels it, to the height from which it falls. But this is not found very agreeable to obſervation. Friction, and many imperfections of execution in the delivery of the water, the direction of its impulſe, &c. may be expected to make a defalcation from this theoretical performance. But the actual performance, even of mills of acknowledged imperfection, conſiderably exceeds this, and ſometimes is found nearly double of this quantity. The truth is, that the particular fact from which Mr Parent firſt deduced this maxim (namely, the performance of what is called *Parent's* or *Dr Barker's mill*), is, perhaps of all that could have been ſelected, the leaſt calculated for being the foundation of a general rule, being of a nature ſo abſtruſe, that the firſt mathematicians of Europe are to this day doubtful whether they have a juſt conception of its principles. Mr Smeaton's experiments ſhew very diſtinctly, that the maximum of performance of an underſhot wheel correſponds to a velocity conſiderably greater than one-third of the ſtream, and approaches nearly to one-half; and he aſſigns ſome reaſons for this which ſeem well founded. But, independent of this, the performance of Mr Smeaton's model was much greater than what correſponds with the velocity by the above mentioned eſtimation of f. The theory of the impulſion of fluids is extremely imperfect; and Daniel Bernoulli ſhews, from very unqueſtionable principles, that the impulſe of a narrow vein of fluid on an extended ſurface is double of what was generally ſuppoſed; and his concluſions are abundantly confirmed by the experiments adduced by him.

ot accu- ate.

29 his ſub- itute is ſeful, even here it not alto- ether ex- t.

It is by no means pretended, that the maxim of conſtruction is reduced to the great ſimplicity enounced in the propoſition now under conſideration. We only ſuppoſed, that a caſe had been obſerved where the preſſure exerted by ſome natural agent did follow the proportions of v^q. This being admitted, the propoſition is ſtrictly true. But we do not know any ſuch caſe; yet is the propoſition of conſiderable uſe: for we can affirm, on the authority of our own obſervations, that the action both of men and of draught horſes does not deviate very far from the proportions of v^2. The obſervations were made on men and horſes tracking a lighter along a canal, and working ſeveral days together, without having any knowledge of the purpoſe of the obſervations. The force exerted was firſt meaſured by the curvature and weight of the track rope, and afterwards by a ſpring ſteelyard. This was multiplied by the number of yards per hour, and the product conſidered as the momentum. We found the action of men to be very nearly as $\overline{e - m}^2$. The action of horſes, loaded ſo as not to be able to trot, was nearly as $\overline{e - m}^{1,7}$.

The practitioner can eaſily avail himſelf of the maxim, although the function q ſhould never be reduced to any algebraic form. He has only to inſtitute a train of experiments on the natural agent, and ſelect that velocity which gives the higheſt product when multiplied by its correſponding preſſure.

30 Two methods of availing ourſelves of this maxim.

When this ſelection has been made, we have two ways of giving our working machines the maximum of effect, having once aſcertained the preſſure f which our natural power exerts on the impelled point of the machine when it is not allowed to move.

1. When the reſiſtance ariſing from the work, and from friction, is a given quantity; as when water is to be raiſed to a certain height by a piſton of given dimenſions.

Since the friction in all the communicating parts of the machine vary in the ſame proportion with the preſſure, and ſince theſe vary in the ſame proportion with the reſiſtance, the ſum of the reſiſtance and friction may be repreſented by $b\,r$, b being an abſtract number. Let n be the undetermined velocity of the working point; or let $m : n$ be the proportion of velocities at the impelled and working points. Then, becauſe the preſſures at theſe points balance each other, in the caſe of uniform motion, they are inverſely as the velocities at thoſe points. Therefore we muſt make $b\,r : p = m : n$, and $n = \frac{p\,m}{b\,r}, = \frac{\frac{q^q}{\overline{q+1}^q}f\,m}{b\,r}, = m\frac{q^q f}{\overline{q+1}^q b\,r}$, or $m : n = \overline{q+1}^q \times b\,r : q^q f$.

2. On the other hand, when $m : n$ is already given, by the conſtruction of the machine, but $b\,r$ is ſuſceptible of variation, we muſt load the machine with more and more work, till we have reduced the velocity of its impelled point to $\frac{e}{q+1}$.

In either caſe, the performance is expreſſed by what expreſſes $p\,m$, that is, by $f\,e \times \frac{q^q}{\overline{q+1}^{q+1}}$. But the uſeful performance, which is really the work done, will be had by dividing the value now obtained by the number b, which expreſſes the ſum of the reſiſtance overcome by the working point and the friction of the machine.

Recapitulation.

What has been now delivered contains, we imagine, the chief principles of the theory of machines, and points out the way in which we muſt proceed in applying them to every caſe. The reader, we hope, ſees clearly the imperfection of a conſideration

tion of machines which proceeds no farther than the ſtatement of the proportions of the ſimultaneous preſſures which are excited in all the parts of the machine by the application of the external forces, which we are accuſtomed to call the *power* and the *weight*. Unleſs we take alſo into conſideration, the immediate effect of mechanical force applied to body, and combine this with all the preſſures which ſtatical principles have enabled us to aſcertain, and by this combination be able to ſay what portion of unbalanced force there is acting at one and all of the preſſing points of the machine, and what will be the motion of *every part* of it in conſequence of this overplus, we have acquired no knowledge that can be of ſervice to us. We have been contemplating, not a working machine, but a ſort of balance. But, by reaſoning about theſe unbalanced forces in the ſame ſimple manner as about the fall of heavy bodies, we were able to diſcover the momentary accelerations of every part, and the ſenſible motion which it would acquire in any aſſigned time, if all the circumſtances remain the ſame. We found that the reſults, although deduced from unqueſtionable principles, were quite unlike the obſerved motions of moſt working machines. Proceeding ſtill on the ſame principles, we conſidered this deviation as the indication, and the preciſe meaſure, of ſomething which we had not yet attended to, but which the deviation brought into view, and enabled us to aſcertain with accuracy. Theſe are the changes which happen in the exertions of our actuating powers by the velocity with which we find it convenient to make them act. Thus we learn more of the nature of thoſe powers; and we found it neceſſary to diſtinguiſh carefully between the apparent magnitude of our actuating power and its real exertion in doing our work. This conſideration led us to a fundamental propoſition concerning all working machines when they have attained an uniform motion; namely, that the power and reſiſtance then really exerted on the machine preciſely balance each other, and that the machine is preciſely in the condition of a ſteelyard loaded with its balanced weights, and moved round its axis by ſome external force diſtinct from the power and the weight. We found that this force is the previous overplus of impelling power, before the machine had acquired the uniform motion; and on this occaſion we learned to eſtimate the effect produced, by the momentum (depending on the form of the machine) of the quantity of motion produced in the whole aſſemblage of power, reſiſtance, and machine.

31
Theory of machines ſtill intricate, eſpecially of ſuch as reciprocate.

The theory of machines ſeemed to be now brought back to that ſimplicity of equilibrium which we had ſaid was ſo imperfect a foundation for a theory; but in the availing ourſelves of the maxim founded on this general propoſition, we ſaw that the equilibrium is of a very different kind from a quieſcent equilibrium. It neceſſarily involves in it the knowledge of the momentary accelerations and their momenta; without which we ſhould not perceive that one ſtate of motion is more advantageous than another, becauſe all give us the ſame proportion of forces in equilibrio.

But this is not the only uſe of the previous knowledge of the momentary accelerations of machines; there are many caſes where the machine works in this very ſtate. Many machines accelerate throughout while performing their work; and their efficacy depends entirely on the final acceleration. Of this kind is the coining preſs, the great forge or tilt mill, and ſome other capital engines. The ſteam engine, and the common pump, are neceſſarily of this claſs, although their efficacy is not eſtimated by their final acceleration. A great number of engines have reciprocating motions in different ſubordinate parts. The theory of all ſuch engines requires for its perfection an accurate knowledge of the momentary accelerations; and we muſt uſe the formulæ contained in the firſt part of this article.

32
Working and returning ſtrokes.

Still, however, the application of this knowledge has many difficulties, which make a *good* theory of ſuch machines a much more intricate and complicated matter than we have yet led the reader to ſuppoſe. In moſt of theſe engines, the whole motion may be divided into two parts. One may be called the WORKING STROKE, and the other in which the working points are brought back to a ſituation which fits them for acting again, may be called the RETURNING STROKE. This return muſt be effected either by means of ſome immediate application of the actuating power, or by ſome other force, which is counteracted during the working ſtroke, and muſt be conſidered as making part of the reſiſtance. In the ſteam engine, it is generally done by a counterpoiſe on the outer end of the great working beam. This muſt be accounted a part of the reſiſtance, for it muſt be raiſed again; and the proportions of the machine for attaining the maximum muſt be computed accordingly. The quantity of this counterpoiſe muſt be adjuſted by other conſiderations. It muſt be ſuch, that the deſcent of the pump rods in the pit may *juſt employ the whole time* that is neceſſary for filling the cylinder with ſteam. If they deſcend more briſkly (which an unſkilful engineer likes to ſee), this muſt be done by means of a greater counterpoiſe, and this employs more power to raiſe it again. Deſaguliers deſcribes a very excellent machine for raiſing water in a bucket by a man's ſtepping into an oppoſite bucket, and deſcending by his preponderancy. When he comes to the bottom, he ſteps out, goes up a ſtair, and finds the bucket returned and ready to receive him again. This machine is extremely ſimple, and perhaps the beſt that can be contrived; and yet it is one of the moſt likely to be a very bad one. The bucket into which the man ſteps muſt be brought up to its place again by a preponderancy in the machine when unloaded. It may be returned ſooner or later. It ſhould arrive preciſely at the ſame time with the man. If ſooner, it is of no uſe, and waſtes power in raiſing a counterpoiſe which is needleſsly heavy; if later, time is loſt: Therefore, the perfection of this very ſimple machine requires the judicious combination of two maximums, each of which varies in a ratio compounded of two other ratios. Suppoſe the man to employ a minute to go up ſtairs 50 feet, which is very nearly what he can do from day to day as his only work, and ſuppoſe him to weigh 150 pounds, and that he acts by means of a ſimple pulley—the maximum for a lever of equal arms would require him to raiſe about 60 pounds of water. But when all the other circumſtances are calculated, it will be found that he muſt raiſe 138 pounds (neglecting the inertia of the machine). He ſhould raiſe 542 pounds 10 feet in a minute; and this is nearly the moſt exact valuation of a man's work.

There is the ſame neceſſity of attending to a variety of of circumſtances in all machines which reciprocate in the whole or any conſiderable part of their motion. The force employed for bringing the machine into another working poſition, muſt be regulated by the time neceſſary for obtaining a new ſupply of power; and then the proportion of *m* to *n* muſt be ſo adjuſted, that the work performed, divided by the *whole* time of the working and returning ſtrokes, may give the greateſt quotient. It is ſtill a difficult thing, therefore, to conſtruct a machine in the moſt perfect manner, or even to ſay what will be the performance of a machine already conſtructed; yet we ſee that every circumſtance is ſuſceptible of accurate computation.

With reſpect to machines which acquire a ſort of uniform motion in general, although ſubject to partial reciprocations, as in a pumping, ſtamping, forging engine, it is alſo difficult to aſſign the rate even of this general uniform motion. We may, however, ſay, that it will not be greater than if it were uniform throughout. Were it entirely free from friction, it would be exactly the ſame as if uniform; becauſe the accelerations during the advantageous ſituations of the impelling power would compenſate the retardations. But friction diminiſhes the accelerations, without diminiſhing the retardations.

We may conclude this article with ſome obſervations tending to the general improvement of machines.

33 Uniformity f motion hroughout of great dvantage.

Nothing contributes more to the perfection of a machine, eſpecially ſuch as is maſſive and ponderous, than great uniformity of motion. Every irregularity of motion waſtes ſome of the impelling power; and it is only the greateſt of the varying velocities which is equal to that which the machine would acquire if moving uniformly throughout; for while the motion accelerates, the impelling force is greater than what balances the reſiſtance then actually oppoſed to it, and the velocity is leſs than what the machine would acquire if moving uniformly: and when the machine attains its greateſt velocity, it attains it becauſe the power is then not acting againſt the whole reſiſtance. In both of theſe ſituations, therefore, the performance of the machine is leſs than if the power and reſiſtance were exactly balanced; in which caſe it would move uniformly.

34 How to at- in this.

Every attention ſhould therefore be given to this, and we ſhould endeavour to remove all cauſe of irregularity. The communications of motion ſhould be ſo contrived, that if the impelled point be moving uniformly, by the uniform preſſure of the power, the working point ſhall alſo be moving uniformly. Then we may generally be certain, that the maſſy parts of the machine will be moving uniformly. When this is not done through the whole machine, there are continual returns of ſtrains and jolts; the inertia of the different parts acting in oppoſite directions. Although the whole momenta may always balance each other, yet the general motion is hobbling, and the points of ſupport are ſtrained. A great engine ſo conſtructed, commonly cauſes the building to tremble; but when uniform motion pervades the whole machine, the inertia of each part tends to preſerve this uniformity, and all goes ſmoothly. It is alſo deſerving of remark, that when the communications are ſo contrived that the uniform motion of one part produces uniform motion on the next, the preſſures at the communicating points remain conſtant or invariable. Now the accompliſhing of this is always within the reach of mechanics.

35 Beſt forms for the teeth of wheels. Plate XXXIII. fig. 1.

One of the moſt uſual communications in machinery is by means of toothed wheels acting on each other. It is of importance to have the teeth ſo formed, that the preſſure by which one of them A urges the other B round its axis ſhall be conſtantly the ſame. It can eaſily be demonſtrated, that when this is the caſe, the uniform angular motion of the one will produce a uniform angular motion of the other; or, if the motions are thus uniform, the preſſures are invariable. This is accompliſhed on this principle, that the mutual actions of ſolid bodies on each other in the way of preſſure are perpendicular to the touching ſurfaces. Therefore let the tooth *a* preſs on the tooth *b* in the point C; and draw the line FCDE perpendicular to the touching ſurfaces in the point C. Draw AF, BE perpendicular to FE, and let FE cut the line AB in D. It is plain, from the common principles of mechanics, that if the line FE, drawn in the manner now deſcribed, always paſs through the ſame point D, whatever may be the ſituation of the acting teeth, the mutual action of the wheels will always be the ſame. It will be the ſame as if the arm AD acted on the arm BD. In the treatiſes on the conſtruction of mills, and other works of this kind, are many inſtructions for the formation of the teeth of wheels; and almoſt every noted millwright has his own noſtrums. Moſt of them are egregiouſly faulty in reſpect of mechanical principle. Indeed they are little elſe than inſtructions how to make the teeth clear each other without ſticking. Mr de la Hire firſt pointed out the above mentioned principle, and juſtly condemned the common practice of making the ſmall wheel or pinion in the form of a lantern (whence it alſo took its name), conſiſting of two round diſks, having a number of cylindrical ſpokes (fig. 2.) The ſlighteſt inſpection of this conſtruction ſhews, that, in the different ſituations of the working teeth, the line FCE continually changes its interſection with AB. If the wheel B be very ſmall in compariſon of the other, and if the teeth of A take deep hold of the cylindrical pins of B, the line of action EF is ſometimes ſo diſadvantageouſly placed, that the preſſure of the one wheel has ſcarcely any tendency at all to turn the other.

Epicycloids recommended by De la Hire.

Mr de la Hire, or Dr Hooke, was, we think, the firſt who inveſtigated the form of tooth which procured this conſtant action between the wheels; and in a very ingenious diſſertation, publiſhed among the Memoirs of the Academy of Sciences at Paris 1668, the former of theſe gentlemen ſhews, that this will be enſured by forming the teeth into epicycloids. Mr Camus of the ſame Academy has publiſhed an elaborate diſſertation on the ſame ſubject, in which he proſecutes the principle of Mr de la Hire, and applies it to all the variety of caſes which can occur in practice. There is no doubt as to the goodneſs of the principle; and it has another excellent property, "that the mutual action of the teeth is abſolutely without any friction." The one tooth only applies itſelf to the other, and rolls on it, but does not ſlide or rub in the ſmalleſt degree. This makes them laſt long, or rather does not allow them to wear in the leaſt. But the conſtruction is ſubject to a limitation which muſt not be neglected. The teeth muſt be ſo made, that the curved part of the tooth *b* is acted on by a flat part of the tooth *a* till it comes to the line AB in the courſe of its action; after which

which the curved part of *a* acts on a flat part of *b*; or the whole action of *a* on *b* is either completed, or only begins at the line AB, joining the centres of the wheels.

36 A better form.

Another form of the teeth ſecures the perfect uniformity of action without this limitation, which requires very nice execution. Let the teeth of each wheel be formed by evolving its circumference; that is, let the acting face GCH of the tooth *a* have the form of the curve traced by the extremity of the thread FC, unlapped from the circumference. In like manner, let the acting face of the tooth *b* be formed by unlapping a thread from its circumference. It is evident, that the line FCE, which is drawn perpendicularly to the touching ſurfaces in the point C, is juſt the direction or poſition of the evolving threads by which the two acting faces are formed. This line muſt therefore be the common tangent to the two circles or circumferences of the wheels, and will therefore always cut the line AB in the ſame point D. This form allows the teeth to act on each other through the whole extent of the line FCE, and therefore will admit of ſeveral teeth to be acting at the ſame time (twice the number that can be admitted in Mr de la Hire's method). This, by dividing the preſſure among ſeveral teeth, diminiſhes its quantity on any one of them, and therefore diminiſhes the dents or impreſſions which they unavoidably make on each other. It is not altogether free from ſliding and friction, but the whole of it can hardly be ſaid to be ſenſible. The whole ſlide of a tooth three inches long, belonging to a wheel of ten feet diameter, acting on a tooth of a wheel of two feet diameter, does not amount to $\frac{1}{60}$th of an inch, a quantity altogether inſignificant.

In the formation of the teeth of wheels, a ſmall deviation from theſe perfect forms is not perhaps of very great importance, except in caſes where a very large wheel drives a very ſmall one (a thing which a good engineer will always avoid). As the conſtruction, however, is exceedingly eaſy, it would he unpardonable to omit it. Well formed teeth, and a great number of them acting at once, make the communication of motion extremely ſmooth and uniform. The machine works without noiſe, and the teeth laſt a very long time without ſenſibly changing their ſhape. But there are caſes, ſuch as the pallets of clocks and watches, where the utmoſt accuracy of form is of the greateſt importance for the perfection of the work.

37 Maxim for the conſtruction of ſtampers, &c.

When heavy ſtampers are to be raiſed, in order to drop on the matters to be pounded, the wipers by which they are lifted ſhould be made of ſuch a form, that the ſtamper may be raiſed by a uniform preſſure, or with a motion almoſt perfectly uniform. If this is not attended to, and the wiper is only a pin ſticking out from the axis, the ſtamper is forced into motion at once. This occaſions violent jolts to the machine, and great ſtrains on its moving parts and their points of ſupport; whereas when they are gradually lifted, the inequality of deſultory motion is never felt at the impelled point of the machine. We have ſeen piſtons moved by means of a double rack on the piſton-rod. A half wheel takes hold of one rack, and raiſes it to the required height. The moment the half wheel has quitted that ſide of the rack, it lays hold of the other ſide, and forces the piſton down again. This is propoſed as a great improvement; correcting the unequable motion of the piſton moved in the common way by a crank. But it is far inferior to the crank motion. It occaſions ſuch abrupt changes of motion, that the machine is ſhaken by jolts. Indeed if the movement were accurately executed, the machine would be ſhaken to pieces, if the parts did not give way by bending and yielding. Accordingly, we have always obſerved that this motion ſoon failed, and was changed for one that was more ſmooth. A judicious engineer will avoid all ſuch ſudden changes of motion, eſpecially in any ponderous part of a machine.

When ſeveral ſtampers, piſtons, or other reciprocal movers, are to be raiſed and depreſſed, common ſenſe teaches us to diſtribute their times of action in a uniform manner, ſo that the machine may always be equally loaded with work. When this is done, and the obſervations in the preceding paragraph attended to, the machine may be made to move almoſt as ſmoothly as if there were no reciprocations in it. Nothing ſhews the ingenuity of the author more than the artful yet ſimple and effectual contrivances for obviating thoſe difficulties that unavoidably ariſe from the very nature of the work that muſt be performed by the machine, and of the power employed. The inventive genius and ſound judgment of Watt and Boulton are as perceptible to a ſkilled obſerver in theſe ſubordinate parts of ſome of their great engines, as in the original diſcovery on which their patent is founded. In ſome of thoſe engines the maſs of dead matter which muſt be put into motion, and this motion deſtroyed and again reſtored in every ſtroke, is enormous, amounting to above an hundred tons. The ingenious authors have even contrived to draw ſome advantages from it, by allowing a great want of equilibrium in certain poſitions; and this has been condemned as a blunder by engineers who did not ſee the uſe made of it.

38 The unavoidable i equalities of moving power mu be compe ſated by the conſtruction.

There is alſo great room for ingenuity and good choice in the management of the moving power, when it is ſuch as cannot immediately produce the kind of motion required for effecting the purpoſe. We mentioned the converſion of the continued rotation of an axis into the reciprocating motion of a piſton, and the improvement which was thought to have been made on the common and obvious contrivance of a crank, by ſubſtituting a double rack on the piſton-rod, and the inconvenience ariſing from the jolts occaſioned by this change. We have ſeen a great forge, where the engineer, in order to avoid the ſame inconvenience ariſing from the abrupt motion given to the great ſledge hammer of ſeven hundred weight, reſiſting with a five-fold momentum, formed the wipers into ſpirals, which communicated motion to the hammer almoſt without any jolt whatever; but the reſult was, that the hammer roſe no higher than it had been raiſed in contact with the wiper, and then fell on the iron bloom with very little effect. The cauſe of its inefficiency was not gueſſed at; but it was removed, and wipers of the common form were put in place of the ſpirals. In this operation, the rapid motion of the hammer is abſolutely neceſſary. It is not enough to *lift* it up; it muſt be *toſſed* up, ſo as to fly higher than the wiper lifts it, and to ſtrike with great force the ſtrong oaken ſpring which is placed in its way. It compreſſes this ſpring, and is reflected by it with a conſiderable velocity, ſo as to hit the iron as if it had fallen from a great height. Had it it been allowed to fly to that height, it would have fallen upon the iron with ſomewhat more force (becauſe no oaken ſpring is perfectly elaſtic); but this would have required more than twice the time.

38 Great inconveniences of a reciprocating power.

In employing a power which of neceſſity reciprocates, to drive machinery which requires a continuous motion (as in applying the ſteam engine to a cotton or a griſt mill), there alſo occur great difficulties. The neceſſity of reciprocation in the firſt mover waſtes much power; becauſe the inſtrument which communicates ſuch an enormous force muſt be extremely ſtrong, and be well ſupported. The impelling power is waſted in imparting, and afterwards deſtroying, a vaſt quantity of motion in the working beam. The ſkilful engineer will attend to this, and do his utmoſt to procure the neceſſary ſtrength of this firſt mover, without making it a vaſt load of inert matter. He will alſo remark, that all the ſtrains on it, and on its ſupports, are changing their directions in every ſtroke. This requires particular attention to the manner of ſupporting it. If we obſerve the ſteam engines which have been long erected, we ſee that they have uniformly ſhaken the building to pieces. This has been owing to the ignorance or inattention of the engineer in this particular. They are much more judiciouſly erected now, experience having taught the moſt ignorant that no building can withſtand their deſultory and oppoſite jolts, and that the great movements muſt be ſupported by a framework independent of the building of maſonry which contains it (B).

The engineer will alſo remark, that when a ſingle ſtroke ſteam engine is made to turn a mill, all the communications of motion change the direction of their preſſure twice every ſtroke. During the working ſtroke of the beam, one ſide of the teeth of the intervening wheels is preſſing the machinery forward; but during the returning ſtroke, the machinery, already in motion, is dragging the beam, and the wheels are acting with the other ſide of the teeth. This occaſions a rattling at every change, and makes it proper to faſhion both ſides of the teeth with the ſame care.

It will frequently conduce to the good performance of an engine, to make the action of the reſiſting work unequable, accommodated to the inequalities of the impelling power. This will produce a more uniform motion in machines in which the momentum of inertia is inconſiderable. There are ſome beautiful ſpecimens of this kind of adjuſtment in the mechaniſm of animal bodies.

39 Nature, operation, and uſe of Fly.

It is very cuſtomary to add what is called a Fly to machines. This is a heavy diſk or hoop, or other maſs of matter, *balanced on its axis*, and ſo connected with the machinery as to turn briſkly round with it. This may be done with the view of rendering the motion of the whole more regular, notwithſtanding unavoidable inequalities of the accelerating forces, or of the reſiſtances occaſioned by the work. It becomes a Regulator. Suppoſe the reſiſtance extremely unequal, and the impelling power perfectly conſtant; as when a bucket wheel is employed to work *one* pump. When the piſton has ended its working ſtroke, and while it is going down the barrel, the power of the wheel being ſcarcely oppoſed, it accelerates the whole machine, and the piſton arrives at the bottom of the barrel with a conſiderable velocity. But in the riſing again, the wheel is oppoſed by the column of water now preſſing on the piſton. This immediately retards the wheel; and when the piſton has reached the top of the barrel, all the acceleration is undone, and is to begin again. The motion of ſuch a machine is very hobbling: but the ſuperplus of accelerating force at the beginning of a returning ſtroke will not make ſuch a change in the motion of the machine if we connect the fly with it. For the accelerating momentum is a determinate quantity. Therefore, if the radius of the fly be great, this momentum will be attained by communicating a ſmall angular motion to the machine. The momentum of the fly is as the ſquare of its radius; therefore it reſiſts acceleration in this proportion; and although the overplus of power generates the ſame momentum of rotation in the whole machine as before, it makes but a ſmall addition to its velocity. If the diameter of the fly be doubled, the augmentation of rotation will be reduced to one-fourth. Thus, by giving a rapid motion to a ſmall quantity of matter, the great acceleration during the returning ſtroke of the piſton is prevented. This acceleration continues, however, during the whole of the returning ſtroke, and at the end of it the machine has acquired its greateſt velocity. Now the working ſtroke begins, and the overplus of power is at an end. The machine accelerates no more; but if the power is juſt in equilibrio with the reſiſtance, it keeps the velocity which it has acquired, and is ſtill more accelerated during the *next* returning ſtroke. But now, at the beginning of the ſubſequent working ſtroke, there is an overplus of reſiſtance, and a retardation begins, and continues during the whole riſe of the piſton; but it is inconſiderable in compariſon of what it would have been without the fly; for the fly, retaining its acquired momentum, drags forward the reſt of the machine, aiding the impelling power of the wheel. It does this by all the communications taking into each other in the oppoſite direction. The teeth of the intervening wheels are heard to drop from their former contact on one ſide, to a contact on the other. By conſidering this proceſs with attention, we eaſily perceive that, in a few ſtrokes, the overplus of power during the returning ſtroke comes to be ſo adjuſted to the deficiency during the working ſtroke, that the accelerations and retardations exactly deſtroy each other, and every ſucceeding ſtroke is made with the ſame velocity, and an equal number of ſtrokes is made in every ſucceeding minute. Thus the machine acquires a general uniformity with periodical inequalities. It is plain, that by ſufficiently enlarging either the diameter or the weight

---

(B) The gudgeons of a water-wheel ſhould never reſt on the wall of the building. It ſhakes it; and if ſet up ſoon after the building has been erected, it prevents the mortar from taking firm bond; perhaps by ſhattering the calcareous cryſtals as they form. When the engineer is obliged to reſt the gudgeons in this way, they ſhould be ſupported by a block of oak laid a little hollow. This ſoftens all tremors, like the ſprings of a wheel carriage. This practice would be very ſerviceable in many other parts of the conſtruction.

weight of the fly, the irregularity of the motion may be rendered as ſmall as we pleaſe. It is much better to enlarge the diameter. This preſerves the friction more moderate, and the pivot wears leſs. For theſe reaſons, a fly is in general a conſiderable improvement in machinery, by equaliſing many exertions that are naturally very irregular. Thus, a man working at a common windlaſs, exerts a very irregular preſſure on the winch. In one of his poſitions in each turn he can exert a force of near 70 pounds without fatigue, but in another he cannot exert above 25; nor muſt he be loaded with much above this in general. But if a large fly be connected properly with the windlaſs, he will act with equal eaſe and ſpeed againſt 30 pounds.

40
It is a powerful regulator.

This regulating power of the fly is without bounds, and may be uſed to render uniform a motion produced by the moſt deſultory and irregular power. It is thus that the moſt regular motion is given to mills that are driven by a ſingle ſtroke ſteam engine, where for two or even three ſeconds there is no force preſſing round the mill. The communication is made through a maſſive fly of very great diameter, whirling with great rapidity. As ſoon as the impulſe ceaſes, the fly, continuing its motion, urges round the whole machinery with almoſt unabated ſpeed. At this inſtant all the teeth, and all the joints, between the fly and the firſt mover, are heard to catch in the oppoſite direction.

If any permanent change ſhould happen in the impelling power, or in the reſiſtance, the fly makes no obſtacle to its producing its full effect on the machine; and it will be obſerved to accelerate or retard uniformly, till a new general ſpeed is acquired exactly correſponding with this new power and reſiſtance.

Many machines include in their conſtruction movements which are equivalent with this intentional regulator. A flour mill, for example, cannot be better regulated than by its milſtone; but in the Albion mills, a heavy fly was added with great propriety; for if the mills had been regulated by their milſtones only, then at every change of ſtroke in the ſteam engine, the whole train of communications between the beam, which is the firſt mover, and the regulating milſtone, which is the very laſt mover, would take in the oppoſite direction. Although each drop in the teeth and joints be but a trifle, the whole, added together, would make a conſiderable jolt. This is avoided by a regulator immediately adjoining to the beam. This continually preſſes the working machinery in one direction. So judiciouſly were the movements of that noble machine contrived, and ſo nicely were they executed, that not the leaſt noiſe was heard, nor the ſlighteſt tremor felt in the building.

Mr Valoué's beautiful pile engine employed at Weſtminſter Bridge is another remarkable inſtance of the regulating power of a fly*. When the ram is dropped, and its follower diſengaged immediately after it, the horſes would inſtantly tumble down, becauſe the load, againſt which they had been ſtraining hard, is at once taken off; but the gin is connected with a very large fly, which checks any remarkable acceleration, allowing the horſes to lean on it during the deſcent of the load; after which their draught recommences immediately. The ſpindles, cards, and bobbins, of a cotton mill, are alſo a ſort of flies. Indeed all bulky machines of the rotative kind tend to preſerve their motion with ſome degree of ſteadineſs, and their great momentum of inertia is as uſeful in this reſpect as it is prejudicial to the acceleration or any reciprocation when wanted.

41
A bad conſtruction of a fly.

There is another kind of regulating fly, conſiſting of wings whirled briſkly round till the reſiſtance of the air prevents any great acceleration. This is a very bad one for a *working* machine, for it produces its effect by *really waſting* a part of the moving power. Frequently it employs a very great and unknown part of it, and robs the proprietor of much work. It ſhould never be introduced into any machine employed in manufactures.

42
A conical pendulum is the moſt perfect regulator.

Some rare caſes occur where a very different regulator is required; where a certain determined velocity is found neceſſary. In this caſe the machine is furniſhed, at its extreme mover, with a conical pendulum, conſiſting of two heavy balls hanging by rods, which move in very nice and ſteady joints at the top of a vertical axis. It is well known, that when this axis turns round, with an angular velocity ſuited to the length of thoſe pendulums, the time of a revolution is determined. Thus, if the length of each pendulum be 39$\frac{1}{5}$ inches, the axis will make a revolution in two ſeconds very nearly. If we attempt to force it more ſwiftly round, the balls will recede a little from the axis, but it employs as long time for a revolution as before; and we cannot make it turn ſwifter, unleſs the impelling power be increaſed beyond all probability; in which caſe the pendulum will fly out from the centre till the rods are horizontal, after which every increaſe of power will accelerate the machine very ſenſibly. Watt and Boulton have applied this contrivance with great ingenuity to their ſteam engines, when they are employed for driving machinery for manufactures which have a very changeable reſiſtance, and where a certain ſpeed cannot be much departed from without great inconvenience. They have connected this receſs of the balls from the axis (which gives immediate indication of an increaſe of power or a diminution of reſiſtance) with the cock which admits the ſteam to the working cylinder. The balls flying out, cauſe the cock to cloſe a little, and diminiſh the ſupply of ſteam. The impelling power diminiſhes the next moment, and the balls again approach the axis, and the rotation goes on as before, although there may have occurred a very great exceſs or deficiency of power. The ſame contrivance may be employed to raiſe or lower the feeding ſluice of a water mill employed to drive machinery.

43
A fly ſom times col- lects pow

A fly is ſometimes employed for a very different purpoſe from that of a regulator of motion—it is employed as a *collector of power*. Suppoſe all reſiſtance removed from the working point of a machine furniſhed with a very large or heavy fly immediately connected with the working point. When a ſmall force is applied to the impelled point of this machine, motion will begin in the machine, and the fly begin to turn. Continue to preſs uniformly, and the machine will accelerate. This may be continued till the fly has acquired a very rapid motion. If at this moment a reſiſting body be applied to the working point, it will be acted on with very great force; for the fly has now accumulated in its circumference a very great momentum. If a body were expoſed immediately to the action of this circumference, it would be violently ſtruck. Much more will it be ſo, if the body be expoſed to the action of the working

---

* See Pile-*Engine*, Encycl.

working point, which perhaps makes one turn while the fly makes a hundred. It will exert a hundred times more force there (very nearly) than at its own circumference All the motion which has been accumulated on the fly during the whole progreſs of its acceleration is exerted in an inſtant at the working point, multiplied by the momentum depending on the proportion of the parts of the machine. It is thus that the coining preſs performs its office ; nay, it is thus that the blackſmith forges a bar of iron. Swinging the great ſledge hammer round his head, and urging it with force the whole way. this accumulated motion is at once extinguiſhed by impact on the iron. It is thus we drive a nail ; and it is thus that by accumulating a very moderate force exerted during four or five turns of a fly, the whole of it is exerted on a punch ſet on a thick plate of iron, ſuch as is employed for the boilers of ſteam engines. The plate is pierced as if it were a bit of cheeſe. This accumulating power of a fly has occaſioned many who think themſelves engineers to imagine, that a fly really adds power or mechanical force to an engine; and, not underſtanding on what its efficacy depends, they often place the fly in a ſituation where it only added a uſeleſs burden to the machine. It ſhould always be made to move with rapidity. If intended for a mere regulator, it ſhould be near the firſt mover. If it is intended to accumulate force in the working point, it ſhould not be far ſeparated from it. In a certain ſenſe, a fly may be ſaid to add power to a machine, becauſe by accumulating into the exertion of one moment the exertions of many, we can ſometimes overcome an obſtacle that we never could have balanced by the ſame machine unaided by the fly.

It is this accumulation of force which gives ſuch an appearance of power to ſome of our firſt movers. When a man is unfortunately catched by the teeth of a paltry country mill, he is cruſhed almoſt to mummy. The power of the ſtream is conceived to be prodigious; and yet we are certain, upon examination, that it amounts to the preſſure of no more than fifty or ſixty pounds. But it has been acting for ſome time; and there is a milſtone of a ton weight whirling twice round in a ſecond. This is the force that cruſhed the unfortunate man; and it required it all to do it, for the mill ſtopped. We ſaw a mill in the neighbourhood of Elbingroda in Hanover, where there was a contrivance which diſengaged the milſtone when any thing got entangled in the teeth of the wheels. It was tried in our ſight with a head of cabbage. It cruſhed it indeed, but not violently, and would by no means have broken a man's arm.

44
implicity
f conſtruc-
ion recom-
ended.

It is hardly neceſſary to recommend ſimplicity in the conſtruction of machines. This ſeems now ſufficiently underſtood. Multiplicity of motions and communications increaſes frictions ; increaſes the unavoidable loſſes by bending and yielding in every part ; expoſes to all the imperfections of workmanſhip ; and has a great chance of being indiſtinctly conceived, and therefore conſtructed without ſcience. We think the following conſtruction of a capſtan or crab a very good example of the advantages of ſimplicity. It is the invention of an untaught but very ingenious country tradeſman.

45
Example
of a very
ſimple and
powerful
capſtan.

Fig. 3. EAB is the barrel of the capſtan, ſtanding vertically in a proper frame, as uſual, and urged round by bars ſuch as EF. The upper part A of the barrel is 17 inches in diameter, and the lower B is 16. C is a ſtrong pulley 16 inches in diameter, having a hook D, which takes hold of a hawſer attached to the load. The rope ACB is wound round the barrel A, paſſes over the pulley C, and is then wound round the barrel B in the oppoſite direction. No farther deſcription is neceſſary, we think, to ſhew that, by heaving by the bar F, ſo as to wind more of the rope upon A, and unwind it from B, the pulley C muſt be brought nearer to the capſtan by about three inches for each turn of the capſtan ; and that this ſimple capſtan is equivalent to an ordinary capſtan of the ſame length of bar EF, and diameter of barrel B, combined with a 16 fold tackle of pulleys; or, in ſhort, that it is 16 times more powerful than the common capſtan ; free from the great loſs by friction and bending of ropes, which would abſorb a third of the power of a 16 fold tackle ; and that whereas all other engines become weaker as they multiply the power to a greater degree (unleſs they are proportionally more bulky), this engine becomes really ſtronger in itſelf. Suppoſe we wanted to have it twice as powerful as at preſent ; nothing is neceſſary but to cover the part B of the barrel with laths a quarter of an inch thick. In ſhort, the nearer the two barrels are to equality, the more powerful does it become. We give it to the public as an excellent capſtan, and as ſuggeſting thoughts which an intelligent engineer may employ with great effect. By this contrivance, and uſing an iron wire inſtead of a catgut, we converted a common eight day clock into one which goes for two months.

We intended to conclude this article with ſome obſervations on the chief claſſes of powers which are employed to drive machinery; ſuch as water, wind, atmoſpheric preſſure, gunpowder, and the force of men and other animals, giving ſome notion of their abſolute magnitudes, and the effect which may be expected from them. We ſhould then have mentioned what has been diſcovered as to their variation by a variation of velocity. And we intended to conclude with an account of what knowledge has been acquired concerning friction, and the loſs of power in machinery ariſing from this cauſe, and from the ſtiffneſs of ropes, and ſome other cauſes: But we have not yet been able to bring theſe matters into a connected form, which would ſuggeſt the methods and means of farther information thereon. We muſt endeavour to find another opportunity of communicating to the public what we may yet learn on thoſe ſubjects.

We have now eſtabliſhed the principles on which machines muſt be conſtructed, in order that they may produce the greateſt effect ; but it would be improper to diſmiſs the ſubject without ſtating to our readers Mr Bramah's new method of producing and applying a more conſiderable degree of power to all kinds of machinery requiring motion and force, than by any means at preſent practiſed for that purpoſe. This method, for which on the 31ſt of March 1796 he obtained a patent, conſiſts in the application of water or other denſe fluids to various engines, ſo as, in ſome inſtances, to cauſe them to act with immenſe force; in others, to communicate the motion and powers of one part of a machine to ſome other part of the ſame machine; and, laſtly, to communicate the motion and force of one machine to another, where their local ſituations preclude the application of all other methods of connection.

The firſt and moſt material part of this invention will be clearly underſtood by an inſpection of fig. 4. where "A is a cylinder of iron, or other materials, ſufficiently ſtrong, and bored perfectly ſmooth and cylindrical; into which is fitted the piſton B, which muſt be made perfectly water-tight, by leather or other materials, as uſed in pump making. The bottom of the cylinder muſt alſo be made ſufficiently ſtrong with the other part of the ſurface, to be capable of reſiſting the greateſt force or ſtrain that may at any time be required. In the bottom of the cylinder is inſerted the end of the tube C; the aperture of which communicates with the inſide of the cylinder, under the piſton B, where it is ſhut with the ſmall valve D, the ſame as the ſuction-pipe of a common pump. The other end of the tube C communicates with the ſmall forcing pump or injector E, by means of which water or other denſe fluids can be forced or injected into the cylinder A, under the piſton B. Now, ſuppoſe the diameter of the cylinder A to be 12 inches, and the diameter of the piſton of the ſmall pump or injector E only one quarter of an inch, the proportion between the two ſurfaces or ends of the ſaid piſtons will be as 1 to 2304; and ſuppoſing the intermediate ſpace between them to be filled with water or other denſe fluid capable of ſufficient reſiſtance, the force of one piſton will act on the other juſt in the above proportion, viz. as 1 is to 2304. Suppoſe the ſmall piſton in the injector to be forced down when in the act of pumping or injecting water into the cylinder A, with the power of 20 cwt. which could eaſily be done by the lever H; the piſton B would then be moved up with a force equal to 20 cwt. multiplied by 2304. Thus is conſtructed a hydro-mechanical engine, whereby a weight amounting to 2304 tons can be raiſed by a ſimple lever, through equal ſpace, in much leſs time than could be done by any apparatus conſtructed on the known principles of mechanics; and it may be proper to obſerve, that the effect of all other mechanical combinations is counteracted by an accumulated complication of parts, which renders them incapable of being uſefully extended beyond a certain degree; but in machines acted upon or conſtructed on this principle, every difficulty of this kind is obviated, and their power ſubject to no finite reſtraint. To prove this, it will be only neceſſary to remark, that the force of any machine acting upon this principle can be increaſed *ad infinitum*, either by extending the proportion between the diameter of the injector and the cylinder A, or by applying greater power to the lever H.

"Fig 5. repreſents the ſection of an engine, by which very wonderful effects may be produced inſtantaneouſly by means of compreſſed air. AA is a cylinder, with the piſton B fitting air-tight, in the ſame manner as deſcribed in fig. 4 C is a globular veſſel made of copper, iron, or other ſtrong materials, capable of reſiſting immenſe force, ſimilar to thoſe of air guns. D is a ſtrong tube of ſmall bore, in which is the ſtop-cock E. One of the ends of this tube communicates with the cylinder under the piſton B, and the other with the globe C. Now, ſuppoſe the cylinder A to be the ſame diameter as that in fig. 4. and the tube D equal to one quarter of an inch diameter, which is the ſame as the injector fig. 4.: then, ſuppoſe that air is injected into the globe C (by the common method), till it preſſes againſt the cock E with a force equal to 20 cwt. which can eaſily be done; the conſequence will be, that when the cock E is opened, the piſton B will be moved in the cylinder AA with a power or force equal to 2304 tons; and it is obvious, as in the caſe fig. 4. that any other unlimited degree of force may be acquired by machines or engines thus conſtructed.

"Fig. 6. is a ſection, merely to ſhew how the power and motion of one machine may, by means of fluids, be transferred or communicated to another, let their diſtance and local ſituation be what they may. A and B are two ſmall cylinders, ſmooth and cylindrical; in the inſide of each of which is a piſton, made water and air tight, as in figs 4. and 5. CC is a tube conveyed under ground, or otherwiſe, from the bottom of one cylinder to the other, to form a communication between them, notwithſtanding their diſtance be ever ſo great; this tube being filled with water or other fluid, until it touch the bottom of each piſton; then, by depreſſing the piſton A, the piſton B will be raiſed. The ſame effect will be produced *vice verſa*: thus bells may be rung, wheels turned, or other machinery put inviſibly in motion, by a power being applied to either.

"Fig. 7. is a ſection, ſhewing another inſtance of communicating the action and force of one machine to another; and how water may be raiſed out of wells of any depth, and at any diſtance from the place where the operating power is applied. A is a cylinder of any required dimenſions, in which is the working piſton B, as in the foregoing examples: into the bottom of this cylinder is inſerted the tube C, which may be of leſs bore than the cylinder A. This tube is continued, in any required direction, down to the pump cylinder D, ſuppoſed to be fixed in the deep well EE, and forms a junction therewith above the piſton F; which piſton has a rod G, working through the ſtuffing-box, as is uſual in a common pump. To this rod G is connected, over a pulley or otherwiſe, a weight H, ſufficient to overbalance the weight of the water in the tube C, and to raiſe the piſton F when the piſton B is lifted: thus, ſuppoſe the piſton B is drawn up by its rod, there will be a vacuum made in the pump cylinder D, below the piſton F; this vacuum will be filled with water through the ſuction pipe, by the preſſure of the atmoſphere, as in all pumps fixed in air. The return of the piſton B, by being preſſed downwards in the cylinder A, will make a ſtroke of the piſton in the pump cylinder D, which may be repeated in the uſual way by the motion of the piſton B, and the action of the water in the tube C. The rod G of the piſton F, and the weight H, are not neceſſary in wells of a depth where the atmoſphere will overbalance the water in the ſuction of the pump cylinder D, and that in the tube C. The ſmall tube and cock in the ciſtern I, are for the purpoſe of charging the tube C."

That theſe contrivances are ingenious, and may occaſionally prove uſeful, we are not inclined to controvert; but we muſt confeſs, that the advantages of them appear

appear not to us ſo great as to their author. Why they do not, we need not explain to any man who, with a ſufficient degree of mechanical and mathematical knowledge, has peruſed this article with attention. *Mr John Luccock*, however, of Marley, near Leeds, thinks ſo very differently from us on this ſubject, that, on Mr Bramah's principle, he propoſes to apply water or other denſe fluids, ſo as to make them ſupply the place of ſteam in what is commonly called the *ſteam engine*. He calls his engine the *paradoxical machine;* and he got a patent for it on the 28th of February 1799, though it differs in nothing from Mr Bramah's machine, repreſented by fig. 4. except that the tube C in the paradoxical machine is ſupplied with water, not by means of a forcing pump, but from a ciſtern elevated to ſuch a height as, that the water deſcending through the tube may produce its effect merely by its weight. Whether this variation, for it is no improvement, of Mr Bramah's machine intitled its author to a patent, it is not our buſineſs to inquire.

Macpherſon.

MACPHERSON (James, Eſq;), was born in the pariſh of Kinguſie, and county of Inverneſs, in the year 1738. His father was a farmer of no great affluence; and young Macpherſon received the earlier part of his education in one of the pariſh ſchools in the diſtrict called Badenoch. By an anonymous writer in the Edinburgh Magazine, he is ſaid to have been educated in the grammar ſchool of Inverneſs; and he may, for ought that we know to the contrary, have ſpent a year in that ſeminary; but we rather think that he went directly from a country ſchool to the univerſity of Aberdeen. At this our readers need not be ſurpriſed; for at the period to which we refer, ſome of the parochial ſchoolmaſters in Scotland, and more eſpecially in the Highlands, were men eminent for taſte and claſſical literature.

It was in the end of October or the 1ſt of November 1752, that James Macpherſon entered the King's College; where he diſplayed more genius than learning, entertaining the ſociety of which he was a member, and even diverting the younger part of it from their ſtudies, by his humorous and doggerel rhimes. About two years after his admiſſion into the univerſity, the King's College added two months to the length of its annual *ſeſſion* or *term;* which induced Macpherſon, with many other young men, to remove to the Mariſchal College, where the ſeſſion continued ſhort; and it is this circumſtance which leads us to ſuppoſe that his father was not opulent.

Soon after he left college, and perhaps before he left it, he was ſchoolmaſter of Ruthven, or Riven, of Badenoch; and we believe he afterwards delighted as little as his great antagoniſt Johnſon in the recollection of that period when he was compelled, by the narrowneſs of his fortune, to teach boys in an obſcure ſchool. It was during this period, we think in 1758, that he publiſhed *The Highlander*, an heroic poem in ſix cantos, 12mo. Of this work, as we have never ſeen it, we can ſay nothing. By the anonymous writer already quoted, it is mentioned as a "tiſſue of fuſtian and abſurdity;" whilſt others, and they too men of learning and character, have aſſured us, that it indicated conſiderable genius in ſo young an author.

Soon after this publication, Mr Macpherſon quitted his ſchool, and was received by Mr Graham of Balgowan into his family as tutor to his ſons; an employment of which he was not fond, and to which he was not long condemned. In the year 1760 he ſurpriſed the world by the publication of *Fragments of Ancient Poetry, collected in the Highlands of Scotland, and Tranſlated from the Gaelic or Erſe Language*, 8vo. Theſe fragments, which were declared to be genuine remains of ancient Scottiſh poetry, at their firſt appearance delighted every reader; and ſome very good judges, and amongſt the reſt Mr Gray, were extremely warm in their praiſes. Macpherſon had intended to bury them in a Scotch magazine, but was prevented from ſo injudicious a ſtep by the advice of a friend. He publiſhed them therefore in a pamphlet by themſelves, and thus laid the foundation of his future fortune.

As other ſpecimens were ſaid to be recoverable, a ſubſcription was ſet on foot by the Faculty of Advocates at Edinburgh, to enable our author to quit the family of Balgowan, perambulate the Highlands, and ſecure, if he could, the precious treaſure. He engaged in the undertaking, and was ſucceſsful; for all who poſſeſſed any of the long famed works, vied with each other in giving or ſending them to a man who had ſhewn himſelf ſo capable of doing them juſtice.

With his collection of poems, and fragments of poems, he went to London; and tagging them together in the form which he thought beſt, he publiſhed, in 1762, *Fingal, an Ancient Epic Poem, in ſix books*, together with ſeveral other poems, compoſed by Oſſian the ſon of Fingal, tranſlated from the Gaelic language, 4to. The ſubject of this epic poem is an invaſion of Ireland by Swaran king of Lochlin. Cuchullin, general of the Iriſh tribes during the minority of Cormac king of Ireland, upon intelligence of the invaſion aſſembled his forces near Tura, a caſtle on the coaſt of Ulſter. The poem opens with the landing of Swaran; councils are held, battles fought, and Cuchullin is at laſt totally defeated. In the mean time, Fingal, king of the Highlands of Scotland, whoſe aid had been ſolicited before the enemy landed, arrived, and expelled them from the country. This war, which continued but ſix days and as many nights, is, including the epiſodes, the ſtory of the Poem. The ſcene, the heath of Lena, near a mountain called Cromleach in Ulſter. This poem alſo was received with equal applauſe as the preceding Fragments.

The next year he produced *Temora*, an ancient epic poem, in eight books; together with ſeveral other poems compoſed by Oſſian ſon of Fingal, 4to, which, though well received, found the public ſomewhat leſs diſpoſed to beſtow the ſame meaſure of applauſe. Tho' theſe poems had been examined by Dr Blair and others, and their authenticity aſſerted, there were not wanting ſome of equal reputation for critical abilities, who either doubted or declared their diſbelief of the genuineneſs of them.

them. Into this queſtion it would be ſuperfluous to enter here particularly, as we have ſaid enough on it elſewhere. See OSSIAN, *Encycl.*

That any man ſhould ſuppoſe Macpherſon, after his tranſlation of Homer, the *author* of the poems which he aſcribes to Oſſian, appears to us very extraordinary; and it is little leſs extraordinary, that any one ſhould, for a moment, believe in the exiſtence of *manuſcripts* of theſe poems of *very high* antiquity. Part of them he undoubtedly received in manuſcript from Macdonald of Clanronald; but we can affirm, on the beſt authority, that the ſaid manuſcript was written at different times by the Macvurichs, hereditary bards to that family. He may likewiſe have received ſhort manuſcripts elſewhere; but every Highland gentleman of learning and of candour (and none elſe have a right to decide on this queſtion), declares, that by much the greater part of the poems had been preſerved in fragments and popular ſongs from a very remote age by oral tradition. To theſe fragments Macpherſon and his aſſociates (A) gave form; and it was by uniting together fragments of different ages, that he inadvertently furniſhed Gibbon and others with the opportunity of objecting, that the poems are ſometimes inconſiſtent with the truth of hiſtory. This, however, is no ſolid objection to their authenticity; for every Weſt Highlander ſixty years of age remembers to have heard, in his youth, great part of thoſe poems repeated by old men; and is confident that, many centuries ago, the names of *Fiune Mackuil* (Fingal), and of Oſſian's other heroes and heroines, were as familiar to a Highland ear, as the names of Agamemnon, Hector, Helen, &c. were to a Grecian ear at the time when the poems of Homer were reduced into their preſent form. For the ſubſtance of the poems, this is ſuch evidence as none will reject who does not prefer his own cobweb theories to the united teſtimony of a whole people.

With reſpect to authenticity, the poems of Oſſian have indeed been compared with the poems of Rowley; but the compariſon is abſurd. The poems of the Celtic bard were not found in an old cheſt, and preſented to a people who had never before heard either of them or of their author; they were the popular ſongs and traditions of ages collected together, and reduced into form, with additions occaſionally made by the tranſlator. It is ridiculous to aſk how theſe ſongs and ſtories could be ſo long preſerved among a rude and illiterate people; for it is only among ſuch a people, whoſe objects of purſuit are too few to occupy all their attention, that the exploits of their anceſtors can be handed down by tradition; and the moſt ſerious objection which we have ever met with to the tranſlator's account of the origin of the poems, ariſes from his having pretended that he received the greater part of them in old manuſcripts.

After the publication of Oſſian's poems, by which we have reaſon to believe that he gained twelve hundred pounds, Mr Macpherſon was called to an employment which withdrew him, for ſome time, both from the muſes and from his country. Captain Johnſtone was appointed governor of Penſacola, and Mr Macpherſon accompanied him as his ſecretary, being at the ſame time made ſurveyor-general of the Floridas. If our memory does not deceive us, ſome difference aroſe between the principal and his dependant, and they parted before their return to England. Having contributed his aid to the ſettlement of the civil government of that colony, he viſited ſeveral of the Weſt India iſlands, and ſome of the provinces of North America, and returned to England in the year 1766, where he retained for life his ſalary as ſurveyor, which we believe was L. 200 a-year.

He ſoon returned to his ſtudies, and in 1771 produced *An Introduction to the Hiſtory of Great Britain and Ireland*, 4to; a work which he ſays, "without any of the ordinary incitements to literary labour, he was induced to proceed in by the ſole motive of private amuſement." The ſubject of this performance, it might reaſonably be ſuppoſed, would not excite any violent controverſial acrimony; yet neither it nor its author could eſcape from ſeveral moſt groſs and bitter invectives, for ſome of which he perhaps gave too great occaſion.

His next performance produced him neither reputation nor profit. In 1773 he publiſhed, *The Iliad of Homer*, tranſlated in two volumes 4to; a work fraught with vanity and ſelf-conſequence, and which met with the moſt mortifying reception from the public. It was condemned by the critics, ridiculed by the wits, and neglected by the world. Some of his friends, and particularly Sir John Elliott, endeavoured to reſcue it from contempt, and force it into notice. Their ſucceſs was not equal to their efforts.

About this time ſeems to be the period of Mr Macpherſon's literary mortifications. In 1773 Dr Johnſon and Mr Boſwell made the tour to the Hebrides; and in the courſe of it, the former took ſome pains to examine into the proofs of the authenticity of Oſſian. The reſult of his inquiries he gave to the public in 1775, in his narrative of the tour; and his opinion was unfavourable. "I believe they (*i. e.* the poems, ſays he), never exiſted in any other form than that which we have ſeen. The editor or author never could ſhew the original; nor can it be ſhewn by any other. To revenge reaſonable incredulity by refuſing evidence, is a degree of inſolence with which the world is not yet acquainted; and ſtubborn audacity is the laſt refuge of guilt. It would be eaſy to ſhew it if he had it. But whence could it be had? It is too long to be remembered, and the language had formerly nothing written. He has doubtleſs inſerted names that circulate in popular ſtories, and may have tranſlated ſome wandering ballads, if any can be found; and the names and ſome of the images being recollected, make an inaccurate auditor imagine that he has formerly heard the whole."

Again, he ſays, "I have yet ſuppoſed no impoſture but in the publiſher; yet I am far from certainty, that ſome tranſlations have not been lately made, that

---

(A) We have been aſſured that he had aſſociates: and that for the deſcription of Cuchullin's chariot in particular he was indebted to Mr Macpherſon of *Stramazhie*; a man of native genius, and though not poſſeſſed of very extenſive erudition, well acquainted with Gaelic poetry.

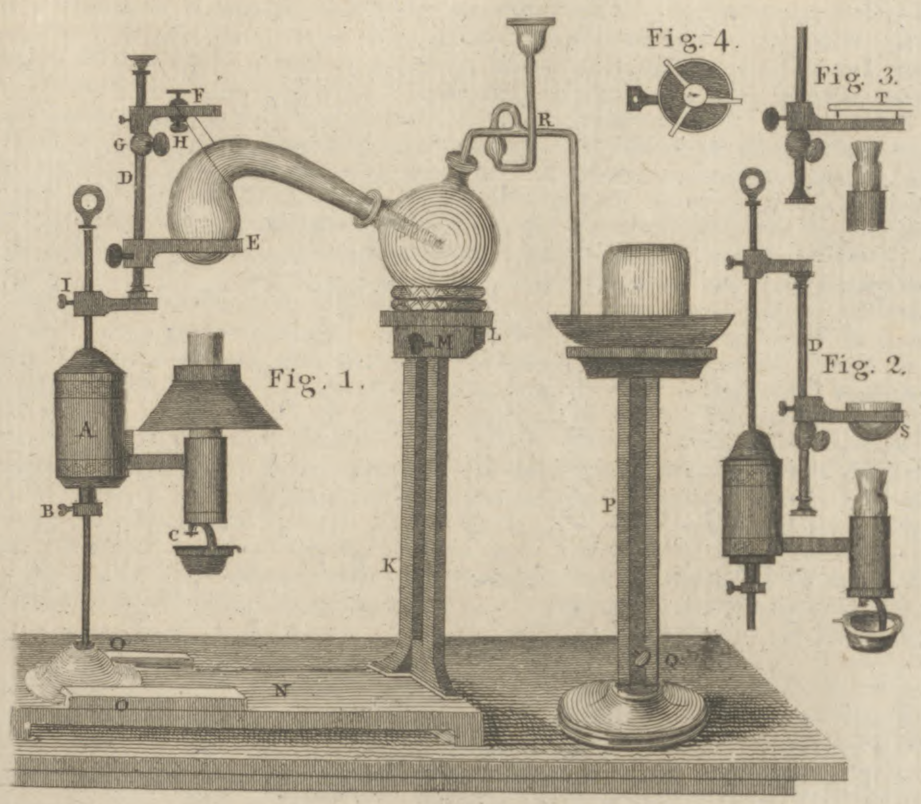


Fig. 2.

Fig. 1.

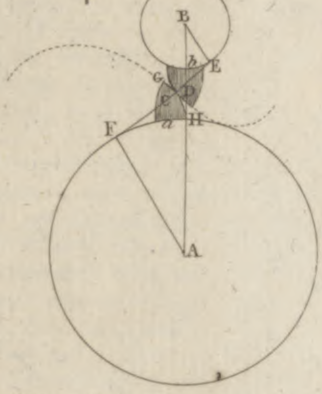
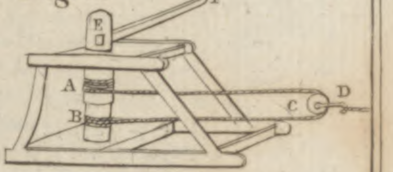
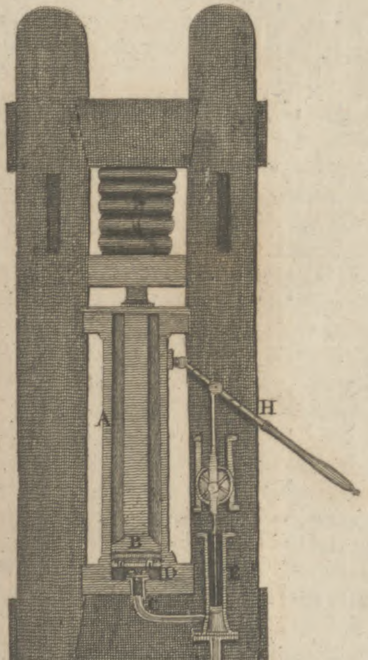


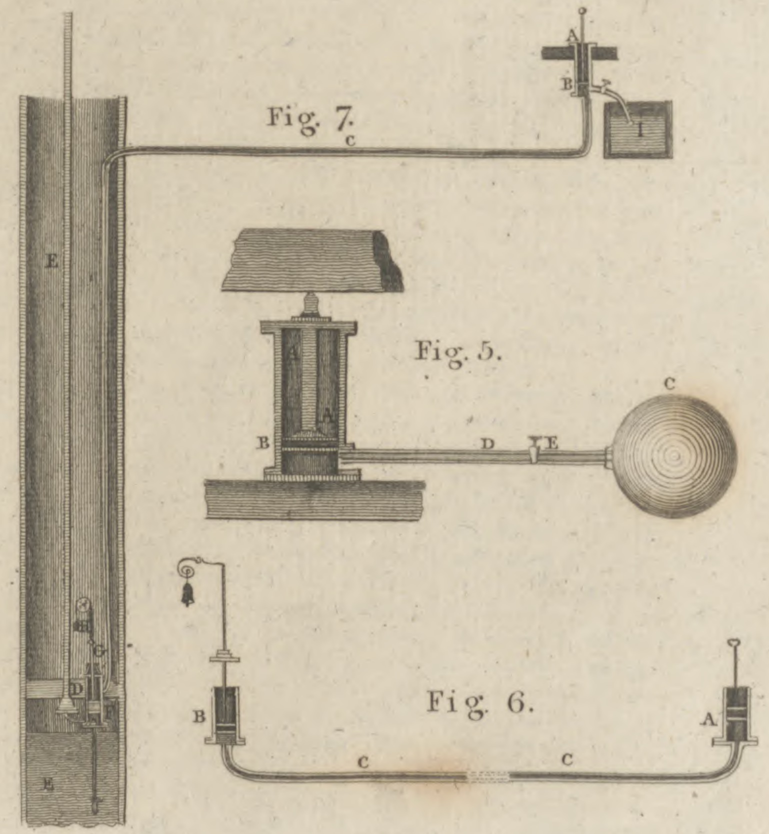
Fig. 3.



MACHINERY

Fig. 4.





D. Lizars Sculp^t

may now be obtruded as parts of the original work.

"Credulity on the one part is a ſtrong temptation to deceit on the other, eſpecially to deceit of which no perſonal injury is the conſequence, and which flatters the author with his own ingenuity. The Scots have ſomething to plead for their eaſy reception of an improbable fiction: they are ſeduced by their fondneſs for their ſuppoſed anceſtors. Neither ought the Engliſh to be much influenced by Scotch authority; for of the paſt and preſent ſtate of the whole Erſe nation, the Lowlanders are at leaſt as ignorant as ourſelves. To be ignorant is painful; but it is dangerous to quiet our uneaſineſs by the deluſive opiate of haſty perſuaſion."

Theſe reaſonings, if reaſonings they can be called, might have been eaſily anſwered, had not Macpherſon pretended to the poſſeſſion of at leaſt one manuſcript which certainly never exiſted. He did not, however, attempt to anſwer them; but adopted a mode of proceeding which tended only to convince the world that Johnſon's opinion had ſome foundation, and that the editor of Oſſian had more imagination than ſound judgement. Prompted by his evil genius, he ſent a menacing letter to his illuſtrious antagoniſt, which produced the following brief but ſpirited reply:

"Mr James Macpherſon, No date.

"I received your fooliſh and impudent letter. Any violence that ſhall be offered to me, I will do my beſt to repel; and what I cannot do for myſelf, the law ſhall do for me; for I will not be hindered from expoſing what I think a cheat, by the menaces of a ruffian. What! Would you have me retract? I thought your work an impoſition: I think ſo ſtill; and, for my opinion, I have given reaſons, which I dare you to refute. Your abilities, ſince your *Homer*, are not ſo formidable; and what I hear of your morality, inclines me to believe rather what you ſhall prove than what you ſhall ſay."

Whether this letter ſhewed to Macpherſon the imprudence of his conduct, or that he had been made ſenſible of his folly by the interpoſition of friends, we know not; but certain it is, we hear no more afterwards of this ridiculous affair, except that our author is ſuppoſed to have aſſiſted Mr Macnicol in an anſwer to Dr Johnſon's Tour, printed in 1779. This ſuppoſition we are inclined to conſider as well-founded, becauſe we have been told by a gentleman of veracity, that Mr Macnicol affirms, that the ſcurrility of his book, which conſtitutes a great part of it, was inſerted, unknown to him, after the manuſcript was ſent for publication to London.

In 1775 Mr Macpherſon publiſhed *The Hiſtory of Great Britain from the Reſtoration to the Acceſſion of the Houſe of Hanover*, in two volumes 4to; a work in our opinion of great merit, though by one party it has been induſtriouſly, and, we are ſorry to add, too ſucceſsfully, decried. As an hiſtorian, our author could not indeed boaſt the attic elegance of a Robertſon, the ſplendour of a Gibbon, or the philoſophical profundity of a Hume; but his *ſtyle*, though it has ſometimes been the avowed, was not the real, cauſe of the coldneſs with which his hiſtory was received. The writer of this ſketch once ſaw a gentleman of rank, and of the Whig intereſt, turn over one of Macpherſon's volumes, and heard him ſay, upon ſhutting the book, "I cannot bear that work." He was aſked if he thought the narrative falſe? and he replied, "No! It is too true; but I cannot bear it, becauſe it gives me a bad opinion of thoſe great men to whom I have been accuſtomed to look back with reverence as to the ſaviours of my country."

That it has been abhorred by others on the ſame account, we have not a doubt; and yet language has no name too contemptuous for thoſe who will not follow truth whitherſoever ſhe may lead them; or who, on the abſurd pretence of having already made up their minds, will not ſtudy the evidence on both ſides of a diſputed queſtion in our national hiſtory. A man needs not ſurely diſapprove of the Revolution, or of the ſubſequent ſettlements, though he ſhould find complete proofs that Danby and Sunderland were crooked politicians, that Marlborough was ungrateful, or even that King William himſelf was not that upright and diſintereſted character which from their infancy they have been taught to believe. It is no uncommon thing for Divine Providence to accompliſh good ends by wicked inſtruments. Every Proteſtant ſurely conſiders the Reformation as one of the moſt bleſſed events that have taken place in the world ſince the firſt preaching of the goſpel of Chriſt; yet he would be a hardy champion who ſhould undertake to vindicate the motives which influenced the conduct of the firſt reformers—of Henry VIII. for inſtance, or even of Luther himſelf. And why may not the Revolution be conſidered as in the higheſt degree beneficial to the country, though the conduct of ſome of thoſe who brought it about ſhould be found to be ſuch as Macpherſon repreſents it?

That author certainly acted with great fairneſs; as together with the hiſtory he publiſhed the proofs upon which his facts were founded, in two quarto volumes, intitled, *Original Papers, containing the ſecret Hiſtory of Great Britain, from the Reſtoration to the Acceſſion of the Houſe of Hanover; to which are prefixed, Extracts from the Life of James II. as written by himſelf.* Theſe papers were chiefly collected by Mr Carte, but are not all of equal authority. They, however, clear up many obſcurities, and ſet the characters of many perſons in paſt times in a different light from that in which they have been uſually viewed. On this account we have no heſitation to ſay, that he who is capable of ſacrificing prejudice to truth, and wiſhes to underſtand the politics of the reigns of James, and William, and Anne, ſhould ſtudy with care the volumes of Macpherſon.

Soon after this period, the tide of fortune flowed very rapidly in Mr Macpherſon's favour, and his talents and induſtry were amply ſufficient to avail himſelf of every favourable circumſtance which aroſe. The reſiſtance of the Colonies called for the aid of a ready writer to combat the arguments of the Americans, and to give force to the reaſons which influenced the conduct of government, and he was ſelected for the purpoſe. Among other things (of which we ſhould be glad to receive a more particular account), he wrote a pamphlet, which was circulated with much induſtry, intitled, *The Rights of Great Britain aſſerted againſt the Claims of the Colonies; being an Anſwer to the Declaration of the General Congreſs*, 8vo, 1776, and of which many editions were publiſhed. He alſo was the author of *A ſhort Hiſtory of Oppoſition during the laſt Seſſion of*

Parliament, 8vo, 1779; a pamphlet which, on account of its merit, was by many aſcribed to Mr Gibbon

But a more lucrative employment was conferred on him about this time. He was appointed agent to the nabob of Arcot, and in that capacity exerted his talents in ſeveral appeals to the public in behalf of his client. Among others, he publiſhed, *Letters from Mahommed Ali Chan, Nabob of Arcot, to the Court of Directors; to which is annexed, a State of Facts relative to Tanjore, with an Appendix of Original Papers*, 4to, 1777; and he was ſuppoſed to be the author of *The Hiſtory and Management of the Eaſt India Company from its Origin in 1600 to the preſent Times*, vol. i. containing the affairs of the Carnatic, in which the rights of the nabob are explained, and the injuſtice of the Company proved, 4to, 1779.

In his capacity of agent to the nabob, it was probably thought requiſite that he ſhould have a ſeat in the Britiſh Parliament. He was accordingly in 1780 choſen member for Camelford; but we do not recollect that he ever attempted to ſpeak in the Houſe. He was alſo rechoſen in 1784 and 1790.

He had purchaſed, we think before the year 1790, an eſtate in the pariſh in which he was born; and changing its name from *Retz* to *Belville*, built on it a large and elegant manſion, commanding a very romantic and pictureſque view; and thither he retired, when his health began to fail, in expectation of receiving benefit from the change of air. He continued, however, to decline; and after lingering ſome time, died at his ſeat at Belville, in Inverneſs, on the 17th of February 1796.

He appears to have died in very opulent circumſtances; and by his will, dated June 1793, gave various annuities and legacies to ſeveral perſons to a great amount. He alſo bequeathed L. 1000 to John Mackenzie of Figtree Court, in the Temple, London, to defray the expence of printing and publiſhing Oſſian in the original. He directed L. 300 to be laid out in erecting a monument to his memory in ſome conſpicuous ſituation at Belville, and ordered that his body ſhould be carried from Scotland, and interred in the Abbey Church of Weſtminſter, the city in which he had paſſed the beſt part of his life. His remains were accordingly taken from the place where he died, and buried in the Poets Corner of Weſtminſter church.

MAGMA is properly the *refuſe* of any ſubſtance which has been ſubjected to preſſure; but, in chemiſtry, the term is ſometimes uſed to denote a mixture of two or more bodies, reduced to the conſiſtence of dough or paſte.

MAGNETISM,

IN natural philoſophy.—Our intention in the preſent article was principally to give a more diſtinct account of the theory of Mr Æpinus than is contained in the article MAGNETISM of the *Encyclopædia Britannica*, referring for proof and illuſtration to the many facts contained in that article: but, on more mature conſideration, we concluded, that this method would fret and confuſe the reader by continual references, and leave but a feeble impreſſion at laſt. We have therefore preferred the putting the whole into the form of a ſhort treatiſe on magnetiſm, ſimilar to our ſupplementary article of ELECTRICITY. This, we hope, will be more perſpicuous and ſatisfactory; ſtill leaving to the reader the full uſe of all the information contained in the article MAGNETISM of the Dictionary.

1
Reaſons why the ancients were ignorant of natural philoſophy.

The knowledge which the antient naturaliſts poſſeſſed of this ſubject was extremely imperfect, and affords, we think, the ſtrongeſt proof of their ignorance of the true method of philoſophiſing; for there can hardly be named any object of phyſical reſearch that is more curious in itſelf, or more likely to engage attention, than the apparent life and activity of a piece of rude unorganiſed matter. This had attracted notice in very early times; for Thales attributed the characteriſtic phenomenon, the attraction of a piece of iron, to the agency of a mind or ſoul reſiding in the magnet. Philoſophers, as they were called, ſeem to have been contented with this lazy notice of a ſlight ſuggeſtion, unbecoming an inquirer, and rather ſuch as might be expected from the moſt incurious peaſant. Even Ariſtotle, the moſt zealous and the moſt ſyſtematic ſtudent of Nature of whoſe labours we have any account, has collected no information that is of any importance. We know that the general imperfection of ancient phyſics has been aſcribed to the little importance that was attached to the knowledge of the material world by the philoſophers of Greece and Rome, who thought human nature, the active purſuits of men, and the ſcience of public affairs, the only objects deſerving their attention. Moſt of the great philoſophers of antiquity were alſo great actors on the ſtage of human life, and deſpiſed acquiſitions which did not tend to accompliſh them for this dignified employment: but they have not given this reaſon themſelves, though none was more likely to be uppermoſt in their mind. Socrates diſſuades from the ſtudy of material nature, not becauſe it was unworthy of the attention of his pupils, but becauſe it was too difficult, and that certainty was not attainable in it. Nothing can more diſtinctly prove their ignorance of what is really attainable in ſcience, namely, the knowledge of the *laws of nature*, and their ignorance of the only method of acquiring this knowledge, viz. obſervation and experiment. They had entertained the hopes of diſcovering the *cauſes* of things, and had formed their philoſophical language, and their mode of reſearch, in conformity with this hopeleſs project. Making little advances in the diſcovery of the cauſes of the phenomena of material nature, they deſerted this ſtudy for the ſtudy of the conduct of man; not becauſe the diſcovery of cauſes was more eaſy and frequent here, but becauſe the ſtudy itſelf was more immediately intereſting, and becauſe any thing like ſuperior knowledge in it puts the poſſeſſor in the deſirable ſituation of an adviſer, a man of ſuperior wiſdom; and as this ſtudy was cloſely connected with morals, becauſe the fear of God is truly the beginning of wiſdom, the character of the philoſopher acquired an eminence and dignity which was highly flattering to human vanity. Their procedure in the moral and intellectual ſciences is ſtrongly marked with the ſame ignorance of the true method of

philo-

philoſophiſing; for we rarely find them forming general propoſitions on copious inductions of facts in the conduct of men. They always proceed in the ſynthetic method, as if they were fully converſant in the firſt principles of human nature, and had nothing to do but to make the application, according to the eſtabliſhed forms of logic. While we admire, therefore, the ſagacity, the penetration, the candid obſervation, and the happy illuſtration, to be found in the works of the ancient moraliſts and writers on juriſprudence and politics, we cannot but lament that ſuch great men, frequently engaged in public affairs, and therefore having the fineſt opportunities for deducing general laws, have done ſo little in this way; and that their writings, however engaging and precious, cannot be conſidered as any thing more refined than the obſervations of judicious and worthy men, with all the diffuſeneſs and repetition of ordinary converſation. All this has ariſen from the want of a juſt notion of what is attainable in this department of ſcience, namely, the laws of intellectual and moral nature; and of the only poſſible method of attaining this knowledge, viz. obſervation and experiment, and the formation of general laws by the induction of particular facts.

2
Dr Gilbert vas the firſt xperimenal enquirer bout magetiſm.

We have been led into theſe reflections by the inattention of the ancients to the curious phenomena of magnetiſm; which muſt have occurred in conſiderable and entertaining variety to any perſon who had taken to the experimental method. And we have hazarded theſe free remarks, expecting the acquieſcence of our readers, becauſe the ſuperior knowledge which we, in theſe later days, have acquired of the magnetical phenomena, were the firſt fruits of the true method of philoſophiſing. This was pointed out to the learned world in 1590 by our celebrated countryman Chancellor Bacon, in his two great works, the *Novum Organum Scientiarum*, and *De Argumentis Scientiarum*. Dr Gilbert of Colcheſter, a philoſopher of eminence in many reſpects, but chiefly becauſe he had the ſame juſt views of philoſophy with his noble countryman, publiſhed about the ſame time his *Phyſiologia Nova, ſeu Tractatus de Magnete et Corporibus magneticis*. In the introduction, he recounts all the knowledge of the antients on the ſubject, and their ſupine inattention to what was ſo entirely in their hands; and the impoſſibility of ever adding to the ſtock of uſeful knowledge, ſo long as men imagined themſelves to be philoſophiſing while they were only repeating a few cant words, and the unmeaning phraſes of the Ariſtotelian ſchool. It is curious to remark the almoſt perfect ſameneſs of Dr Gilbert's ſentiments and language with thoſe of Lord Bacon. They both charge, in a peremptory manner, all thoſe who pretend to inform others, to give over their dialectic labours, which are nothing but ringing changes on a few trite truths, and many unfounded conjectures, and immediately to betake themſelves to experiment. He has purſued this method on the ſubject of magnetiſm with wonderful ardour, and with equal genius and ſucceſs; for Dr Gilbert was poſſeſſed both of great ingenuity, and a mind fitted for general views of things. The work contains a prodigious number and variety of obſervations and experiments, collected with ſagacity from the writings of others, and inſtituted by himſelf with conſiderable expence and labour. It would indeed be a miracle, if all Dr Gilbert's general inferences were juſt, or all his experiments accurate. It was untrodden ground. But, on the whole, this performance contains more real information than any writing of the age in which he lived, and is ſcarcely exceeded by any that has appeared ſince. We may hold it with juſtice as the firſt fruits of the Baconian or experimental philoſophy.

This work of Dr Gilbert's relates chiefly to the loadſtone, and what we call magnets, that is, pieces of ſteel which have acquired properties ſimilar to thoſe of the loadſtone. But he extends the term *magnetiſm*, and the epithet *magnetic*, to all bodies which are affected by loadſtones and magnets in a manner ſimilar to that in which they affect each other. In the courſe of his inveſtigation, indeed, he finds that theſe bodies are only ſuch as contain iron in ſome ſtate or other: and in proving this limitation he mentions a great variety of phenomena which have a conſiderable reſemblance to thoſe which he allows to be magnetical, namely, thoſe which he called *electrical*, becauſe they were produced in the ſame way that amber is made to attract and repel light bodies. He marks with care the diſtinctions between theſe and the characteriſtic phenomena of magnets. He ſeems to have known, that all bodies may be rendered electrical, while ferrugineous ſubſtances alone can be made magnetical.

3
His treatiſe contains many diſcoveries.

It is not ſaying too much of this work of Dr Gilbert's to affirm, that it contains almoſt every thing that we know about magnetiſm. His unwearied diligence in ſearching every writing on the ſubject, and in getting information from navigators, and his inceſſant occupation in experiments, have left very few facts unknown to him. We meet with many things in the writings of poſterior inquirers, ſome of them of high reputation, and of the preſent day, which are publiſhed and received as notable diſcoveries, but are contained in the rich collection of Dr Gilbert. We by no means aſcribe all this to mean plagiariſm, although we know traders in experimental knowledge who are not free from this charge. We aſcribe it to the general indolence of mankind, who do not like the trouble of conſulting originals, where things are mixed with others which they do not want, or treated in a way, and with a painful minuteneſs, which are no longer in faſhion. Dr Gilbert's book, although one of thoſe which does the higheſt honour to our country, is leſs known in Britain than on the continent. Indeed we know but of two Britiſh editions of it, which are both in Latin; and we have ſeen five editions publiſhed in Germany and Holland before 1628. We earneſtly recommend it to the peruſal of the curious reader. He will (beſides the ſound philoſophy) find more facts in it than in the two large folios of Scarella.

After this moſt deſerved eulogy on the parent of magnetical philoſophy, it is time to enter on the ſubject.

4
We can only claſs the phenomena.

In mechanical philoſophy, a phenomenon is not to be conſidered as explained, unleſs we can ſhew that it is the certain reſult of the laws of motion applied to matter. It is in this way that the general propoſitions in phyſical aſtronomy, in the theory of machines, in hydraulics, &c. are demonſtrated. But the phenomena called *magnetical* have not as yet obtained ſuch an explanation. We do not ſee their immediate cauſe, nor can we ſay with confidence that they are the effects of any

any particular kind of matter, acting on the bodies either by impulſion or preſſure.

All that can be done here is to claſs the phenomena in the moſt diſtinct manner, according to their generality. In this we obtain a two-fold advantage. We may take it for granted that the moſt general phenomenon is the neareſt allied to the general cauſe. But, farther, we obtain by this method a true theory of all the ſubordinate phenomena. For a juſt theory is only the pointing out the general fact of which the phenomenon under conſideration is a particular inſtance. Beginning therefore with the phenomenon which comprehends all the particular caſes, we explain thoſe caſes in ſhewing *in what manner* they are included in the general phenomenon, and thus we ſhall be able to predict what will be the reſult of putting the body under conſideration into any particular ſituation. And perhaps we may find, in them all, coincidences which will enable us to ſhew that they are all modifications of a fact ſtill more general. If we gain this point, we ſhall have eſtabliſhed a complete theory of them, having diſcovered the general fact in which they are all comprehended. Should we for ever remain ignorant of the cauſe of this general fact, we have nevertheleſs rendered this a complete branch of mechanical theory. Nay, we may perhaps diſcover ſuch circumſtances of reſemblance between this general fact and others, with which we are better acquainted, that we ſhall, with great probability at leaſt, be able to aſſign the cauſe of the general fact itſelf, by ſhewing the law of which it is a particular inſtance.

We ſhall attempt this method on the preſent occaſion.

5
First leading fact. Iron arranges itſelf in a particular poſition.

The leading facts in magnetiſm are the two following:

1. If any oblong piece of iron, ſuch as a bar, rod, or wire, be ſo fitted, that it can aſſume any direction, it will arrange itſelf in a certain determinate direction with reſpect to the axis of the earth. Thus, if, in any part of Britain, an iron or ſteel wire be thruſt through a piece of cork, as repreſented in fig. 1. ſo as that the whole may ſwim level in water, and if it be laid in the water nearly north-weſt and ſouth-eaſt, it will ſlowly change its poſition, and finally ſettle in a direction, making an angle of about 25 degrees with the meridian.

Plate XXXIV.

This experiment, which we owe to Dr Gilbert (ſee B. I. ch. 11.), is delicate, and requires attention to many circumſtances. The force with which the iron tends toward this final poſition is extremely weak, and will be balanced by very minute and otherwiſe inſenſible reſiſtances; but we have never found it fail when executed as here directed. An iron wire of the ſize of an ordinary quill, and about eight or ten inches long, is very fit for the purpoſe. It ſhould be thruſt through the cork at right angles to its axis; and ſo adjuſted, by repeated trials, as to ſwim level or parallel to the horizon. The experiment muſt alſo be made at a great diſtance from all iron; therefore in a baſon of ſome other metal or earthen ware. It may ſometimes require a very long while before the motion begin; and if the wire has been placed at right angles to the direction which we have mentioned as final, it will never change its poſition: therefore we have directed it to be laid in a direction not too remote, yet very ſenſibly different from the final direction.

But this is not the true poſition affected by the iron rod. If it be thruſt through a piece of wood or cork perfectly ſpherical, in ſuch a manner that it paſſes thro' its centre, and if the centre of gravity coincide with this centre, and the whole be of ſuch weight as to remain in any part of the water, without either aſcending or deſcending, then it will finally ſettle in a plane inclined to the meridian about 25°, and the north end will be depreſſed about 73° below the horizon.

All this is equivalent with ſaying, that if any oblong piece of iron or ſteel be very nicely poiſed on its centre of gravity, and at perfect liberty to turn round that centre in every direction, it will finally take the poſition now mentioned.

We have farther to obſerve with regard to this experiment, that it is indifferent which end of the rod be placed toward the north in the beginning of the experiment. That end will finally ſettle toward the north; and if the experiment be repeated with the ſame rod, but with the other end north, it will finally ſettle in this new attitude. It is, however, not always that we find pieces of iron thus perfectly indifferent. Very frequently one end affects the northerly poſition, and we cannot make the other end aſſume its place: the cauſes of this difference will be clearly ſeen by and bye.

6
Magnetical poſition.

The poſition thus affected by a rod of iron is called by Dr Gilbert the MAGNETICAL POSITION or DIRECTION. It is not the ſame, nor parallel, in all parts of the earth, as will be more particularly noticed afterwards.

7
Second fact. Iron attracts and repels iron.

2. The other leading fact is this: When a piece of iron, lying in the *magnetical* poſition, or nearly ſo, and at perfect liberty to move in every direction, is approached by another oblong piece of iron, held nearly in the ſame poſition, it is attracted by it; that is, the moveable piece of iron will gradually approach to the one that is preſented to it, and will at laſt come into contact with it, and may then be ſlowly drawn along by it.

This phenomenon, although not ſo delicate as the former, is ſtill very nice, becauſe the attraction is ſo weak that it is balanced by almoſt inſenſible obſtructions. But the experiment will ſcarcely fail if conducted as follows: Let a ſtrong iron wire be made to float on water by means of a piece of cork, in the manner already deſcribed, having one end under water. See fig. 1. B.

When it is nearly in the magnetical poſition, bring the end of a pretty big iron rod, ſuch as the point of a new poker, within a quarter of an inch of its ſouthern end (holding the poker in a poſition not very different from the magnetical poſition), and hold it there for ſome time, not exactly ſouthward from it, but a little to one ſide. The floating iron will be obſerved to turn towards it with an accelerated motion; will touch it, and may then be drawn by it through the water in any direction. We ſhall have the ſame reſult by approaching the northern extremity of the floating iron with the upper end of the poker.

The ſame phenomenon may be obſerved by ſuſpending the firſt piece of iron by its middle by a long and ſlender hair or thread. The ſuſpenſion muſt be long, otherwiſe the ſtiffneſs of the hair or thread may be ſufficient for balancing the very ſmall force with which the pieces of iron tend toward each other. The phenomenon

non may alſo be obſerved in a piece of iron which turns freely on a fine point, like the needle of the mariner's compaſs.

In this, as in the former experiment, the ends of the pieces of iron are obſerved, in general, to be indifferent; that is, either end of the one will attract either end of the other. It often happens, however, that the ends are not thus indifferent, and that the end of the moveable piece of iron, inſtead of approaching the other, will be obſerved to recede from it, and appear to avoid it. We ſhall ſoon learn the cauſe of this difference in the ſtates of iron.

8 This action mutual.

It is ſcarcely neceſſary to remark, that we muſt infer from theſe experiments, that the action is mutual between the two pieces of iron. Either of them may be the moveable piece which approaches the other, manifeſting the attraction of that other. This reciprocity of action will be abundantly verified and explained in its proper place.

9 Not peculiar to magnets or loadſtone;

Theſe two facts were long thought to be peculiar to loadſtones and artificial magnets, that is, pieces of iron which have acquired this property by certain treatment with loadſtones; but they were diſcovered by Dr Gilbert to be inherent in all iron in its metallic ſtate; and were thought by him to be neceſſary conſequences of a general principle in the conſtitution of this globe. Theſe phenomena are indeed much more conſpicuous in loadſtones and magnets; and it is therefore with ſuch that experiments are beſt made for learning their various modifications.

10 But, in iron, is indifferent, and momentary, and in loadſtones it is fixed and determinate.

But there is another circumſtance, beſides the degree of vivacity, in which the magnetiſm of common iron and ſteel remarkably differs from that of a loadſtone or magnet. When a loadſtone or magnet is ſo ſupported as to be at liberty to take any poſition, it arranges itſelf in the magnetical direction, and *one determined end* of it ſettles in the northern quarter; and if it be placed ſo that the other end is in that ſituation, it does not remain there, but gradually turns round, and, after a few oſcillations, the *ſame end* ultimately ſettles in the north. This is diſtinctly ſeen in the needle of the mariner's compaſs, which is juſt a ſmall magnet prepared in the ſame way with all other magnets. The ſeveral ends of loadſtones or magnets are thus permanently the north or the ſouth ends; whereas we ſaid that either end of a piece of common iron being turned to the northern quarter, it finally ſettles there

It is this circumſtance which has rendered magnetiſm ſo precious a diſcovery to mankind, by furniſhing us with the compaſs, an inſtrument by which we learn the different quarters of the horizon, and which thus tells the direction of a ſhip's courſe through the pathleſs ocean (ſee COMPASS and VARIATION, *Encycl.)*; and alſo ſhews us the directions of the veins and workings in the deepeſt mines. It was natural therefore to call thoſe the north and ſouth ends of the mariner's needle, or of a loadſtone or magnet. Dr Gilbert called them the POLES of the loadſtone or magnet. He had found it convenient for the propoſed train of his experiments to form his loadſtones into ſpheres, which he called TERRELLÆ, from their reſemblance to this globe; in which caſe the north and ſouth ends of his loadſtones were the poles of the terrellæ. He therefore gave the name *pole* to that part of any loadſtone or magnet which thus turned to the north or ſouth. The denomination was adopted by all ſubſequent writers, and now makes a term in the language of magnetiſm.

11 POLES.

Alſo, when we approach either end of a piece of iron A to either end of another B, theſe ends mutually attract; or if either end of a magnet A be brought near either end of a piece of common iron, they mutually attract each other. But if we bring that end of a magnet A which turns to the north near to the *ſimilar* end of another magnet B, theſe ends will not attract each other, but, on the contrary, will repel. If the two magnets are made to float on pieces of wood, and have their north poles fronting each other, the magnets will retire from each other; and in doing ſo, they generally turn round their axes, till the north pole of one front the ſouth pole of the other, and then they run together. This is a very notable diſtinction between the magnetiſm of magnets and that of common iron; and whenever we ſee a piece of iron ſhew this permanent diſtinction of its ends, we muſt conſider it as a magnet, and conclude that it has met with ſome peculiar treatment.

It is not, however, ſtrictly true, that the poles of loadſtones or magnets are ſo fixed in particular parts of their ſubſtance, nor that the poles of the ſame name ſo conſtantly repel each other; for if a ſmall or weak magnet A have its pole brought near the ſimilar pole of a large or ſtrong magnet B, they are often found to attract when almoſt touching, although at more conſiderable diſtances they repel each other. But this is not an exception to the general propoſition; for when the north pole of A is thus attracted by the north pole of B, it will be found, by other trials, to have all the qualities of a ſouth pole, while thus in the neighbourhood of the north pole of B.

12 Magnetic FORCE and POLARITY.

The magnetic properties and phenomena are conveniently diſtinguiſhed into thoſe of FORCE and of POLARITY. Thoſe of the firſt claſs only were known to the ancients, and even of them their knowledge was extremely ſcanty and imperfect. They may all be claſſed under the following general propoſitions.

13 Similar poles repel and diſſimilar poles attract, each other.

1. The ſimilar poles of two magnets repel each other with a force decreaſing as the diſtances increaſe.
2. The diſſimilar poles of two magnets attract each other with a force decreaſing as the diſtances increaſe.
3. Magnets arrange themſelves in a certain determinate poſition with reſpect to each other.

14 The law of attraction and repulſion is of difficult inveſtigation.

The firſt object of reſearch in our farther examination of theſe properties is the relation which is obſerved to obtain between the diſtances of the acting poles and their force of action. This has accordingly occupied much attention of the philoſophers, and numberleſs experiments have been made in order to aſcertain the law of variation, both of the attraction and the repulſion. A great number of theſe have been narrated in the article MAGNETISM of the *Encycl.* from which it appears that it has been a matter of great difficulty, and had not been aſcertained with certainty or preciſion when that article was publiſhed. It is obvious, from the nature of the thing, that the determination is very difficult, and the inveſtigation very complicated. We can only obſerve the ſimultaneous motion of the whole magnet; yet we know that there are four ſeparate actions coexiſting and contributing in different directions, and with different forces, to the ſenſible effect. The force which we meaſure, in any way whatever, is compounded

pounded of four different forces, which we cannot ſeparate and meaſure apart; for the north pole of A repels the north pole of B, and attracts its ſouth pole, while the ſouth pole of A exerts the oppoſite forces on the ſame poles of B. The attraction which we obſerve is the exceſs of two unequal attractions above two unequal repulſions. The ſame might be ſaid of an obſerved repulſion. Nay, the matter is incomparably more complicated than this; becauſe, for any thing that we know, *every* particle of A acts on *every* particle of B, and is acted on by it; and the intenſity of thoſe actions may be different at the ſame diſtances, and is certainly different when the diſtances are ſo. Thus there is a combination of an unknown number of actions, each of which is unknown individually, both in direction and intenſity. The preciſe determination is therefore, in all probability, impoſſible. By preciſe determination, we mean the law of mutual action between two magnetic particles, or that preciſe function of the diſtance which defines the intenſity of the force; ſo that meaſuring the diſtance of the acting particles on the axis of a curve, the ordinates of the curve may have the proportions of the attractions and repulſions.

It is almoſt needleſs to attempt any deduction of the law of variation from the numerous experiments which have been publiſhed by different philoſophers. An ample collection of them may be ſeen in Scarella's treatiſe. Mr Muſchenbroek has made a prodigious number; but all are ſo anomalous, and exhibit ſuch different laws of diminution by an increaſe of diſtance, that we may be certain that the experiments have been injudicious. Attention has not been paid to the proper objects. Magnets of moſt improper ſhapes have been employed, and of moſt diffuſe polarity. No notice has been taken of a circumſtance which, one ſhould think, ought to have occupied the chief attention; namely, the joint action of four poles, of which the experiment exhibits only the complex reſult. A very ſlight reflection might have made the enquirer perceive, that the attractions or repulſions are not the moſt proper phenomena for declaring the preciſe law of variation; becauſe what we obſerve is only the exceſs of a ſmall difference of attractions and repulſions above another ſmall difference. Mr Hawkſbee and Dr Brook Taylor employed a much better method, by obſerving the deviations from the meridian which a magnet occaſioned in a compaſs needle at different diſtances. This is occaſioned by the difference of the two ſums of the ſame forces; and this difference may be made a hundred times greater than the other. But they employed magnets of moſt improper ſhapes.

15
Judicious experiments by Mr Lambert.

We muſt except from this criticiſm the experiments of Mr Lambert, recorded in the Memoirs of the Academy of Berlin for 1756, publiſhed in 1758. This moſt ſagacious philoſopher (for he highly merits that name) placed a mariner's needle at various diſtances from a magnet, in the direction of its axis, and obſerved the declination from the magnetic meridian produced by the magnet, and the obliquity of the magnet to the axis of the needle. Thus, was the action of the magnet ſet in oppoſition and equilibrium with the natural polarity of the needle. But the difficulty was to diſcover in what proportion each of thoſe forces was changed by their obliquity of action on this little lever. No man excelled Mr Lambert in addreſs in deviſing methods of mathematical inveſtigation. He obſerved, that when the obliquity of the magnet to the axis of the needle was 30°, it cauſed it to decline 15°. When the obliquity was 75°, the diſtance being the ſame, it declined 30°. Call the obliquity *o*, and the declination *d*, and let *f* be that function of the angle which is proportionable to the action. Alſo let *p* be the natural polarity of the needle, and *m* the force of the magnet. It is evident that

$$p \times f,\ 15 = m \times f,\ 30$$

And $p : m = f,\ 30 : f,\ 15$; for the ſame reaſon

$$p : m = f,\ 75 : f,\ 30$$

Therefore $f.\ 15 : f\ 30 = f,\ 30 : f,\ 75°$.

But it is well known that

Sine 15 : Sine 30 = Sine 30 : Sine 75.

Hence Mr Lambert was led to conjecture, that the ſine was that function of the angle which was proportional to the action of magnetiſm on a lever. But one experiment was inſufficient for determining this point. He made a ſimilar compariſon of ſeveral other obliquities and declinations with the ſame diſtances of the magnet, and alſo with other diſtances; and he put it paſt all diſpute, that his conjecture was juſt.

Had Mr Lambert's experiments terminated here, it muſt be granted that he has made a notable diſcovery in the theory of the intimate nature of magnetiſm. It completely refutes all the theories which pretend to explain the action of a magnet by the impulſion of a ſtream of fluid, or by preſſure ariſing from the motion of ſuch a ſtream; for in this caſe the preſſure on the needle muſt have diminiſhed in the duplicate ratio of the ſine. The directive power with the angle 90 muſt be 4 times greater than with the angle 30°; whereas it was obſerved to be only twice as great. Magnetiſm does not act therefore by the impulſion or preſſure of a ſtream of fluid, but in the manner of a ſimple incitement, as we conceive attraction or repulſion to act.

Having aſcertained the effect of obliquity, Mr Lambert proceeded to examine the effect of diſtance; and, by a moſt ingenious analyſis of his obſervations, he diſcovered, that if we repreſent the force of the magnet by *f*, and the diſtance of the neareſt pole of the magnet from the centre of the needle by δ, and if a be a conſtant quantity, nearly equal to two-thirds of the length of the needle, we have *f* proportional to $\overline{\delta - a}^2$.

Mr Lambert found this hold with very great exactneſs with magnets ten times larger, and needles twice as ſhort. But he acknowledges, that it gives a very ſingular reſult, as if the action of a magnet were exerted from a centre beyond itſelf. He attributes this to its true cauſe, the ſtill great complication of the reſult, ariſing from the action of the remote pole of the magnet. He therefore takes another method of examination, which we ſhall underſtand by and bye, when we conſider the *directive* power of a magnet. We have mentioned this imperfect attempt chiefly on account of the unqueſtionable manner in which he has aſcertained the effect of obliquity, and the importance of this determination.

We have attempted this inveſtigation in a very ſimple manner. We got ſome magnets made, conſiſting of two balls connected by a ſlender rod. By a very particular mode of impregnation, we gave them a pretty good magne-

magnetiſm ; and the force of each pole ſeemed to reſide almoſt in the centre of the ball. This was our object in giving them this ſhape. It reduced the examination both of the attractive and of the directive power to a very eaſy computation. The reſult was, that the force of each pole varied in the inverſe duplicate ratio of the diſtance. The error of this hypotheſis in no caſe amounted to $\frac{1}{15}$th of the whole. In computing for the phenomena of the directive power, the irregularities and deviations from this ratio were much ſmaller.

The previous knowledge of this function would greatly expedite and facilitate our farther inveſtigation: but we muſt content ourſelves with a very imperfect approximation, and with arriving at the deſired determination by degrees, and by a very circuitous route.

16
tempt
explain
e pheno-
ena with-
t a pre-
e know-
lge of
is law.

It is a matter of experience, that when two magnets are taken, each of which is as nearly equal as poſſible in the ſtrength of both poles, then, if they are placed with their axes in one ſtraight line, and the north pole of one fronting the ſouth pole of the other, they attract each other with a force which diminiſhes as the diſtance increaſes ; and this variation of force is regular, that is, without any ſudden changes of intenſity, till it becomes inſenſible. No inſtance has occurred of its breaking ſuddenly off when of any ſenſible force, but it appears to diminiſh continually like gravity. No inſtance occurs in which attraction is changed into repulſion.

But it is, moreover, to be particularly remarked, that, having made this obſervation with the north pole of A fronting the ſouth pole of B, if the experiment be repeated with the ſouth pole of A fronting the north pole of B, the reſults will be preciſely the ſame. And, laſtly, it is a matter of unexcepted experience, that the ſenſible action of A on B, meaſured by the force which is neceſſary for preventing the farther approach of B, is preciſely equal to the action of B on A. This is the caſe, however unequal the force of the two magnets may be ; that is, although A may ſupport ten pounds of iron, and B only ten ounces.

Now, the ſimpleſt view we can take of this experiment is, by ſuppoſing the whole action of one end or pole of a magnet to be exerted at one point of it. This will give us four actions of A on B, accompanied by as many equal and oppoſite actions of B on A. It is plain that we may content ourſelves with the inveſtigation of one only of theſe ſets of actions.

What we obſerve is the exceſs of the attractions of the poles of A for the diſſimilar poles of B above the repulſions of the ſame poles of A for the ſimilar poles of B. At all diſtances there is ſuch an exceſs. The ſum of the attractions exceeds the ſum of the repulſions competent to every diſtance.

Now this will really happen, if we ſuppoſe that the poles of a magnet are of equal ſtrength, and that, however theſe different magnets differ in ſtrength, they have the ſame law of diminution by an increaſe of diſtance. The firſt circumſtance is a very poſſible thing, and the laſt is demonſtrated by the obſerved equality of action and reaction. Every thing will now appear very plain, by repreſenting (as we did in ELECTRICITY, *Suppl.* n° 44, &c.) the intenſities of attraction and repulſion by the ordinates of a curve, of which the abſciſſæ repreſent the diſtances of the acting poles.

Therefore let A and B (fig. 2.) repreſent the two magnets, placed with their four poles S, N, s, n, in a ſtraight line. In the ſtraight line Oq take Om, Op, On, Oq, reſpectively equal to Ns, Nn, Ss, Sn ; and let MPNQ be a curve line, having Oq for its axis and aſſymptote ; and let the curve, in every part, be convex towards its axis. Then draw the ordinates mM, pP, nN, qQ, to the curve. Theſe ordinates will repreſent the intenſities of the forces exerted between the poles of the magnets, in ſuch a manner as to fulfil all the conditions that are really obſerved : For mM repreſents the attraction of the north pole N of the magnet, A for the ſouth pole s of the magnet B ; pP repreſents the repulſion of N for n ; nN repreſents the repulſion of S for s ; and qQ repreſents the attraction of S for n. The diſtance between m and n, or between p and q, is equal to the length of the magnet A, and mp, or nq, is equal to that of B. Mm, Pp, and Nn, Qq, are pairs of equidiſtant ordinates. It ſurely requires only the inſpection of the figure to ſee that, in whatever ſituation along the axis we place thoſe pairs of equidiſtant ordinates, the ſum of Mm and Qq will always exceed the ſum of Pp and Nn ; that is, the ſum of the attractions will always exceed that of the repulſions. This will not be the caſe if the curve, whoſe ordinates are proportional to the forces, have a point Z of contrary flexure, as is repreſented by the dotted curve P′ZQ′. For this curve, having Oq for its aſſymptote (in order to correſpond with forces which diminiſh continually by an increaſe of diſtance, but do not abruptly ceaſe) muſt have its convexity turned toward this aſſymptote in the remote parts. But there will be an arch MPZ between Z and O, which is concave toward the aſſymptote. In which caſe, it is poſſible that Mm + Qq ſhall be leſs than Pp + Nn ; and then the repulſions will exceed the attractions ; which is contrary to the whole train of obſervation.

It may be thought, that if the repulſion exerted between two particles be always leſs than the attraction at the ſame diſtance, the phenomena will be accounted for, although the law of action be not repreſented by ſuch a curve as has been aſſumed. Undoubtedly they will, while the diſſimilar poles front each other. But the reſults of ſuch a ſuppoſition will not agree with the phenomena while the ſimilar poles front each other : For it is an uncontradicted fact, that when two fine hard magnets, whoſe poles are nearly or exactly of equal vigour, have their ſimilar poles fronting each other, the repulſions fall very little ſhort of the attractions at the ſame diſtances when their poſition is changed : When the diſtances are conſiderable, ſcarcely any difference can be obſerved in the beginning of the experiment. The differences, alſo, which are obſerved at ſmaller diſtances, are obſerved to augment by continuing the magnets in their places without changing their diſtances ; and therefore ſeem to ariſe from ſome change produced by each on the magnetiſm of the other. And, accordingly, if we invert one of the magnets, we ſhall find that the attractions have been diminiſhed as much as the repulſions. Now, the conſequences of magnetic repulſion, being always weaker than attraction, would be the reverſe of this. The differences would appear moſt remarkable in the greater diſtances, and magnets might be found which repel at ſmall diſtances, and attract at greater diſtances ; which is contrary to all obſervation.

From all this it follows, with ſufficient evidence for our

our preſent purpoſe, that the function of the diſtance which expreſſes the law of magnetic action muſt be repreſented by the ordinates of a curve of the hyperbolic kind, referred to its aſſymptote as an axis; and therefore always convex toward this axis. We think it alſo ſufficiently clear, that the conſequences which we have deduced from the ſimple ſuppoſition of four acting points, inſtead of the combined action of every particle, may be adopted with ſafety. For they would be juſt, if there were only thoſe four particles; they would be juſt with reſpect to another four particles—therefore they would be juſt when theſe are joined; and ſo on of any number. Therefore the curve, whoſe ordinates expreſs the mean action of each pole, as if exerted by its centre of effort, will have the ſame general form: It will be convex toward its aſſymptotic axis.

It will greatly aid our conceptions of the combined actions of the four magnetic poles, if we notice ſome of the primary properties of a curve of this kind, limited by no other condition.

17 Unqueſtionable inferences from the phenomena.

Draw the chords MQ, PN, MP, NQ. Biſect them in B, D, E, F, and join EF. Draw the ordinates E e F f, and BD b (cutting EF in C). Draw P u parallel to the axis, cutting E e in ϵ. Draw alſo Q i parallel to the axis, cutting F f in φ. Alſo draw FHL parallel to the axis, and P o t parallel to QN; and draw PL l, and P e x, cutting M m in l and x.

Let each ordinate be repreſented by the letter at its interſection with the axis. Thus, the ordinates M m and Q q may be repreſented by m and q, &c.

Becauſe MP is biſected in E, M t is double of E ϵ; M l is double of EL; M x is double of E e. Alſo, becauſe P t is parallel to QN, and P u to Q i, we have $t\,u = \mathrm{N}\,i$. From theſe premiſes, it is eaſy to perceive, that,

1. $\mathrm{B}\,b = \frac{m+q}{2}$.
2. $\mathrm{D}\,b = \frac{p+n}{2}$.
3. $\mathrm{BD} = \frac{\overline{m+q} - \overline{p+n}}{2}$.
4. $\mathrm{M}u = m - p$.
5. $u\,t = n - q$.
6. $\mathrm{M}\,t = \overline{m-p} - \overline{n-q}$.
7. $\mathrm{E}\,e = \frac{m+p}{2}$.
8. $\mathrm{F}\,f = \frac{n+q}{2}$.
9. $\mathrm{M}\,l = \overline{m+p} - \overline{n+q}$.
10. $\mathrm{EL} = \frac{\overline{m+p} - \overline{n+q}}{2}$.
11. $\mathrm{CD} = \frac{\overline{m+q} - \overline{p+n}}{4}$.
12. $\mathrm{CH} = \frac{\overline{m+p} - \overline{n+q}}{4}$.

Theſe combinations will ſuggeſt to the attentive reader the explanation of many modifications of the combined action of the four poles of two magnets. They are all comprehended in one propoſition, which it will be convenient to render familiar to the thought; namely, if two pairs of equidiſtant ordinates be taken, the ſum of the two extremes exceeds that of the intermediate ones. $m + q$ is greater than $p + n$. Alſo, the difference between the pair neareſt to O exceeds the difference between the remote pair.

Now, conceiving theſe ordinates to repreſent the mutual actions of the magnetic poles, we ſee that their tendency to or from each other, or their ſenſible attractions or repulſions, are expreſſed by $\overline{m+q} - \overline{n+p}$; that is, by the exceſs of the ſum of the actions of the neareſt and moſt remote poles above the ſum of the actions of the intermediate diſtant poles. It will alſo be frequently convenient to conſider this tendency as repreſented by $\overline{m-p} - \overline{n-q}$; that is, by the exceſs of the difference of the actions of the neareſt pole of A on the two poles of B, above the difference of the actions of its remote pole on the ſame poles of B.

Let us now conſider ſome of the chief modifications of theſe actions.

18 Explanation of the obſerved attraction of magnets,

1. Let the diſſimilar poles front each other. It is plain that $m + q$ repreſent attractions, and that $p + n$ repreſent repulſions. Alſo $m + q$ is greater than $p + n$. Therefore the magnets will attract each other. This attraction is alſo repreſented by $\overline{m-p} - \overline{n-q}$.

Now $\overline{m+q} - \overline{p+n}$ is evidently equal to M t, or to twice E o, or to twice BD, or to four times CD.

This action will be increaſed,

1. By increaſing the ſtrength of either of the magnets. The action of the magnets is the combined action of each acting particle of the one on each acting particle of the other; and it is mutual. Therefore all the ordinates will increaſe in the ratio of the ſtrength of each magnet, and their ſums and differences will increaſe in the ſame ratio.

2. By diminiſhing the diſtance between the magnets. For this brings all the ordinates nearer to O, while their diſtances mp, pn, nq, remain as before. In this caſe it is plain, that M u, the difference of M m and P p, will increaſe faſter than $t\,u$ or N i, the difference between N n and Q q. Therefore M t will increaſe; that is, the attraction will increaſe.

3. By increaſing the length of A, while the diſtance between them remains the ſame. For O m remaining the ſame, as alſo $m\,p$ and $n\,q$, while $n\,q$ is only removed farther from $m\,p$, it is plain M u remains the ſame, and that N i and $t\,u$ are diminiſhed; therefore M t muſt increaſe, or the attraction muſt increaſe.

4. By increaſing the length of B, the diſtance between them remaining the ſame. For this increaſes $m\,p$ and $n\,q$; and conſequently increaſes M u and $t\,u$. But M u increaſes more than $t\,u$; and therefore M t is increaſed, and the attraction or tendency is increaſed.

All theſe conſequences of our original ſuppoſition, that the magnetic action may be repreſented by the ordinates of a curve every where convex to an aſſymptotic axis, are ſtrictly conformable to obſervation.

19 And of their rep ſions.

If we place the magnets with their ſimilar poles fronting each other, it is evident that the ordinates which expreſſed attractions in the former caſe, will now expreſs repulſions; and that the forces with which the magnets now repel each other, are equal to thoſe with which they attracted when at the ſame diſtances. When the experiments are made with good loadſtones, or very fine magnets, tempered extremely hard, and having the energy of their poles ſenſibly reſiding in a ſmall ſpace very near the extremities, the reſults are alſo very near-

ly

ly conformable to this mathematical theory; but there is generally a weaker action. The magnets ſeldom repel as ſtrongly as they attract at the ſame diſtance; at leaſt when theſe diſtances are ſmall. If one or both of the magnets is ſoft, or if one of them be much more vigorous than the other, there are obſerved much greater deviations from this theory. The repulſions are *conſiderably* weaker than the attractions at the ſame diſtance, and the law of variation becomes extremely different. When placed at very conſiderable diſtances, they repel. As the magnet B is brought nearer to A, the repulſion increaſes, agreeably to the theory, but not ſo faſt. Bringing them ſtill nearer, the repulſion ceaſes to increaſe, then gradually diminiſhes, and frequently vaniſhes altogether, before the magnets are in contact; and when brought ſtill nearer, it is changed into attraction.

20
ming
eptions
iated.

But more careful obſervation ſhews, that this ano maly does not invalidate the theory. It is found that the vigour of the magnets is permanently changed by this proceſs. The magnets act on each other in ſuch a way as to weaken each other's magnetiſm. Nay, it frequently happens, that the weaker or the ſofter of the two has had its magnetiſm changed, and that the pole neareſt to the other has changed its nature. While they are lying in contact, or at ſuch a diſtance that they attract, although their ſimilar poles front each other, it is found that the pole of one of them is really changed; although it may ſometimes recover its former ſpecies again, but never ſo vigorouſly as when the other magnet is removed. In ſhort, it is obſerved, that the magnetiſm is diminiſhed in all experiments in which the magnets repel each other, and that it is improved in all experiments in which they attract.

We have hitherto ſuppoſed the magnets placed with their axes in one ſtraight line. If they are differently placed, we cannot aſcertain by this ſingle circumſtance of the law of magnetic action, whether they will attract or repel—we muſt know ſomewhat more of the variation of force by a change of diſtance.

21
RECTIVE
WER ex-
ined.

If the magnet B be not at liberty to approach toward A, or recede from it, but be ſo ſupported at its centre B that it can turn round it, it is very plain that it will retain the poſition in which it is drawn in the figure. For its ſouth pole *s* being more attracted by N than it is repelled by S, is, on the whole, attracted by the magnet A; and, by this attraction, it would vibrate like a pendulum that is ſupported at the centre B. In like manner, its north pole *n* is more repelled by N than it is attracted by S, and is, on the whole, repelled. The part B *n* would therefore alſo vibrate like a pendulum round B. Thus each half of it is urged into the very poſition which it now has; and if this poſition be deranged a little, the attraction of *s* B toward A, and the repulſion of *n* B from it, would impel it toward the poſition *s* B *n*.

This will be very evident, if we put the magnet B into the poſition $s'Bn'$, at right angles to the line AB. The pole s' and the pole n' are urged in oppoſite, and therefore conſpiring, directions with equal forces, very nearly at right angles to $n's'$, if the magnet B be ſmall. In any oblique poſition, the forces will be ſomewhat unequal, and account muſt be had of the obliquity of the action, in order to know the preciſe rotative momentum of the actions.

Dr Gilbert has given to this modification of the action of A on B, the name of VIS DISPONENS; which we may tranſlate by DIRECTIVE POWER or FORCE. Alſo, that modification of the tendency of B to or from A is called by him the VERTICITAS of B. We might call it the VERTICITY of B; but we think that the name POLARITY is ſufficiently expreſſive of the phenomenon; and as it has come into general uſe, we ſhall abide by it.

22
Its meaſure.

It is not ſo eaſy to give a general, and at the ſame time preciſe, meaſure of the directive power of A and polarity of B. The magnet B muſt be conſidered as a lever; and then the force tending to bring it into its ultimate poſition *n s* depends both on the diſtance of its poles from N and S, and alſo on the angle which the axis of B makes with the line AB. When the axis of B coincides with AB, the force acting on its poles, tending to *keep* them in that ſituation, is evidently $\overline{m+p}-\overline{n+q}$, and therefore may be repreſented by M *l* (in fig. 2.), or by twice EL. or by four times CH. If B has the poſition $n'Bs'$, perpendicular to AB, let the ordinates E*e* and F*f* cut the curve on I and K; and draw KL parallel to the axis (our figure cauſes this line almoſt to coincide with QL, and in all important caſes it will be nearly the ſame). In this caſe IL will expreſs one half of this force. Either of theſe eſtimations of this modification of the mutual action of the magnets, will be ſufficient for the objects we have in view.

23
How increaſed and diminiſhed.

The directive power of A, and the polarity of B, are increaſed,

1. By increaſing the ſtrength of one or both of the magnets. This is evident,

2. By diminiſhing the diſtance of the magnets. For this, by increaſing the ſum of M *m* and P *p* more than the ſum of N *n* and Q *q*, muſt increaſe EL or M *l*.

3. By increaſing the length of A. For this, by removing *n* and *q* farther from *m* and *p*, muſt depreſs the points L and *l*, and increaſe EL, or IL, or M *l*.

4. By diminiſhing the length of B, while the diſtance N *s* between the magnets remains the ſame. For this, by bringing *p* and *q* nearer to *m* and *n*, muſt increaſe M *m* + P *p* more than N *n* + Q *q*. Or, by bringing E *e* and F *f* nearer to M *m* and N *n*, it muſt increaſe EL and M *l*.

If the diſtance N *n* between the pole of A and the remote pole of B remain the ſame, the directive force of A, and polarity of B, are diminiſhed by diminiſhing the length of B, as is eaſily ſeen from what has been juſt now ſaid. It is alſo diminiſhed, but in a very ſmall degree, by diminiſhing the length of B, when the diſtance between the centres of A and B remain the ſame. For, in this caſe, the ordinates I *e* and K *f* retain their places; but the points *m* and *p* approach to *e*; and this brings the interſection E of the ordinate and chord nearer to I, and diminiſhes EL, becauſe the point L is not ſo much depreſſed by the approach of F to K as E is depreſſed.

24
Circumſtances affecting the proportion of the attractive and directive powers.

But in all caſes, the *ratio* of the directive power of A to its attractive force, or of the polarity of B to its tendency to A, is increaſed by diminiſhing the length of B. For it is plain, that by diminiſhing *m p* and *n q*, while I *e* and K *f* keep their places, the point *o* is raiſed, and the point L is depreſſed; and therefore the ratio of EL to E *o*, or of M *l* to M *t*, is increaſed. We even ſee that, by diminiſhing the length of B continually

and

and without end, the ratio of Ml to Mt may be made to exceed any ratio that can be aſſigned.

25
The polarity of a ſmall magnet may be great while the attraction is inſenſible.

Now, ſince diminiſhing the length of B increaſes the ratio of the directive power of A to its attractive power, while increaſing the length of A increaſes both, and alſo increaſes the ratio of EL to E o (as is very eaſily ſeen), and ſince this increaſe may be as great as we pleaſe, it neceſſarily follows, that if the ſame very ſmall magnet B be placed at ſuch diſtances from a large and ſtrong magnet A, and from a ſmaller and leſs vigorous one C, as to have equal polarities to both, its tendency to A will be leſs than its tendency to C. It may even be leſs in any ratio we pleaſe, by ſufficiently diminiſhing the length of B.

Dr Gilbert obſerved this; and he expreſſes his obſervation by ſaying, that the directive power extends to greater diſtances than the attracting power. We muſt juſt conclude, that the laſt becomes *inſenſible* at ſmaller diſtances than the firſt. This will be found a very important obſervation. It may be of uſe to keep in mind, that the directive power of a magnet A on another magnet B, is the difference of the *ſums* of the actions of each pole of A on both poles of B; and the attractive power of A for another magnet B, is the difference of the *differences* of theſe actions.

It may be alſo remarked juſt now, that the directive force of A always exceeds its attractive force by the quantity $2\ (p - q)$. For their difference may be expreſſed by tl, which is equal to twice o L. Now ϵe is equal to Pp, or to p; and ϵ L is equal to Pp — Ff, or to Pp — Qq — Fϵ, or to Pp — Qq — $o\epsilon$. Therefore $o\text{L} = \text{P}p - \text{Q}q$, and $tl = 2\ (\text{P}p - \text{Q}q), = 2\ (p - q)$.

By inſpecting this figure with attention, we obtain indications of many intereſting particulars. If the lengths of the magnets A and B are the ſame, the point n in the axis of the curve will coincide with p. As the length of A increaſes, the part nq is removed farther from the part mp. The line Pt becomes leſs inclined to the axis, and is ultimately parallel to it, when n is infinitely remote. At this time L falls on e; ſo that the ultimate ratio of the attraction to the polarity is that of Eϵ to Ee, when the magnet A is infinitely long. It is then the ratio of the difference of the actions of the neareſt pole of A on the two poles of B to the ſum of theſe actions. Hence it follows, that when A is very great and B very ſmall, the polarity of B is vaſtly greater than its tendency to A. It may have a great polarity when its tendency is inſenſible.

The ratio of the polarity to the attraction alſo increaſes by increaſing the diſtance of the magnets while their dimenſions continue the ſame. This will appear, by remarking that the chords MP and NQ muſt interſect in ſome point w; and that when the four points m, p, n, and q, move off from O, keeping the ſame diſtances from each other, Eo will diminiſh faſter than EL, and the ratio of EL to EO will continually increaſe.

Therefore when a ſmall magnet B is placed at ſuch a diſtance from a great magnet A, and from a ſmaller one C, as to have equal polarity to both, its tendency to C will exceed its tendency to A. For the polarities being equal, it muſt be farther from the great magnet; in which caſe the ratio of its polarity to its attraction is increaſed.

And this will alſo obtain if the magnets differ alſo in ſtrength. For, to have equal polarities, B muſt be ſtill farther from the great and powerful magnet.

For all theſe reaſons, a large and powerful magnet may exert a ſtrong directive power, while its attractive power is inſenſible.

26
Peculiarities of oblique poſitions of two magnets.

We have hitherto ſuppoſed the magnet B to be placed in the direction of the axis of A, and only at liberty to turn round its centre B. But let its centre be placed on the centre of A, as in fig. 3. it muſt evidently take a poſition which may be called ſubcontrary to that of A, the north pole of B turning toward the ſouth pole of A, and its ſouth pole turning toward the north pole of A.

The ſame thing muſt happen when the centre of B is placed in B, any where in the line AE perpendicular to NS. S attracts n with a force nb, while N repels n with a force no, ſomewhat ſmaller than nb. Theſe two compoſe the force nd. In like manner, the two forces se and sf, exerted by N and S on the pole s, compoſe the force sq. Now if the axis of the magnet B be parallel to NS, but the poles in a contrary poſition, and if each magnet be equally vigorous in both poles, the magnet B will retain this poſition; becauſe the forces nb and se are equal, as alſo the forces nc and sf. Theſe muſt compoſe two forces nd and sq, which are equal, and equally inclined to ns; and they will therefore be in equilibrio on this lever.

Let us now place the centre of the ſmall magnet in C, neither in the axis of the other, nor in the perpendicular AE. Let its north pole n point toward the centre of A. It cannot remain in this poſition; for N repels n with a force nc, while S attracts it with a force nb (ſmaller than nc, becauſe the diſtance is greater). Theſe two compoſe a force nd conſiderably different from the direction cn of its axis. In like manner, the ſouth pole s of the ſmall magnet is acted on by two forces se and sf, exerted by the two poles of A, which compoſe a force sq nearly equal and parallel to nd, but in a nearly oppoſite direction. It is plain that theſe forces muſt turn the ſmall magnet round its centre C, and that it cannot reſt but in a poſition nearly parallel to nd or sf. Its poſition is better repreſented by fig. 4. with its ſouth pole turned toward the north pole of the other magnet, and its north pole in the oppoſite direction.

What the preciſe poſition will be, depends on that function of the diſtance which is always proportional to the intenſity of the action; on the force of each of the poles of A, and on the length of the magnet B. Nay, even when we know this function, the problem is ſtill very intricate.

27
Means
acquirin
near me
ſure of t
law of a
tion.

There are methods by which we may approximate to the function with ſucceſs. If the magnet B be indefinitely ſmall, ſo that we may conſider the actions on its two poles as equal, the inveſtigation is greatly ſimplified. For, in this caſe, each pole of the ſmall magnet B (fig. 5.) may be conceived as coinciding with its centre. Then, drawing NB, SB, and taking Bb toward N, to repreſent the force with which N attracts the ſouth pole of B, and taking Bc, in SB produced, to repreſent the force with which S repels the ſame pole, the compound force acting on this pole is Bd, the diagonal of a parallelogram Bb, dc. In like manner, we muſt take Be, in Nb produced, and equal to Bb,

to

to repreſent the repulſion of N for the north pole of B, and B f equal to B c, to repreſent the attraction of S for this pole. The compound force will be B g, equal and oppoſite to B d. It follows evidently from this inveſtigation, that the ſmall magnet will not reſt in any poſition but dg. In this ſuppoſition, therefore, of extreme minuteneſs of the magnet B, one of the parallelograms is ſufficient. We may farther remark, that we have this approximation ſecure againſt any error ariſing from the ſuppoſition that all the action of each pole of B is exerted by one point. Although we ſuppoſe it diffuſed over a conſiderable portion of the magnet, ſtill the extreme minuteneſs of the whole makes the action, even on its extreme points, very nearly equal.

28
w of ac-
n inverſ-
ared—
AGNE-
CCURVE

Hence may be derived a conſtruction for aſcertaining the poſition of the needle, when the function m of the diſtance is given, or for diſcovering this function by obſervation of the poſition of the needle.

Let NS (fig. 5. n° 2.) meet the direction of the needle in K. Make BG = BN, and draw NF, GE, SH, perpendicular to BK. It is evident that B b is to B c, or $b\,d$, as the ſine of the angle HBS to the ſine of KBN. Therefore, becauſe BG and BN are equal, we have B b : B c = GE : NF.

Therefore GE : NF = BS^m : BN^m
But SH : GE = BS : BN
Therefore SH : NF = BS^{m+1} : BN^{m+1}
And SK : NK = BS^{m+1} : BN^{m+1}

If magnetic action be inverſely as the diſtance, we have SK : NK = BS^2 : BN^2, and B is in the circumference of a circle which paſſes through S and N, and has BK for a tangent, as is plain by elementary geometry. If the action be inverſely as the ſquare of the diſtance, we have SK : NK = BS^3 : BN^3, and B is in the circumference of a curve of more difficult inveſtigation. But, as in the circle, the ſum of the angles BSN and BNS is a conſtant angle; ſo, in this curve, the ſum of the coſines of thoſe angles is a conſtant quantity. This ſuggeſts a very ſimple conſtruction of the curve. Let it paſs through the point T of the line AT, drawn from the centre of the magnet, perpendicular to its axis. Deſcribe the ſemicircle SPQN, cutting ST and NT in P and Q. Then, in order to find the point where any line SB cuts the curve, let it cut the ſemicircle in p, and apply the line N q = SP + NQ — S p, and produce it till it meet the line SB in B, which is a point in the curve; for it is evident that S p and N q are the coſines of BSN and BNS. We hope to give, by the help of a learned friend, the complete conſtruction of curves for every value of m, in an Appendix to this article. It will form a new and curious claſs, arranged by the functions of the angles at N and S.

But, in the mean time, we have determined the poſition of an indefinitely ſmall needle, in reſpect of a magnet of which we may conceive the polar activity concentrated in two points; and we may, on the other hand, make uſe of the obſerved poſitions of ſuch a needle and magnet for diſcovering the value of m. For, ſince $\frac{SK}{NK} = \frac{SB^{m+1}}{NB^{m+1}}$, it is plain that $m = \frac{\text{Log. } SK : NK}{\text{Log. } SB : NB} - 1$. Thus, in an obſervation which the writer of this article made on a very ſmall needle, and a magnet having globular poles, and $8\frac{1}{8}$ inches between their centres, he found SB = $5\frac{1}{3}$, NB = $\frac{1}{3}$, SK = 11,49, and NK = 3,37. This gives m = 1,97, which differs from 2 only $\frac{1}{60}$th part. Finding it ſo very near the inverſe duplicate ratio of the diſtance, a circle VUZ was deſcribed, the circumference of which is the locus of SB : BN = 8 : 5,333. When the centre of the needle was placed anywhere in the circumference of this circle, it ſcarcely deviated from the point K, except when ſo far removed from the magnet that its natural polarity prevailed over the directive power of the magnet, or ſo near its middle that the action of the cylindrical part became very ſenſible.

It is plain that the length of the needle muſt occaſion ſome deviation from the magnetic direction, by deſtroying the perfect equality of action on its two poles. He therefore employed three needles of $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ of an inch in length; and by noticing the differences of direction, he inferred what would be the direction, if the forces on each pole were preciſely equal. He had the pleaſure of ſeeing that the deviation from the inverſe duplicate ratio of the diſtances was ſcarcely perceptible.

Mr Lambert's experiments on the directive power of the magnet, narrated in his ſecond diſſertation in the 22d volume of the Memoirs of the Academy of Berlin, are the moſt valuable of all that are on record; and the ingenious addreſs with which they are conducted, and the inferences are drawn, would have done credit to Newton himſelf. We earneſtly recommend the careful peruſal of that Eſſay, as the moſt inſtructive of any that we have read. The writer of this found himſelf obliged to repeat all his former experiments, mentioned above, in Mr Lambert's manner, and with his precaution of keeping the needle in its natural poſition; a circumſtance to which he had not ſufficiently attended before. The new reſults were ſtill more conformable to his conjecture as to the law of variation. Mr Lambert cloſes his diſſertation with an hypotheſis, "that the force of each tranſverſe element of a magnet is as its diſtance from the centre, and its action on a particle of another magnet is inverſely as the ſquare of the diſtance." On this ſuppoſition, he calculates the poſition of a very ſmall needle, and draws three of the curves to which it ſhould be the tangent. Theſe are very exactly coincident with ſome that he obſerved. We tried this with ſeveral magnetic bars, and found it very conformable to obſervation in ſome magnets; but deviating ſo far in the caſe of other magnets, that we are convinced that there is no rule for the force of each tranſverſe element of a magnet, and that the magnetiſm is differently diſpoſed in different magnets. It was chiefly this which induced us to form the magnets employed in this reſearch of two balls united by a ſlender rod. Lichtenberg, in his notes on Erxleben's Natural Philoſophy, ſays, that there is a MS. of the celebrated Tobias Mayer in the library of the Academy of Gottingen, in which he aſſumes the hypotheſis above-mentioned, and gives a conſtruction of the magnetic curves founded on it, making them a kind of catenaria. The interior curves do indeed reſemble the catenaria, but the exterior are totally unlike. But there is no occaſion for much argument to convince us, that the firſt part of this hypotheſis is not only gratuitous, but unwarranted by any general phenomena. We know that a magnetical bar may have its magnetiſm very differently diſpoſed; for it may have more than two poles, and the intermediate poles *cannot* have this diſpoſition of the magnetiſm.

netiſm. Such a diſpoſition is perhaps poſſible; but is by no means general, or even frequent. We are diſpoſed to think, that permanent magnetiſm muſt have its intenſity diminiſhing in the very extremity of the bar. The reader may gueſs at our reaſons from what is ſaid in ELECTRICITY, *Suppl.* n° 222.

29 Primary and secondary, or simple and compound curves.

The following very curious and inſtructive phenomenon was the firſt thing which greatly excited the curioſity of the writer of this article, and long puzzled him to explain it. Indeed it was his endeavours to explain it which gradually opened up to him the theory of the mutual action of magnets contained in theſe paragraphs, and firſt gave him occaſion to admire the ſagacity of Dr Gilbert, and to ſee the connecting principle of the vaſt variety of obſervations and experiments which that philoſopher had made It ſeems owing to the want of this connecting principle, that a book ſo rich in facts ſhould be ſo little read, and that ſo many of Dr Gilbert's obſervations have been publiſhed by others as new diſcoveries.

Amuſing himſelf in the ſummer 1758 with magnetic experiments, two large and ſtrong magnets A and B (fig. 6), were placed with their diſſimilar poles fronting each other, and about three inches apart. A ſmall needle, ſupported on a point, was placed between them at D, and it arranged itſelf in the ſame manner as the great magnets. Happening to ſet it off to a good diſtance on the table, as at F, he was ſurpriſed to ſee it immediately turn round on its pivot, and arrange itſelf nearly in the oppoſite direction. Bringing it back to D reſtored it to its former poſition. Carrying it gradually out along DF, perpendicular to NS, he obſerved it to become ſenſibly more feeble, vibrating more ſlowly; and when in a certain point E, it had no polarity whatever towards A and B, but retained any poſition that was given it. Carrying it farther out, it again acquired polarity to A and B, but in the oppoſite direction; for it now arranged itſelf in a poſition that was parallel to NS, but its north pole was next to N, and its ſouth pole to S.

This ſingular appearance naturally excited his attention. The line on which the magnets A and B were placed had been marked on the table, as alſo the line DF perpendicular to the former. The point E was now marked as an important one. The experiments were interrupted by a friend coming in, to whom ſuch things were no entertainment. Next day, wiſhing to repeat them to ſome friends, the magnets A and B were again laid on the line on which they had been placed the day before, and the needle was placed at E, expecting it to be neutral. But it was found to have a conſiderable verticity, turning its north pole toward the magnet B; and it required to be taken farther out, toward F, before it became neutral. While ſtanding there, ſomething chanced to joggle the magnets A and B, and they inſtantly ruſhed together. At the ſame inſtant, the little magnet or needle turned itſelf briſkly, and arranged itſelf, as it had done the day before, at F, quivering very briſkly, and thus ſhewing great verticity. This naturally ſurpriſed the beholders; and we now found that, by gradually withdrawing the magnets A and B from each other, the needle became weaker—then became neutral—and then turned round on its pivot, and took the contrary poſition. It was very amuſing to obſerve how the ſimply ſeparating the magnets A and B, or bringing them together, made the needle aſſume ſuch a variety of poſitions and degrees of vivacity in each.

The needle was now put in various ſituations, in reſpect to the two great magnets; namely, off at a ſide, and not in the perpendicular DF. In theſe ſituations, it took an inconceivable variety of poſitions, which could not be reduced to any rule; and in moſt of them, it required only a motion of one of the great magnets for an inch or two, to make the needle turn briſkly round on its pivot, and aſſume a poſition nearly oppoſite to what it had before.

But all this was very puzzling, and it was not till after ſeveral months, that the writer of this article, having conceived the notion of the magnetic curves, was in a condition to explain the phenomena. With this aſſiſtance, however, they are very clear, and very inſtructive

Nothing hinders us from ſuppoſing the magnets A and B perfectly equal in every reſpect. Let NHM, NEL, be two magnetic curves belonging to A; that is, ſuch that the needle arranges itſelf along the tangent of the curve. Then the magnet B has two curves SGK, SEI, perfectly equal, and ſimilar to the other two. Let the curves NHM and SGK interſect in C and F. Let the curves NEL and SEI touch each other in E.

The needle being placed at C, would arrange itſelf in the tangent of the curve KGS, by the action of B alone, having its north pole turned toward the ſouth pole S of B. But, by the action of A alone, it would be a tangent to the curve NHM, having its north pole turned away from N. Therefore, by the combined action of both magnets, it will take neither of theſe poſitions, but an intermediate one, nearly biſecting the angle formed by the two curves, having its north pole turned toward B.

But remove the needle to F. Then, by the action of the magnet A, it would be a tangent to the curve FM, having its north pole toward M. By the action of B, it would be a tangent to the curve KFG, having its north pole in the angle MFG, or turned toward A. By their joint action, it takes a poſition nearly biſecting the angle GFM, with its north pole toward A.

Let the needle be placed in E. Then, by the action of the magnet A, it would be a tangent to the curve NEL, with its north pole pointing to F. But, by the action of B, it will be a tangent to SEI, with its north pole pointing to D. Theſe actions being ſuppoſed equal and oppoſite, it will have no verticity, or will be neutral, and retain any poſition that is given to it.

The curve SEI interſects the curve NHM in P and Q. The ſame reaſoning ſhews, that when the needle is placed at P, it will arrange itſelf with its north pole on the angle SPH: but, when taken to Q, it will ſtand with its north pole in the angle EQM.

From theſe facts and reaſonings we muſt infer, that, for every diſtance of the magnets A and B, there will be a ſeries of curves, to which the indefinitely ſhort needle will always be a tangent. They will riſe from the adjoining poles on both ſides, croſſing diagonally the lozenges formed by the PRIMARY or SIMPLE curves, as in fig. 6. Theſe may be called COMPOUND or SECONDARY magnetic curves. Moreover, theſe ſecondary

condary curves will be of two kinds, according as they paſs through the firſt or ſecond interſections of the primary curves, and the needle will have oppoſite poſitions when placed on them. Theſe two ſets of curves will be ſeparated by a curve GEH, in the circumference of which the needle will be neutral. This curve paſſes through the points where the primary curves touch each other. We may call this the *line of neutrality* or inactivity.

We now ſee diſtinctly the effect of bringing the magnets A and B nearer together, or ſeparating them farther from each other. By bringing them nearer to each other, the point E, which is now a point of neutrality, may be found in the *ſecond* interſection (ſuch as F) of two magnetic curves, and the needle will take a ſubcontrary poſition. By drawing them farther from each other, E may be in the *firſt* interſection of two magnetic curves, and the needle will take a poſition ſimilar to that of C.

If the magnets A and B are not placed ſo as to form a ſtraight line with their four poles, but have their axes making an angle with each other, the contacts and interſections of their attending curves may be very different from thoſe now repreſented; and the poſitions of the needle will differ accordingly. But it is plain, from what has been ſaid, that if we knew the law of action, and conſequently the form of the primary curves, we ſhould always be able to ſay what will be the poſition of the needle. Indeed, the conſideration of the ſimple curves, although it was the mean of ſuggeſting to the writer of this article the explanation of thoſe more complicated phenomena, is by no means neceſſary for this purpoſe. Having the law of magnetic action, we muſt know each of the eight forces by which the needle is affected, both in reſpect of direction and intenſity; and are therefore able to aſcertain the ſingle force ariſing from their compoſition.

Secondary curves of repulſion.

When the ſimilar poles of A and B are oppoſed to each other, it is eaſy to ſee, that the poſition of the needle muſt be extremely different from what we have been deſcribing. When placed anywhere in the line DF, between two magnets, whoſe north poles front each other in N and S, its north pole will always point away from the middle point D. There will be no neutral point E. If the needle be placed at P or Q, its north pole will be within the angle EPH, or FQI. This poſition of the magnets gives another ſet of ſecondary curves, which alſo croſs the primary curves, paſſing diagonally through the lozenges formed by their interſection. But it is the other diagonal of each lozenge which is a chord to thoſe ſecondary curves. They will, therefore, have a form totally different from the former ſpecies.

30
Remarks on this inveſtigation.

The conſideration of this compounded magnetiſm is important in the ſcience, both for explaining complex phenomena, and for advancing our knowledge of the great deſideratum, the law of magnetic action. It ſerves this purpoſe remarkably. By employing a very ſmall needle, the points of neutrality aſcertain very nearly where the magnetic curves have a common tangent, and ſhews the poſition of this tangent. By placing the two magnets ſo as to form various angles with each other, we can, by means of theſe neutral points, know the poſition of the tangent in every point of the curve, and thus can aſcertain the form of the curve, and the law of action, with conſiderable accuracy. The writer of this article took this method; and the reſult confirmed him in the opinion, that it was in the inverſe duplicate ratio of the diſtances. The chief (perhaps the only) ground of error ſeemed to be the difficulty of procuring large magnets, having the action of each pole very much concentrated. Large magnets muſt be employed. He attempted to make ſuch, conſiſting of two ſpherical balls, joined by a ſlender rod. But he could not give a ſtrong magnetiſm to magnets of this form, and was forced to make uſe of common bars, the poles of which are conſiderably diffuſed. This diffuſion of the pole renders it very difficult to ſelect with propriety the points from which the diſtances are to be eſtimated, in the inveſtigation of the relation between the forces and diſtances.

He tried another method for aſcertaining this ſo much deſired law, which had alſo the ſame reſult. Having made a needle conſiſting of two balls joined by a ſlender rod, and having touched it with great care, ſo that the whole ſtrength of its poles ſeemed very little removed from the centres of the balls, he counted the number of horizontal vibrations which it made in a given time by the force of terreſtrial magnetiſm. He then placed it on the middle of a very fine and large magnet, placed with its poles in the magnetic meridian, the north pole pointing ſouth. In this ſituation he counted the vibrations made in a given time. He then raiſed it up above the centre of the large magnet, till the diſtance of its poles from thoſe of the great magnet were changed in a certain proportion. In this ſituation its vibrations were again counted. It was tried in the ſame way in a third ſituation, conſiderably more remote from the great magnet. Then, having made the proper reduction of the forces correſponding to the obliquity of their action, the force of the poles of the great magnet was computed from the number of vibrations. To ſtate here the circumſtances of the experiment, the neceſſary reductions, and the whole computations, would occupy ſeveral pages, and to an intelligent reader would anſwer little purpoſe. Mr Lambert's excellent diſſertation in the 22d vol. of the *Mem. de l'Acad. de Berlin*, will ſhew the prolixity and intricacy of this inveſtigation. Suffice it to ſay, that theſe experiments were the moſt conſiſtent with each other of any made by the writer of this article, with the view of aſcertaining the law of magnetic action; and it is chiefly from their reſult that he thinks himſelf authoriſed to ſay, with ſome confidence, that it is inverſely as the ſquare of the diſtance. Theſe experiments were firſt made in a rough way in 1769 and 1770. In 1775, obſerving that Mr Æpinus ſeemed to think the action inverſely as the diſtance (ſee his *Tentam. Theor. Electr. et Magn.* § 301. &c.), they were repeated with very great care; and to theſe were added another ſet of experiments, made with the ſame magnet and the ſame needle, placed not above the magnet, but at one ſide (but always in the line through the centre, perpendicular to the axis, ſo that the actions of the two poles might be equal). This diſpoſition evidently ſimplifies the proceſs exceedingly. The reſult of the whole was ſtill more ſatisfactory. This concluſion is alſo confirmed by the experiments of Mr Coulomb in the Memoirs of the Academy of Sciences at Paris for 1786 and 1787. It would ſeem therefore to be pretty well eſtabliſhed. Another method, which ſeems ſuſceptible of conſiderable accuracy, ſtill remains to be tried. It will be mentioned in due time.

Such then are the general laws obſerved in the mutual action of magnets. We think it ſcarcely neceſſary to enter into a farther detail of their conſequences, correſponding to the innumerable varieties of poſitions in which they may be placed with reſpect to each other. We are confident, that the ſenſible actions will always be found agreeable to the legitimate conſequences of the general propoſitions which we have eſtabliſhed in the preceding paragraphs. We proceed therefore to conſider ſome phyſical facts not yet taken notice of, which have great influence on the phenomena, and greatly aſſiſt us in our endeavours to underſtand ſomething of their remote cauſe.

31
Magnetiſm is temporary and periſhing.

Magnetiſm, in all its modifications of attraction, repulſion, and direction, is, in general, of a temporary or periſhing nature. The beſt loadſtones and magnets, unleſs kept with care, and with attention to certain circumſtances, are obſerved to diminiſh in their power. Natural loadſtones, and magnets made of ſteel, tempered as hard as poſſible, retain their virtue with greateſt obſtinacy, and ſeldom loſe it altogether, unleſs in ſituations which our knowledge of magnetiſm teaches us to be unfavourable to its durability. Magnets of tempered ſteel, ſuch as is uſed for watch-ſprings, are much ſooner weakened, part with a greater proportion of their force by ſimple keeping, and finally retain little or none. Soft ſteel and iron loſe their magnetiſm almoſt as ſoon as its producing cauſe is removed, and cannot be made to retain any ſenſible portion of it, unleſs their metallic ſtate ſuffer ſome change.

1. Hurt by improper poſition.

1. Nothing tends ſo much to impair the power of a magnet as the keeping it in an improper poſition. If its axis be placed in the magnetic direction, but in a contrary poſition, that is, with the north pole of it where the ſouth pole tends to ſettle, it will grow weaker from day to day; and unleſs it be a natural loadſtone, or be of hard tempered ſteel, it will, after no very long time, loſe its power altogether.

2. By heat; effects of thunder and electricity.

2. This diſſipation of a ſtrong magnetic power is greatly promoted by heat. Even the heat of boiling water affects it ſenſibly; and if it be made red hot, it is entirely deſtroyed. This laſt fact has long been known. Dr Gilbert tried it with many degrees of violent heat, and found the conſequences as now ſtated; but having no thermometers in that dawn of ſcience, he could not ſay any thing preciſe. He only obſerves, that it is deſtroyed by a heat not ſufficient to make it viſible in a dark room. Mr Canton found even boiling water to weaken it; but on cooling again the greateſt part was recovered.

3. By violent treatment.

3. What is more remarkable, magnetiſm is impaired by any rough uſage. Dr Gilbert found, that a magnet which he had impregnated very ſtrongly, was very much impaired by a ſingle fall on the floor; and it has been obſerved ſince his time, that falling on ſtones, or receiving any concuſſion which cauſes the magnet to ring or ſound, hurts it much more than beating it with any thing ſoft and yielding. Grinding a natural loadſtone with coarſe powders, to bring it into ſhape, weakens it much; and loadſtones ſhould therefore be reduced into a ſhape as little different from their natural form as poſſible; and this ſhould be done briſkly, cutting them with the thin diſks of the lapidary's wheel, cutting off only what is neceſſary for leaving their moſt active parts or poles as near their extremities as we can.

All theſe cauſes of the diminution of magnetiſm are more operative if the magnet be all the while in an improper poſition.

4. By other magnets.

4. Laſtly, magnetiſm is impaired and deſtroyed by placing the magnet near another magnet, with their ſimilar poles fronting each other. We have had occaſion to remark this already, when mentioning the experiments made with magnets in this poſition, for aſcertaining the general laws or variations of their repulſion. We there obſerved, that magnets ſo ſituated always weakened each other, and that a powerful magnet often changed the ſpecies of the neareſt pole of one leſs powerful. This change is recovered, in part at leaſt, when it has taken place in a loadſtone or a magnet of hard ſteel; but in ſpring tempered ſteel the change is generally permanent, and almoſt to the full extent of its condition while the magnets are together. It is to be remarked, that this change is gradual; and is expedited by any of the other cauſes, particularly by heat or by knocking.

32
Magnetiſm may be acquired,

On the other hand, magnetiſm is acquired by the ſame means, when ſome other circumſtances are attended to.

1. By magnetical poſition;

1. A bar of iron, which has long ſtood in the magnetic direction, or nearly ſo, will gradually acquire magnetiſm, and the ends will acquire the polarity correſponding to their ſituation. In this country, and the north of Europe, the old ſpindles of turret vanes, old bars of windows, &c. acquire a ſenſible magnetiſm; their lower extremity becoming a north pole, and the other end a ſouth pole. Gilbert ſays, that this was firſt obſerved in Mantua, in the vane ſpindle of the Auguſtine church—"*Vento flexa* (ſays he) *de prompta, et apothecario cuidam conceſſa, attrahebat ferrea ramenta, vi perquam inſigni.*" The upper bar of a hand rail to a ſtair on the north ſide of the higheſt part of the ſteeple of St Giles's church in Edinburgh is very magnetical; and the upper end of it, where it is lodged in the ſtone, is a vigorous ſouth pole. It is worth notice, that the parts of ſuch old bars acquire the ſtrongeſt magnetiſm when their metallic ſtate is changed by expoſure to the air, becoming foliated and friable. It would be worth while to try, whether the æthiops martialis, produced by ſteam in the experiments for decompoſing water, will acquire magnetiſm during its production. The pipe and the wires, which are converted into the ſhining æthiops, ſhould be placed in the magnetic direction.

2. By hammering;

2. If a bar of ſteel be long hammered while lying in the magnetic direction, it acquires a ſenſible magnetiſm (See Dr Gibert's plate, repreſenting a blackſmith hammering a bar of iron in the magnetic direction). The points of drills, eſpecially the great ones, which are urged by very great preſſure; and broaches, worked by a long lever, ſo as to cut the iron very faſt, acquire a ſtrong magnetiſm; and the lower end always becomes the north pole (*Phil. Tranſ.* xx. 417.) Even driving a hard ſteel punch into a piece of iron, gives it magnetiſm by a ſingle blow. In ſhort, any very violent ſqueeze given to a piece of tempered ſteel renders it magnetic, and its polarity correſponds with its poſition during the experiment. We can ſcarcely take up a cutting or boring tool in a ſmith's ſhop that is not magnetical. Even

ſoft ſteel and iron acquire permanent magnetiſm in this way. Iron alſo acquires it by twiſting and breaking. It is therefore difficult to procure pieces of iron or ſteel totally void of determinate and permanent magnetiſm; and this frequently mars the experiments mentioned in the firſt paragraphs of this article. The way therefore to enſure ſucceſs in theſe experiments is to deprive the rods of their accidental magnetiſm, by ſome of the methods mentioned a little ago. Let them be heated red hot, and allowed to cool while lying in a direction perpendicular to the magnetic direction (nearly E. N. E. and W. S. W. in this country).

By heat. 3. As heat is obſerved to deſtroy magnetiſm, ſo it may alſo be employed to induce it on ſubſtances that are ſuſceptible of magnetiſm. Dr Gilbert makes this obſervation in many parts of his work. He ſays, that the ores of iron which are in that particular metallic ſtate which he conſiders as moſt ſuſceptible of magnetiſm, will acquire it by long continuance in a red heat, if laid in the magnetic direction, and that their polarity is conformable to their poſition, that end of the maſs which is next the north becoming the north pole. He alſo made many experiments on iron and ſteel bars expoſed to ſtrong heats in the magnetical direction. Such experiments have been made ſince Gilbert's time in great number. Dr Hooke, in 1684, made experiments on rods of iron and ſteel one-fifth of an inch in diameter, and ſeven inches long. He found them to acquire permanent magnetiſm by expoſure to ſtrong heat in the magnetic direction, and if allowed to cool in that direction. But the magnetiſm thus acquired by ſteel rods was much ſtronger, and more permanent, if they were ſuddenly quenched with cold water, ſo as to temper them very hard. He found, that the end which was next to the north, or the lower end of a vertical bar, was always its permanent north pole. Even quenching the upper end, while the reſt was ſuffered to cool gradually, became a very ſenſible ſouth pole. No magnetiſm was acquired if this operation was performed on a rod lying at right angles to the magnetical direction.

In theſe trials the polarity was always eſtimated by the action on a mariner's needle, and the intenſity of the magnetiſm was eſtimated by the deviation cauſed in this needle from its natural poſition. Dr Gilbert made a very remarkable obſervation, which has ſince been repeated by Mr Cavallo, and publiſhed in the Philoſophical Tranſactions as a remarkable diſcovery. Dr Gilbert ſays, p. 69. "*Bacillum ferreum, valide ignitum appone verſorio excito; ſtat verſorium, nec ad tale ferrum convertitur: ſed ſtatim ut primum de candore aliquantulum remiſerit, confluit illico.*" In ſeveral other parts of his treatiſe he repeats the ſame thing with different circumſtances. It appears, therefore, that while iron is red hot, it is not ſuſceptible of magnetiſm, and that it is during the cooling in the magnetic direction that it acquires it. Gilbert endeavoured to mark the degree of heat moſt favourable for this purpoſe; but being unprovided with thermometers, he could not determine any thing with preciſion. He ſays, that the verſorium, or mariner's needle, was moſt deranged from its natural poſition a little while after the bar of iron ceaſed to ſhine in day-light, but was ſtill pretty bright in a dark room. But there are other experiments which we have made, and which will be mentioned by and bye; by which it appears, that although a bright red or a white heat makes iron unſuſceptible of magnetiſm while in that ſtate, it prediſpoſes it for becoming magnetical. When a bar of ſteel was made to acquire magnetiſm by tempering it in the magnetical direction, we found that the acquired magnetiſm was much ſtronger when the bar was made firſt of all very hot, even although allowed to come to its moſt magnetical ſtate before quenching, than if it had been heated only to that degree; nay, we always found it ſtronger when it was quenched when red hot. We offer no explanation at preſent; our ſole buſineſs juſt now being to ſtate facts, and to generalize them, in the hopes of finding ſome fact which ſhall contain all the others.

4. By juxtapoſition. 4. The moſt diſtinct acquiſitions and changes of magnetiſm are by juxtapoſition to other magnets and to iron. As the magnetiſm of a loadſtone or magnet is weakened by bringing its pole near the ſimilar pole of another magnet, it is improved by bringing it near the other pole; and it is always improved by bringing it near any piece of iron or ſoft ſteel.

But this action, and the mutual relation of magnets and common iron, being the moſt general, and the moſt curious and inſtructive of all the phenomena of magnetiſm, they merit a very particular conſideration.

Of the communication of Magnetiſm.

33 Communication of magnetiſm. THE whole may be comprehended in one propoſition, which may be ſaid to contain a complete theory of magnetiſm.

Fundamental propoſition.

Any piece of iron, when in the neighbourhood of a magnet, is a magnet, and its polarity is ſo diſpoſed that the magnet and it mutually attract each other.

The phenomena which reſult from this fundamental principle are infinitely various, and we muſt content ourſelves with deſcribing a ſimple caſe or two, which will ſufficiently enable the reader to explain every other.

34 Attractive power communicated. Take a large and ſtrong magnet NAS (fig. 7.), of which N is the north, and S the ſouth pole. Let it be properly ſupported in a horizontal poſition, with its poles free, and at a diſtance from iron or other bodies. Take any ſmall piece of common iron, not exceeding two or three inches in length, ſuch as a ſmall key. Take alſo another piece of iron, ſuch as another ſmaller key, or a bit of wire about the thickneſs of an ordinary quill.

1. Hold the key horizontally, near one of the poles, (as ſhewn at n° 1.), taking care not to touch the pole with it; and then bring the other piece of iron to the other end of the key (it is indifferent which pole is thus approached with the key, and which end of the key is held near the pole). The wire will hang by the key, and will continue to hang by it, when we gradually withdraw the key horizontally from the magnet, till, at a certain diſtance, the wire will drop from the key, becauſe the magnetiſm imparted from this diſtance is too weak. That this is the ſole reaſon of its dropping, will appear by taking a ſhorter, or rather a ſlenderer, bit of wire, and touch the remote end of the key with it: it will be ſupported, even though we remove the key ſtill farther from the magnet.

2. Hold the key *below* one of the poles, as at n° 2. or 3. and touch its remote end with the wire. It will be ſuſpended in like manner, till we remove the key too far from the magnet.

3. Hold

3. Hold the key *above* the poles, as at n° 4. or 5. and touch its adjacent end with the wire (taking care that the wire do not alſo touch the magnet). The wire will ſtill be ſupported by the key, till both are removed too far from the magnet.

Thus it appears, that in all theſe ſituations the key has ſhewn the characteriſtic phenomenon of magnetiſm, namely, attraction for iron. In the experiment with the key held above the pole, the wire is in the ſame ſituation in reſpect to magnetiſm as the key is when held below the pole; but the actions are mutual. As the key attracts the wire, ſo the wire attracts the key.

If the magnet be ſupported in a vertical poſition, as in fig. 8. the phenomena will be the ſame; and when the key is held directly above or directly below the pole, it will carry rather a heavier wire than in the horizontal poſition of the magnet and key.

Inſtead of approaching the magnet with the key and wire, we may bring the magnet toward them, and the phenomena will be ſtill more palpable. Thus, if the bit of wire be lying on the table, and we touch one end of it with the key, they will ſhew no connection whatever. While we hold the key very near one end of the wire, bring down the pole of a magnet toward the key, and we ſhall then ſee the end of the wire riſe up and ſtick to the key, which will now ſupport it. In like manner, if we lay a quantity of iron filings on the table, and touch them with the key, in the abſence of the magnet, we find the key totally inactive. But, on bringing the magnet anyhow near the key, it immediately attracts the iron filings, and gathers up a heap of them.

35 Alſo a directive power.

In the next place, this vicinity of a magnet to a piece of iron gives it a directive power. Let NAS (fig. 9.) be a magnet, and BC (n° 1.) a key held near the north pole, and in the direction of the axis. Bring a very ſmall mariner's needle, ſupported on a ſharp point, near the end C of the key which is fartheſt from N. We ſhall ſee this needle immediately turn its ſouth pole towards C, and its north pole away from C. This poſition of the needle is indicated at *c*, by marking its north pole with a dart, and its ſouth with a croſs. Thus it appears that the key has got a directive power like a magnet, and that the end C is performing the office of a north pole, attracting the ſouth pole of the needle, and repelling its north pole. It may indeed be ſaid, that the needle at *c* arranges itſelf in this manner by the directive power of the magnet; for it would take the ſame poſition although the key were away. But if we place the needle at *b*, it will arrange itſelf as there repreſented, ſhewing that it is influenced by the key, and not (wholly at leaſt) by the magnet. In like manner, if we place the needle at *a*, we ſhall ſee it turn its north pole toward B, notwithſtanding the action of the magnet on it. This action evidently tends to turn its north pole quite another way; but it is influenced by B, and B is performing the office of a ſouth pole.

In like manner, if we place the key as at n° 2. we ſhall obſerve the end B attract the ſouth pole of the needle placed at *a*, and the end C attract the north pole of a needle placed in *b*. In this ſituation of the key, we ſee that B performs the office of a north pole, and C performs the office of a ſouth pole.

Thus it appears that the key in both ſituations has become a magnet, poſſeſſed of both an attractive and a directive power. It has acquired two poles.

36 The attraction of iron is owing to the diſpoſition of its own temporary magnetiſm

Laſtly, the magnetiſm of the key is ſo diſpoſed, that the two magnets NAS and BC muſt mutually attract each other; for their diſſimilar poles front each other. Now, it is a matter of uniform and uncontradicted obſervation, that when a piece of iron is thus placed near a magnet, and the diſpoſition of its magnetiſm is thus examined by means of a mariner's needle, the diſpoſition is ſuch that two permanent magnets with their poles ſo diſpoſed muſt attract each other. The piece of iron, therefore, having the ſame magnetic relation to the magnet that a ſimilar and ſimilarly diſpoſed magnet has, muſt be affected in the ſame manner. We cannot, by any knowledge yet contained in this article, give any preciſe intimation in what way the polarity of the piece of iron will be diſpoſed. This depends on its ſhape as much as on its poſition. By deſcribing two or three examples, a notion is obviouſly enough ſuggeſted, which, although extremely gratuitous, and perhaps erroneous, is of ſervice, becauſe it has a general analogy with the obſerved appearances.

If one end of a ſlender rod or wire be held near the north pole of the magnet, while the rod is held in the direction of the axis (like the key in fig. 7. n° 1.), the near end becomes a ſouth, and the remote end a north pole. Keeping this ſouth pole in its place, and turning the rod in any direction from thence, as from a centre, the remote end is always a north pole. And, in general, the end of any oblong piece of iron which is neareſt to the pole of a magnet becomes a pole of the oppoſite name, while the remote end becomes a pole of the ſame name with that of the magnet.

If the iron rod be held perpendicularly to the axis, with its middle very near the north pole of the magnet, the two extremities of the iron become north poles, and the middle is a ſouth pole.

If the north pole of a magnet be held perpendicular to the centre of a round iron plate, and very near it, this plate will have a ſouth pole in its centre, and every part of its circumference will have the virtue of a north pole.

If the plate be ſhaped with points like a ſtar, each of theſe points will be a very diſtinct and vigorous north pole.

Something like this will be obſerved in a piece of iron of any irregular ſhape. The part immediately adjoining to the north pole of the magnet will have the virtue of a ſouth pole, and all the remote protuberances will be north poles.

The notion naturally ſuggeſted by theſe appearances is, that the virtue of a north pole ſeems to reſide in ſomething that is moveable, and that is protruded by the north pole of the magnet toward the remote parts of the iron; and is thus conſtipated in all the remote edges, points, and protuberances, much in the ſame manner as electricity is obſerved to be protruded to the remote parts and protuberances of a conducting body by the preſence of an overcharged body. This notion will greatly aſſiſt the imagination; and its conſequences very much reſemble what we obſerve.

As a farther mark of the complete communication of every magnetic power by mere vicinity to a magnet, we may here obſerve, that the wire D, of fig. 7. n° 2. and 3. will ſupport another wire, and this another; and ſo on, to a number depending on the ſtrength of the magnet. The key has therefore become a true magnet in every reſpect; for it induces complete magnetiſm on the appended wire. That this is not the ſame operation of the great magnet (at leaſt not wholly ſo), appears by examining the magnetiſm of D with the needle, which will be ſeen to be more influenced by D than by A. This fact has been long known. The ancients ſpeak of it: They obſerve, that a loadſtone cauſes an iron ring to carry another ring, and that a third; and ſo on, till the ſtring of rings appears like a chain.

37 ception plained. What has now been ſaid will explain a ſeeming exception to the univerſality of the propoſition. If the key be held in the ſituation and poſition repreſented by fig. 10. the bit of wire will not be attracted by it; and we may imagine that it has acquired no magnetiſm: But if we bring a mariner's needle, or a bit of wire, near to its remote end B, it will be ſtrongly attracted, and ſhew B to be a north pole. The needle held near to C will alſo ſhew C to be a ſouth pole. Alſo, if held near to D, it will ſhew D to be a north pole. Now the ends C, both of the key and of the wire, being ſouth poles, they cannot attract each other, but, on the contrary, they will repel; and therefore the wire will not adhere to the key. And if the key of fig. 17. nº 4. with the wire hanging to it, be gradually carried outward, beyond the north pole of the magnet, and then brought down till its lower end be level with the pole, the wire will drop off.

There is, however, one exception to the propoſition. If the key in fig. 7. with its appending wire D, be gradually carried from any of the ſituations 2, 3, 4, or 5, toward the middle of the magnet, the wire will drop off whenever it arrives very near the middle. If we ſuppoſe a plane to paſs through the magnetic centre A, perpendicular to the axis (which plane is very properly called the magnetic equatorial plane by Gilbert), a ſlender piece of iron, held anywhere in this plane, acquires no ſenſible magnetiſm. It gives no indication of any polarity, *and it is not attracted by the magnet.* It is well known, that the activity of a loadſtone or magnet reſides chiefly in two parts of it, which have been called its poles; and that thoſe are the beſt magnets or loadſtones in which this activity is leaſt diffuſed; and that a certain circumference of every loadſtone or magnet is wholly inactive. When a loadſtone or magnet of any ſhape is laid among iron filings, it collects them on two parts only of its ſurface; and between theſe there is a ſpace all round, to which no filings attach themſelves.

We preſume that the reader already explains this appearance to himſelf. Many things ſhew a contrariety of action of the two poles of a magnet. We have already obſerved, that the north pole of a ſtrong magnet will produce a ſtrong northern polarity in the remote end of a ſmall ſteel bar; and, if it be then applied near to that end in the oppoſite direction, it will deſtroy this polarity, and produce a ſouthern polarity. In whatever theſe actions may conſiſt, there is ſomething not only different but oppoſite. They do not blend their effects, as the yellow and blue making rays do in producing green. They oppoſe each other, like mechanical preſſures or impulſions. We have every mark of mechanical action; we have local motion, though unſeen, except in the gradual progreſſion of the magnetical faculties along the bar; but we have it diſtinctly in the ultimate effect, the approach or receſs of the magnets: and in theſe phenomena we ſee plainly, that the forces, in producing their effects, act in oppoſite directions. Whatever the internal inviſible motions may be, they are compoſed of motions whoſe equivalents are the ſame with the equivalents of the ultimate, external, ſenſible motions; therefore the internal motions are oppoſite and equal if the ſenſible motions are ſo, and converſely.

Adopting this principle, therefore, that the actions of the two poles are not only different but oppoſite, it follows, that if they are alſo equal and act ſimilarly, each muſt *prevent* the action of the other; and that there will be a mechanical equilibrium—it may even be called a magnetical equilibrium. Therefore if every part of a ſlender rod, or of a thin plate of iron, lie in the plane of the magnetic equator, the magnetic ſtate (in whatever it may conſiſt) cannot be produced in it. It will exhibit no magnetiſm; have no polar faculties; and we can ſee no reaſon why it ſhould be attracted by the magnet, or ſhould attract iron. We muſt not forget to obſerve in this place, that iron in a ſtate of incandeſcence acquires no magnetiſm by juxtapoſition. We have already remarked, that iron in this ſtate does not affect the magnet. If a bar of red hot iron be ſet near a mariner's needle, it does not affect it in the ſmalleſt degree till it almoſt ceaſes to appear red hot in day-light, as has been obſerved by Dr Gilbert. All actions that we know are accompanied by equal and oppoſite re-actions; and we ſhould expect, what really happens in the preſent caſe, namely, that red hot iron ſhould not be rendered magnetical and attractable.

38 Magnetiſm not impaired by communication. There is a very remarkable circumſtance which accompanies the whole of this communication of magnetiſm to a piece of iron. It does not impair the power of the magnet; but, on the contrary, improves it. This fact was obſerved, and particularly attended to, by Dr Gilbert. He remarks, that a magnet, in the hands of a judicious philoſopher, may be made to impart more magnetiſm than it poſſeſſes to each of ten thouſand bars of ſteel, and that it will be more vigorous than when the operations began. A magnet (ſays he) may be ſpoiled by injudicious treatment with other magnets, but never can touch a piece of common iron without being improved by it. He gives a more direct proof. Let a magnet carry as heavy a lump of iron as poſſible by its lower pole. Bring a great lump of iron cloſe to its upper pole, and it will now carry more. Let it be loaded with as much as it can carry while the lump of iron touches its upper pole. Remove this lump, and the load will inſtantly drop off. But the following experiment ſhews this truth in the moſt convincing manner:

Let NAS (fig. 11.) be a magnet, not very large, nor of extreme hardneſs. Let CD be a ſtrong iron wire, hanging perpendicularly from a hook by a ſhort thread or loop. The magnet, by its action on CD, renders D a north pole and C a ſouth pole, and the polarity of D's magnetiſm fits it for being attracted. Let it aſſume the poſition C *e*, and let this be very carefully marked. Now bring a great bar of iron *s* B *n* near to the other end of the magnet. We ſhall inſtantly perceive the wire C *e* approach to the ſouth pole of the magnet, taking a poſition C *f*. Withdraw the bar of iron, and C *f* will fall back into the poſition C *e*. As we bring the iron bar gradually nearer to the magnet,

the

the wire will deviate farther from the perpendicular, and when the bar B touches the magnet CD, will ſtart a great way forward. It is alſo farther to be obſerved, that the larger the bar of iron is, the more will CD deviate from the perpendicular.

Now this muſt be aſcribed to the action of the bar on the magnet. For if the magnet be removed, the bar alone will make no ſenſible change on the poſition of the wire. We know that the bar of iron becomes magnetical by the vicinity of the magnet. If we doubt this, we need only examine it by means of a piece of iron or a mariner's needle. This will ſhew us that *s* has become a ſouth, and *n* a north pole. Here then are two magnets with their diſſimilar poles fronting each other. In conformity with the whole train of magnetical phenomena, we muſt conclude that they attract each other, and muſt improve each other's magnetiſm.

39 Therefore nothing is transferred.

This is a moſt important circumſtance in the theory of magnetiſm. For it ſhews us, that, in rendering a piece of iron magnetic, there is no material communication. There is no indication of the transference of any ſubſtance reſiding in the magnet into the piece of iron; nor is there even any transference of a power or quality. Were this the caſe, or if the ſubſtance or quality which was in A be now transferred to B, it can no longer be in A; and therefore the phenomena reſulting from its preſence and agency muſt be diminiſhed. We muſt ſay that the magnet has excited powers inherent, but dormant, in the iron; or is, at leaſt, the occaſion of this excitement, by diſturbing, in ſome adequate manner, the primitive condition of the iron. We muſt alſo ſay, that the competency of the magnet and of the iron to produce the phenomena, is owing to the ſame circumſtances in both; becauſe we ſee nothing in the phenomena which authoriſes us to make any diſtinction between them. Whatever therefore cauſes one magnet to attract another, is alſo the reaſon why a piece of iron in the neighbourhood of a magnet attracts another piece of iron; and we muſt ſay that the cauſe of polarity, or the origin of the directive power, is the ſame in both. Now we underſtand perfectly the directive power of a magnet, as exerted on another magnet. We ſee that it ariſes from a combination and mechanical compoſition of attractions and repulſions. It muſt be the ſame in this magnetiſm now inherent in the iron. The piece of iron directs a mariner's needle, as a magnet would direct it; therefore, as there is ſomething in a piece of iron which *now* attracts ſomething in another piece of iron, ſo there is ſomething in the firſt which repels ſomething in the laſt.

40 Objections anſwered by a curious fact.

It may indeed be ſaid that it is not a piece of iron, but a mariner's needle, or magnet, that is thus directed by our iron magnetiſed by vicinity to a magnet. This objection is completely removed by the moſt curious of all the facts which occur in this manner of producing magnetiſm. Take a piece of common iron, faſhion it, and fit it up preciſely like a mariner's needle, and carefully avoid every treatment that can make it magnetical. Set it on its pivot, and bring it near the north pole of a magnet, placing the end, made like the ſouth pole of the needle, next to the north pole of the magnet. In ſhort, place it by hand exactly as a real mariner's needle would arrange itſelf. It will retain that poſition. Now carry it round the magnet, along the circumference of a magnetic curve, or in any regular and continuous route. This piece of iron will, in every ſituation, aſſume the very ſame poſition or attitude which the real magnetical needle would aſſume if in the ſame place, and it will oſcillate preciſely in the ſame way.

Here then it is plain, that there is no diſtinction of power between the magnetiſm of the iron and of the real needle. To complete the proof: Inſtead of approaching the magnet with this iron needle, bring it into the vicinity of a piece of iron, which is itſelf magnetical only by vicinity to a magnet, it will arrange itſelf juſt as the real needle would do, with the ſole difference, that it does not indicate the *kind* of polarity exiſting in the extremities of the iron, becauſe either end of it will be attracted by them. And this circumſtance leads us to the conſideration of the only diſtinction between the magnetiſm of a loadſtone or magnet and that of common iron.

41 Magnetiſm of iron is tranſitory and indifferent; but that of magnets is durable and determinate.

The magnetiſm of common iron is momentary, and therefore indifferent; whereas that of a magnet is permanent and determinate. When iron becomes magnetic in the way now mentioned, it remains ſo only while the magnet remains in its place; and when that is removed, the iron exhibits no ſigns of magnetiſm. Therefore when the north pole of a magnet has produced a ſouth pole in the neareſt end of an iron wire, and a north pole at its remote end, if we turn the magnet, and preſent its ſouth pole, the neareſt end of the wire inſtantly becomes a north pole, and the other a ſouth pole; and this change may be made as often, and as rapidly, as we pleaſe. This is the reaſon which made us direct the experimenter on the iron needle to begin his operation, by placing the end marked for a ſouth pole next to the north pole of the magnet. It becomes a real ſouth pole in an inſtant, and acts as ſuch during its peregrination round the magnet. But in any one of its ſituations, if we turn it half round with the finger, the end which formerly turned away from a pole of the magnet, will now turn as vigorouſly toward it. Therefore, in carrying the iron needle round the magnet, we directed the progreſs to be made in a continuous line, to avoid all chance of miſtaking the polarities.

42 MAGNETISM OF INDUCTION.

For all the reaſons now adduced, we think ourſelves obliged to ſay, that the magnetiſm produced on common iron by mere juxtapoſition to a magnet, is generated without any *communication* of ſubſtance or faculty. The power of producing magnetical phenomena is not *ſhared* between the magnet and the iron. We ſhall call it INDUCED MAGNETISM; MAGNETISM BY INDUCTION.

We have ſaid that induced magnetiſm of common iron is quite momentary. This muſt be underſtood with careful limitations. It is ſtrictly true only in the caſe of the fineſt and pureſt ſoft iron, free of all knots and hard veins, and therefore in its moſt metallic ſtate. Iron is rarely found in a ſtate ſo very pure and metallic; and even this iron will acquire permanent and determinate magnetiſm by induction, if it has been twiſted or hammered violently, although not in the magnetic direction; alſo the changes produced (we imagine) on the pureſt iron by the action of the atmoſphere make it ſuſceptible of fixed magnetiſm. But the magnetiſm thus inducible on good iron is ſcarcely ſenſible, and of no duration, unleſs it has lain in the neighbourhood of a magnet for a very long while.

What has now been ſaid of common iron, is alſo true of it when in the ſtate of ſoft ſteel.

But

43 empered el acires du ble magtiſm.

But any degree of temper that is given to ſteel makes a very important change in this reſpect. In the firſt place, it acquires magnetiſm more ſlowly by induction than an equal and ſimilar piece of common iron, and finally acquires leſs. Theſe differences are eaſily examined by the deviations which it cauſes in the mariner's needle from the magnetic meridian, and by its attraction.

When the inducing magnet is removed, ſome magnetiſm remains in the ſteel bar, which retains the polarity which it had in the neighbourhood of the magnet.

Steel tempered to the degree fit for watch ſprings acquires a ſtrong magnetiſm, which it exhibits immediately on the removal of the magnet. But it diſſipates very faſt; and, in a very few minutes, it is reduced to leſs than one-half of its intenſity while in contact with the magnet, and not two thirds of what it was immediately on removal from it. It continues to diſſipate for ſome days, though the bar be kept with care; but the diſſipation diminiſhes faſt, and it retains at leaſt one-third of its greateſt power for any length of time, unleſs careleſsly kept or injudiciouſly treated.

Steel tempered for ſtrong cutting tools, ſuch as chiſels, punches, and drills for metal, acquires magnetiſm ſtill more ſlowly by induction, and acquires leſs of it while in contact with the magnet; but it retains it more firmly, and finally retains a greater proportion of what it had acquired.

Steel made as hard as poſſible, is much longer in acquiring all the magnetiſm which ſimple juxtapoſition can give to it. It acquires leſs than the former; but it retains it with great firmneſs, and finally retains a much greater proportion.

Such ores of iron as are ſuſceptible of magnetiſm, are nearly like hard ſteel in theſe reſpects; that is, in the time neceſſary for their *greateſt* impregnation, and in the durability of the acquired magnetiſm. They differ exceedingly in reſpect to the degree of power which they can attain by mere juxtapoſition, and the varieties ſeem to depend on heterogeneous mixture. We muſt obſerve, that few ores of iron are ſuſceptible of magnetiſm in their natural ſtate. The ordinary ores, conſiſting of the metal in the ſtate of an oxyd, and combined with ſulphur, are not magnetizable while remaining in that ſtate. Moſt ores require roaſting, and a ſort of cementation, in contact with inflammable ſubſtances. This matter is not well underſtood; but it would ſeem that complete metallization is far from being the moſt favourable condition, and that a certain degree of oxydation, and perhaps ſome other compoſition, yet unknown, make the beſt loadſtones. But all this is extremely obſcure. The late Dr Gowin Knight made a compoſition which acquired a very ſtrong and permanent magnetiſm, but the ſecret died with him. Dr Gilbert ſpeaks of ſimilar compoſitions, in which ferrugineous clays were ingredients; but we know nothing of the ſtate of the metal in them, nor their mode of acquiring magnetiſm.

44 duction magnemis gra al and ogreſſive.

It is of peculiar importance to remark that the acquiſition of magnetiſm is gradual and progreſſive, and that the gradation is the more perceptible in proportion as the ſteel is of a harder temper. When a magnet is brought to one end of a bar of common iron, its remote extremity, unleſs exceedingly long, acquires its utmoſt magnetiſm immediately. But when the north pole of a magnet is applied to one end of a bar of hard ſteel, the part in contact immediately becomes a ſouth pole, and the far end is not yet affected. We obſerve a north pole formed at ſome diſtance from the contact, and beyond this a faint ſouth pole. Theſe gradually advance along the bar. The remote extremity becomes firſt a faint ſouth pole, and it is not till after a very long while (if ever) that it becomes a ſimple, vigorous, north pole. More frequently it remains a diffuſed and feeble north pole: nay, if the bar be very long, it often happens that we have a ſucceſſion of north and ſouth poles, which never make their way to the far end of the bar. This phenomenon was firſt obſerved (we think) by Dr Brook Taylor, who gives an account of his obſervations in the *Philoſophical Tranſactions*, n° 344.

45 Iron is attracted only becauſe it becomes magnetical.

From the account we have given of theſe phenomena of induced magnetiſm, it appears that the temporary magnetiſm is always ſo diſpoſed that the ſum of the mutual attractions of the diſſimilar poles exceeds the ſum of the repulſions between the ſimilar poles, and that therefore the two magnets tend to each other. This is evidently equivalent to ſaying, that a piece of unmagnetic iron is always attracted by a magnet. No exception has ever been obſerved to this fact; for Pliny's ſtory of a Theamedes, or loadſtone, which repels iron, is allowed by all to have been a fable.

We think ourſelves authoriſed to ſay that this attraction of the loadſtone for iron, or this tendency of iron to the loadſtone, is a ſecondary phenomenon, and is the *conſequence* of the proper diſpoſition of the induced magnetiſm. The proofs already given of the compound nature of this phenomenon, namely, that it ariſes from the exceſs of two attractions above two repulſions, need (we imagine) no addition. But the following conſiderations place the matter beyond doubt:

1. The magnetiſm of the two poles is evidently of an oppoſite nature; the one repelling what the other attracts. If the one attracts iron, therefore, the other ſhould repel it. But each pole, by inducing a magnetiſm oppoſite to its own, on the neareſt end of the iron, and the ſame with its own on the remote end, and its action diminiſhing with an increaſe of diſtance, there muſt always be an exceſs of attraction, and the iron muſt be attracted.

2. Each of the magnets A and B, in either of the poſitions repreſented in fig. 12. would alone attract the piece of common iron C. But when placed together, the ſouth pole of A tends to render the upper end of C a north pole; while the north pole of B tends to make it a ſouth pole. If their actions be nearly equal, the weight of C cannot be ſupported by the magnetiſm induced by any difference of action that may remain. While C is hanging by B alone, let A be gradually brought near; it gradually deſtroys the action of the north pole of B, ſo that C gradually loſes its magnetiſm and polarity, and its weight prevails.

3. In all thoſe caſes where the induction of magnetiſm is ſlow, the attraction is weak in proportion. This is particularly remarked by Dr Gilbert. If we take pieces of common iron, and of ſteel of different tempers, but all of the ſame ſize and form, we ſhall find that the iron is much more ſtrongly attracted than any of the reſt, and that the attraction for each of them is weaker in proportion as they are harder. This diverſity is ſo accurately obſerved, that when the piece is thoroughly

ſuſceptible of magnetiſm, we can tell, with conſiderable preciſion, what degree will be ultimately acquired and how much will be finally retained. Alſo, the attraction of the magnet for any of thoſe pieces of ſteel increaſes exactly in proportion as their acquired magnetiſm increaſes.

4. An ore of iron incapable of acquiring magnetiſm is not attracted by a magnet. But we know that, by cementation with charcoal duſt, they may be rendered ſuſceptible of magnetiſm. In this ſtate they are attracted. It is an univerſal fact, that any ſubſtance that is attracted by a magnet may be rendered magnetical, and that none elſe can. We have already obſerved that red hot iron is not attracted; nor does it acquire any directive power while in that ſtate. From all this we muſt conclude, that the previous induction of magnetiſm is the mean of the obſerved attraction of magnets for iron, and that this is not a primary fact in magnetiſm.

Theſe obſervations alſo complete the proof that magnetic attraction and repulſion are equal at the ſame diſtance, and follow the ſame law. Dr Gilbert ſeems to think, that the repulſion is always weaker than the attraction; and this is almoſt the only miſtake in conception into which that excellent philoſopher has fallen. But it only requires a fair compariſon of facts to convince a good logician, that ſince, *in every caſe*, and at every diſtance, either pole of a magnet attracts either end of a piece of common iron, it is impoſſible that one of theſe forces can exceed the other. It might be ſo, were it not that induced magnetiſm is durable in proper ſubſtances. And if we take magnets which have been made ſuch by induction, and preſent them to each other with their ſimilar poles fronting each other, they never fail to repel each other at conſiderable diſtances, and even at very ſmall diſtances for a few moments; and this is the caſe whichever poles are next each other. This cannot be on any other ſuppoſition. Caſes would occur of polarity without attraction, or of attraction without polarity. Such have never been ſeen, any more than the Theamedes, always repelling iron.

46 Phenomena of iron ſhreds and filings.

Let a great number of ſmall oblong pieces of iron be lying very near each other on the ſurface of quickſilver. Bring a ſtrong magnet into the midſt of them. It immediately renders them all magnetical by induction. The one neareſt the north pole of the magnet immediately turns one end toward it, and the other end away from it. The ſame effect is produced on the one that is juſt beyond this neareſt one. Thus the remote end of the firſt becomes a north pole, and the neareſt end of the ſecond becomes a ſouth pole. Theſe, being very near each other, muſt mutually attract. The ſame thing may be ſaid of a third, a fourth; and ſo on. And thus it appears, that not only is magnetiſm induced on them all, but alſo, that the magnetiſm of each is ſo diſpoſed, that both ends of it are in a ſtate of attraction for the ends of ſome of its neighbours; and that they will therefore arrange themſelves by coaleſcence in ſome particular manner. Should a parcel of them chance to be ſtanding with their centres in a magnetic curve, with their heads and points turned in any ways whatever, the moment that the magnet is brought among them, and ſet in the axis of that magnetic curve, the whole pieces of this row will inſtantly turn towards each other, and their ends will adhere together, if they are near enough; otherwiſe they will only point toward each other, forming a ſet of tangents to the magnetic curve, reaching from one pole of the magnet to the other.

Or, ſuppoſe a vaſt number of ſmall bits of iron, each ſhaped like a grain of barley, a little oblong. Let them be ſcattered over the ſurface of a table, ſo near each other as juſt to have room to turn round. Let a magnet be placed in the midſt of them. They will all have magnetiſm induced on them in an inſtant; and ſuch as are not already touching others, will turn round (becauſe they reſt on the table by one point only), and each will turn its ends to the ends of its neighbours; and thus they will arrange themſelves in curves, which will not differ greatly from true magnetic curves (becauſe each grain is very ſhort), iſſuing from one pole of the magnet, and terminating in the other.

Does not this ſuggeſt to the reflecting reader an explanation of that curious arrangement of iron filings round a magnet, which has ſo long entertained and puzzled both the philoſophers and the unlearned, and which has given riſe to the Carteſian and other theories of magnetiſm? The particles of iron filings are little rags of ſoft iron torn off by the file, and generally a little oblong. Theſe *muſt* have magnetiſm induced on them by a magnet, and, while falling through the air from the hand that ſtrews them about the magnet, they are at perfect liberty to arrange themſelves magnetically; and *muſt therefore ſo arrange themſelves*, forming on the table curves, which differ very little indeed from the true magnetic curves. Suppoſe them ſcattered about the table before the magnet is laid on it. If we pat the table a little, ſo as to throw it into tremors, this will allow the particles to dance, and turn round on their points of ſupport, till they coaleſce by their ends in the manner already deſcribed.

All this is the genuine and inevitable conſequence of what Dr Gilbert has taught us of induced magnetiſm. It muſt be ſo; and cannot be otherwiſe. This curious arrangement of iron filings round a magnet is therefore not a primary fact, and a foundation for a theory, but the reſult of principles much more general.

47 Remarks on the theories by impulſion.

Moſt of our readers know that this diſpoſition of iron filings has given riſe to the chief mechanical theories which have been propoſed by ingenious men for the explanation of all the phenomena of magnetiſm. An inviſible fluid has been ſuppoſed to circulate through the pores of a magnet, running along its axis, iſſuing from one pole, ſtreaming round the magnet, and entering again by the other pole. This is thought to be indicated by thoſe lines formed by the filings. The ſtream, running alſo through *them*, or around them, arranges them in the direction of its motion, juſt as we obſerve a ſtream of water arrange the flote graſs and weeds. It would require a volume to detail the different manners in which thoſe mechanicians attempt to account for the attraction, repulſion, and polarity of magnetic bodies, by the mechanical impulſion of this fluid. Let it ſuffice to ſay, that almoſt every ſtep of their theories is in contradiction to the acknowledged laws of impulſion. Nay, the whole attempt is againſt the firſt rule of all philoſophical diſcuſſion, never to admit for an explanation of phenomena the agency of any cauſe which we do not know to exiſt, and to operate in the very phenomenon. We know of no ſuch fluid; and we can demonſtrate, that the genuine effects of its impulſion would be totally unlike the phenomena of magnetiſm. But the proper refutation of theſe theories would fill volumes. Let it ſuffice (and to every logician it will abundantly ſuffice) to remark, that this phenomenon is but a ſecondary fact, depending on, and reſulting from, principles much more general, viz the induction of magnetiſm, and the attraction of diſſimilar, and repulſion of ſimilar, poles.

The above explanation of the curious diſpoſition of iron filings round a magnet, occurred to the writer of this article while ſtudying natural philoſophy, on ſeeing the Profeſſor exhibit Mr Henſhaw's beautiful experiment in proof of terreſtrial magnetiſm *. He at that time imagined himſelf the author, and promiſed himſelf ſome credit for the thought. But having ſeen the *Phyſiologia Nova de Magnete* by Dr Gilbert, he found that it had not eſcaped the notice of that ſagacious philoſopher; as will appear paſt diſpute from the following paſſage, as well as ſome others, leſs pointed, in that work: "Magnetica fruſta (that is, ſubſtances ſuſceptible of magnetiſm) bene et convenienter intra vires poſita, mutuo cohærent. Ferramenta, preſente magnete (etiamſi magnetem non attingant), concurrunt, ſolicité ſe mutuo quærunt, et amplexantur, et, conjuncta, quaſi ferruminantur. Scobs ferrea, vel in pulverem redacta, fiſtulis impoſita chartaceis—ſupra lapidem meridionaliter locata, vel propius tantum admota, in unum coaleſcet corpus; et ſubito tam multæ partes concreſcunt et combinantur; ferrumque aliud affectat conjuratorum turma et attrahit, ac ſi unum tantum et integrum eſſet ferri bacillum; dirigiturque ſupra lapidem in ſeptemtriones et meridiem. Sed cum longius a magnete removeantur (tanquam ſoluta rurſus) ſeparantur, et diffluunt ſingula corpuſcula." B. ii. c. 23.

See VA-
IATION,
ncycl.
.621.

Mr Æpinus alſo had taken the ſame view of the ſubject *. It is alſo very clearly conceived and expreſſed by the celebrated David Gregory, Savilian Profeſſor of aſtronomy in the Univerſity of Oxford, in a MS. volume of notes and commentaries, written by him in 1693, on Newton's *Principia*, and uſed by Newton in improving the ſecond edition. The M. S. is now in the library of the univerſity of Edinburgh. Gregory's words are as follow: "Mihi ſemper dubium viſum eſt num magnetica virtus mechanicé, *i. e.* per impulſum, producatur. Mirum eſt, effluvia, quæ ferrum agitare valent, bracteas aureas *interpoſitas* ne vel minimum a loco movere. Lucretii et Carteſii theoriam, de fugato intermedio aëre, refutat experimentum infra aquam inſtitutum. *Sulci in limatura ferri, magneti in plano cujuſvis meridiani circumpoſita, non fiunt ab effluviis ſecundum iſtos canales motis, ſed ex inde, quod ipſa ramenta, magnetice excitata, ſeſe ſecundum longitudinem et ſecundum polos diſponunt*. Ex altera vero parte exinde quod vis magnetica, interveniente flamma aut calore, interrumpatur, quod virga ferrea, vel diuturno ſitu perpendiculari, vel in eo ſitu frigeſcendo, virtutem magneticam a tellure acquirat, ut nos docet perſpicaciſſimus Gilbertus. Quod mallei ſuper incudem ictu forti ad alterum extremum, virtutem acquirat magneticam; quod ictu forti vel ſaltem fortiori ad alterum extremum poli permutantur, ut qui prius ſeptemtriones reſpiciebat nunc auſtrum reſpicit; quod ictu forti ad medium, virtutem illam prorſus amittat. Hæc inquam, et ſimilia, mechanicam ejus qualitates ortum arguunt. Hugenius, præter gravitatem, etiam magneticam, et electricam virtutem, aliaſque plures experimento novit vires naturales, ut mihi ipſi narravit hac eſtate anni 1693. Qualis ut hæc forſitan quod cymba papyracea, prope labra vaſis aquam, cui innatet, continentis, poſita, labrum viciniſſimum continuo, et cum impetu petat (A)." *Nat. MS. in Prop.* 23. ii. *Prin.*

* See § 306.

48 Filings are weakly attracted.

Not only the mere arrangement of the filings in curve lines follows of neceſſity from the properties of induced magnetiſm, but all the ſubordinate circumſtances of this phenomenon are included in the ſame explanation. By continuing to tap the table, and throw it into tremors, the filings are obſerved to approach gradually, but very ſlowly, to the poles of the magnet. Each particle is a very ſmall temporary magnet. The attractive power of the great magnet, $\overline{m-p}-\overline{n-q}$, is therefore extremely ſmall in proportion to its directive power, $\overline{m+p}-\overline{n+q}$. And we obſerve that the accumulation of the filings round the poles of the magnet is ſo much the ſlower as the filings are finer.

49 Curious fact.

If a paper be laid above the magnet, and the filings be ſprinkled on it, we obſerve them to conſtipate along its edges, while none remain immediately above its ſubſtance; they are all beyond, or on the outſide of its outline, and they are obſerved not to be lying flat on the paper, but to be ſtanding obliquely on one point. They move off from the paper immediately above the magnet, becauſe they repel each other. They ſtand obliquely from the edges, becauſe that is the direction of a magnetic meridian at its parting from the pole. If the magnet be at ſome diſtance below the paper, then tapping the paper will cauſe the filings to move away from the magnet laterally. This ſingular and unexpected appearance is owing to the combination of gravity with the magnetic action. A particle, ſuch as *n s* (fig. 13.), reſts on the paper by the point *n*, which is a temporary north pole (S being ſuppoſed the ſouth pole of the magnet). The particle takes a poſition *n s* nearer to the horizon than the poſition *n o*, which it would take if its centre of gravity *b* were ſupported. The poſition is ſuch, that its weight, acting vertically at *b*, is in equilibrio with the magnetic repulſion *s d*, exerted between S and *s*. When the paper is tapped, it is beaten down, or withdrawn from *n*, and the particle of iron is left for a moment in the air. It therefore turns quickly round *b*, in order to aſſume a poſition parallel to *n o*, and it meets the paper, as that riſes again after the ſtroke, in a point farther removed from the magnet, and again deſcends by its weight (turning round the newly ſupported point *n*), till it again takes a poſition parallel to *n s*, but farther off, as repreſented by the dotted line. Thus it travels gradually outwards from the magnet, appearing to be repelled, although it is really attracted by it. If the magnet be held above the paper, at a little diſtance, the filings, when we repeatedly pat the paper, gradually collect into a heap under it. This will appear very plainly to one who conſiders the ſituation of a particle in the manner now explained.

(A) Perhaps it may be proper to obſerve, that Dr Gregory expreſſes his differing in his opinion from Newton about magnetiſm. Newton, in this propoſition, thinks, that the law of magnetic action approaches to the inverſe triplicate ratio of the diſtances. Dr Gregory invalidates the argument uſed by Newton.

50 Filings arrange in magnetic curves.

The curve lines formed by very fine filings approach very nearly to the form of the primary curve which indicates the law of magnetic action in the way already explained. If the magnet be placed under water, and if filings be ſprinkled copiouſly on the ſurface of it from a gauze ſearce, held at ſome diſtance above it, the reſiſtance to their motion through the water gives them time to arrange themſelves magnetically before they reach the bottom, and the lines become more accurate. But they were ſo much deranged by any method that we could take for removing the water, and meaſuring them, that we were diſappointed in our expectations of obtaining a very near approximation to the law of action.

51 Alſo in ſecondary curves.

We took notice of ſome very ſingular phenomena of a compaſs needle in the neighbourhood of two magnets, and we obſerved that, in this caſe alſo, the needle was always a tangent to a curve of another kind, and which we called *ſecondary* and *compound magnetic curves*. Theſe are produced in the ſame way, by ſtrewing iron filings round the magnets. Many repreſentations have been given of theſe curves by different authors, particularly by Muſchenbrock, in his *Eſſais de Phyſique*; and by Fuſs in the *Comment. Petropolit.* Great uſe has been made of theſe arrangements of filings by two magnets in the theories of magnetiſm propoſed by thoſe who inſiſt on explaining all motion by impulſe. When the diſſimilar poles of two magnets A and B (fig. 14.) face each other, the curves formed by the filings conſiderably reſemble thoſe which ſurround a ſingle magnet, and give the whole ſomewhat of the appearance of a magnet with very diffuſed poles. The arranging fluid, which ſtreams from one pole of a magnet, is ſuppoſed to meet with no obſtruction to its entry into the adjoining pole of the other magnet, but, on the contrary, to be impelled into it; and therefore (ſay the propoſers) it circulates round both as one magnet, and by its vortex brings the magnets together; which phenomenon we call the attraction of the magnets. But when the ſimilar poles front each other; for example, the poles from which the arranging fluid iſſues, then the two ſtreams meet, obſtruct each other, accumulate, and, by this accumulation, cauſe the magnets to recede from each other; which we call the repulſion of the magnets. This is the only explanation of this kind that can make any pretenſions to probability, or indeed that can be conceived. For how the free circulation in the former caſe can bring the two magnets together, no perſon can form to himſelf any conception. We ſee nothing like this produced by any vortex that we are acquainted with. All ſuch vortices cauſe bodies to ſeparate. But even this explanation of magnetic repulſion is inadmiſſible. It will not apply to the repulſion of the receiving poles; and the phenomena of the filings are inconſiſtent with the notion of accumulation. The filings indeed accumulate, and they look not unlike two ſtreams which oppoſe each other, and deflect to the ſides (See fig. 15.): But, unfortunately, by tapping the paper gently, the filings do not move off from the magnets, but approach them much faſter than in any other experiment. The phenomenon receives a complete and palpable explanation from the principles we have eſtabliſhed. Both magnets concur in giving the ſame polarity to every particle of the filings. Thus, if the fronting poles are north poles, each particle has its neareſt end made a vigorous ſouth pole, and its remote end a north pole; and it is *therefore* ſtrongly attracted towards both magnets while it is arranged in the tangent to the ſecondary curve of that claſs, which croſſes the others nearly at right angles.

52 Magnets muſt affect each other.

Since it is found, that the magnetiſm, even of natural loadſtones and hard ſteel, and ſtill more thoſe of ſofter tempered ſteel, are continually tending to decay; and ſince we find that it may be induced by mere approach to a magnet; and ſince we know that magnets may oppoſe each other in producing it—it is reaſonable to ſuppoſe, that when a piece of iron has acquired a ſlight, though permanent magnetiſm, by the vicinity of a magnet, a magnet applied in the oppoſite direction will deſtroy it, and afterwards produce the oppoſite magnetiſm.

Accordingly, we may change the poles of ſoft magnets at pleaſure.

Farther; ſince we find that loadſtones and hard tempered ſteel bars are diſtinguiſhed from ſoft ones only by the *degree* of obſtinacy with which they retain their preſent condition, we ſhould alſo expect that hard magnets will even affect each other. It muſt therefore happen, that a powerful magnet applied to a weak one, ſo that their ſimilar poles are in contact, ſhall weaken, deſtroy, and even change the magnetiſm of the weaker. Dr Knight's famous magazine of magnets enabled him to change the poles of the greateſt and the ſtrongeſt natural loadſtone, or artificial magnet, that could be given him, in the ſpace of one minute.

53 Attractio muſt appear to ex ceed repu ſion.

We now ſee clearly the reaſon why magnetic repulſion is weaker than attraction at the ſame diſtance. When magnets are placed with their ſimilar poles fronting each other, in order to make trials of their repulſion, they really do weaken each other, and are not in the ſame magnetical condition as before. For ſimilar reaſons, we ſee how experiments with magnets attracting each other rather improve them, and make their attractive powers appear greater than they are. All theſe effects muſt be moſt remarkable in ſoft magnets, eſpecially when long.

54 The obſe ved law differs fr the true.

We alſo ſee, that the obſerved law of attraction and repulſion between two magnets muſt be different from the real law of magnetic action. For, in the experiments made on attraction at different diſtances, beginning with the greateſt diſtance, the magnetiſm is continually increaſing, and the attraction will appear to increaſe in a higher rate than the juſt one: the contrary may happen, if we begin with the ſmaller diſtances. The reſults of experiments on repulſion muſt be ſtill more erroneous; becauſe it is eaſier to diminiſh any accumulation which required an exertion to produce it, than to puſh it ſtill farther.

55 Magneti improve by inducing it c iron.

We have now a complete explanation of the remarkable fact, that the induction of magnetiſm does not weaken the magnet employed; but, on the contrary, improves it. The magnetiſm induced on the iron cauſes it to act on the magnet employed in the very ſame manner that a permanent magnet of the ſame ſhape, ſize, and ſtrength, would do. Nay, it will have even a greater effect; for as it improves the magnet, its own induced magnetiſm will improve; and will therefore ſtill farther improve the magnet.

56.

Hence it is, that, in whatever manner a magnet touches a piece of iron, it improves by it. It may be hurt by a magnet in an improper poſition; but it always puts common iron into a ſtate which increaſes its own magnetiſm.

magnetiſm. This has been known as long as magnetiſm itſelf; and the ancients conceived the notion, that the magnet ſomehow fed upon the iron (B).

We think that theſe obſervations authoriſe us to ſay, that in reducing a loadſtone into a convenient ſhape, as much as poſſible of the operation ſhould be performed by grinding them with emery, in cavities made in large blocks of *hammered* iron. The magnetiſm induced on the iron muſt be favourable to the conſervation of that in the loadſtone; which, we are perſuaded, is rapidly diſſipated by the tremors into which this very elaſtic ſubſtance is thrown by the grinding with coarſe powders in any mould but iron. We imagine, that the cutting off ſlices by the lapidaries wheel has the ſame bad effect.

57. Not only will a magnet lift a greater lump of iron by its north pole, when another lump is applied to its ſouth pole, but it will lift a greater piece of iron from an anvil than from a wooden table: for the magnet induces the properly diſpoſed polarity, not only in the iron which it lifts, but alſo in the anvil, or any piece of iron immediately beyond it. This is ſo diſpoſed as to increaſe the magnetiſm of the piece of iron between them; and therefore to increaſe their attraction. The magnetiſm induced on the anvil is alſo in part, and perhaps chiefly, induced by the intervening iron. Theſe experiments are extremely variable in their reſults.—Sometimes a ſmall magnet will pull an iron wire from a large and ſtrong one. Sometimes this will be done even by a piece of unmagnetic iron; and the reſults appear quite capricious. But they are accurately fixed, depending on the induced compound magnetiſm. Mr Æpinus has ſtated ſome of the more ſimple caſes, in which we can tell which magnet ſhall prevail. But the unfolding even of theſe caſes would take a great deal of room, and muſt be omitted here. Beſides, we are too imperfectly acquainted with the degree of magnetiſm induced on the various parts of an iron rod, and the degree of magnetiſm inherent in the various parts of the magnets, to be able to ſay, with certainty, even in thoſe ſimple caſes, on which ſide the ſuperiority of attraction will remain.

58
aking of
ificial
agnets.

We may now proceed to deduce from this theory (for ſo it may juſtly be called, ſince all is reduced to one fact) the proceſs for communicating magnetiſm to bodies fitted for receiving and retaining it; that is, the method of making artificial magnets. We ſhall not employ much time on this, becauſe the moſt approved methods have been delivered at length in the article Magnetism of the *Encyclopædia Britannica*; and therefore we ſhall juſt make ſuch obſervations on them as ſerve to confirm, or to perfect them by the theory. We acknowledge, that we do not know the internal proceſs by which magnetiſm is induced, nor even in what this magnetiſm conſiſts. All that we know is, that the bringing the pole of a magnet near to any magnetiſable matter, produces a magnetiſm of the kind oppoſite to that of the pole employed. We know that this is the caſe with both poles, and that it obtains at all the diſtances where magnetiſm is obſerved. We know that the action of one pole is contrary to that of the other; that is, it counteracts the other, prevents it from producing its effect, and deſtroys it when already produced: and we know, that the production of theſe effects reſembles in its reſult the protruſion of ſomething fluid through the pores of the body, conſtipating it in all remote parts; as if the virtue of a pole reſided in this moveable matter. This is nearly all that we know of it; and by theſe facts and notions we muſt judge of the propriety and effect of all the proceſſes for magnetiſing bodies.

The moſt ſimple method of magnetiſing a ſteel bar, is to apply the north pole of a magnet to that end which we wiſh to render a ſouth pole. Attention to the effects of this application is very inſtructive. Have in readineſs a very ſmall compaſs needle, turning on its pivot. It ſhould not exceed half an inch in length, and ſhould be as hard tempered as poſſible, and ſtrongly impregnated. Immediately after the application of the magnet, carry the needle along the ſide of the bar. If the bar be long, and very hard, we ſhall obſerve a ſouth polarity at the place of contact; a north polarity at a ſmall diſtance from it; beyond this a weak ſouth polarity; then a weak and diffuſed north polarity, &c.; toward the remote end the polarity will be found very uncertain. The ſame thing may be diſcovered by laying a ſtiff paper on the bar, and ſprinkling iron filings over it, and then gently tapping the paper, to make them arrange themſelves in curve lines; which will point out the various poles, and ſhew whether they are diffuſed or conſtipated. It is very amuſing and inſtructive to obſerve the progreſs of this impregnation. In a few minutes after the firſt application of the magnet, we ſhall perceive the ſtate of magnetiſm very ſenſibly changed. The north pole will be farther from the magnet, and will be more diſtinct; the ſouthern polarity will alſo be protruded, and may appear for a moment at the remote extremity. The change advances; but the progreſs is more ſlow, and at laſt is inſenſible. When the bar is not harder than the temper of a cutting tool, the proceſs is ſoon over; and if the bar is but ſix or eight inches long, the remote end ſhews the north polarity in a very few minutes. When the bar is very hard, the progreſs of impregnation is greatly expedited by ſtriking it ſo as to make it ſound. If it be ſuſpended by a ſtring in a vertical poſition, and the magnet applied to its lower end, the ſtriking it with a key will make it ring; and in this way make the progreſs of magnetization very quick: but it does not allow it to acquire all the magnetiſm that can be given it by a very ſtrong magnet.

But this is a bad way of impregnation. It is ſeldom that uniform magnetiſm, with only two poles, and thoſe of

---

(B) So Claudian.——“ Nam ferro nurunt vitam, ferrique vigore
Veſcitur, hoc dulces epulas, hoc pabula novit
Hinc proprias renovat vires, hinc fuſa per artus
Aſpera ſecretum ſervant alimenta vigorem
Hoc abſente perit, triſti morientia torpent
Membra fame, venaſque ſitis conſumit apertas.”

Pliny ſays, “ Sola hæc materia (ferrum) vires ab eo lapide, accipit retinetque longo tempore, aliud apprehendens ferrum, ut annulorum catena ſpectetur interdum, quod imperitum vulgus ferrum appellat vivum.

of equal ſtrength, can be given. Even when there are but two, the remote pole is generally diffuſed, and therefore feeble. It is much improved by employing two magnets, one at each end. And if the bar is not more than ſix or eight inches long, and good magnets are employed, the magnetiſm is abundantly regular. This, accordingly, is practiſed for the impregnation of dipping needles, which muſt not be touched, leſt we diſturb the centre of gravity of the needle. But in all caſes, this method is tedious, and does not give ſtrong magnetiſm.

The method which was uſually practiſed before we had obtained a pretty clear knowledge of magnetiſm, was to apply the pole of a magnet to one end of the bar, and paſs it along to the other end, preſſing moderately. This was repeated ſeveral times on both ſides of the bar, always beginning the ſtroke at the ſame end as at firſt, and, in bringing the magnet back to that end, keeping it at a diſtance from the bar. The effect of this operation was to leave the end at which we began the ſtroke poſſeſſed of the polarity of the pole employed.

A general notion of the proceſs may be given as follows, obſerving, however, that there occur very many great and capricious anomalies. When the north pole N (fig. 16.) of the magnet A is ſet on the end C of the bar CBD, a ſouth pole is produced at C, and a north pole at D, when the length of the bar is moderate. As the magnet advances ſlowly along the bar, the ſouthern polarity at C firſt increaſes, then diminiſhes, and vaniſhes entirely when N has arrived at a certain point *a*; after which, a northern polarity appears at C, and increaſes during the whole progreſs of the magnet. In the mean time, the northern polarity firſt produced at D increaſes till the magnet reaches a certain point *e*, then diminiſhes, vaniſhes when the magnet reaches a certain point *f*; after which, a ſouthern polarity appears at D, which increaſes till the magnet reaches D. Mr Brugmann, who firſt attended minutely to theſe particulars (for Gilbert ſpeaks of them pointedly), calls *a* and *f* *points of indifference*, and *e* the *culminating* point of the pole D, and *i* the culminating point of the pole C. Hardly can any general rule be given for the ſituation of theſe points, nor even for the order in which they ſtand; ſo great and capricious are the anomalies in an amazing ſeries of experiments narrated by Brugmann and by Van Swinden. Repeating the operation, and beginning at C, the northern polarity there is weakened (ſometimes deſtroyed), then reſtored, and continually increaſed during the reſt of the ſtroke. The ſouthern polarity at D is alſo firſt weakened, and ſometimes deſtroyed; then reſtored, and finally augmented. The points *i*, *a*, *e*, *f*, change their ſituations, and frequently their order.

Van Swinden has attempted to deduce ſome general laws from his immenſe liſt of experiments, avoiding every conſideration of a hypotheſis, or the leaſt conjecture by what means theſe faculties are excited. But though we have peruſed his inveſtigation with care and candor, we muſt acknowledge, that we have not derived any knowledge which can help us to predict the reſult of particular modes of treatment with any greater preciſion than is ſuggeſted by a ſort of common ſenſe, aided (or perhaps perverted) by a vague notion, that theſe energies reſide in ſomething, which avoids the pole of the ſame name, carrying along with it this diſtinctive energy or polarity. This conception tallies perfectly with theſe obſervations of Brugmann and Van Swinden; and admits of all the anomalies in the ſituation of Bergmann's indifferent and culminating points, if we only ſuppoſe that this motion is obſtructed by the particles of the body. We muſt leave this to the reflection of the reader, who will *gueſs* how, when the magnet is between C and *i*, this ſubſtance, avoiding the pole N of the magnet, eſcapes below it, and goes toward the farther end. As the magnet advances, it drives ſome of this back again, &c &c. This is gratuitous; but it aids the fancy, which, without ſome conception of this kind, has no object of ſteady contemplation. We have no thought when we ſpeak of the generating at C, or *a*, or *e*, a faculty of ſome kind, by the exertion of the ſame faculty in N. The conception is too abſtracted, and much too complex. We muſt content ourſelves with knowing, that N produces a ſouth pole immediately under it, and a north pole everywhere elſe, or endeavours to do ſo. It is unneceſſary to inſiſt longer on this method: Common ſenſe ſhews it to be a very injudicious one.

This method was greatly improved by beginning the friction at the centre. Apply the north pole at the centre or middle of the bar, and draw it over the end intended for the ſouth pole. Having done this ſeveral times to one end on both ſides, turn the magnet, applying its ſouth pole to the middle of the bar, and drawing it ſeveral times over the end intended for the north pole.

It was ſtill more improved by employing two magnets at once, placed as in fig. 17. on the middle B of the bar, and drawing them away from each other, over the ends of it, as ſhewn by the directing darts, and repeating this operation. It is plain that, as far as we underſtand any thing of this matter, this proceſs muſt be much preferable to either of the former two. The magnets A and E certainly concur in producing a properly diſpoſed magnetiſm on all that lies between them; and therefore on the whole bar at the end of each ſtroke. The end C muſt become a north, and D a ſouth pole. Still, however, as the ſtroke goes on to the point of indifference, each magnet tends to weaken the polarity of the parts ſituated beyond it.

This method continued to be practiſed till about the year 1750. Mr Canton, availing himſelf of the experiments of Mr Mitchell of Cambridge, publiſhed his method by the DOUBLE TOUCH as it is called. See *Monthly Review* for 1785.

59
Metho
double
touch.

We need not repeat what has been detailed in the *Encyclopædia*, MAGNETISM, p. 440, &c. and ſhall only make ſome obſervations on the peculiar advantages of this proceſs, as preſcribed by Mitchell, Canton, and improved by Mr Antheaume, in his memoir *ſur les Aimans artificiels* 1766, which was crowned by the Academy of Sciences. (See alſo diſſertations on the ſubject by *Le Maire and Du Hamel*, 1745).

There is an evident propriety in the arrangement invented by Mr Mitchell, repreſented in fig. 18. The magnetiſm induced on the two pieces of ſoft iron AD and BC is an excellent method for *ſecuring* every acceſſion of magnetiſm to either of the bars. A good deal depends on the proper ſize and length of theſe pieces; and our ignorance of the interior proceſs obliges us to have recourſe to experiment alone for aſcertaining this. Whatever circumſtances induce the ſtrongeſt magnetiſm on on thoſe pieces of iron, will cauſe them to produce the greateſt effect on the ſteel bars; and this will be indicated by a greater attraction. Therefore that diſtance will be the beſt which enables two bars AB and DC to lift the greateſt weight hung on the piece AD or BC. When we impregnated bars whoſe breadth was about one-tenth of their length, and their thickneſs about one-half of their breadth, we found, that if AD was about one fourth, or nearly one third, of AB, they carried more than if it was either much longer or much ſhorter. Mr Antheaume's addition of the two great bars of iron E and F makes a ſenſible improvement of the *beginning* of the impregnation, when very weak magnets are employed; but did not ſeem to us to be of any farther ſervice on the table. This is agreeable to any theory which can be eſtabliſhed by what we have ſaid hitherto.

The method of employing the magnets A and E (fig. 19), preſcribed by Mitchell and Canton, is extremely judicious. The meeting of the diſſimilar poles at top increaſes the magnetiſm of each. The two diſſimilar poles F and G, certainly tend to give a regular and proper magnetiſm to the part FG of the bar which lies between them; and this is the caſe on whatever part of the bar they are placed. But each pole tends to deſtroy the preſent magnetiſm of what lies between it and the pole of the bar on that ſide. But mark—they tend to produce the deſired magnetiſm on what lies between them with the *ſum* of their forces; while each tends to deſtroy the magnetiſm of the part without it by the *difference* only of their forces. Therefore, on the whole, as they are moved to and fro along the bar, and the foremoſt one even made to paſs over the end of it a little way, they always add to the magnetiſm already acquired. This conſideration ſeems to enjoin ſetting F and G extremely near each other; for this ſeems to increaſe the ſum, and to diminiſh the difference of their action. But it may be a queſtion, Whether we gain more by ſtrongly magnetiſing a very ſmall part during the very ſhort while that the magnets paſs over it, or by acting on more of the bar at once, and continuing a weaker action for a longer while on this larger portion. Mr Æpinus adds another conſideration depending on his notion of the internal proceſs; but we defer this to another opportunity. The ſafeſt direction ſeems to be, to place them at the diſtance which enables them to lift the greateſt weight. They are then undoubtedly acting with the greateſt effect.

Mr Antheaume directs to place the touching magnets as in fig. 20. for a reaſon to be mentioned afterwards. Mr Æpinus alſo recommends it for reaſons founded on his own hypotheſis. We muſt ſay, that, in our trials, we have found this method very ſenſibly ſuperior, eſpecially in the latter parts of the operation, when the reſiſtance to farther impregnation becomes nearly a balance for the accumulating power of the magnets; and we conſider this as no inconſiderable argument for the juſtice of Mr Æpinus's hypotheſis.

The great advantage of this method is the regularity of the magnetiſm which it produces. We never find more than two poles; and when the bars are hard, and of uniform texture, the polarity is very little diffuſed, and ſeemingly confined to a very ſmall ſpace at the very extremities of the bar. This is indeed a prodigious advantage in point of ſtrength. It is no leſs ſo in order to fit the magnets for experiments on the law of magnetic action; for the latitude which the diffuſed condition of the poles gives in the ſelection of the points from which the diſtances are to be computed, has hitherto hindered us from pronouncing on the law of magnetic action with the preciſion of which we think it fully ſuſceptible. This method alſo is the only one by which we have been able to impregnate two bars joined end to end, conſidering them as one bar. We have ſometimes (though very rarely) ſucceeded in this; ſo that when filings were ſtrewed over them, the appearance could not be diſtinguiſhed from a ſingle bar.—*N. B.* Yet even in this caſe, in one experiment with two bars of ſix inches long, treated as one, when it could not be diſtinguiſhed, either by the appearance of the filings, or by going round it very near with a compaſs needle, a very ſmall compaſs needle diſcovered a neutral point, and a reverſion of polarity ſimilar to fig. 14. at F, ſhewing that it was really acting as two bars. Perhaps it muſt always be ſo; and this queſtion is of conſiderable importance in the eſtabliſhment of any theory of the internal proceſs.

It deſerves remark, that, in order to ſucceed in this attempt, a very conſiderable preſſure is neceſſary. We were obliged to clean the ends of the bars very carefully, and to force the frame of bars and ſoft pieces of iron ſtrongly together by wedges, in the manner of a form of types. We thought that wetting the ends of the bars with pure water aided the experiment; and we are *very certain* that oil not only greatly obſtructed it, but even ſenſibly impeded the common proceſs. We had put a ſingle drop of oil on a pair of bars which we were touching in the common Cantonian method, that the magnets might be more eaſily drawn along them; but we were ſurpriſed at finding that we could not give a ſtrong impregnation. The oil undoubtedly prevents the cloſe contact. We found the fineſt gold leaf produce the ſame effect in a great degree; as alſo talc, of which a ſquare inch weighed $\frac{1}{24}$th of a grain. We do not infer any thing like obſtruction to the paſſage of ſomething material, but rather aſcribe it to mere diſtance; although we are of opinion, that in the impregnation of two contiguous bars, ſo that the magnetiſm (whatever it is) is diſpoſed *preciſely* as in one bar, there *is* a material transference. But we ſhall ſpeak of this in its due place.

It is not unworthy of remark, that we found bars to acquire more powerful magnetiſm when pretty well poliſhed than when rough. But we alſo found, that bars conſiderably rough acquired the firſt degrees of it much more expeditiouſly than thoſe which are ſmooth; although we never could bring them to that high degree of magnetiſm that the ſame bars acquired after they had been poliſhed. We think it probable that the tremors, occaſioned by the rough and harſh ſurfaces of the hard ſteel, are the cauſes of this phenomenon.

Some more obſervations on this method of the double touch will be made afterwards, when we conſider the hypotheſis of Mr Æpinus: and we conclude the preſent ſubject, by attempting to explain ſome puzzling appearances which frequently occur in making artificial magnets.

60
Difficulties explained.

A bar touched by a very ſtrong magnet has been ſaid by Muſchenbroek to be impaired by going over it with a weaker magnet. If it had been made as ſtrong as as poſſible, the weaker magnet, when paſſed over it in the way practiſed by Muſchenbroek, muſt *firſt* deſtroy part of this magnetiſm; and having done ſo, it is unable to raiſe it anew to the ſame degree of vigour.

Yet (ſays Muſchenbroek with ſurpriſe) a large bar of common iron has greatly improved the magnet. A very large piece of iron *muſt* do this (eſpecially if ſhaped like a horſeſhoe, and applied with both heels), if the bar be not already at its maximum.

It was thought wonderful, that, in the method of double touch, not only was the magnetiſm of the magnets employed not impaired, but, beginning with two magnets, whoſe power is almoſt inſenſible, and repeating the operations in the preciſe manner deſcribed by Mitchell or Canton, not only the bars intended to be made magnetical, but alſo the magnets employed, may be brought to their higheſt poſſible ſtate of magnetiſm. This is in evident conformity to the general facts of induced magnetiſm, and affords the ſtrongeſt proof that nothing is communicated in this operation, but that powers reſiding in the bars are excited, or brought into action. The manipulation merely *gives occaſion* to this action, as a ſpark of fire kindles a city.

61 Explanation of the beginning of Savery, Canton, and Antheaume's proceſs.

There ſtill remain ſome circumſtances of this method, as practiſed by Savery, Canton, and Antheaume, which are extremely curious and important.

Mr Savery had obſerved a ſmall bit of ſteel acquire very ſenſible magnetiſm by lying long in contact with the lower end of a great window bar. Telling this to a friend, he was, for the firſt time, informed, that this had been long obſerved, and that Dr Gilbert had made ſome curious inferences from it. Mr Savery wanted ſome magnets, and was at a diſtance from town. Reflecting, like a philoſopher, on what he had heard and obſerved, he ſaw here a ſource of magnetiſm which he could increaſe, in the manner commonly practiſed in making magnets. He placed the bar AB (fig. 21.) to be magnetiſed between two great bars of common iron C and D, placing all the three in the magnetical direction. He took another bar EF, and put two little pieces of iron, like the armour of a loadſtone, on its ends; and with thoſe ends he rubbed the bar AB, rubbing the upper half of it with the end F, and the lower with the end E. The reſult of this was a very briſk magnetiſm in a few minutes, which, by various well deviſed alternations, he brought to its higheſt degree. His numerous experiments publiſhed in the Philoſophical Tranſactions in 1746, contain much curious information, highly deſerving the attention of the philoſophers. Mr Canton, proceeding on the ſame principle, that bars of iron, which have been long in a vertical poſition, acquire an efficient magnetiſm, begins his operations by placing his ſteel bar on the head of a kitchen poker, and rubs it with the lower end of a pair of kitchen tongs. Mr Antheaume adheres more ſtrictly to the inferences from the principle of terreſtrial magnetiſm, and repeats preciſely the previous diſpoſition of things practiſed by Mr Savery, placing his little ſteel bar AB (fig. 22.) between two great bars C and D of common iron, and arranging the whole in the magnetic direction. Then, proceeding moſt judiciouſly on the ſame principle, he greatly improves the proceſs, by employing two bars EF and GH for the touch, holding them about an inch apart, inclined about 15° to the bar AB. It is plain, that the lower end of each of theſe five bars is a north pole, and the upper end a ſouth pole. Therefore the poles F and G concur in giving the proper magnetiſm to the portion FG of the ſteel bar which is between them; and by rubbing it with theſe poles up and down, overpaſſing each extremity about half an inch, he muſt ſoon give to the bar AB a regular magnetiſm; weak, perhaps, but to be afterwards increaſed in the Cantonian method, on a horizontal table. In this manner did Mr Antheaume make magnets of very great ſtrength in 1766. See his *Diſſertation* already quoted.

62 Gilbert's terreſtrial magnetiſ

Theſe obſervations naturally bring us to the Physiologia Nova de Magnete et corporibus Magneticis of Dr Gilbert; a diſcovery which the ſagacious Kepler claſſes among the greateſt in the annals of ſcience.

It could not be that a phenomenon ſo general, and ſo intereſting and important as the natural polarity of magnetic bodies, would be long known without exciting curioſity about its cauſe. Accordingly the philoſophers of the 16th century ſpeculated much about it, and entertained a variety of opinion, if that can be called an opinion which can hardly be ſaid to expreſs a thought. We have in *Marſigli Ficino* a ſhort notice of many of theſe opinions. Some maintained that the needle was directed by a certain point in the heavens, as if that were ſaying more than that it always pointed one way. Others, with more appearance of reaſoning, aſcribed the direction to vaſt magnetic rocks. But all this was without giving themſelves the trouble of trying to aſcertain what ſituation of ſuch rocks would produce the direction that is obſerved. Fracaſtori was, if we miſtake not, the firſt who thought this trouble at all neceſſary; and he obſerves very ſenſibly, that if thoſe rocks are ſuppoſed to be in any place yet viſited by navigators, and if they act as loadſtones do (a circumſtance which he ſays muſt be admitted, if we attempt to explain), the direction of the needle will be very different from what we know it to be. He therefore places them in the inacceſſible polar regions, but not in the very pole. Norman, the diſcoverer of the dip of the mariner's needle, or of the true magnetic direction, was naturally led by his diſcovery to conceive the directing cauſe as placed in the earth; becauſe the north point of the needle, in every part of Europe, points very far below the horizon. But although he calls the treatiſe in which he announces his diſcovery the *New Attractive*, he does not expreſs himſelf as ſuppoſing the needle to be attracted by any point within the earth, but only that it is always directed to that point.

It is to Dr Gilbert of Colcheſter that we owe the opinion now univerſally admitted, that magnetic polarity is a part of the conſtitution of this globe. Norman had, not long before, diſcovered, that if a ſteel needle be very exactly balanced on a horizontal axis, like the beam of a common balance, ſo that it would retain any poſition given it, and if it be then touched with a magnet, and placed on its axis in the magnetic meridian, it is no longer in equilibrio, but (at London) the north point of it will dip 72 or 73 degrees below the horizon. He did not, however, publiſh his diſcovery till he had obtained information how it ſtood in other parts of the world. The differences in the variation in different places naturally ſuggeſted the neceſſity of this to him. Being a maker of mariners compaſſes,

paſſes, and teacher of navigation in London, he had the faireſt opportunities that could be deſired, by furniſhing dipping needles to ſuch of the navigators, his ſcholars, as he knew moſt able to give him good information. And the accounts which he received made his diſcovery, when announced to the world, a very complete thing ; for the commanders of ſhips engaged in long voyages, and particularly to China, informed him that, in the vicinity of the equator, his dipping needles remained parallel to the horizon, but that in coming toward the north pole, the north end of the needle was depreſſed, and that the ſouth end dipped in like manner at the Cape of Good Hope, and in the Indian Ocean ; that the needle gradually approached the horizontal poſition as the ſhip approached the equator, but that in coming to the north of it at Batavia, the north point again dipped, and at Canton was ſeveral degrees below the horizon.

On theſe authorities, Norman boldly ſaid that, in the equatoreal regions, the needle was horizontal, and that either end dipped regularly as it approached either pole ; and that in the poles of the earth, the needle was perpendicular to the horizon. He therefore announced this as a diſcovery, not only ſingularly curious, but alſo of immenſe importance ; for by means of a dipping needle the latitude of a ſhip at ſea may be found without ſeeing the ſun or ſtars.

Dr Gilbert, comparing this poſition of the compaſs needle with the poſitions which he had obſerved ſmall needles aſſume in his numerous experiments in relation to a magnet, as we have deſcribed at great length, was naturally led to the notion of the earth's being a great loadſtone, or as containing one, and that this arranged the dipping, or, in general, the mariner's needle, in the ſame manner as he obſerved a great magnet arrange a ſmall needle poiſed on its pivot. He therefore compoſed his *Phyſiologia Nova de Magnete, et de Tellure magno Magnete;* in which he notices ſo many points of reſemblance to the directive power of a magnet, that the point ſeems no longer to admit of any doubt. Dr Gilbert's theory may be thus expreſſed :

All the phenomena of natural magnetiſm are analogous to what we ſhould obſerve, if the earth were a great magnet, having its poles near the poles of the earth's equator, the north pole not far from Baffin's Bay, and the ſouth pole nearly in the oppoſite part of the globe. A dipping needle, under the influence of this great magnet, muſt arrange itſelf in a plane which paſſes through the poles of the magnet, the poſition of which plane is indicated (at leaſt nearly) by the ordinary compaſs needle ; and it will be inclined to the horizon ſo much the more as we recede from the equator of the great magnet.

This opinion of Dr Gilbert was not leſs ingenious than important ; and if firmly eſtabliſhed, it furniſhes a complete theory of all the phenomena of magnetiſm. But obſervations were neither ſufficiently numerous in the time of Dr Gilbert, nor ſufficiently accurate, to enable that great genius to aſſign the poſition of this great magnet, nor the laws of its action. The theory was chiefly founded on the phenomena of the dipping needle ; phenomena which might have been unknown for ages, had the firſt notice of them fallen into any other hands than Norman's. They are not, like thoſe of variation, which might be made by any ſailor. They require for their exhibition a dipping needle, and the attention to circumſtances which can occur only to a mathematician. A dipping needle is to this day, notwithſtanding all our improvements in the arts, one of the moſt delicate and difficult taſks that an inſtrument maker can take in hand, and a good one cannot be had for leſs than twenty guineas. We are confident that ſuch as even Norman could make were far inferior to what are now made, and quite unfit for uſe at ſea while the ſhip is under ſail, although they may be tolerably exact for an obſervation of the dip in any port ; and we preſume that it was ſuch obſervations only that Norman confided in. Our readers will readily conceive the difficulty of poiſing a needle with ſuch a perfect coincidence of its centre of gravity and axis of motion, and perfect roundneſs of this axis, that it ſhall remain in any poſition that is given it. Add to this, that a grain of duſt, inviſible to the niceſt eye, getting under one ſide of this axis, may be ſufficient for making it aſſume another poſition. It muſt alſo be a difficult matter to preſerve this delicate thing, ſo as that no change can happen to it. Beſides, all this muſt be performed on a piece of tempered ſteel which we are certain has no magnetiſm. Where can this be got, or what can inſure us againſt magnetiſm? Nor is there leſs difficulty in making the obſervations without great riſk of error. If the needle, moveable only in a vertical plane, be not ſet in the plane of a magnetic meridian, it will always dip too much. At London, where the magnetic direction is inclined 73° to the horizon, if it be in a plane 20° from the magnetic meridian, it will ſtand almoſt perpendicular ; for it is eaſy to ſee, by the mechanical reſolution of forces, that it will take the poſition which brings it neareſt to the true magnetic direction. This, we think, is confirmed by ſeveral of Norman's and other old obſervations of dip. They are much greater than they have been ſince found in the ſame places.

63
Daniel Bernoulli's dipping needle.

Mr Daniel Bernoulli has given a very ingenious principle, by which we can make a dipping needle which will give a very accurate obſervation on ſhore ; and being ſo eaſily executed, it deſerves to be generally known. Let a dipping needle be made in the beſt manner that can be done by a workman of the place, and balanced with ſome care before impregnation, ſo that we may be certain that when touched it will take nearly the true dip. Touch it, and obſerve the dip. Deſtroy its magnetiſm, and then alter its balance in ſuch a manner that, without any magnetiſm, it will arrange itſelf in the inclination of the obſerved dip. Now touch it again, giving it the ſame poles as before. It is plain that it will now approach exceedingly near indeed to the true dip, becauſe its want of *perfect* equilibrium deranged it but a few degrees from the proper direction. If this ſecond obſervation of the dip ſhould differ ſeveral degrees from the firſt, by the inaccurate firſt formation of the needle, it will be proper to repeat the operation. Very rarely indeed will the third obſervation of the dip vary from the truth half a degree.

Mr Bernoulli makes this ſimple contrivance anſwer the purpoſe of an univerſal inſtrument in the following ingenious manner. A very light braſs graduated circle EFG (fig. 23.) is fixed to one ſide of the needle, concentric with its axis, and the whole is balanced as nicely as poſſible before impregnation. A very light index

CD is then fitted on the axis, ſo as to turn rather ſtiffly on it. This will deſtroy the equilibrium of the needle. If the needle has been made with perfect accuracy, and perfectly balanced, the addition of this index would cauſe it always to ſettle with the index perpendicular to the horizon, whatever degree of the circle it may chance to point at. But as this is ſcarcely to be expected, ſet the index at various degrees of the circle, and note what inclination the unmagnetic needle takes for each place of the index, and record them all in a table. Suppoſe, for example, that when the index is at 50, the needle inclines 46° from the horizon. If in any place we obſerve that the needle (rendered magnetic by lying between two ſtrong magnets), having the index at 50, inclines 46°, we may be certain that this is the dip at that place; for the needle is not deranged by the magnetiſm from the poſition which gravity alone would give it. As we generally know ſomething of the dip that is to be expected in any place, we muſt ſet the index accordingly. If the needle does not ſhew the expected dip, alter the poſition of the index, and again obſerve the dip. See whether this ſecond poſition of the index and this dip form a pair which is in the table. If they do, we have got the true dip. If not, we muſt try another poſition of the index. Noticing whether the agreement of this laſt pair be greater or leſs than that of the former pair, we learn whether to change the poſition of the index in the ſame direction as before, or in the oppoſite. The writer of this article has a dipping needle of this kind, made by a perſon totally unacquainted with the making of philoſophical inſtruments. It has been uſed at Leith, at Cronſtadt in Ruſſia, at Scarborough, and at New York, and the dip indicated by it did not in any ſingle trial differ $1\frac{1}{2}$ degrees from other trials, or from the dip obſerved by the fineſt inſtruments. He tried it himſelf in Leith Roads, in a rough ſea; and does not think it inferior, either in certainty or diſpatch, to a needle of the moſt elaborate conſtruction. It is worthy of its moſt ingenious author, and of the public notice, becauſe it can be made for a moderate expence, and therefore may be the means of multiplying the obſervations of the dip, which are of immenſe conſequence in the theory of magnetiſm, and for giving us an accurate knowledge of the magnetical conſtitution of this globe.

64
Opinions concerning the great magnet contained in this globe.

This knowledge is ſtill very imperfect, owing to the want of a very numerous collection of obſervations of the dip. They are of more importance than thoſe of the horizontal deviations from the meridian. All that we can ſay is, that the earth acts on the mariner's needle as a great loadſtone would do. But we do not think that the appearances reſemble the effects of what we would call a good loadſtone, having the regular magnetiſm of two vigorous poles. The dips of the needle in various parts of the earth ſeem to be ſuch as would reſult from the action of an extremely irregular loadſtone, having its poles exceedingly diffuſed. The increaſe of the dip, as we recede from thoſe places where the needle is horizontal, is too rapid to agree with the ſuppoſition of two poles of conſtipated magnetiſm, whether we ſuppoſe the magnetic action in the inverſe ſimple or duplicate ratio of the diſtances, unleſs the great terreſtrial magnet be of much ſmaller dimenſions than what ſome other appearances oblige us to ſuppoſe. If there be four poles, as Dr Halley imagined, it will be next to impoſſible to aſcertain the poſitions of the dipping needle. It will be a tangent to one of the ſecondary magnetic curves, and theſe will be of a very intricate ſpecies. We cannot but conſider the diſcovery of the magnetic conſtitution of this globe as a point of very great importance, both to the philoſopher and to ſociety. We have conſidered it with ſome care; but hitherto we have not been able to form a ſyſtematic view of the appearances which gives us any ſatisfaction. The well informed reader is ſenſible, that the attempt by means of the horizontal or variation needle is extremely tedious in its application, and is very unlikely to ſucceed; at the ſame time it muſt be well underſtood. The two diſſertations by Euler, in the 13th and 22d volumes of the Memoirs of the Royal Academy at Berlin, are moſt excellent performances, and give a true notion of the difficulty of the ſubject. Yet, even in theſe, a circumſtance is overlooked, which, for any thing we know to the contrary, may have a very great effect. If the magnetic axis be far removed from the axis of revolution, as far, for example, as Mr Churchman places it, the magnetic meridians will be (generally) much inclined to the horizon; and we ſhall err very far, if we ſuppoſe (as in Euler's calculus) that the dipping needle will arrange itſelf in the vertical plane, paſſing through the direction of the horizontal or variation needle; or if we imagine that the poles of the great magnet are in that plane. We even preſume to think that Mr Euler's aſſumption of the place of his fictitious poles (namely, where the needle is vertical), in order to obtain a manageable calculus, is erroneous The introduction of this circumſtance of inclination of the magnetic meridians to the horizon, complicates the calculation to ſuch a degree as to make it almoſt unmanageable, except in ſome ſelected ſituations. Fortunately, they are important ones for aſcertaining the places of the poles. But the inveſtigation by the poſitions of the dipping needle is incomparably more ſimple, and more likely to give us a knowledge of a multiplicity of poles. The conſideration of the magnetic curves (in the ſenſe uſed in the preſent article), teaches us that we are not to imagine the poles immediately under thoſe parts of the ſurface where the needle ſtands perpendicular to the horizon, nor the magnetic equator to be in thoſe places where the needle is horizontal; a notion commonly and plauſibly entertained. Unfortunately our moſt numerous obſervations of the dip are not in places where they are the moſt inſtructive. A ſeries ſhould be obtained, extending from New Zealand northward, acroſs the Pacific Ocean to Cape Fairweather on the weſt coaſt of North America, and continued through that part of the continent. Another ſeries ſhould extend from the Cape of Good Hope, up along the weſt coaſt of Africa to the tropic of Capricorn; from thence acroſs the interior of Africa (where it would be of great importance to mark the place of its horizontality) through Sicily, Italy, Dalmatia, the eaſt of Germany, the Gulph of Bothnia, Lapland, and the weſt point of Greenland. This would be nearly a plane paſſing through the probable ſituations of the poles. Another ſeries ſhould be made at right angles to this, forming a ſmall circle, croſſing the other near Cape Fairweather. This would paſs near Japan, through Borneo, and the weſt end of New Holland; alſo near Mexico, and a few degrees weſt of Eaſter Iſland. In this place, and at Borneo, the

See VARIATION, *Encycl.*

the inclination of the magnetic plane to the horizon would be conſiderable, but we cannot find this out. It may, however, be diſcovered in other points of this circle, where the dip is conſiderable. We have not room in this ſhort account to illuſtrate the advantages derived from theſe ſerieſes; but the reflecting reader will be very ſenſible of them, if he only ſuppoſes the great magnet to be accompanied by its magnetic curves, to which the needle is always a tangent. He will then ſee that the firſt ſeries from New Zealand to Cape Fairweather, and the ſecond from Cape Fairweather round the other ſide of the globe, being in one plane, and at very different diſtances from the magnetic axis, muſt contain very inſtructive poſitions of the needle. But we ſtill confeſs, that when we compare the dips already known with the variations, they appear ſo irreconcileable with the reſults of an uniform regular magnetiſm, that we deſpair of ſucceſs. Every thing ſeems to indicate a multiplicity of poles, or, what is ſtill more adverſe to all calculation, an irregular magnetiſm with very diffuſed polarity.

Much inſtruction may ſurely be expected from the obſervations of the Ruſſian academicians and their eleves, who are employed in ſurveying that vaſt empire; yet we do not meet with a ſingle obſervation of the dip of the needle in all the bygone publications of that academy, nor indeed are there many of the variation.

65 nd con- rning the uation of poles.

For want of ſuch information, philoſophers are extremely divided in their opinions of the ſituation of the magnetic poles of this globe. Profeſſor Kruſſt, in the 17th volume of the Peterſburgh Commentaries, places the north pole in lat. 70° N. and long. 23° W. from London; and the ſouth pole in lat. 50° S. and long. 92° E.

Wilcke of Stockholm, in his indication chart (*Swed. Mem.* tom. xxx p. 218.), places the north pole in N. Lat. 75°, near Baffin's Bay, in the longitude of California. The ſouth pole is in the Pacific Ocean, in lat. 70° S.

Churchman places the north pole in lat. 59° N and long. 135° W. a little way inland from Cape Fairweather; and the ſouth pole in lat. 59° S. Long. 165° E. due ſouth from New Zealand.

A planiſphere by the Academy of Sciences at Paris for 1786, places the magnetic equator ſo as to interſect the earth's equator in long. 75°, and 155° from Ferro Canary Iſland, with an inclination of 12 degrees nearly, making it a great circle very nearly. But we are not informed on what authority this is done; and it does not accord with many obſervations of the dip which we have collected from the voyages of ſeveral Britiſh navigators, and from ſome voyages between Stockholm and Canton. Mr Churchman has given a ſketch of a planiſphere with lines, which may be called parallels of the dip. Thoſe parts of each parallel that have been aſcertained by obſervation are marked by dots, ſo that we can judge of his authority for the whole conſtruction. It is but a ſketch, but gives more ſynoptical information than any thing yet publiſhed. The magnetic equator cuts the earth's equator in long. 15°, and 195° E. from Greenwich, in an angle of nearly 17 degrees. The circles of magnetic inclination are not parallel, being conſiderably nearer to each other on the ſhort meridian than on its oppoſite. This circumſtance, being founded on obſervation, is one of the ſtrongeſt arguments for the exiſtence of a magnet of tolerable regularity, as the cauſe of all the poſitions of the compaſs needle; for ſuch *muſt* be the poſitions of the circles of equal dip, if the axis of this magnet is far removed from the axis of rotation, and does not interſect it.

Now, if the ſituation of the poles be any thing near the average or medium of theſe determinations, and if we form all our notions by analogy, comparing the poſitions of the compaſs needle in relation to the great terreſtrial magnet, with the poſitions aſſumed by a ſmall needle in the neighbourhood of a magnet, we muſt conclude, that the magnetical conſtitution of this globe has little or no reference to its regular external form. The axis of the magnet is very far removed from that of the globe (at leaſt 1500 miles), and is not nearly parallel to it, nor in the ſame plane. It required the ſagacity and the ſkill of a Euler to ſubject ſuch anomalous magnetiſm to any rules of computation; and every perſon qualified to judge of the ſubject muſt allow his diſſertation in the 13th volume of the Berlin Memoirs to be a work of wonderful reſearch. It is a very agreeable thing to ſee ſuch a conformity between the lines which expreſs the regular magnetiſm of Euler's diſſertation, and the lines drawn by Dr Halley from obſervation, and which appeared to himſelf ſo capricious, that he deſpaired (notwithſtanding his conſummate ſkill in geometry) of their ever being reduced to a mathematical and preciſe ſyſtem. 66.

67 Confirmations of Dr Gilbert's phyſiology.

Without detracting from the merit of Dr Gilbert, we may preſume to ſay that his notion of the earth's being a great magnet was not, in his mind, more than a ſagacious conjecture, formed from a very general and even vague compariſon. Yet the compariſon was ſufficiently good to give him great confidence in his opinion that the action of this great magnet, in perfect conformity to what we obſerve in our experiments with magnets, is the ſource of all the magnetiſm that we obſerve. If there was nothing elſe in proof of the juſtneſs of his theory, it is abundantly proved by the beautiful experiment of Mr Henſhaw, mentioned in the article VARIATION, *Encycl.* p. 621. col. 2. An iron bar held nearly upright, attracts the ſouth end of a compaſs needle with its lower end; and if that end of the bar be kept in its place, and the bar turned round till it becomes the upper end, the ſouth point of the needle immediately turns away from it, and the north end is now attracted. This experiment may be perfectly imitated with artificial magnetiſm.

Having ſupported a large magnet SAN (fig. 24.), ſo that its ends are detached from ſurrounding bodies, place a ſmall needle B (poiſed on its pivot) about three inches below the north pole N of the magnet, and in ſuch a ſituation that its polarity to the magnet may be very weak. Take now a ſmall piece of common iron, and hold it in the poſition repreſented at C. Its lower end becomes a north pole, attracting the ſouth pole of the needle. Keeping this in its place, turn round the piece of iron into the poſition D; the ſouth pole of B will now avoid it, and the north pole will be attracted. We directed the needle to be ſo placed, that its polarity, in relation to the magnet, may be weak. If it be ſtrong, it may act on the end of C or D like a magnet, and counteract the magnetiſm induced on C or D by vicinity to A.

An

An anonymous writer in the Philoſophical Tranſactions, N° 177. Vol. XV. relates ſeveral obſervations made during a voyage to the Eaſt Indies, which are quite conformable to this. A few leagues northweſt from the iſland Aſcenſion, the ſouth point of the compaſs needle hardly ſhewed any tendency to or from the lower end of an iron bar. It ſeemed rather to avoid the upper end; it was not in the leaſt affected by the middle of the bar; but when the bar was laid horizontal, in the magnetic direction, its two ends affected the diſſimilar ends of the compaſs needle very ſtrongly; but when horizontal, and lying at right angles to the magnetic direction, its polarity was altogether indifferent.

As the other phenomena of induced artificial magnetiſm have the ſame reſemblance to the phenomena of natural magnetiſm, a bar which has remained long in the vicinity of a magnet acquires magnetiſm (permanent) in the ſame way, and modified by the ſame circumſtances, as in natural magnetiſm. Hammering a bit of common iron in the immediate vicinity of a magnet, gives it very good magnetiſm. Expoſing a red hot bar to cool in the neighbourhood of a magnet has the ſame effect. Alſo quenching it ſuddenly has the ſame effect. Quenching a ſmall red hot ſteel bar between two magnets, was found by us to communicate a much ſtronger magnetiſm than we could give it by any other method. Its form indeed was very unfavourable for the ordinary method of touching; for it conſiſted of two little ſpheres connected by a ſlender rod, and could ſcarcely be impregnated in any other way than by placing it for a very long while between magnets. In all theſe experiments, the polarity acquired is preciſely ſimilar to that acquired by the ſame treatment in relation to this ſuppoſed great terreſtrial magnet. In ſhort, in whatever manner we purſue this analogy in our experiments, we find the reſemblance moſt perfect in the phenomena.

We cannot but think, therefore, that this new phyſiology of the magnet by Dr Gilbert is well eſtabliſhed; and we think ourſelves authoriſed to aſſume it as a propoſition fully demonſtrated, that the earth is a great magnet, or contains a great magnet, the agency of which produces the direction of the magnetic needle, and all the magnetiſm which iron acquires by long continuance in a proper poſition. It is this which made us ſay, in the beginning of this article, that attraction and polarity were not confined to magnets, but were properties belonging to all iron in its metallic ſtate. We now ſee the reaſon why any piece of iron brought very near to another piece will attract it—both become magnetical, in conſequence of the agency of the great magnet; and their magnetiſm is ſo diſpoſed, that their mutual attractions exceed their repulſions. Alſo, why an iron rod, placed nearly in the magnetical direction, will finally arrange itſelf in that direction. Alſo, why the terreſtrial polarity of common iron is indifferent, and either end of the rod will ſettle in the north, if it have nearly that poſition at firſt. The magnetiſm induced by mere momentary poſition is ſo feeble as to yield to any artificial magnetiſm. As a moment was ſufficient for imparting it, a moment ſuffices for deſtroying it; and another moment will impart the oppoſite magnetiſm. But artificial magnetiſm requires more force for its production, and ſome of it remains when the producing cauſe is removed, and it does not yield at once to the contrary magnetiſm. That there is no farther difference appears from this, that long continued poſition gives determined and permanent magnetiſm, and that it is deſtroyed by an equally long continuance in the contrary poſition. It ſeems to be very generally true, that a magnet will carry more by its north than by its ſouth pole. It ſhould be ſo in this part of the world, becauſe the terreſtrial magnetiſm induced on the iron conſpires with the magnetiſm induced by the north pole of a magnet, but counteracts the magnetiſm induced by the ſouth pole.

The propriety of Mr Savery's, Mr Canton's, and Mr Antheaume's proceſſes for beginning the impregnation of hard ſteel bars is now plain, and the ſuperior effect of the two great bars of common iron in the propoſed method of Mr Antheaume. We cannot but take this opportunity of paying the proper tribute of praiſe to the ingenuity of Mr Savery. Every circumſtance of his proceſs was ſelected in conſequence of an accurate conception of magnetiſm, and the combination of this ſcience with Dr Gilbert's theory. His proceſs is the ſame with Antheaume's in every reſpect, except the circumſtance of the double touch borrowed from Mitchell and Canton. Theſe obſervations do not detract from the diſcernment of Mitchell and Canton, who ſaw in thoſe experiments what had eſcaped the attention of hundreds of readers.

68 Seeming objection deduced from the want of ſenſible a traction.

But there occurs an objection to this theory of Dr Gilbert, which was urged againſt it with great force. We obſerve no tendency in the magnet or compaſs needle toward this ſuppoſed magnet. An iron or ſteel bar is not found to increaſe its tendency downwards, that is, is not ſenſibly heavier, when its ſouth pole is uppermoſt in this part of the world. A needle ſet afloat on a piece of cork arranges itſelf quickly in the proper direction; but if continued ever ſo long afloat, it has never been obſerved to approach the north ſide of the veſſel. This is quite unlike what we obſerve in the mutual actions of magnets, or the action of magnets on iron. This objection appears to have given Dr Gilbert ſome concern; and he mentions many experiments which have been tried on purpoſe to diſcover ſome magnetical tendency. He gets rid of it as well as he can, by ſaying, that the directive power of a magnet extends much farther than its attractive power. He confirms this by ſeveral experiments. But Dr Gilbert had not ſtudied the ſimultaneous actions of the four poles, nor explained, by the principles of compound motion, how theſe produced all the poſſible poſitions of the needle. Indeed, the compoſition of mechanical forces was by no means familiar with philoſophers at the end of the 16th century. We ſee it now very diſtinctly. The polarity of the needle, or the force with which it turns itſelf into the magnetical poſition, depends on the difference between the *ſums* of the actions of each pole of the magnet on both the poles of the needle; whereas its tendency towards the magnet depends on the difference of the *differences* of thoſe actions (ſee n° 22, 25.) The firſt may thus be very great when the other is almoſt inſenſible. We ſee, that coarſe iron filings heap about the magnet very faſt, and that very fine filings approach it very ſlowly. Now, the largeſt magnet that we can employ, when compared with the great magnet in the earth, is but as a particle of the fineſt filings that can be conceived. This ſurely diminiſhes exceedingly, if it does not entirely annihilate the objection: but as we have heard it urged by many as an improbable thing, that a long magnet, kept afloat for many months (which has been done) ſhall not ſhew the *ſmalleſt* tendency towards the pole of the terreſtrial magnet, we think it deſerves to be conſidered with accuracy, and the queſtion decided in a way which will admit of no doubt.

69
s com-
ely an-
red.

Let the very ſmall magnet C (fig. 25.) be placed near a great magnet A, and then near a ſmaller magnet B, in ſuch a manner that its polarity to both ſhall be the ſame; and then let us determine the proportion between the attractions of A and B for the ſmall magnet C.

This will evidently depend on the law of magnetic action. For greater ſimplicity of inveſtigation, we ſhall content ourſelves with ſuppoſing the action to be inverſely as the diſtance.

Let AN, $= $AS, $= a$; BN $= b$; C$n = c$, AC $= d$, BC $= \delta$; and let the abſolute force of A be to that of B at the ſame diſtance as m to 1.

The magnetic action being ſuppoſed proportional to $\frac{1}{d}$, we have,

1. Action of AN on C$s = \frac{m}{d-a-c}$.

2. ——— AN on C$n = -\frac{m}{d-a+c}$.

3. ——— AS on C$s = -\frac{m}{d+a-c}$.

4. ——— AS on C$n = \frac{m}{d+a+c}$.

5. The whole action $= \frac{8macd}{\overline{d^2-\overline{a+c}^2}\vert^2 \times \overline{d^2-\overline{a-c}^2}\vert^2}$.

6. If c be very ſmall in compariſon with a or b, the whole action of A is very nearly $= \frac{8macd}{\overline{d^2-a^2}^2}$.

7. And the tendency of C to B is, in like manner, $= \frac{8bc\delta}{\overline{\delta^2-b^2}^2}$.

The directive powers of A and B are at their maximum ſtate when C is placed with its axis at right angles to the lines AC or BC. In which caſe we have,

8. The directive power of A $= \frac{4ma}{d^2-a^2}$.

9. The directive power of B $= \frac{4b}{\delta^2-b^2}$.

When theſe directive powers are made equal, by placing C at the proper diſtances from A and B, we have,

10. $4ma : 4b$, or $ma : b = d^2 - a^2 : \delta^2 - b^2$
And $ma\delta^2 - mab^2 = bd^2 - ba^2$
$ma\delta^2 = b(d^2 - a^2) + mab^2$.

11. $\delta^2 = \frac{b}{ma}(d^2 - a^2) + b^2$.

12. $\delta = \sqrt{\frac{b}{ma}(d^2 - a^2) + b^2}$.

Let the attractions of A and B for the very ſmall magnet C, when its polarity to both is the ſame, be expreſſed by the ſymbols α and β. We have $\alpha : \beta = \frac{8macd}{(d^2-a^2)^2} : \frac{8bc\delta}{(\delta^2-b^2)^2}$, which, by n° 10. is $= \frac{8(d^2-a^2)cd}{(d^2-a^2)^2} : \frac{8(\delta^2-b^2)c\delta.}{(\delta^2-b^2)^2} = \frac{d}{d^2-a^2} : \frac{\delta}{\delta^2-b^2}$, $= bd : ma\delta$; that is,

13. Attr^n of A : attr^n of B $= bd : ma\delta$.

As an example of this compariſon, let us ſuppoſe the great terreſtrial magnet to be a thouſand times larger and ſtronger than the magnet whoſe attraction we are comparing with that of terreſtrial magnetiſm. Let us alſo ſuppoſe the diſtance from the pole of the great magnet to be ſmall, ſo that its attraction may be conſiderable. Let us make $d = 1200$, a being $= 1000$, and $b = 1$. Theſe are all very reaſonable ſuppoſitions. Subſtituting theſe values in the formula, we have attr^n of A : attr^n of B $= 1 : 1000$ very nearly; and therefore when the needle, when placed near a magnet, vibrates by its polarity as faſt as it does by natural magnetiſm, its tendency toward that magnet muſt be altogether inſenſible; for the diſproportion is incomparably greater than that of 1 to 1000, in the largeſt magnets with which we can make experiments. Obſerve alſo, that we have taken the caſe where the attractions are the ſtrongeſt, viz. when the magnet C is placed in the axis of A or B. In the oblique poſitions, tangents to the magnetic curves, the attractions are ſmaller, almoſt in any ratio.

We took the inverſe ratio of the diſtances for the law of action, only becauſe the analyſis was very ſimple. It is very evident, that the diſproportion will be ſtill more remarkable if the action be inverſely as the ſquare of the diſtance.

The objection therefore to the origin of the polarity of the compaſs needle, and of all other magnets, namely, the action of a great magnet contained in the earth, appears plainly to be of no force. We rather think that the want of all ſenſible attraction, where there is a briſk polarity, is a proof of the juſtneſs of the conjecture; for if the compaſs needle were arranged by the action of magnetic rocks, or even extenſive ſtrata, near the ſurface of the earth, the attractions would bear a greater proportion to the polarities. We have even obſerved this. A conſiderable maſs of magnetic ſtratum was found to derange the needle of a ſurveyor's theodolite at a conſiderable diſtance all around (about 140 yards). The writer placed the needle on a thin lath, which juſt floated it on water in a large wooden diſh, and ſet it in a place where it was drawn about 15 degrees from the magnetic meridian. It was left in that ſituation a whole night, well defended from the wind by a board laid on the diſh. Next morning it was found applied to that ſide of the diſh which was neareſt to the diſturbing rocks. It had moved about ſix inches. This was repeated three times, and each time it moved in the ſame direction (nearly), which differed conſiderably from the direction of the needle itſelf.

It is now plain that we may, with confidence, aſſume Dr Gilbert's theory of terreſtrial magnetiſm as ſufficiently eſtabliſhed. And, ſince we muſt certainly call that the north pole of the great magnet which is ſituated in the northern parts of the earth, and ſince thoſe poles of magnets which attract each other have oppoſite polarities, we muſt ſay, that what we call the north pole of a mariner's needle, or of any other magnet, has the ſouthern polarity.

We may now venture to go farther with Dr Gilbert, and

70 The great magnet is the ſource of all natural magnetiſm.

and to ſay that *all* the magnetiſm which we obſerve, whether in nature or art, is either the immediate or the remote effect of the action of the great magnet. As ſoft bars ſoon acquire a tranſient magnetiſm; as hard bars, after long expoſure, acquire a ſenſible and permanent magnetiſm—we muſt infer, that ores of iron, which are in a ſtate fit for impregnation, muſt acquire a ſenſible and permanent magnetiſm, by continuing, for a ſeries of ages, in the bowels of the earth. And thus the magnetiſm of loadſtones, which, till the diſcovery of the natural magnetiſm acquired by poſition, were the ſources of all our magnetical phenomena, is now proved to be a neceſſary conſequence of the exiſtence and agency of a great magnet contained in the bowels of the earth.

71 Loadſtones in the mine may have their poles in any poſition.

It ſeems to reſult from this theory, that, in theſe northern parts of the world, that part of every natural loadſtone that is at the extremity of the line drawn through the ſtone in the magnetic direction ſhould be its pole; and that the loadſtone, when properly poiſed, ſhould of itſelf aſſume the very poſition which it had in the mine. Dr Gilbert complains of the inattention of miners *(rude hominum genus, lucro potius quam phyſicæ conſulentes)* to this important circumſtance. Once, however, he had the good fortune to be advertiſed of a great magnetic maſs lying in its matrix. He repaired quickly to the mine, examined it, and marked its points which were in the extremities of the magnetic line. When it was detached from its matrix, he had the pleaſure of finding its poles in the very places he expected. The loadſtone was of conſiderable ſize, weighing about 20 pounds.—Mr Wilcke gives in the Swediſh Commentaries ſeveral inſtances of the ſame kind.

But ſhould this always be the caſe? By no means. There are many circumſtances which may give the magnetiſm of a loadſtone a very different direction. We have fonnd, that ſimple juxtapoſition to a magnet will ſometimes give a ſucceſſion of poles to a long bar of hard ſteel. The ſame thing may happen to an extenſive vein of magnetiſable matter. The loadſtone taken out of this vein may have been placed like that of a ſoft bar placed in the magnetic line, if lying in one part of the vein; if taken from another part of it, its polarity may be the very reverſe; and in another part it may have no magnetiſm, although completely fitted for acquiring it. It may have its poles placed in a direction different from all theſe, in conſequence of the vicinity of a greater loadſtone. As loadſtones poſſeſſed of vigorous magnetiſm are always found only in ſmall pieces, and in pieces of various ſizes and force, we muſt expect every poſition of their poles. The only thing that we can expect by theory is, that adjoining loadſtones will have their friendly poles turned toward each other, and a general prevalence of or tendency to a polarity ſymmetrical with that of the earth. The reader will find ſome more obſervations to this purpoſe in the article VARIATION, *Encycl.* p. 623. as alſo in Gilbert's treatiſe, B. III. c. 2. p. 121.

Nor ſhould all ſtrata or maſſes of iron ore be magnetical. We know that none are ſuſceptible of induced magnetiſm, but ſuch as are, to a certain degree, in the metallic ſtate. Such ores are not abundant. Nay, even all of ſuch ſtrata do not neceſſarily acquire magnetiſm by the action of the great magnet. If their principal dimenſions lie nearly perpendicular to the magnetic direction, they will not acquire any ſenſible quantity. A ſtratum in this country, riſing about 17 degrees to the N. N. W. will ſcarcely acquire magnetiſm. It may alſo happen, that the influence of the great magnet is counteracted by that of ſome extenſive ſtratum inacceſſible to man, by reaſon of its great depth.

72 Probable cauſe of their great natural vigour.

Thus we ſee, that all the appearances of the original magnetiſm of loadſtones are perfectly conſiſtent with the notion that they are effects of one general coſmical cauſe, the action of the great magnet contained in the earth, and that there is no occaſion to ſuppoſe this great magnet to differ, in its conſtitution or manner of action, from the ſmall maſſes of ſimilar matter called loadſtone. The only difficulty that preſents itſelf is the great ſuperiority of magnetic force obſervable in ſome loadſtones over other maſſes of ores circumjacent, which are not diſtinguiſhable by us by any other circumſtance. We acknowledge ourſelves unable to ſolve this difficulty; for the magnetiſm of ſuch pieces is ſometimes incomparably ſtronger than what a bar of iron acquires by poſition; yet this bar is much more ſuſceptible than the ores which are fit for becoming loadſtones. Perhaps there is ſome chemical change which obtains gradually in certain maſſes, which aids the impregnation, in the ſame way that we know that being red hot deſtroys all magnetiſm, whether in a metal bar or in an ore. This ſeems to be confirmed by what we ſee in ſome old iron ſtanchions, which acquire the ſtrongeſt magnetiſm in thoſe parts of their ſubſtance which are combining themſelves with ingredients floating in the atmoſphere. That part which is caſed in the ſtone, and exfoliates and ſplits with ruſt, being converted into ſomething like what is called finery cinder, becomes highly and permanently magnetic. Such peculiarities as theſe, operating for ages, may allow a degree of magnetical impregnation (in whatever this may conſiſt) to take place, to which we can ſee no reſemblance in our experiments. It would be worth while to place iron wires in a tube in the magnetic direction, which could be kept of a proper red heat, while it is converted into æthiops by ſteam. It is not unlikely that it wonld acquire a ſenſible and permanent magnetiſm in this way. It may be, that the little atoms, as they arrange themſelves in a ſort of cryſtalline or ſymmetrical form, may alſo arrange ſo as to favour magnetiſm. Were this tried in the vicinity of a ſtrong magnet, the effect might be more remarkable and preciſe. Perhaps, too, while iron is precipitated in a metallic form from its ſolutions by another metal, ſomething of the ſame kind may happen. We know, that proper ores of iron, expoſed to cementation in a low red heat, in the magnetic direction, become magnetic.

73 Natural cauſes of the chan of the m netic dir tion.

Notice has been taken in the *Encycl.* art. VARIATION, of the attempts of ingenious men to explain the change which is obſerved in all parts of the globe, on the direction of the mariner's needle, the gradual change of the variation. The hypotheſis of Dr Halley, that the globe which we inhabit is hollow, and incloſes a magnetic nucleus, moving round another axis, is not inconſiſtent with any natural law, if he did not ſuppoſe the interval filled up with ſome fluid. The action of the nucleus and ſhell on the intervening fluid would gradually bring the two to one common motion of rotation, as may be inferred from the reaſonings employed by Newton in his remarks on the Carteſian vortices.

Leaving

Leaving out this circumſtance, there is only another cauſe which can affect, and muſt affect, the rotation of both; namely, the mutual action of the magnetic nucleus, and the maſſes of magnetic matter in the ſhell. If the axis of rotation of this nucleus be different from the line joining its magnetic poles, theſe poles will have a motion relative to the ſhell; and this motion may eaſily be conceived ſuch as will produce the changes of magnetic direction which we obſerve. It may even produce a motion of the northern magnetic pole in one direction, and of the ſouthern pole in the oppoſite direction, and this with the appearance of different periods of rotation, as ſuppoſed by Mr Churchman. We may here obſerve, by the way, that the change of magnetic direction in this country is not nearly ſo great as is commonly imagined. The horizontal needle has ſhifted its poſition about 35° at London ſince 1585; but the point of the dipping needle has not changed 10°. We may alſo obſerve, that when the pole of the central magnet changes its place, the magnetiſm of an extenſive ſtratum, influenced by it, may ſo alter its diſpoſition, as to change the poſition of the compaſs needle in the oppoſite direction to that of the change which the central magnet alone would induce on it.

But as motions have not yet been aſſigned to this nucleus, which quadrate with the obſerved poſitions of the needle, and as the very exiſtence of it is hypothetical, it may not be amiſs to examine, whether ſuch a change of variation may not be explained by what we know of the laws of magnetiſm, and of the internal conſtitution of this earth?

1. It is pretty certain, that the veins in which loadſtones are found are not parts of the great magnet. This appears from their having two poles while in the mine, and alſo from the very ſmall depth to which man has been able to penetrate. When we compare the poſitions of the dipping needle with thoſe of a ſmall needle near a magnet, we muſt infer, that the poles are very far below the ſurface.

Yet we know, that there are magnetiſable ſtrata of very great extent occupying a very conſiderable portion of the external covering. Though their bulk and abſolute power may be ſmall, when compared with thoſe of the great magnet, yet their greater vicinity to the needles on which obſervations are made, may give them a very ſenſible influence. In this way may a great deal of the obſerved irregularities of the poſitions of the needle be accounted for. In the Lagoon at Teneriffe, *Feuillée* obſerved the variation 13° 30′ weſt in 1724, while at the head of the iſland it was only 5°. The dip at the Lagoon was 63° 30′, greatly ſurpaſſing what was obſerved in the neighbourhood. Muller found, in the mountains of Bohemia, great and deſultory differences of declination, amounting ſometimes to 50°. At Mantua, the variation in 1758 was 12°; while at Bononia and Brixia it was nearly 18°. Great irregularities were obſerved by Goëte in the Gulph of Finland, eſpecially near the iſland of Suſſari, among ſome rocks: on one of theſe, the needle ſhewed no polarity. Captain Cook and Captain Phipps obſerved differences of 10°, extending to a conſiderable diſtance, on the weſt coaſts of North America. In the neighbourhood of the iſland Elba in the Mediterranean, the poſition of the needle is greatly affected by the iron ſtrata, in which that iſland ſo much abounds. In this country, there are alſo obſerved ſmall deviations, which extend over conſiderable tracts of country, indicating a great extent of ſtrata that are weakly magnetic. Since ſuch ſtrata receive their magnetiſm by induction, in a manner ſimilar to a bar of hard ſteel, and ſince we know that this receives it gradually, it may very probably happen, that a long ſeries of years may elapſe before the magnetiſm attains its ultimate diſpoſition.

Here, then, is a neceſſary change of the magnetic direction; and although it may be very different in different places, according to the diſpoſition and the power of thoſe ſtrata, there muſt be a general vergency of it one way.

2. It is well known that all metals, and particularly iron, are in a progreſs of continual production and demetallization. The veins of metals, and more particularly thoſe of iron, are evidently of poſterior date to that of the rocks in which they are lodged. Chemiſtry teaches us, by the very nature of the ſubſtances which compoſe them, that they are in a ſtate of continual change. This is another cauſe of change in the magnetic direction. Nay, we know that ſome of them have ſuddenly changed their ſituation by earthquakes and volcanoes. Some of the ſtreams of lava from Veſuvius and Ætna abound in iron. This has greatly changed its ſituation; and if the ſtrata from which it proceeded were magnetical, the needle in its neighbourhood muſt be affected. Nay, ſubterranean heat alone will effect a change, by changing the magnetiſm of the ſtrata. Mr Lievog, royal aſtronomer at Beſſeſtedt in Iceland, writes, that the great eruption from Hecla in 1783, changed the direction of the needle nine degrees in the immediate neighbourhood. This change was produced at a mile's diſtance from the frozen lava; and it diminiſhed to two degrees at the diſtance of 2½ miles. He could not approach any nearer, on account of the heat ſtill remaining in the lava, after an interval of 14 months.

All theſe cauſes of change in the direction of the mariner's needle muſt be partial and irregular. But there is another cauſe, which is coſmical and univerſal. Dr Halley's ſuppoſition of four poles, or, at leaſt, the ſuppoſition of irregular and diffuſed poles, ſeems the only thing that will agree with the obſervations of declination. We know that all magnetiſm of this kind (that is, diſpoſed in this manner) has a natural tendency to change. The two northern poles may have the ſame or oppoſite polarities. If they are the ſame, their action on each other tends to diminiſh the general magnetiſm, and to cauſe the centre of effort to approach the centre of the magnet. If they have oppoſite polarities, the contrary effect will be produced. The general magnetiſm of each will increaſe, and the pole (or its centre of effort) will approach to the ſurface. In either of theſe caſes, the compound magnetiſm of the whole may change exceedingly, by a change by no means conſiderable in the magnetiſm of each pair of poles. It is difficult to ſubject this to calculation; but the reader may have very convincing proof of it, by taking a ſtrong and a weaker magnet of the ſame length, and one of them, at leaſt, of ſteel not harder than ſpring temper. Lay them acroſs each other like an acute letter X; and then place a compaſs needle, ſo that its plane of rotation may be perpendicular to the plane of the X. Note exactly the poſition in which the needle ſettles. In a few minutes after, it will be found to change conſiderably, although no remarkable change has yet happened to the magnets themſelves.

---

74 Speculations about the origin of magnetiſm. Hypotheſis of Æpinus.

We flatter ourſelves, that our readers will grant that the preceding pages contain what may juſtly be called a theory of magnetiſm, in as much as we have been able to include every phenomenon in one general fact, the induction of magnetiſm; and have given ſuch a deſcription of that fact and its modifications, that we can accurately predict what will be the appearances of magnets and iron put into any deſired ſituation with reſpect to each other. If our notions of philoſophical diſquiſition (delivered in art. Philosophy, *Encycl. Brit.*) be juſt, we have explained the ſubordinate phenomena, or have given a theory of magnetiſm.

But it is not eaſy to ſatisfy human curioſity. Men have even inveſtigated, or ſought for cauſes of the perſeverance of matter in its preſent condition. We have not been contented with Newton's theory of the celeſtial motions, and have ſought for the cauſe of that mutual tendency which he called gravitation, and of which all the motions are particular inſtances.

Philoſophers have been no leſs inquiſitive after what may be the cauſe of that mutual attraction of the diſſimilar poles, and the repulſion of the ſimilar poles, and that faculty of mutual impregnation, or excitement, which ſo remarkably diſtinguiſh iron, in its various ſtates, from all other ſubſtances. The action of bodies on each other at a diſtance, has appeared to them an abſurdity, and all have had recourſe to ſome material intermedium. The phenomenon of the arrangement of iron filings is extremely curious, and naturally engages the attention. It is hardly poſſible to look at it without the thought ariſing in the mind of a ſtream iſſuing from one pole of the magnet, moving round it, entering by the other pole, and again iſſuing from the former outlet. Accordingly, this notion has been entertained from the earlieſt times, and different ſpeculatiſts have had different ways of conceiving how this ſtream operated the effects which we obſerve.

The ſimpleſt and moſt obvious was juſt to make it act like any other ſtream of fluid matter, by impulſion. Impulſion is the thing aimed at by all the ſpeculatiſts. They have a notion, that we conceive this way of communicating motion with intuitive clearneſs, and that a thing is fully explained when it can be ſhewn that it is a caſe of impulſion. We have conſidered the authority of theſe explanations in the article Impulsion of this *Supplement*, and need not repeat our reaſons for refuſing it any pre-eminence. But even when we have ſhewn the phenomena to be caſes of impulſion by ſuch a ſtream, the greateſt difficulty, the moſt curious and the moſt embarraſſing, is to aſcertain the ſources of this impulſive motion of the fluid—How, and from what cauſe does it begin? What forces bend it in curves round the magnet? Thoſe philoſophers, whoſe principle obliges them to explain gravitation alſo by impulſe, muſt have another ſtream to impel this into its curves. Acting by impulſion, this magnetic ſtream muſt loſe a quantity of motion equal to what it communicates. What is to reſtore this? What directs it in a particular courſe thro' the magnet? And what is it that can totally alter that courſe—in a moment—in all the phenomena of induced magnetiſm? How does it impel? Lucretius, either of himſelf, or ſpeaking after the Greek philoſophers, makes it impel, not the iron, but the ſurrounding air, ſweeping it out of the way; and thus giving occaſion for the ſurrounding air to ruſh around the magnet, and to hurry the bits of iron toward it. There is, perhaps, more ingenious refinement in this thought than in any of the impulſive theories adopted ſince his day by Des Cartes, Euler, and other great philoſophers: But it is ſagaciouſly remarked by D. Gregory, in his MS. notes on Newton, that this theory of Lucretius falls to the ground; becauſe the experiments ſucceed juſt as well under water as in the air. As to the explanations, or deſcriptions, of the canals and their dock gates, opening in one direction, and ſhutting in the other, conſtructions that are changed in an inſtant in a bar of iron, by changing the poſition of the magnet, we only wonder that men, who have a reputation to loſe, ſhould ever hazard ſuch crude and unmechanical dreams before the public eye. The mind of man cannot conceive the poſſibility of their formation; and if they are really formed, the effects ſhould be the very oppoſite of thoſe that are obſerved: the ſtream ſhould move thoſe bodies leaſt which afford ready channels for its paſſage. If a rag of iron filings be arranged by the impulſion of ſuch a ſtream, it ſhould be carried along by it; and if it is *impelled toward* one end of the magnet, it ſhould be impelled *from* the other end. Since we now know, that each particle of filings is a momentary magnet, we muſt allow a ſimilar ſtream whirling round each. Is that an explanation which exceeds all power of conception?

But has it ever been ſhewn, that there is any impulſion at all in theſe phenomena? Where is the impelling ſubſtance? The only argument ever offered for its exiſtence is, that we are reſolved that the phenomena of magnetiſm ſhall be produced by impulſion, and the arrangement of iron filings looks ſomewhat like a ſtream. But enough of this. We truſt that we have ſhewn the way in which this arrangement obtains in the cleareſt manner. Every particle becomes magnetic by induction. This is a fact, which ſets all reaſoning at defiance. The polarity of each rag is ſo diſpoſed, that their adjoining ends turn to each other. This is another uncontrovertible fact. And theſe two facts explain the whole. The arrangement of iron filings, therefore, is a ſecondary fact, depending on principles more general; and therefore cannot, conſiſtently with juſt logic, be aſſumed as the foundation of a theory.

Had magnetiſm exhibited no phenomena beſides the attraction and repulſion of magnets, it is likely that we ſhould not have proceeded very far in our theories, and would have contented ourſelves with reducing theſe phenomena to their moſt general laws. But the communication of magnetiſm ſeems a great myſtery. The ſimple approach of a magnet communicates theſe powers to a piece of iron; and this without any diminution of its own powers. On the contrary, beginning with magnets which have hardly any ſenſible power, we can, by a proper alternation of the manipulations, communicate the ſtrongeſt magnetiſm to as many hard ſteel bars as we pleaſe; and the original magnets ſhall be brought to their higheſt degree of magnetiſm. We have no notion of powers or faculties, but as qualities of ſome ſubſtances in which they are inherent. Yet here is no appearance of ſomething abſtracted from one body, and communicated to, or ſhared with another. The proceſs is like kindling a great fire by a ſimple ſpark; here is no communication, but only *occaſion* given to the exertion of powers inherent in the combuſtible matter. It appears probable, that the caſe is the ſame in magnetiſm; and that all that is performed in making a magnet is the excitement of powers already in the ſteel, or the giving occaſion for their exertion; as burning the thread which ties together the two ends of a bow, allows it to unbend. This notion did not eſcape the ſagacity of Dr Gilbert; and he is at much pains to ſhew, that the *coitio magnetica* is a quality inherent in all magnetical bodies, and only requires the proper circumſtance for its exertion. He is not very fortunate in his attempts to explain *how* it is developed by the vicinity of a magnet, and how this faculty, or actual exertion of this power, becomes permanent in one body, while in another it requires the conſtant preſence of the magnet.

74 Magnetical hypotheſis of Æpinus.

It is to Mr Æpinus, of the Imperial Academy of St Peterſburgh, that we are indebted for the firſt really philoſophical attempt to explain all theſe myſteries. We mentioned, in the article ELECTRICITY, *Suppl.* the circumſtance which ſuggeſted the firſt hint of this theory to Æpinus, *viz.* the reſemblance between the attractions and repulſions of the tourmaline and of a magnet. A material cauſe of the electric phenomena had long been thought familiar to the philoſophers. They had attributed them to a fluid which they called an electric fluid, and which they conceived to be ſhared among bodies in different proportions, and to be transferable from one to another. Dr Franklin's theory of the Leyden phial, which led him to think that the faculty of producing the electrical phenomena depended on the deficiency as well as the redundancy of this fluid, combined with the phenomena of induced electricity, ſuggeſted to Æpinus a very perſpicuous method of ſtating the analogy of the tourmaline and the magnet; which he publiſhed in 1758 in a paper read to the academy.

Reflecting more deeply on theſe things, Mr Æpinus came by degrees to perceive the perfect ſimilarity between all the phenomena of electricity by poſition and thoſe of magnetiſm; and this led him to account for them in the ſame manner. As the phenomena of the Leyden phial, explained in Franklin's manner, ſhews that a body may appear electrical all over, by having leſs than its natural quantity of the electric fluid, as well as by having more, it ſeemed to follow, that it may alſo be ſo in reſpect to different parts of the ſame body; and therefore a body may become electrified in oppoſite ways at its two extremities, merely by abſtracting the fluid from one end, and condenſing it in the other; and thus may be explained the phenomena of induced electricity, where nothing appears to have been communicated from one body to the other. If this be the caſe, the two ends of a body rendered electric by induction ſhould exhibit the ſame diſtinctions of phenomena that are exhibited by bodies wholly redundant and wholly deficient. The redundant ends ſhould repel each other; ſo ſhould the deficient ends; and a redundant part ſhould attract a deficient. All theſe reſults of the conjecture tally exactly with obſervation, and give a high degree of probability to the conjecture. The ſimilarity of theſe phenomena to the attractions of the diſſimilar poles of a magnet, and the repulſions of the ſimilar poles, is ſo ſtriking, that the ſame mode of explanation forces itſelf on the mind, and led Mr Æpinus to think, that the faculty of producing the magnetical phenomena belonged to a magnetical fluid, reſiding in all bodies ſuſceptible of magnetiſm; and that the exertion of this faculty require nothing but the abſtraction of the fluid from one end of the magnetic bar, and its conſtipation in the other. And this conjecture was confirmed by obſerving, that in the induction of magnetiſm on a piece of iron, the power of the magnet is not diminiſhed.

All theſe circumſtances led Mr Æpinus to frame the following hypotheſis:

1. There exiſts a ſubſtance in all magnetic bodies, which may be called the magnetic fluid; the particles of which repel each other with a force decreaſing as the diſtance increaſes.

2. The particles of magnetic fluid attract, and are attracted by the particles of iron, with a force that varies according to the ſame law.

3. The particles of iron repel each other according to the ſame law.

4. The magnetic fluid moves, without any conſiderable obſtruction, through the pores of iron and ſoft ſteel; but is more and more obſtructed in its motion as the ſteel is tempered harder; and in hard tempered ſteel, and in the ores of iron, it is moved with the greateſt difficulty.

In conſequence of this ſuppoſed attraction for iron, the fluid may be contained in it in a certain determinate quantity. This quantity will be ſuch, that the accumulated attraction of a particle for all the iron balances, or is equal to, the repulſion of all the fluid which the iron contains. The quantity of fluid competent to a particle of iron is ſuppoſed to be ſuch, that the repulſion exerted between it and the fluid competent to another particle of iron is alſo equal to its attraction for that particle of iron: And therefore the attraction between the fluid in an iron bar A for the iron of another bar B, is juſt equal to its repulſion for the fluid in B; it is alſo equal to the repulſion of the iron in A for the iron in B. This quantity of fluid reſiding in the iron may be called its NATURAL QUANTITY.

In conſequence of the mobility through the pores of the iron, the magnetic fluid may be abſtracted from one end of a bar, and condenſed in the other, by the agency of a proper external force. But this is a violent ſtate. The mutual repulſion of the particles of condenſed fluid, and the attraction of the iron which it has quitted, tend to produce a more uniform diſtribution. If we reflect on the law of action, we ſhall clearly perceive, that ſomewhat of this tendency muſt obtain in every ſtate of condenſation and rarefaction, and that there can be a perfect equilibrium only when the fluid is diffuſed with perfect uniformity. This, therefore, may be called the NATURAL STATE of the iron.

If the reſiſtance oppoſed by the iron to the motion of the magnetic fluid be like that of perfect fluids to the motion of ſolid bodies, ariſing entirely from the communication of motion, there is no tendency to uniform diffuſion ſo weak as not to overcome ſuch reſiſtance, and finally to produce this uniform diſtribution. But (as is more probable) if the obſtruction reſembles that of a clammy fluid, or of a ſoft plaſtic body like clay, ſome of the accumulation, produced by the agency of an external force, may remain when the force is removed; the diffuſion will ceaſe whenever the equaliſing force is juſt in equilibrio with the obſtruction.

All the preceding circumſtances of the hypotheſis are

are ſo perfectly analogous to the hypotheſis of Mr Æpinus for explaining the electrical phenomena, which is given in detail in the article Electricity of this *Supplement*, that it would be ſuperfluous to enter into a minute diſcuſſion of their immediate reſults. We therefore beg the reader to peruſe that part of the article Electricity where the elements of Æpinus's hypotheſis are delivered, and the phenomena of induced electricity explained (*viz.* from nº 11. to 60. incluſive), and to ſuppoſe the diſcourſe to relate to the *magnetical* fluid. Let N, S, *n*, *s*, be conſidered as the overcharged and undercharged parts of a magnetical body, or the poles of a magnet, and of iron rendered magnetical by induction. We ſhall confine our obſervations in this place to thoſe circumſtances in which the mechanical phenomena of magnetiſm are limited by the circumſtance, that magnets always contain their natural quantity of fluid; ſo that their action on iron, and on each other, depends entirely on its unequable diſtribution; as is the caſe with induced electricity.

75
Magnetiſm how induced on iron by juxtapoſition.

Let the magnet NAS (fig. 26.), having its north pole NA overcharged, be ſet near to the bar *n* B *s* of common iron, and let their axes form one ſtraight line. Then (as in the caſe of electrics) the overcharged pole NA acts on the bar B only by means of the redundant fluid which it contains. For that portion of its fluid, which is juſt ſufficient for ſaturating the iron, will repel the fluid in B, juſt as much as the iron in NA attracts it; and therefore the fluid in B ſuſtains no change from this portion of the fluid in NA. In like manner, the pole SA acts on B only in conſequence of the iron in SA, which is not ſaturated or attended by its equivalent fluid.

If the fluid in B is immoveable, even the redundant fluid in NA, and redundant iron in SA, will produce no *ſenſible* effect on it: For every particle of iron in B is accompanied by as much fluid as will balance, by its repulſions and attractions, the attractions and repulſions of the equidiſtant particle of iron. But as the magnetical fluid in B is ſuppoſed to be eaſily moveable, it will be repelled by the redundant fluid in AN toward the remote extremity *n*, till the reſiſtance that it meets with, joined to its own tendency to uniform diffuſion, juſt balances the repulſion of AN. This tendency to uniform diffuſion obtains as ſoon as any fluid quits its place; as has been ſufficiently explained in the Supplementary article Electricity, nº 16. 17. &c.

But, at the ſame time, the redundant iron in AS attracts the fluid in B, and would abſtract it from B *n*, and condenſe it into B *s*. This attraction oppoſes the repulſion now mentioned. But, becauſe AS is more remote from every point of B than AN is from the ſame point, the repulſions of the redundant fluid in AN will prevail; and, on the whole, fluid will be propelled toward *n*, and will be rarefied on the part B *s*. But as to what will be the law of diſtribution, both in the redundant and deficient parts of B, it is plain that nothing can be ſaid with preciſion. This muſt depend on the diſtribution of the fluid in the magnet NAS. The more diffuſed that we ſuppoſe the redundant fluid and matter in the magnet, the farther removed will the centres of effort of its poles be from their extremities; the ſmaller will be the action of AN and AS, the ſmaller will be their difference of action; and therefore the ſmaller will be the condenſation in B *n*, and the rarefaction in B *s*. Hence we learn, in the outſet of this attempt to explanation, that the action of a magnet will be ſo much the greater as its poles are more concentrated. This is agreeable to obſervation, and gives ſome credit to the hypotheſis. We can juſt ſee, in a very general manner, that the fluid will be rarer than its natural ſtate in *s*, and denſer in *n*; and that the change of denſity is gradual, and that the denſity may be repreſented by the ordinates of ſome line *c b d* (fig. 27.), while the natural denſity is repreſented by the ordinates to the line C *b* D, parallel to *s n*. There will be ſome point B of the iron bar, where the fluid will be of its natural denſity, and the ordinate B *b* will meet the line *c b d* in the point of its interſection with CD.

All this action is internal and imperceptible. Let us inquire what will be the *ſenſible* external action. There is a ſuperiority of attraction towards the magnet: For ſince the magnetic action is ſuppoſed to diminiſh continually by an increaſe of diſtance, the curve, whoſe ordinates repreſent the forces, has its convexity toward the axis. Alſo, the force of the poles AN, AS are equal at equal diſtances: For, by the hypotheſis, the attraction and repulſion of an individual particle are equal at equal diſtances; and the condenſation in AN is equal to the deficiency in AS, by the ſame hypotheſis; becauſe NAS ſtill contains its natural quantity of fluid. Therefore the action of both poles may be expreſſed by the ordinates of the ſame curve, and they will differ only by reaſon of their diſtances. We may therefore expreſs the actions by the four ordinates Mm, Pp, Nn, Qq, of fig. 2.; of which the property (deduced from the ſingle circumſtance of its being convex toward the axis) is, that $Mm + Qq$ is greater than $Pp + Nn$. There is therefore a ſurplus of attraction. It is only this ſurplus that is perceived. The fluid, moveable in B, but retained by it ſo as not to be allowed to eſcape, is preſſed towards its remote end *n* by the exceſs $Pp - Qq$ of the repulſion of the redundant fluid in AN, above the attraction of the redundant iron in AS. This exceſs on every particle of the fluid is tranſmitted, by the common laws of hydroſtatics, to the ſtratum immediately incumbent on the extremity *n*, and B is thus preſſed away from A. But every particle of the ſolid matter in B is attracted towards A by the exceſs $Mm - Nn$ of the attraction of the redundant fluid in AN above the repulſion of the redundant iron in AS: and this exceſs is greater than the other; for $m + q$ is greater than $p + n$.

The piece of common iron *n* B *s* is therefore attracted, *in conſequence* of the fluid in it having been propelled towards its remote extremity, and diſtributed in a manner ſomewhat reſembling its diſtribution in NAS. Now, in this hypotheſis, magnetiſm is held to depend entirely on the diſtribution of the fluid. B has therefore become a magnet, has magnetiſm induced on it, and, only in conſequence of this induction, is attracted by A.

Had we ſuppoſed the deficient, or ſouth pole of A, to have been neareſt to B, the redundant matter in AN would have attracted the moveable fluid in B more than the remoter redundant fluid in AS repels it; and, on this account, the magnetic fluid would have been conſtipated in B *s*, and rarefied in B *n*. It would, in this caſe alſo, have been diſtributed in a manner ſimilar to its ſituation in the magnet. And B would therefore have been a momentary magnet, having its redundant pole fronting the deficient or diſſimilar pole of A. It is plain, that there would be the ſame ſurplus of attraction in this as in the former inſtance, and B would (on the whole) be attracted in conſequence, and only in conſequence, of having had a properly diſpoſed magnetiſm induced on it by juxtapoſition. The ſenſible attraction, in this caſe, is a *conſequence* of the diſtribution now deſcribed; becauſe, ſince the fluid conſtipated in the end next to A cannot quit B, the tendency of this fluid toward A muſt preſs the ſolid matter of B in this direction (by hydroſtatical laws) more than this ſolid matter is repelled in the oppoſite direction.

Thus it appears, that the hypotheſis tallies preciſely with the induction of magnetiſm. We do not call this an explanation of the phenomenon; for the fact is, that it is the hypotheſis that is explained by the phenomenon: That is, if any perſon be told that induced magnetiſm is produced by the action of a fluid, in conſequence of its ſituation being changed, he will find, that in order to agree with the attraction of diſſimilar, and the repulſion of ſimilar poles, he muſt accommodate the fluid to the phenomena, by giving it the properties aſſigned to it by Æpinus.

76 Conformity of the hypotheſis with a vaſt variety of phenomena.

But the agreement with this ſimpleſt poſſible caſe of the moſt ſimple example of induced magnetiſm, is not enough to make us adopt the hypotheſis as adequate to the explanation of all the magnetic phenomena. We muſt confront the hypotheſis with a variety of obſervations, to ſee whether the coincidence will be without exception.

When the key CB, in fig. 8. is brought below the conſtipated north pole N of the magnet SAN, its own moveable fluid is propelled from C towards B, and is diſpoſed in CB nearly after the ſame manner as in SAN. Therefore the redundant fluid in the lower end of the key repels the moveable fluid in the wire BD more than the redundant matter in the upper end C attracts it; and thus the fluid is rarefied in the upper end of the wire BD, and condenſed in its lower end D. CB and BD therefore are two temporary magnets, having their diſſimilar poles in contact, or neareſt to each other. This is all that is required for their attraction. This effect is promoted by the action of N on the wire BD, alſo propelling the fluid toward D; and thus increaſing the mutual attraction of CB and BD. In like manner, when the key CB is held above the magnet, the moveable fluid in it is more attracted by the redundant matter in SA than it is repelled by the more remote redundant fluid in AN. The ſame thing happens to the fluid in the wire BD. Therefore CB and BD muſt attract each other; and the key will carry the wire, although the magnet is below it, and alſo attracts it. This ſingularity proceeds from the almoſt perfect mobility of the fluid in the two pieces of common iron, which renders their poles extremely conſtipated; whereas the hardneſs required for the fixed magnetiſm of the magnet prevents this complete conſtipation and rarefaction. This can be ſtrictly demonſtrated in the caſe of ſlender rods of iron; but we can ſhew, and experience confirms it, that in other caſes, depending on the ſhape and the temper of the pieces, the wire will not adhere to the key, but to the magnet.

In the various ſituations and poſitions of the key and wire repreſented in fig. 7. the actions of ſome of the poles on the moveable fluid in the iron are oblique in regard to the length of the pieces; but, ſince the moveable matter is ſuppoſed to be a fluid, it will ſtill be propelled along the pieces, notwithſtanding their obliquity, in the ſame manner as gravity makes water occupy the lower end of a pipe lying obliquely. If indeed the magnetic fluid could eſcape from the iron without any obſtruction by the propulſion of the magnet, it could produce no attraction, or ſenſible motion, any more than light does in a tranſparent body. What is demonſtrated of the electric fluid in the Supplemental article Electricity, n° 133. is equally true here. Why the fluid does not eſcape when it is ſo perfectly moveable, is a queſtion of another kind, and will be conſidered afterwards; at preſent, the *hypotheſis* is, that it does not eſcape.

If the key and wire have the poſition fig. 10. n° 1. the fluid is expelled from the parts in contact, and is condenſed in the remote ends. So far from attracting each other, the key and wire muſt repel. They are temporary magnets, having their ſimilar poles fronting each other. They muſt repel each other, if preſented in a ſimilar manner to the ſouth pole of the magnet.

If they be preſented as in n° 2. fig. 10. where the actions of both poles of the magnet are equal, the ſtate of the fluid in them will not be affected. The redundant pole of the magnet repels the moveable fluid in both the key and the wire toward the upper ends; but the deficient pole acts equally on it in the oppoſite direction. It therefore remains uniformly diſtributed through their ſubſtance; and therefore they can exhibit no appearance of magnetiſm.

But if the key and wire be preſented to the *ſame* part of the magnet, but in another poſition, as ſhewn in fig. 8. n° 3. the fluid of the key will be abſtracted from C, and condenſed in B, by the joint action of both poles of the magnet. The ſame thing will happen in the wire BD. Here, therefore, we have two magnets with their diſſimilar poles touching. They will attract each other ſtrongly; and if carried gradually toward the upper or lower end of the magnet, they will ſeparate before the point B arrives abreaſt of N or S. For ſimilar reaſons, the pieces of iron preſented to the middle of the magnet, as in fig. 10 will have one ſide a weak north pole, and the other ſide a weak ſouth pole; but this will not be conſpicuous, unleſs the pieces be broad.

This experiment ſhews, in a very perſpicuous manner, the competency of the hypotheſis to the explanation of the phenomena. When the fluid is not moved, magnetiſm is not induced, even on the moſt ſuſceptible ſubſtance.

When a piece of iron A (fig. 10.), nearly as large as the magnet can carry, hangs at either pole, a large piece of iron B, brought near to the pole on the other ſide, ſhould cauſe it immediately to fall If S be the deficient pole, it cauſes the fluid in A to aſcend to the top, and A is attracted: but, for the ſame reaſon, it cauſes the fluid in B to accumulate in its lower end. This redundant fluid muſt evidently counteract the redundant matter in S, in the induction of the magnetic ſtate on A. Being more remote from A than S is, it cannot wholly prevent the accumulation in the upper end of A; but it renders it ſo trifling, that the remaining attraction thence ariſing cannot ſupport the weight of A. This is a very inſtructive experiment.

But if, on the contrary, we bring a large piece of iron C below the heavy key A, this piece C will have its fluid accumulated in its upper end, both by the action of A on it, and by the action of the magnet. The attraction of the magnet for A ſhould therefore be augmented; and a magnet ſhould carry a heavier lump of iron when a great lump is beyond it. And it is clear (we think), for ſimilar reaſons, that the magnetiſm of the magnet itſelf in fig. 11. ſhould be increaſed by bringing a great lump of iron near its oppoſite pole: for the magnet differs from common iron only in the *degree* of the mobility of its fluid.

When a compaſs needle is placed oppoſite to the redundant pole N of a magnet AN (fig. 28.), it arranges itſelf magnetically. If a piece of common iron be now preſented laterally to the near point of the needle, the redundant matter in the adjoining parts of the needle and the iron ſhould make them repel; but if preſented to the remote end, the redundant matter in the iron ſhould attract the redundant fluid in that end of the needle, and that end ſhould turn toward the iron.

A parcel of ſlender iron wires, carried by the pole of a magnet, as in fig. 29. ſhould avoid each other. If N be the redundant pole, the fluid in each wire will be driven to the remote end, where it muſt repel the ſimilarly ſituated fluid of its neighbour. The ſame external appearance muſt be exhibited by pieces of wire hanging at the deficient pole of the magnet.

The redundant pole of a magnet A (fig. 30.) being held vertically above the centre of two pieces of common iron, moveable round a ſlender pin, renders the middle of each deficient, and their extremities redundant; therefore they ſhould repel each other, and ſpread out. The ſame effect ſhould be produced by the under charged pole of A.

The redundant pole of a magnet A being applied to one branch of the piece of forked iron NCS (fig. 31.), ſhould drive the fluid into its remote parts C, and then the branch NC ſhould be able to induce the magnetic ſtate on a bit of iron D. But if the deficient pole S of another magnet B be applied to the other branch, theſe two actions ſhould counteract each other at C, and the iron ſhould remain indifferent, and fall.—Yet the magnet B alone would equally cauſe C to carry the piece of iron.

It is ſurely unneceſſary to demonſtrate, that the conſequence of this hypotheſis muſt be, that when a magnet puts any piece of iron into the magnetic ſtate, its own magnetiſm is improved. For the induced magnetiſm of the iron is always ſo diſpoſed as to give the fluid in the magnet a greater conſtipation where already condenſed, and to abſtract more fluid from the parts already deficient. If magnetiſm be produced by ſuch a fluid, a magnet muſt always improve by lying any how among pieces of iron.

But the caſe may be very different when magnets are kept in each others neighbourhood. When the overcharged poles of two magnets are placed fronting each other, the redundant fluid in each repels that in the other more than it attracts the remoter redundant iron. The magnets muſt therefore repel each other. Moreover, in rendering them magnetical, the repulſion of redundant fluid, or the attraction of redundant matter of ſome other magnet, had been employed; and when the magnet was removed, ſome of the conſtipated fluid overcame the obſtruction to its uniform diffuſion, and eſcaped into the deficient pole; what remains is withheld by the obſtruction, and the reſtoring forces are juſt in equilibrio with this obſtruction. If we now add to them the repulſion of redundant fluid, directed toward the deficient pole, ſome more of the conſtipated fluid muſt be driven that way, and the magnet muſt be weakened. Nay, it may be deſtroyed, and even reverſed, if one of the magnets be very powerful, and have its own magnetiſm very fixed; that is, if its fluid be very redundant, and meet with very great obſtruction to its motion. Hence it alſo ſhould follow, that the repulſion obſerved between two magnets ſhould be weaker at the ſame diſtance than their attraction, and ſhould follow a different law. For, in the courſe of the experiments, the ſituation of the fluid in the magnets is continually changing, and approaching to a ſtate of uniform diffuſion.

77
Explanation of the directive power, and of polarity.

Let us now examine into the ſenſible effect of this fluid on a magnet which cannot move from its place, but can turn on its centre like a compaſs needle. This ſcarcely requires any diſcuſſion. We ſhould only be repeating, with regard to the redundant fluid and redundant matter, what we formerly ſaid in regard of north pole and ſouth pole; the little magnet muſt arrange itſelf nearly in the tangent of a magnetic curve. But it requires a more minute inveſtigation to determine what the ſenſible phenomenon ſhould be when the fluid of the little magnet is perfectly moveable.

Suppoſe therefore a particle C (fig. 32.) of magnetic fluid, at perfect liberty to move in every direction, and acted on by the redundant and deficient poles of a magnet NAS. The redundant iron in S attracts C in the direction and with the force CF, while the redundant fluid in N repels it in the direction and with the force CD. By their joint action it muſt be urged in the direction and with the force CE, the diagonal of the parallelogram CDEF, which muſt be accurately a tangent to a magnetic curve. If this particle of fluid belong to the piece of iron *n* C *s*, which lies in that very direction, it will unqueſtionably be puſhed towards the extremity *n*. The ſame muſt happen to other particles. Hence it appears that a piece of common iron in this ſituation and poſition muſt become a magnet, and muſt retain this poſition; only the mechanical energy of the lever may change the equilibrium of the magnetic forces a little; becauſe when the piece of iron *n* C *s* has any ſenſible magnitude, the action on its different points will be a little unequal, and may compoſe diagonals which divide a little from the tangent.

Should the iron needle chance not to have the exact poſition, but not deviate very far from it, it is alſo clear that the fluid, not being able to eſcape, will preſs on the ſide toward which it is impelled; and thus will cauſe the needle to turn on its pivot, and finally arrange itſelf in magnetical and mechanical equilibrium, deviating ſo much the leſs from a tangent to a magnetic curve as the piece of iron is ſmaller. Any piece of common iron, held in the neighbourhood of a magnet, will become more overcharged at one end and undercharged at the other, in proportion as the poſition of its length comes nearer to the tangent of a magnetic curve. A ſlender wire held perpendicular to this poſition, that

is,

is, perpendicular to the curve, ſhould not acquire any ſenſible magnetiſm, either attractive or directive.

78 E lana- ti of the c es fo ed by ir filings.

We ſurely need not now employ many words to ſhew that a parcel of iron filings, ſtrewed round a magnet, ſhould arrange themſelves in the primary magnetic curves, or that when ſtrewed round two magnets they ſhould form the ſecondary or compoſite curves.

79 E ana- ti of tr ſitory a of per- m ent m netiſm, a of in- d rent a deter- m ate n netiſm.

Let us now enquire more particularly into the modifications of this accumulation of magnetic fluid which may reſult from the nature of the piece of iron, as it is put into the magnetic ſtate. The propelling force of A acts againſt the mutual repulſion of the particles of fluid in B, and alſo againſt the obſtruction to its motion through the pores of B. The greater this obſtruction, the ſmaller will be the accumulation which ſuffices, in conjunction with the obſtruction and the attraction of the deſerted iron, to balance the propulſive force of the redundant fluid in the overcharged pole of A. This circumſtance therefore muſt limit the accumulation that can be produced in a given time. Therefore the magnetiſm produced on ſoft ſteel or iron ſhould be greater than that produced in hard ſteel at the ſame diſtance. Hence the great advantage of ſoft poles, or of armour, or of capping, to a loadſtone, or to a bundle of hard bars. The beſt form and dimenſions of this armour is certainly determinable by mathematical principles, if we knew the law of magnetical action, and the diſpoſition of the magnetiſm in our loadſtone; but theſe are too imperfectly known in all caſes for us to pretend to give any exact rules. We muſt decide experimentally by making the caps large at firſt, and reducing them till we find the loadſtone carry leſs; then make them a ſmall matter larger. The chief things to be minded are the purity, the uniformity, and the ſoftneſs of the iron, and the cloſeſt poſſible contact.

If the obſtruction reſemble that to motion through a clammy fluid, the final accumulation in hard ſteel may be nearly equal to that in iron, but will require much longer time. Alſo, becauſe ſuch obſtruction to the motion of the fluid will nearly balance the propelling force in parts that are far removed from the magnet, the accumulation will begin thereabouts, while the bar beyond is not yet affected. A redundant pole will be formed in that place. This will operate on what is *immediately* beyond it, driving the fluid farther on, and occaſioning another accumulation at a ſmall diſtance. This may produce a ſimilar effect in a ſtill ſmaller degree farther on. Thus the ſteel bar will have the fluid alternately condenſed and rarefied, and contain alternate north and ſouth poles. This ſtate of diſtribution will not be permanent; fluid will be gradually changing its place; theſe poles will gradually advance along the bar, the remoter poles becoming gradually more diffuſe and faint; and it will not be till after a very long time that a regular magnetiſm with two poles will be produced. To ſtate mathematically the procedure of this mechaniſm would require many pages. Yet it may be done in ſome ſimple caſes, as Newton has ſtated the proceſs of aerial undulation. But we cannot enter upon the taſk in this limited diſſertation. What is ſaid in the Supplementary article ELECTRICITY (n° 217, 218.) on the diſtribution of the electric fluid in an imperfect inſulator, will aſſiſt the reader to form a notion of the ſtate of magnetiſm during its induction. That ſuch alternations proceed from ſuch mechaniſm, we have ſufficient proof in the inſtances mentioned in the former part of this article. The wave, or curl, produced on the ſurface of a clammy fluid, is a phenomenon of the ſame kind, and owing to ſimilar cauſes.

When the magnet which has produced all theſe changes is removed, it is evident that a part of this accumulation will be undone again. The repulſion of the condenſed fluid, and the attraction of the deſerted iron, will bring back ſome of the fluid. But it is very evident, that a part of the accumulation will remain, by reaſon of the obſtruction to its motion in returning; and this remainder muſt be ſo much the greater as the obſtruction to the change of ſituation is greater. In ſhort, we cannot doubt but that the magnetiſm which remains will be greater in hard than in ſpring tempered ſteel.

80 Rationale of the proceſs for making magnets.

Thus have we traced the hypotheſis in a great variety of circumſtances and ſituations, and pointed out what ſhould be the external appearance in each. We did not, in each inſtance, mention the perfect coincidence of theſe conſequences with what is really obſerved, but left it to the recollection of the reader. The coincidence is indeed ſo complete, that it ſeems hardly poſſible to refuſe granting that nature operates in this or ſome very ſimilar manner. We get ſome confidence in the conjecture, and may even proceed to explain complicated phenomena by this hypothetical theory. We might proceed to ſhew, that the effects of all the methods practiſed by the artiſts in making artificial magnets are eaſy conſequences of the hypotheſis: but this is hardly neceſſary. We ſhall juſt mention ſome facts in thoſe proceſſes which have puzzled the naturaliſts.

1. A ſtrong magnet is known to communicate the greateſt magnetiſm to a bar of hard ſteel; but Muſchenbroek frequently found, that a weak magnet would communicate more to a ſoft than to a hard bar.

Explanation. When the magnet is ſtrong enough to impregnate both as highly as they are capable of, the hard bar muſt be the ſtrongeſt; but if it can ſaturate neither, the ſpring-tempered bar muſt be leſt the moſt magnetical.

2. A ſtrong magnet has ſometimes communicated no higher magnetiſm than a weaker one; both have been able to ſaturate the bar.

3. A weak magnet has often impaired a ſtrong one by ſimply paſſing along it two or three times; but a piece of iron always improves a magnet by the ſame treatment.

Explanation. When the north pole of a weak but hard magnet is ſet on the north pole of a ſtrong one, it muſt certainly repel part of the fluid towards the other end, and thus it muſt weaken the magnet. When it is carried forward, it cannot repel this back again, becauſe it is not of itſelf ſuppoſed capable of making the magnet ſo ſtrong. But the end of a piece of iron, always acquiring a magnetiſm oppoſite to that of the part which it touches, muſt increaſe the accumulation of fluid where it is already condenſed, and muſt expel more from thoſe parts which are already deficient.

4. All the parts of the proceſs of the double touch, as practiſed by Meſſis Mitchell and Canton, are eaſily explained by this hypotheſis. A particle of fluid *p* (fig. 33.), ſituated in the middle between the two magnets, is repelled in the direction *pe* by the redundant pole of the magnet AN, whoſe centre of effort is ſuppoſed to be

be at C. It is attracted with an equal force in the direction *p d* toward the centre of effort of the deficient pole of AS. By theſe combined actions it is impelled in the direction *p f*. Now it is plain that, although by increaſing the diſtance between N and S, the forces with which theſe poles act on *p* are diminiſhed, yet the compound force *p f* may increaſe by the diminution of the angle *d p e*. If the action is as $\frac{1}{x^2}$, *p f* will be greateſt when $\frac{\text{Coſ. } d p f}{d p^2}$ is a maximum, or (nearly) when Sin.^{2} *d p f* × Coſ. *d p f* is a maximum: but this depends on the place of the centre of effort. We can, however, gather from this obſervation, that the nearer we ſuppoſe the centres of effort of the poles N and S to the extremities of the magnets, the nearer muſt they be placed to each other. But we muſt alſo attend to another circumſtance; that by bringing the poles nearer together, although we produce a greater action on the intervening fluid, this action is exerted on a ſmaller quantity of it, and therefore a leſs effect may be produced. This makes a wider poſition preferable; but we have too imperfect a knowledge of the circumſtances to be able to determine this with accuracy. The unfavourable action on the fluid beyond the magnets muſt alſo be conſidered. Yet all this may be aſcertained with preciſion in ſome very ſimple inſtances, and the determination might be of ſervice, if we had not a better method, independent of all hypotheſes or theory; namely, to place the magnets at the diſtance where they are *obſerved* to lift the heavieſt bar of iron; then we are certain that their action is moſt favourable, all circumſtances being combined.

We alſo ſee a ſufficient reaſon for preferring the poſition of the magnets employed by Mr Antheaume (and before him by Mr Servington Savery), in his proceſs for making artificial magnets. The form of the parallelogram *d p e f* is then much more favourable, the diagonal *p f* being much longer.

We alſo ſee, in general, that, by the method of double touch, a much greater accumulation of fluid may be produced than by any other known proceſs.

And, laſtly, ſince no appearances indicate any difference between natural and artificial magnetiſm, this hypotheſis is equally applicable to the explanation of the phenomena of natural magnetiſm; ſuch as the poſition of the horizontal, and of the dipping needle, and the impregnation of natural loadſtones.

Having ſuch a body of evidence for the aptitude of this hypotheſis for the explanation of phenomena, it will ſurely be agreeable to meet with any circumſtances which render the hypotheſis itſelf more probable. Theſe are not wanting: although it muſt be acknowledged that nothing has yet appeared, beſides the phenomena of magnetiſm, to give us any indication of the exiſtence of ſuch a fluid; but there are many particulars in their appearance which greatly reſemble the mechanical properties of a fluid.

81
Probability of the exiſtence of a magnetical fluid.

Heating a rod of iron, and allowing it to cool in a poſition perpendicular to the magnetic direction, deſtroys its magnetiſm. Iron is expanded by heat. If the particles of the magnetic fluid are retained between thoſe of the iron, notwithſtanding the forces which tend to diffuſe them uniformly, they may thus eſcape from between the ferrugineous particles which with-held them. For ſimilar reaſons, magnetiſm ſhould be acquired by heating a bar and letting it cool in the magnetic direction. But, beſides this evident mechanical *opportunity* of motion, the union of fire (or whatever name the neologiſts may chooſe to give to the cauſe of expanſion and of heat) with the particles of iron may totally change the action of thoſe particles on the particles of fluid in immediate contact with them; nay, it may even change the ſenſible law of action between magnet and magnet. Of this no one can doubt who underſtands the application of mathematical ſcience to corpuſcular attraction (See Boscovich, *Suppl.*) A change may be produced in the action between magnets without any remarkable change happening in the actions within the magnet, and it may be juſt the reverſe. The union of fire with the magnetic fluid may increaſe the mutual repulſion of its parts, as it does in all aerial fluids or gaſes. This alone would produce a diſſipation of ſome magnetiſm. It may increaſe the attraction (at inſenſible diſtances) between the fluid and the iron, as it does in numberleſs caſes in chemiſtry.

82
Farther grounds of belief.

It is well known that violently knocking or hammering a magnet weakens its force, and that hammering a piece of iron in the magnetic direction will give it ſome magnetiſm. By this treatment the parts of the iron are put into a tremulous motion, alternately approaching and receding from each other. In the inſtants of their receſs, the pent-up particles of the fluid may make their eſcape. A quantity of ſmall ſhot may be uniformly mixed with a quantity of wheat, and will remain ſo for ever, if nothing diſturb the veſſel; but continue to tap it ſmartly with a ſtick for a long time, and the grains of ſmall ſhot will eſcape from their confinements, and will all go to the bottom. We may conceive the particles of magnetic fluid to be affected in the ſame way. The ſame effect is produced by grinding or filing magnets and loadſtones. The latter are frequently made worthleſs by grinding them into the proper ſhape. This ſhould be avoided as much as poſſible, and it ſhould always be done in moulds made of ſoft iron and very maſſive; but this will not always prevent the diſſipation of *ſtrong* magnetiſm. As a farther reaſon for aſſigning this cauſe for the diſſipation in ſuch caſes, it muſt be obſerved (Muſchenbroek takes notice of it), that a magnet or loadſtone may be ground at its neutral point without much damage. But we had the following moſt diſtinct example of the proceſs. A very fine artificial magnet was ſuſpended by a thread, with its ſouth pole down. A perſon was employed to knock it inceſſantly with a piece of pebble, in ſuch a manner as to make it ring very clearly, being extremely hard and elaſtic. Its magnetiſm was examined from time to time with a very ſmall compaſs needle. In three quarters of an hour, its magnetiſm was not only deſtroyed, but the lower end ſhewed ſigns of a north pole. The ſame magnet was again touched, and made as ſtrong as before, and was then wound about very tight with wetted whipcord, leaving a ſmall part bare in the middle. It was again knocked with the pebble, but could no longer ring. At the end of three quarters of an hour its magnetiſm was ſtill vigorous, and was not near gone after two hours and a quarter. We diſcharged a Leyden jar (coated with gold leaf) in the ſame way. It ſtood on the top of an axis; and while this was turned round, the edge was rubbed with a very dry cork filled

with

with roſin, and faſtened to the end of a glaſs rod. This made the jar ſound like the glaſs of a harmonica. One of them was ſplit in this operation.

A ſmall bar of ſteel was heated red hot and tempered hard between two ſtrong magnets lying in ſhallow boxes filled with water, and was more ſtrongly impregnated in this way than in any other that we could think of for a bar of that ſhape. It has not yet been aſcertained in what temperature it is moſt ſuſceptible of magnetiſm, but it was conſiderably hotter than to be juſt viſible in a dark place. It is no objection to our way of conceiving magnetiſm, that the fluid is immoveable or inactive when the iron is red hot. Either of theſe, or both of them, may reſult from the union with the cauſe of heat. Even a particular degree of expanſion may ſo change the law of action as to make it *immoveable*; or the union with caloric may render it *inactive* at all ſenſible diſtances. We cannot but think, that ſome very inſtructive facts might be obtained by experiments made on iron in the moment of its production, and changes in various chemical proceſſes. All magnetiſm is gone when it is united with ſulphur and arſenic in the greateſt number of ores; and when it is in the ſtate of an ochre, ruſt, æthiops, or ſolution in acids; and when united with aſtringent ſubſtances, ſuch as galls. When, and in what ſtate, does it become magnetic? And whence comes the fluid of Æpinus? It were worth while to try, whether magnets have any influence in the formation or cryſtallization of the martial ſalts; and what will be their effect on iron when precipitated from its ſolutions by another metal, &c. &c.

83
hy mag-
s have
ays
re than
pole.

There remains one remarkable fact to be taken notice of, which, in one point of view, is a confirmation of the hypotheſis, but in another preſents conſiderable difficulties. It is well known, that no magnet has ever been ſeen which has but one pole; that is, on the hypotheſis of Æpinus, which is wholly redundant, or wholly deficient. If all magnetiſm be either the immediate or the remote effect of the great magnet contained in the earth, and if it be produced by induction, without any communication of ſubſtance, but only by changing the diſpoſition of the fluid already in the iron, we never ſhould ſee a magnet with only one pole. It muſt be owned, that we never can make ſuch a magnet by any of the proceſſes hitherto deſcribed; but the exiſtence of ſuch does not ſeem impoſſible. Suppoſing a magnet, of the moſt regular magnetiſm, having only two poles; and that we cut it through at the neutral point, or that we cut or break off any part of it—the fact is, (for the experiment has been tried ever ſince men began to ſpeculate about magnetiſm), that each part becomes an ordinary magnet, with two poles, one of which is of the ſame kind as before the ſeparation. The queſtion now is, What ſhould happen according to the theory maintained by Æpinus?—*Tentam. Theor. Elect. et Magnetiſmi*, p. 104, &c.

Let NAS (fig. 34.) be a magnet, of which N is the overcharged pole. Let the ordinates of the curve DAE expreſs the difference between the natural denſity of the fluid, in a ſtate of uniform diffuſion, and its denſity as it is really diſpoſed in the magnet. The area pnND will there expreſs the quantity of redundant fluid in the part nN, and the area qESm expreſſes the fluid wanting in the part Sm. The interſection A marks that part of the magnet where the fluid is of its natural denſity. Suppoſe the part Nn to be ſeparated from the reſt, containing the redundant fluid NDpn. The tendency of this fluid to eſcape from the iron with which it is connected will be greater (Mr Æpinus thinks) than before; becauſe its tendency to quit the magnet formerly was repreſſed by the attractions of the redundant matter contained in AS. This is certainly true of the extremity N; nay, perhaps of all the old external ſurface. Fluid will therefore eſcape. Suppoſe that ſo much has quitted the iron that the point n has the fluid of its natural denſity, as is repreſented in n° 3. there is ſtill a force operating at n, tending to eſcape, ariſing from the repulſion of all the redundant fluid nDN. If this be ſufficient for overcoming the obſtruction, it will really eſcape, and the iron will be left in the ſtate repreſented by n° 4. with an overcharged part fN, and an undercharged part fn.

In like manner, the tendency of the magnetic fluid ſurrounding the magnet to enter into its deficient pole, will be greater when it is ſeparated from the other, not being checked by the repulſion of the redundant fluid in that other.

Mr Æpinus relates ſome experiments which he made on this ſubject. The general reſult of them was, that the moment the parts were ſeparated, each had two poles, and that the neutral point of each magnet was much nearer to the place of their former union than to their other ends. In a quarter of an hour afterward, the neutral points had advanced nearer to their middle, and continued to do ſo, by very ſmall ſteps, for ſome hours, and ſometimes days, and finally were ſtationary in their middles.

84
Defects of this reaſoning.

We acknowledge, that this reaſoning does not altogether ſatisfy us, and that the gradual progreſs of the neutral point toward the middle of each piece, although agreeable to what ſhould reſult from an eſcape of fluid, is not a proof of it. We know already, that the induction of magnetiſm is a progreſſive thing; and we ſhould have expected this change of the ſituation of the neutral point, whatever be the nature of magnetiſm. There is ſomething ſimilar to this, and perhaps equally puzzling, in the immediate recovery of magnetiſm which has been weakened by heat; it is partly recovered on cooling.

But our chief difficulty is this: At the point A (fig. 34.) every thing is in equilibrium before the fracture. The particle A is repelled by the redundant fluid in AN, and attracted by the redundant matter in AS; yet it does not move, for the magnetiſm is ſuppoſed to have permanency. Therefore the obſtruction at A cannot be overcome by the united repulſion of AN and attraction of AS. Nor can the obſtruction at N be overcome by the difference of theſe two forces. Now ſuppoſe AS annihilated. The change made on the ſtate of things at A is ſurely greater than that at N, becauſe the force abſtracted is greater, the diſtance being leſs. It does not clearly appear, therefore, that the removal of AS ſhould occaſion an efflux at N. This, however, is not impoſſible; becauſe the fluid may be ſo diſpoſed, by great conſtipation near N, and no great exceſs of denſity near A, that a ſmaller change at N may produce an efflux there. But ſurely the tendency to eſcape at A muſt now be diminiſhed, inſtead of being greater after the fracture. And if any eſcape from N, this will ſtill more diminiſh that tendency to eſcape from

from A. It does not therefore appear a clear conſequence of the general theory, that the conſtipated fluid ſhould eſcape; and more particularly, that A ſhould become deficient. And with reſpect to the entry of fluid into the other fragment, and its becoming overcharged at *m*, the reaſoning ſeems ſtill leſs convincing. The ſteps of the phyſical proceſs in the two parts of the original magnet are by no means convertible or counterparts of each other. There is nothing in the part AS to reſemble the force of repulſion really exerting itſelf in the correſponding point of AN. There would be, if there were a particle of fluid in that place; but there is not. The tendency therefore of external fluid to enter there, does not reſemble the tendency of the internal fluid to expand and diſſipate. It is true, indeed, the diſcourſe ſhould be confined to points of the ſurface. But the internal motion muſt alſo be conſidered; and the great objection always remains, namely, that the obſtruction at A (n° 1.) or at *n* (n° 3.) is ſufficient to prevent the paſſage of a particle of fluid from the pole AN into the pole AS, when urged by the repulſion of the fluid in the one and the attraction of the iron in the other; and yet will not prevent the eſcape of a particle when one of thoſe cauſes of motion is removed. Add to this, that the whole hypotheſis aſſumes as a principle, that the reſiſtance to eſcape from any point is greater than the obſtruction to motion through the pores. This is readily granted; for however great we ſuppoſe the attraction, in the limits of phyſical contact, it will be no obſtruction to motion through the pores, becauſe the particle is equally affected by the oppoſite ſides of the pores; whereas, in quitting the body altogether, there is nothing beyond the body to counteract the attraction by which it is retained.

There ſeems ſomething wanting to accommodate this beautiful hypotheſis of Mr Æpinus to this remarkable phenomenon; and the coincidence is otherwiſe ſo complete, that we are almoſt obliged to conclude that it is merely a deficiency, ariſing from our not having a ſufficient knowledge of the law of magnetic action. This is quite ſufficient: For it may be ſtrictly demonſtrated, that if the magnetic action decreaſes in higher ratio than that of the ſquares of the diſtances, the permanency of the fluid in any particular diſpoſition has ſcarcely any dependence on the particles at any ſenſible diſtance, and is affected only by the *variations* of its denſity (See ELECTRICITY, *Suppl.* n° 217. for a caſe ſomewhat ſimilar). Therefore, if the fluid be ſo diſpoſed, that its denſity may be repreſented by the ordinates of ſuch a curve as is drawn in fig. 34. having its two extremities concave toward the axis, and a point of contrary flexure at A, the tendency to eſcape at A will be the greateſt poſſible; and when the magnet is broken at A (n° 1.), or when the fluid has taken the arrangement repreſented by n° 3. it *cannot* ſtop there, and *muſt* become deficient in that part. Now, it muſt be acknowledged, that we are not abſolutely certain that the magnetic action is in the preciſe inverſe duplicate ratio of the diſtance. All that we are certain of is, that it is much nearer to it than to either the inverſe ſimple or inverſe triplicate ratio. We own ourſelves rather diſpoſed to aſcribe the preſent difficulty to our ignorance of ſome circumſtance, purely mathematical, overlooked, or miſtaken, than to think a conjecture unfounded, which tallies ſo accurately with ſuch a variety of phenomena.

We may here obſerve, that we are not altogether ſatisfied with Æpinus's form of the experiment. He did not break a magnet; he ſet two ſteel bars end to end, and touched them as one bar, making the magnetiſm perfectly regular; he then ſeparated them, and found that each had two poles. But was he certain that, when joined, they made but one magnet? We have ſometimes ſucceeded in doing this, as we thought, by the curves of iron filings; but on putting the needle with which we were examining their polarity into proper ſituations, we ſometimes found it in the ſecond interſection of the ſecondary curves, ſhewing that the bars were really two magnets, and not one.

On the other hand, when a piece is broken off from a magnet, the ſuccuſſion and elaſtic tremor into which the parts are thrown, and even the bending previous to the fracture, may give opportunity to a diſſipation, which could not otherwiſe happen. The parts ſhould be ſeparated by corroſion in an acid, and the gradual change of magnetiſm ſhould be carefully noted. The writer of this article has made ſome experiments of this nature, the reſults of which preſent ſome curious obſervations: but they are not yet brought to a concluſion that is fit to be laid before the public.

85 Hypotheſis of Prevôt. Mr Prevôt of Geneva, in a diſſertation on the origin of magnetic forces, endeavours to give a theory which obviates the only difficulty in that of Æpinus; but it is incomparably more complex, employing two fluids, which by their union compoſe a third, which he calls combined fluid. There is much ingenuity, and even mathematical addreſs, in adjuſting the relative properties of thoſe fluids. But ſome of them are palpably incompatible; *ex. gr.* the particles of each attract each other, but thoſe of the other kind moſt ſtrongly; yet they are both elaſtic like air. This is ſurely inconceivable.—Granting this, however, he ſuits his different attractions, ſo that a ſtrong elective attraction of the combined fluid for iron decompoſes part of the fluid in the iron, and each of its ingredients occupies oppoſite ends of the bar: then will the bars approach or recede, according as the near ends contain a different or the ſame ingredient. All this is operated without repulſion.

But the whole of this is mere accommodation, like Æpinus's, but ſo much more complex, that it requires very intenſe contemplation to follow the author through the conſequences. Add to this, that his attractions are operated by another fluid, infinitely more ſubtle than either of thoſe already mentioned, every particle of theſe being, as it were, a world in compariſon of thoſe of the other. In ſhort, he adopts all the extravagant ſuppoſitions of Le Sage of Geneva, and every thing is ultimately impulſion. Nor is the contrivance for obviating the difficulty (ſo often mentioned) at all clear and convincing; and it is equally gratuitous with the reſt. We cannot think this hypotheſis at all intitled to the name of *explanation*.

86 Remarks on hypotheſes. This muſt ſerve for an account of the hypotheſis of Æpinus. The philoſophical reader will ſee, that however exactly it may tally with every phenomenon, it cannot be called an explanation of the phenomena; becauſe it is the phenomena which explain the hypotheſis, or give us the characters of the magnetic fluid, if ſuch

ſuch fluid exiſts. But we are not obliged to admit this exiſtence, as we admit that to be the true decyphering of a letter which makes ſenſe of it. In that caſe we know both parts of the ſubject—the characters and the ſounds; but are ignorant which correſponds to which. Did we ſee a fluid abſtracted from one part of a bar and conſtipated in another, and perceive the abſtraction and conſtipation always accompanied by the obſerved attractions and repulſions, the rules of philoſophical diſcuſſion, nay, the conſtitution of our own mind, would oblige us to aſſign the one as the cauſe or occaſion of the other. But this important circumſtance is wanting in the preſent caſe. We think, however, that it merits a cloſe attention; and we entertain great hopes of its being one day completed, by including this ſingle exception.

At the ſame time, it muſt be owned, that it gives no extenſion of knowledge; for it can have no greater extenſion than the phenomena on which it is founded, and cannot, without riſk of error, be applied to an untried caſe, of a kind diſſimilar in its nature to the phenomena on which it is founded. We doubt not but that its ingenious author would have ſaid, that a bit broken off from the north pole of a magnet would be wholly a north pole, if he had not known that the fact was otherwiſe.

But this hypotheſis greatly aids the imagination in conceiving the proceſs of the magnetical phenomena. The more we ſtudy them, the more do they appear to reſemble the protruſion of a fluid through the parts of an obſtructing body. It proceeds gradually. It may be, as it were, overdone, and regorges when the propelling cauſe is removed. The motion is aided by what we know to aid other obſtructed motions. As a fluid would be conſtipated in all protuberances, ſo the faculty of producing the phenomena is greater in all ſuch ſituations, &c. &c. This, joined to the impoſſibility of ſpeaking, with clearneſs of conception, of the propagation of powers without the protruſion of ſomething in which they inhere, gives it a hold of the imagination which is not eaſily ſhaken off.

To ſay that nothing is explained when the attraction of the fluid is not explained, and that this is the main queſtion, gives us little concern. We offer no explanation of this attraction, more than of the attraction of gravity. There is nothing contrary to the laws of human intellect, nothing inconſiſtent with the rules of reaſoning, in ſaying, that things are ſo conſtituted, that when two particles are together, they ſeparate, although we are ignorant of the immediate cauſe of their ſeparation. Thoſe who think that all motion is performed by impulſion, and who explain magnetiſm by a ſtream of fluid circulating round the magnet, muſt have another fluid to impel this fluid into its curvilineal path; for they inſiſt, that the planets are ſo impelled. Then they muſt have a third fluid to deflect the vertical motions of the ſecond, and ſo on without end. This is evident, and it is abſurd. But we have ſaid enough in the article Impulsion, *Suppl.* to ſhew that all *hypotheſes* framed on purpoſe to explain action *e diſtanti* by impulſion are illogical; becauſe impulſion requires explanation as much as the other, and neither the one nor the other will ever be reſolved into any thing but the fiat of the Allwiſe Author of the univerſe.

87 The preceding theory is not a hypotheſis.

We conclude with deſiring the reader to remark, that the explanation which we have given of the magnetical phenomena is independent of the hypotheſis of Æpinus, or any hypotheſis whatever. We have narrated a variety of very diſtinguiſhable facts, and have marked their diſtinctions. We have been able to reduce them to general claſſes; and even to groupe thoſe claſſes into others ſtill more general; and at laſt, to point out one which is diſcoverable in them all. This is giving a philoſophical theory, in the ſtricteſt ſenſe of the word; becauſe we ſhew, in every caſe, the modification of the general fact which allots it this or that particular place in the claſſification. Thus we have ſhewn that the polarity or directive power of magnets is only a modification of the general fact of attraction and repulſion. Dr Gilbert's theory of *terreſtrial* magnetiſm is indeed a hypotheſis, and we enounced it as ſuch. It only claims probability, and we apprehend that a very high degree of credit will be given to it.

We hope that many of our readers will have their curioſity excited by the account we have given of Æpinus's theory. To ſuch we earneſtly recommend the ſerious peruſal of his book *Tentamen Theoriæ Electricitatis et Magnetiſmi, Auct. F. Æpino, Petropoli*, 1759. Van Swinden has included a very good abſtract of it in his 2d volume *Sur l'Electricité*, written by Profeſſor Steiglehner of Ratiſbon or Ingolſtadt. The mathematical part is greatly ſimplified, and the whole is preſented in a very clear and accurate manner. Mr Van Swinden is a profeſſed foe to all hypotheſes; but he is not moderate, and we wiſh that we could ſay that he is candid. He attacks every thing; and takes the opportunity of every analogy pointed out by Æpinus between magnetiſm and electricity to repeat the firſt ſentence of his diſſertation, namely, that magnetiſm and electricity are not the ſame; a thing that Æpinus alſo maintains. But he even charges Æpinus with a miſtake in his fundamental equations, which invalidates his whole theory. He ſays that Æpinus has omitted one of the acting forces aſſumed in his hypotheſis. This is a moſt groundleſs charge; and we own that we cannot conceive how Van Swinden could fall into ſuch a miſtake. We are unwilling to call it intentional, for the mere purpoſe of raiſing a man of ſtraw to knock him down again. Abbé Haüy of the French Academy has alſo publiſhed an abridgment of Æpinus's theory, with many excellent remarks, tending to clear the theory of the only defect that has been found in it. This work was much approved of, and recommended by the Academy. We have not had the good fortune to ſee a copy of it.

88 Analogy of magnetiſm and electricity.

The reader cannot but have remarked the cloſe analogy between the magnetical phenomena and thoſe of induced electricity; indeed, all the phenomena of attraction and repulſion are the ſame in both. The mechanical compoſition of thoſe actions produces a directive power and a polarity, in electrical as well as in magnetical bodies. We can make an electrical needle which will arrange itſelf, with reſpect to the overcharged and undercharged ends of a body electrified by mere poſition, juſt as a compaſs needle is arranged by a magnet. We can touch a ſtick of ſealing wax in the manner of the double touch, ſo as to give it poles of conſiderable force and durability. As a red hot ſteel bar acquires permanent poles by quenching it near a magnet, ſo melted wax acquires them by freezing in the neighbourhood of a poſitive and negative electric. Some have inferred a ſameneſs of origin of theſe two ſpecies of powers from thoſe various circumſtances of reſemblance; but the original cauſes ſeem to be diſtinct on many accounts. Electricity is common to all bodies. The cauſe of magnetiſm can operate only on iron. Although lightning or an electrical ſhock gives polarity to a needle, we need not infer the identity of the cauſe, becauſe the polarity which it gives is always the ſame with that given by great heat; and there is always intenſe heat in this operation. The phenomenon which looks the moſt like an indication of identity of the origin of electricity and magnetiſm is the direction of the rays of the aurora borealis—they converge to the ſame point of the heavens to which the elevated pole of the dipping needle directs itſelf. But this is by no means a ſufficient foundation for eſtabliſhing a ſameneſs. Electricity and magnetiſm may, however, be related by means of ſome powers hitherto unknown. But we are decidedly of opinion, that the electric and magnetic fluid are totally different, although their mechanical actions are ſo like that there is hardly a phenomenon in the one which has not an exact counterpart in the other. But we ſee them both operating, with all their marks of diſtinction, in the ſame body; for iron and loadſtones may be electrified, like any other body, and their magnetiſm ſuffers no change or modification. We can ſet theſe two forces in oppoſition or compoſition, juſt as we can oppoſe or compound gravity with either. While the iron filings are arranging themſelves round a magnet, the mechanical action of electricity may be employed either to promote or hinder the arrangement. They are therefore diſtinct powers, inherent in different ſubjects.

89
They are not, however, effects of the ſame cauſe.

But there are abundance of other phenomena which ſhew this diverſity. There is nothing in magnetiſm like a body overcharged or undercharged *in toto*. There is nothing which indicates the preſence of the fluid to the other ſenſes—nothing like the ſpark, the ſnap, the viſible diſſipation; becauſe the magnetic fluid enters into no union with air, or any thing but iron. There is nothing reſembling that inconceivably rapid motion which we ſee in electricity; the quickeſt motion of magnetiſm ſeems inferior (even beyond compariſon) with the ſloweſt motion along any electric conductor. Therefore there is no poſſibility of diſcharging a magnet as we diſcharge a coated plate. Indeed, the reſemblance between a magnet and a coated plate of glaſs is exceedingly ſlight. The only reſemblance is between the magnet and an inconceivably thin ſtratum of the glaſs, which ſtratum is poſitive in one ſide and negative in the other. The only perfect reſemblance is between the induced magnetiſm of common iron, and the induced electricity of a conductor.

The following ſeem the moſt inſtructive diſſertations on magnetiſm, either as valuable collections of obſervations, or as judicious reaſonings from them, or as the ſpeculations of eminent or ingenious men concerning the nature of magnetiſm.

Gilbertus de Magnete, Lond. 1600, fol.

Æpini Tentamen Theoriæ Magn. et Electr.

Eberhard's Tentam. Theor. Magnetiſmi, 1720.

Diſſertations ſur l'aimant, par du Fay, 1728.

Muſchenbroek Diſſert. Phyſico Experimentalis de Magnete.

Pieces qui ont emporté le prix de l'Acad. des Sciences à Paris ſur la meilleure conſtruction des Bouſſoles de declination. Recueil des pieces couronnées, tom. v.

Euleri opuſcula, tom. iii. continens Theoriam Magnetis, Berlin, 1751.

Æpini Oratio Academica, 1758.

Æpini item Comment. Petrop. nov. tom. x.

Anton. Brugmanni tentam. Phil. de materia Magnetica, Francqueræ, 1765.

There is a German tranſlation of this work by Eiſenbach, with many very valuable additions.

Scarella de Magnete, 2 tom fol.

Van Swinden Tentamina Magnetica, 4to.

Van Swinden ſur l'Analogie entre les phenomenes Electriques et Magnetiques, 3 tom. 8vo.

Diſſertation ſur les Aimans artificielles par Antheaume.

Experiences ſur les Aimans artificielles par Nicholas, Fuſs, 1782.

Eſſai ſur l'Origine des Forces Magnetiques par Mr Prevoſt.

Sur les Aimans artificielles par Rivoir, Paris 1752.

Diſſertatio de Magnetiſmo par Sam. Klingenſtier et Jo. Brander, Holm. 1752.

Deſcription des Courants Magnetiques, Straſbourg, 1753.

Traité de l'Aiman par Dalancé, Amſt. 1687.

Beſides theſe original works, we have ſeveral diſſertations on magnetical vortices by Des Cartes, Bernoulli, Euler, Du Tour, &c. publiſhed in the collections of the works of thoſe authors, and many diſſertations in the memoirs of different academies; and there are many popular treatiſes by the traders in experimental philoſophy in London and Paris. Dr Gown Knight, the perſon in Europe who was moſt eminently ſkilled in the knowledge of the phenomena, alſo publiſhed a diſſertation intitled, *An attempt to explain the Phenomena of Nature by two principles, Attraction and Repulſion*, Lond. 1748, 4to, in which he has included a theory of magnetiſm. It is a very curious work, and ſhould be ſtudied by all thoſe who have recourſe without ſcruple to the agency of inviſible fluids, when they are tired of patient thinking. They would there ſee what thought and combination are neceſſary before an inviſible fluid can be really fitted for performing any office we chooſe to aſſign it. And they will get real inſtruction as to what ſervices we may expect of ſuch agents, and from what taſks they muſt be excluded. The Doctor's theory of magnetiſm is very unlike the reſt of the performance; for he does not avail himſelf of the vaſt apparatus of propoſitions which he had eſtabliſhed, and adopts without any nice adjuſtment the moſt common notions of an impulſive vortex. Both the production and maintenance of this vortex, and its mode of operation, are irreconcileable with the acknowledged laws of impulſion.

Si quid noviſti rectius iſtis, candidus imperti—ſi non—his utere mecum.

APPENDIX.

Inveſtigation of the magnetic curve.

We have been favoured with the following inveſtigation of the curves, to which a needle of indefinite minuteneſs will be a tangent, by Mr Playfair, Profeſſor of Mathematics in the Univerſity of Edinburgh.

Two magnetical poles being given in poſition, the force of each of which is ſuppoſed to be as the *m*th power of the diſtance from it reciprocally, it is required to find a curve, in any point of which a needle (indefinitely ſhort) being placed, its direction, when at reſt, may be a tangent to the curve?

1. Let A and B (fig. 35.) be the poles of a magnet, C any point in the curve required; then we may ſuppoſe the one of theſe poles to act on the needle only by repulſion, and the other only by attraction, and the direction of the needle, when at reſt, will be the diagonal of a parallelogram, the ſides of which repreſent theſe forces. Therefore, having joined AC and BC, let AD be drawn parallel to BC, and make $\frac{1}{AC^m} : \frac{1}{BC^m} :: AC : AD$; join CD, then CDF will touch the curve in C.

2. Hence an expreſſion for AF may be obtained. For, by the conſtruction, $AD = \frac{AC^{m+1}}{BC^m}$, and ſince BC : AD : : BF : FA, and BC − AD : AD : : AB : AF, we have $AF = \frac{AB \times AC^{m+1}}{BC^{m+1} - AC^{m+1}}$.

3. A fluxionary expreſſion for AF may alſo be found in terms of the angles CAB, ABC. In CF take the indefinitely ſmall part CH, draw AH, BH, and from C draw CL perpendicular to AH and CK to BH. Draw alſo BC and AM at right angles to FH. Let the angles CAB = φ, and CBA = ψ; then CAH = $\dot{\varphi}$, and CBH = $-\dot{\psi}$; alſo CL = AC × $\dot{\varphi}$, and CK = − BC × $\dot{\psi}$. Now HC : CL : : AC : AM = $\frac{AC^2 \times \dot{\varphi}}{HC}$; and for the ſame reaſon BC = $-\frac{BC^2 \times \dot{\psi}}{HC}$. Therefore ſince AF : FB : : AM : BC, AF : FB : : $\frac{AC^2 \times \dot{\varphi}}{HC} : -\frac{BC^2 \times \dot{\psi}}{HC}$, and AF : AB : : $\text{ſin.}\,\dot{\psi}^2\dot{\varphi} : -\text{ſin.}\,\psi^2\dot{\varphi} - \text{ſin.}\,\varphi^2\dot{\psi}$; wherefore if AB = *a*, AF = $\frac{-a\dot{\varphi}\,\text{ſin.}\,\psi^2}{\dot{\psi}\,\text{ſin.}\,\varphi^2 + \dot{\varphi}\,\text{ſin.}\,\psi^2}$.

4. If this value of AF be put equal to that already found, a fluxionary equation will be obtained, by the integration of which the curve may be conſtructed. Becauſe $AF = \frac{AB \times AC^{m+1}}{Be^{m+1} - Ae^{m+1}}$; and ſince $AC = \frac{a\,\text{ſin.}\,\psi}{\text{ſin.}\,(\varphi + \psi)}$, and $BC = \frac{a\,\text{ſin.}\,\varphi}{\text{ſin.}\,(\varphi + \psi)}$, we have by ſubſtitution $AF = \frac{a\,\text{ſin.}\,\psi^{m+1}}{\text{ſin.}\,\varphi^{m+1} - \text{ſin.}\,\psi^{m+1}} = -\frac{a\dot{\varphi}\,\text{ſin.}\,\psi^2}{\dot{\psi}\,\text{ſin.}\,\varphi^2 + \dot{\varphi}\,\text{ſin.}\,\psi^2}$. Hence, $\text{ſin.}\,\varphi^2 \times \dot{\psi}\,\text{ſin.}\,\psi^{m+1} + \dot{\varphi}\,\text{ſin}\,\psi^{m+3} = -\text{ſin.}\,\psi^2 \times \dot{\varphi}\,\text{ſin.}\,\varphi^{m+1} + \dot{\varphi}\,\text{ſin.}\,\psi^{m+3}$, and therefore $\dot{\psi}\,\text{ſin.}\,\psi^{m-1} = -\dot{\varphi}\,\text{ſin.}\,\varphi^{m-1}$; and alſo, $\int \dot{\psi}\,\text{ſin.}\,\psi^{m-1} + \int \dot{\varphi}\,\text{ſin.}\,\varphi\, m^{-1} = C$.

5. Theſe fluents are eaſily found when *m* is any whole poſitive number.

If $m = 1$, we have $\dot{\psi} + \dot{\varphi} = 0$.
$m = 2$, $\dot{\psi}\,\text{ſin.}\,\psi + \dot{\varphi}\,\text{ſin.}\,\varphi = 0$.
$m = 3$, $\dot{\psi}\,\text{ſin.}\,\psi^2 + \dot{\varphi}\,\text{ſin.}\,\varphi^2 = 0$.
$m = 4$, $\dot{\psi}\,\text{ſin.}\,\psi^3 + \dot{\varphi}\,\text{ſin.}\,\varphi^3 = 0$, &c.
Therefore, &c.
Alſo if $m = 1$, $\varphi + \psi = C$.
$m = 2$, $\text{coſ.}\,\varphi + \text{coſ.}\,\psi = C$.
$m = 3$, $-\text{ſin.}\,2\varphi + 2\varphi - \text{ſin.}\,2\psi + 2\psi = C$.
$m = 4$, $\text{coſ.}\,3\varphi - 9\,\text{coſ.}\,\varphi + \text{coſ.}\,3\psi - 9\,\text{coſ.}\,\psi = C$, &c. &c.

The firſt of the above equations belongs to a ſegment of a circle deſcribed upon AB, which therefore would be the curve required if the magnetical force were inverſely as the diſtances.

If the magnetical force be inverſely as the ſquare of the diſtance, that is, if $m = 2$, coſ. φ + coſ. ψ is equal to a conſtant quantity. Hence if, beſide the points A and B, any other point be given in the curve, the whole may be deſcribed. For inſtance, let the point E (fig. 36.) be given in the curve, and in the line DE which biſects AB at right angles. Deſcribe from the centre A a circle through E, viz. QER; then AD being the coſine of DAE to the radius AE, the ſum of the coſines of $\varphi \times \psi$ will be everywhere (to the ſame radius) = 2 AD = AB. Therefore to find E, the point in which any other line AN, making a given angle with AB, meets the curve, draw from N, the point in which it meets the circumference of the circle QER, NO, perpendicular to AB, ſo that AO may be the coſine of NAO, and from O toward A take OP = AB, then AP will be the coſine of the angle ABE; ſo to find BE′, draw PQ perpendicular to AP, meeting the circle in Q; join AQ, and draw BE′ parallel to AQ, meeting AE′ in E′, the point E′ is in the curve. In this way the other points of the curve may be found.

The curve will paſs through B, and will cut AB at an angle of which the coſine = RB. If then E be ſuch, that AE = AB, the curve will cut AB at right angles. If E″ be more remote from A, the curve will make with AB an obtuſe angle toward D; in other caſes it will make with it an acute angle.

A conſtruction ſomewhat more expeditious may be had by deſcribing the ſemicircle AFB, cutting AE in F, and AE′ in N, and deſcribing a circle round A, with the diſtance AL = 2AF, cutting AE′ in *b*. If AG be applied in the ſemicircle AFB = N*b*, AG muſt cut AN in a point E of the curve, becauſe AN + BG = 2AF, and AN and GB are coſines of the angles at A and B.

As the lines AN and BG may be applied either above or below AB, there is another ſituation of their interſection E′. Thus A*n* being applied above, and B*g* below, the interſection is in *e*′. The curve has a branch extending below A; and if D*e* be made = DE, and B*e* be drawn, it will be an aſſymptote to this branch. There is a ſimilar branch below B. But theſe portions of the curve evidently ſuppoſe an oppoſite direction of one of the two magnetic forces, and therefore have no connection with the poſition of the needle.

Addition to nº 65.

WE omitted the inſerting in its proper place, nº 65. a hypotheſis of the celebrated aſtronomer Tobias Mayer of Gottingen, by which the direction of the mariner's needle in all parts of the earth may be determined. He ſuppoſes that the earth contains a very powerful magnet of inconſiderable dimenſions, which arranges the needle according to the known laws of magnetiſm. The centre of this magnet was diſtant from the centre of the earth about 480 Engliſh miles in 1756, and a line joining theſe centres interſected the earth's ſurface in a point ſituated in 17° N. Lat. and 183° E. Long. from London. The axis of the magnet is perpendicular to this line, and the plane in which it lies is inclined about 11° to the plane of the meridian, the north end of the axis lying on the eaſt ſide of that meridian.

From theſe data, it will be found that the axis of this magnet cuts the ſurface of the earth about the middle of the eaſtern ſhore of Baffin's Bay, and in another point about 800 miles S.S.W. of the ſouthern point of New Zealand. Profeſſor Lichtenberg of Gottingen, who gives this extract from the manuſcript, ſays, that the hypotheſis is accompanied by a conſiderable liſt of variations and dips calculated by it, and compared with obſervations, and that the agreement is very remarkable. He gives indeed a dozen inſtances in very different regions of the earth. But we ſuſpect that there is ſome error or defect in the data given by him, becauſe the annual changes, which he alſo gives, are ſuch as are inconſiſtent with the data, and even with each other. He ſays, that the diſtance from the centre increaſes about four miles annually, and that *thence* ariſes an annual diminution of 8 minutes in the latitude and 14 in the longitude of that point where the ſtraight line joining the centres meets the ſurface. It can have no ſuch conſequence He ſays alſo, that the above mentioned inclination of the planes increaſes 8 minutes annually. The compound force of the magnet is ſaid to be as the ſquare root of the diſtance inverſely. We are at a loſs to underſtand the meaning of this circumſtance; becauſe Mayer's hypotheſis concerning the law of magnetic action is exceedingly different, as related by Mr Lichtenberg from the ſame manuſcript. But it was our duty to communicate this notice, though imperfect, of the ſpeculations of this celebrated mathematician. See *Exliben's Elem. of Nat. Phil.* publiſhed by Lichtenberg 1784, p. 645.

Addition to n° 64.

Addition to n° 64.

Let HZOF (fig. 37.) be the plane of a magnetic meridian, H n' O the plane of the horizon, and NS the poſition of the magnetic needle in any place, when it is at liberty to ſettle in the true magnetic direction. The angle HON is the inclination or dip of the needle. Let Z n F be a vertical circle, in which a well conſtructed dipping needle can freely play up and down. This needle cannot place itſelf in the magnetic direction, becauſe it can only move in a vertical plane. Its north point is impelled in the direction $n\,o$, and its ſouth point in the direction $s\,p$, both of which are parallel to NS. By the laws of mechanical equilibrium, it cannot reſt, except in ſuch a poſition that the forces $n\,o$ and $s\,p$ are in a plane perpendicular to the plane Z n F. In any other poſition, there would be a force impelling the needle toward that ſide on which $n\,o$ makes an acute angle with the tangent $r\,n\,t$ of the vertical circle. Therefore the ſpherical triangle N n F is right angled in n, and Coſ. NF n : R = Tan. n F : Tan. NF, = Tan. HN : Tan. $n'\,n$. Therefore

$$\text{Tan. } n'n = \frac{\text{Tan. HN}}{\text{Coſ. H}\,n'}, = \text{Tan. HN} \times \text{Sec. H}\,n'.$$

Therefore, in any place, the real inclination of the magnetical direction to the horizon is different from what is pointed out by a dipping needle when it is in a plane which declines from the magnetic meridian; and the tangent of the obſerved dip of the needle exceeds that of the inclination of the magnetic direction in the proportion of radius to the coſine of the deviation HC n', or the proportion of the ſecant of this angle to the radius. If therefore the dipping needle play in a magnetic eaſt and weſt circle, it will ſtand perpendicular to the horizon.

Maleſherbes.

MALESHERBES (Chriſtian William de Lamoignon) was born December the 6th 1721. At the age of 24 he became a counſellor of Parliament, and ſix years afterwards chief preſident of the *cour des aides*. He remained in that important ſituation during a period of 25 years, and diſplayed on many occaſions proofs of firmneſs, eloquence, and wiſdom.

When the prince of Condé was ſent by the king in 1768 to ſilence the magiſtrates who oppoſed the taxes, Maleſherbes replied to him, "Truth. Sir, muſt indeed be formidable, ſince ſo many efforts are made to prevent its approach to the throne." About the ſame time that he became preſident of the *cour des aides*, he was appointed by his father, then chancellor of France, ſuperintendant of the preſs; an office of the greateſt importance, of which the principles which Maleſherbes had imbibed from D'Alembert rendered him very ill qualified to diſcharge the duties. He was what the French called a *philoſopher*; a term with them of the ſame import with a naturaliſt, who openly denies revealed religion, and has no adequate notions of the moral attributes of God. The conſequence was, that when the authors of impious and immoral books were brought before him in his official capacity to undergo examination, he appeared to them as adviſing, aſſiſting, and protecting them, againſt that very power which was veſted in himſelf; and they were commonly diſmiſſed with this ſenſeleſs obſervation, that all books of whatever tendency ſhould be conſidered merely as *objects of commerce*. Had it not been for the protecting influence of Maleſherbes, the *Encyclopedie*, of which the publication was frequently ſuſpended (ſee Diderot in this *Supplement*), would probably have been altogether ſuppreſſed; and the works of Rouſſeau and Raynal, which ſo powerfully contributed to that revolution in which he was overwhelmed, would certainly not have ſpread ſo rapidly over the kingdom of France. It was he, ſaid D'Alembert, who *broke the ſhackles of literature*.

In vain will it be replied, that he left the ſame liberty to the religious as to the impious writers; for that was not always ſtrictly true. The Abbé Barruel has brought the teſtimony of D'Alembert himſelf to prove, that it was much againſt his will that Maleſherbes ſuffered works refuting the ſophiſters to appear; and, as he very properly obſerves, what a miniſter allows with reluctance, he finds abundant means of preventing.

In 1775 he reſigned the office of chief preſident of the *cour des aides*, and was appointed miniſter and ſecretary of ſtate in the place of La Vrillière. Thus placed in the centre of a frivolous yet brilliant court, Maleſherbes did not in the leaſt deviate from his former ſimplicity of life and manners; but, in lieu of complying with the eſtabliſhed etiquette which required magiſtrates, when they became miniſters of ſtate, to exchange their ſable habit and head-dreſs for a coloured ſuit, bag-wig, and ſword, he retained his black coat and magiſterial *peruke!* This is recorded by a panegyriſt to his honour; but we perceive not the honour

which

which it reflects on him. It ſurely requires no great powers of abſtraction to diſcover, that a coloured coat, bag-wig, and ſword, are not in themſelves more frivolous or contrary to nature, than a black coat and enormous peruke; and if the manners of a country have appropriated theſe different dreſſes to different ſtations in life, the individual muſt be actuated by a very abſurd kind of pride, who ſets up his own caprice againſt the public opinion.

As, when inveſted with the power to reſtrain within juſt limits the freedom of the preſs, it was his chief aim to encourage and extend that freedom; ſo, when raiſed to an office which gave him the unlimited power of iſſuing *lettres de cachet*, it was their total ſuppreſſion that became the earlieſt object of his *moſt ardent* zeal. Till that time *lettres de cachet*, being conſidered as a part of the general police, as well as of the royal prerogative, were iſſued not only at the will of the miniſter, but even at the pleaſure of a common clerk, or perſons ſtill more inſignificant. Maleſherbes began by relinquiſhing himſelf this abſurd and iniquitous privilege. He delegated the right to a kind of tribunal, compoſed of the moſt upright magiſtrates, whoſe opinion was to be unanimous, and founded upon open and well eſtabliſhed facts. He had but one more object to attain, and that was to ſubſtitute a legal tribunal in the place of that which he had eſtabliſhed; and this object he was upon the point of accompliſhing, when the intrigues of the court procured the diſmiſſion of Turgot; and Maleſherbes, in conſequence, reſigned on the 12th of May 1776. For this part of his conduct he is intitled to praiſe, which we feel not ourſelves inclined to withhold from his memory. Even M. Barruel admits, that he had many moral virtues, and that he diſplayed real benevolence when alleviating the rigours of impriſonment, and remedying the abuſe of *lettres de cachet*; but France, ſays he, ſhall nevertheleſs demand of him her temples that have been deſtroyed; for it was he who, above all other miniſters, abuſed his authority to eſtabliſh in that kingdom the reign of impiety.

After this epoch he undertook ſeveral journeys into different parts of France, Holland, and Switzerland, where he collected with zeal and taſte objects of every kind intereſting to arts and ſciences. As he travelled with the ſimplicity and economy of a man of letters, who had emerged from obſcurity for the purpoſe of making obſervations and acquiring knowledge, he by that means was enabled to reſerve his fortune for important occaſions, in which it might procure him information on intereſting ſubjects. He travelled ſlowly, and frequently on foot, that his obſervations might be the more minute; and employed part of his time in ſuitably arranging them. Theſe obſervations formed a valuable collection of intereſting matter relative to the arts and ſciences, but which has been almoſt totally deſtroyed by the fury of revolutioniſts, who have done as much prejudice to the intereſts of ſcience as of humanity.

Returning from his travels, Maleſherbes for ſeveral years enjoyed a philoſophic leiſure, which he well knew how to direct to uſeful and important objects. The two treatiſes which he compoſed in the years 1785 and 1786 on the civil ſtate of the proteſtants in France are well known. The law which he propoſed in theſe, was only preparatory to a more extenſive reform; and theſe treatiſes were to have been followed up by another work, the plan of which he had already laid down, when affairs growing too difficult to be managed by thoſe who held the reins of government, they were compelled to call him to their councils. They did not, however, aſſign him the direction of any department, and introduced him merely (as ſubſequent events have ſhewn) to cover their tranſactions under a popular name, and paſs them on the world as acts in which he had taken part. Maleſherbes accepted their overtures merely to ſatisfy the deſire he felt to reveal ſome uſeful truths; but it was not for that purpoſe that they had invited him to their councils. Thoſe who preſided at them took umbrage at his firſt efforts to call their attention to the voice of truth and wiſdom; and ſucceeded ſo well in their oppoſition, that he was reduced to the neceſſity of delivering in writing the counſel which he wiſhed to offer. Such was the origin of two treatiſes relative to the calamities of France, and the means of repairing them. He tranſmitted theſe treatiſes to the king, who never read them; nor was he ever able to obtain a private audience although a miniſter of ſtate.

Such is the account of his laſt conduct in office which is given by his friends; and as we have not read his treatiſes on the calamities of France, we have no right to controvert it. From his known principles, however, we are intitled to conclude, that his plans of reformation were ſimilar to thoſe of Neckar, the offſpring rather of a head teeming with viſionary theories, than of the enlightened mind of a practical ſtateſman, or the corrupt heart of a Jacobin conſpirator.

Perceiving the inutility of his endeavours, diſguſted with what he thought the repeated errors of the government, and deprived of every means of expoſing them, or preventing their fatal effects; after frequent ſolicitations, he at length obtained leave to retire. He repaired to his eſtate at Maleſherbes, and from that moment entirely devoted his time to thoſe occupations that had ever formed the chief pleaſure of his life. He paſſed the evenings and a great part of the night in reading and ſtudy.

In this tranquil ſtate he was paſſing the evening of his days amidſt his woods and fields, when the horrors of the Revolution brought him again to Paris. During the whole of its progreſs, he had his eyes conſtantly fixed on his unhappy ſovereign, and, ſubduing his natural fondneſs of retirement, went regularly to court every Sunday, to give him proofs of his reſpect and attachment. He impoſed it as a duty on himſelf to give the miniſters regular information of the deſigns of the regicide faction *; and when it was determined to bring the king to trial, he voluntarily offered to be the defender of his maſter, in his memorable letter of the 11th of December 1792, that eternal monument of his loyalty and affection. His offer was accepted; and he pleaded the cauſe of the monarch with a ſtrength of argument that nothing could have reſiſted but the bloodthirſty minds of a den of Jacobins. "What Frenchman (ſays a valuable writer), what virtuous man, of any country, can ever forget that affecting ſcene, when the reſpectable old man, penetrating, for the firſt time, into the priſon of the Temple, melted into tears, on finding himſelf preſſed in the arms of his king; and that ſtill more affecting ſcene, when, entruſted with the moſt agonizing commiſſion that a ſubject could poſſibly have to his ſovereign, he threw himſelf at the feet of the innocent victim, while, ſuffocated with his ſobs, his voice,

till

---

* *Bertrand's Memoirs*, vol. iii. chap. 31.

Maleſherbes.

ſtill re-animated by the courage of the virtuous Louis, was inadequate to announce the fatal ſentence of death*.

Having diſcharged this painful and hazardous duty he once more returned to his country reſidence, and reſumed his tranquil courſe of life. But this tranquillity was of ſhort duration. About a twelvemonth afterwards, in the month of December 1793, three worthy members of the Revolutionary Committee of Paris came to reſide with him, his ſon-in-law, and his daughter, and apprehended the two latter as criminals. Left alone with his grandchildren, Maleſherbes endeavoured to conſole the reſt of his unfortunate family with the hopes which he himſelf was far from entertaining, when, the next day, the new formed guards arrived to apprehend him, and the whole of his family, even the youngeſt infants. This circumſtance ſpread a general conſternation throughout the whole department; for there was hardly a man in France, a few ex-jeſuits excepted, who did not revere the mild virtues of the laſt friend of the unfortunate king.

In this calamity Maleſherbes preſerved the undiſturbed equanimity of virtue. His affability and good humour never forſook him, and his converſation was as uſual; ſo that to have beheld him (without noticing his wretched guards), it ſeemed that he was travelling for his pleaſure with his neighbours and friends. He was conducted the ſame night to the priſon of the Madelonette with his grandſon Louis Lepelletier, at the ſame time that his other grandchildren were ſeparated into different priſons. This ſeparation proving extremely afflicting to him, he earneſtly ſolicited againſt it; and at length, on his repeated entreaties, they all met together once more at Port-Libre. They remained there but a ſhort period. The ſon-in-law of Maleſherbes, the virtuous Lepelletier Raſambo, the firſt of them who was arreſted, was ordered into another priſon, and ſacrificed a few days after. Maleſherbes himſelf, his daughter, his grand-daughter, and her huſband, were ſoon after all brought to the guillotine. They approached it with fortitude and ſerenity. It was then that his daughter addreſſed theſe pathetic words to Mademoiſelle Sombreuil, who had ſaved the life of her own father on the 2d of September: "You have had the exalted honour to preſerve *your* father—I have, at leaſt, the conſolation to die with *mine*."

Maleſherbes, ſtill the ſame, even to his laſt moments exhibited to his relations an example of fortitude. He converſed with the perſons that were near him without beſtowing the leaſt attention on the brutalities of the wretches who tied his hands. As he was leaving the priſon to aſcend the fatal cart, he ſtumbled againſt a ſtone, and made a falſe ſtep. "See (ſaid he ſmiling), how bad an omen! A Roman in my ſituation would have been ſent back again." He paſſed through Paris, aſcended the ſcaffold, and ſubmitted to death with the ſame unſhaken courage. He died at the age of 72 years, 4 months, and 15 days. He had only two daughters, and the ſon of one of them alone remains to ſucceed. From this account of Maleſherbes's behaviour at his laſt moments, we are inclined to believe that his intentions were better than ſome parts of his practical conduct; and we know, that having diſpelled the vain illuſions of philoſophiſm, he acknowledged his paſt errors; exclaiming, in the accents of grief, "That falſe philoſophy (to which I confeſs I was myſelf a dupe) has plunged us into the gulph of deſtruction, and, by an inconceivable magic, has faſcinated the eyes of the nation, and made us ſacrifice reality to a mere phantom. For the ſimple words *political liberty*, France has loſt that *ſocial freedom* which ſhe poſſeſſed in every reſpect, in a higher degree, than any other nation! How truly great did the king appear in his laſt moments! All their efforts to degrade him were vain; his unſhaken virtue triumphed over their wickedneſs. It is true, then, that religion alone transfuſes ſufficient courage into the mind of man, to enable him to ſupport, with ſo much dignity, ſuch dreadful trials †.

Malguzzary, Malphaghino.

MALGUZZARY, in the language of Bengal, *payment* of revenue; the *revenue* itſelf.

MALPHAGHINO (John), otherwiſe called John de Ravenna, from the place of his birth, was born in the year 1352, of a family diſtinguiſhed neither by riches nor nobility. His father, however, committed him to the care of Donatus the grammarian, an intimate friend of Petrarch, who at that time taught the Latin tongue with great applauſe at Venice. Donatus thought he diſcovered ſuch happy diſpoſitions in young Malphaghino, that he recommended him to Petrarch, not only as an excellent aſſiſtant to facilitate his labours, by reading or tranſcribing for him, but as a youth of the moſt promiſing talents, and worthy of being formed under the inſpection of the greateſt man of the fourteenth century.

It appears from ſome of Petrarch's letters, for it is from theſe chiefly we can obtain information reſpecting John de Ravenna, that he fully anſwered the expectations formed of him; and that he even gained the favour and affection of his patron ſo much, that he loved him and treated him as if he had been his own ſon. In a letter to John de Certaldo (A), Petrarch highly extols him, not only for his genius and talents, but alſo for his prudent and virtuous conduct. "He poſſeſſes (ſays he) what is very rare in our times, a great turn for poetry, and a noble deſire to become acquainted with every uſeful and ornamental part of knowledge. He is favoured by the Muſes, and already attempts verſes of his own; from which one can foretel, that, if his life be ſpared, and if he goes on as hitherto, ſomething great may be expected from him."

Not long, however, after this panegyric was written, young Malphaghino conceived an inſuperable deſire to ſee the world; and, notwithſtanding all Petrarch's remonſtrances, perſiſted in his reſolution of quitting him. Petrarch's paternal care and regard for his pupil appear, on this occaſion, in the moſt favourable light, as may be ſeen in his letters to Donatus; and his whole behaviour, though the young man inſiſted on leaving him, without aſſigning a ſufficient reaſon for his precipitate and ungrateful conduct, does as much honour to his head as to his heart.

The precipitation with which John de Ravenna carried his plan into execution was not likely to make it anſwer his expectations. He departed without taking with him letters of recommendation which Petrarch offered him to his friends. He, however, purſued his journey over the Appenines, amidſt continual rain, giving out that he had been diſmiſſed by Petrarch; but, though he experienced from many a compaſſion to which he was not entitled by his conduct, he now began to awaken from his dream. He proceeded therefore to Piſa,

---

* Clery's *Journal*, p. 158—196.

† *Bertrand's Memoirs*, chap. 40.

(A) Better known under the name of *Boccaccio* or *Boccace*. Certaldo was the place of his birth.

Fig. 1.

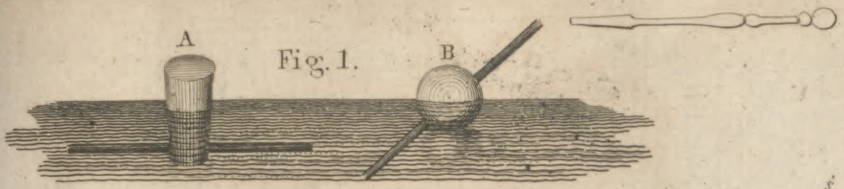


Fig. 2.

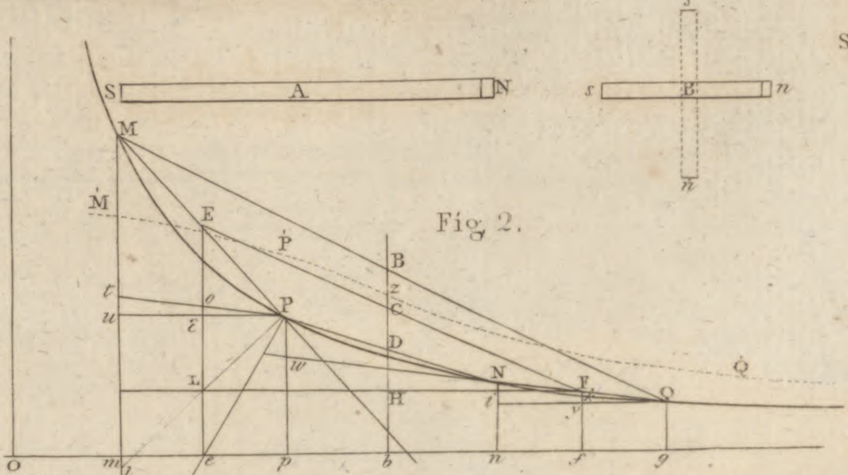


Fig. 3.

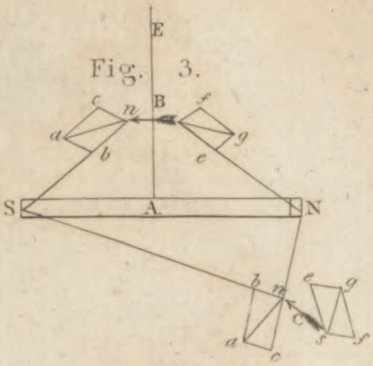


Fig. 4.

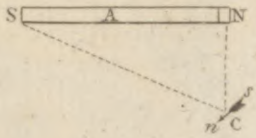


Fig. 8.

Fig. 5.

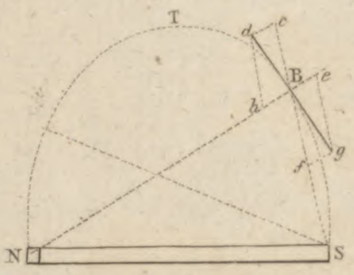


Fig. 5. No. 2.

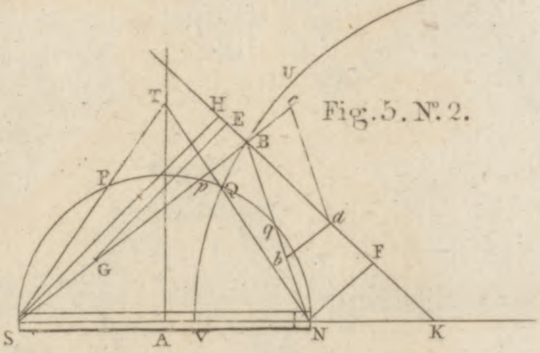


Fig. 9.

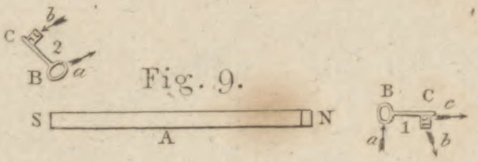


Fig. 7.

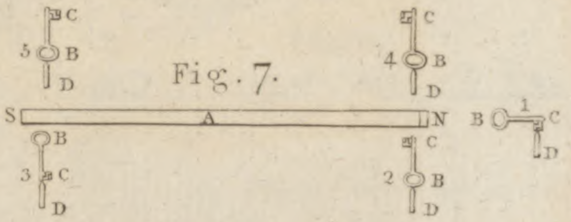


Fig. 10.

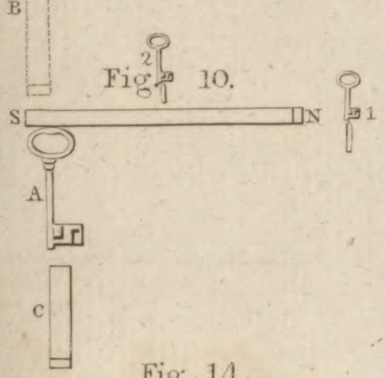


Fig. 6.

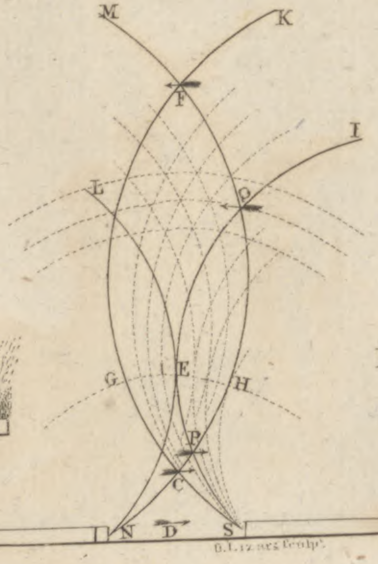


Fig. 13.

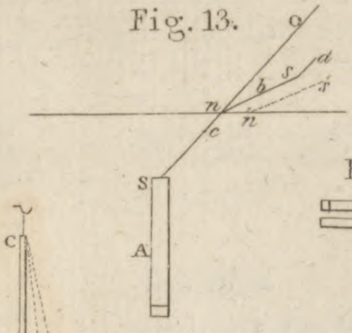


Fig. 12.

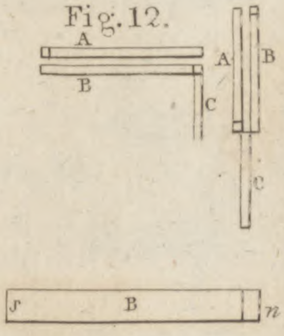


Fig. 11.

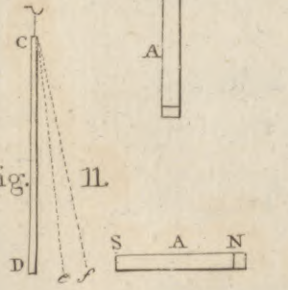
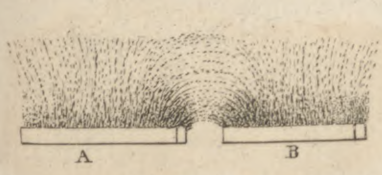


Fig. 14.



B. Lizars sculpt.

Fig 15.

Fig 17.

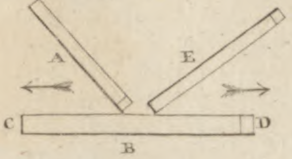


Fig 16.

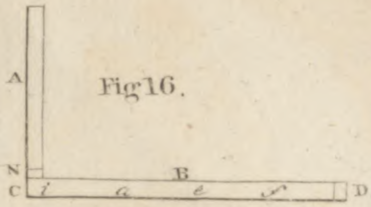


Fig 18.

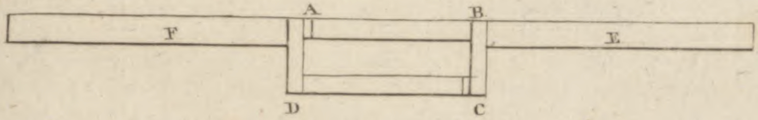


Fig 22.

Fig 21.

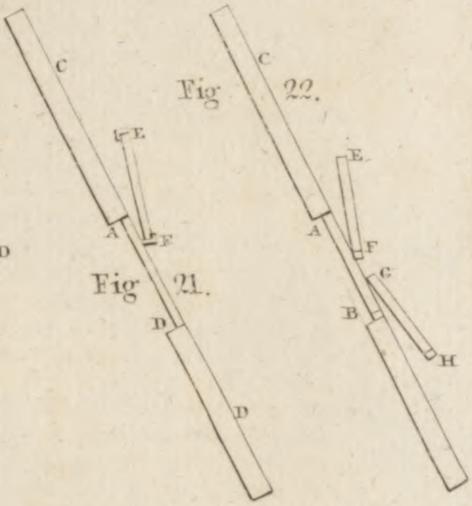


Fig 19.

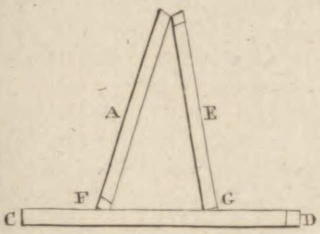


Fig 20.

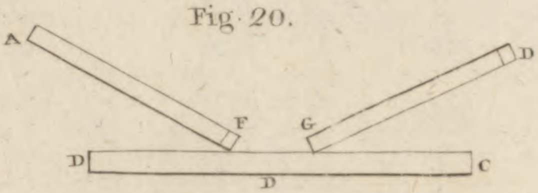


Fig 24.

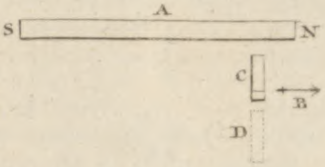


Fig 23.

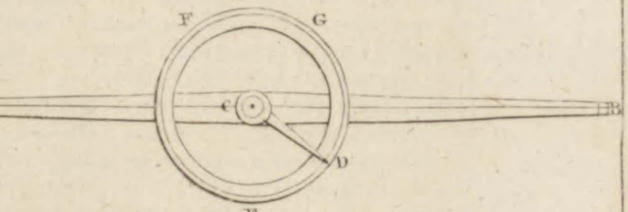


Fig 25.

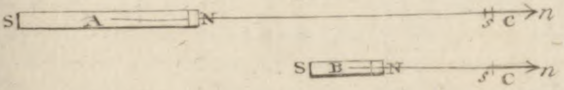


Fig 28.

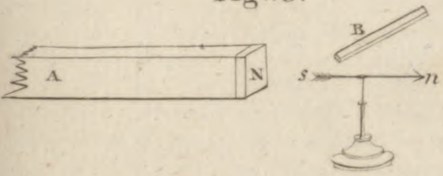


Fig 29.

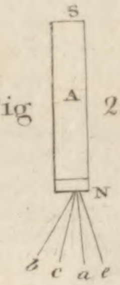


Fig 26.

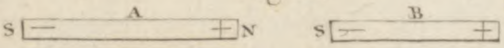


Fig 27.

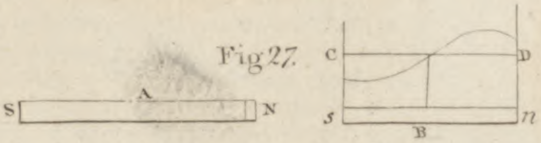


Fig 32.

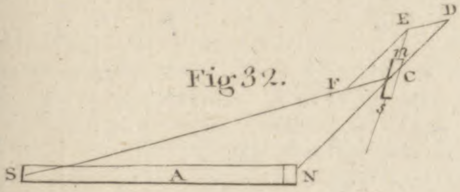


Fig 34.

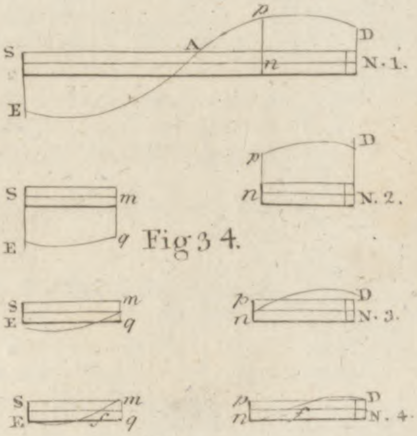


Fig 30.

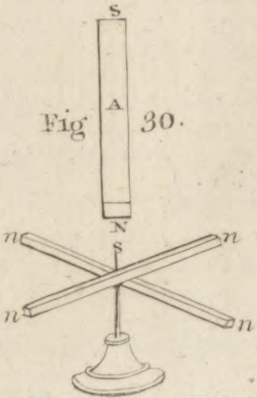


Fig 31.

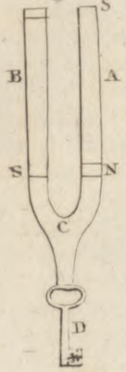
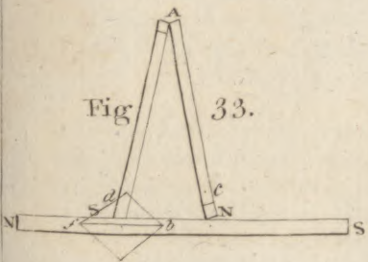


Fig 33.



Piſa, in order to procure a veſſel to carry him back towards Pavia: but being diſappointed, while his money waſted as much as his patience decreaſed, he ſuddenly reſolved to travel back acroſs the Appenines. When he deſcended into the Ligurian plains, he attempted to wade through a river in the diſtrict of Parma, which was much ſwelled by the rains; and being carried by the force of the ſtream into a whirlpool, he would have loſt his life, had he not been ſaved by ſome people who were accidentally paſſing that way. After eſcaping this danger, he arrived, pennyleſs and famiſhed, at the houſe of his former patron, who happened then not to be at home; but he was received and kindly entertained by his ſervants till their maſter returned.

Petrarch, by his intreaties and paternal admonitions, retained the young man at his houſe for about a year, and prevented him from engaging in any more romantic adventures; but, at the end of that period, his deſire for rambling again returned; and as Petrarch found that all attempts to check him would be fruitleſs, he gave him letters of recommendation to two of his friends, Hugo de St Severino and Franciſcus Brunus, at Rome. To the former of theſe, Petrarch ſays, "This youth of rare talents, but ſtill a youth, after propoſing to himſelf various plans, has at length embraced the nobleſt; and as he once travelled, he is now deſirous of doing ſo again, in order to gratify his thirſt of knowledge. He has, in particular, a ſtrong inclination for the Greek language; and entertains a wiſh which Cato firſt conceived in his old age. This wiſh I have endeavoured for ſome years to ſubdue; ſometimes by intreaties, at other times by admonition; ſometimes by repreſenting how much he is ſtill deficient in the Roman language; and ſometimes by laying before him the difficulties which muſt attend him in his journey, eſpecially as he once before left me, and by want was obliged to return. As long as that unfortunate excurſion was freſh in his memory he remained quiet, and gave me hopes that his reſtleſs ſpirit could be overcome and reſtrained. But now, ſince the remembrance of his misfortunes is almoſt obliterated, he again ſighs after the world; and can be retained neither by force nor perſuaſion. Excited by a deſire which betrays more ardour than prudence, he is reſolved to leave his country, friends, and relations, his aged father, and me whom he loved as a father, and whoſe company he preferred to a reſidence at home, and to haſten to you whom he knows only by name. This precipitation even has an appearance of prudence. The young man firſt wiſhed to viſit Conſtantinople; but when I told him that Greece, at preſent, is as poor as it was formerly rich in learning, he gave credit to my aſſertion, and at any rate altered his plan; which he could not carry into execution. He is now deſirous of traverſing Calabria, and the whole coaſt of Italy, diſtinguiſhed formerly by the name of Magna Græcia, becauſe I once told him that there were in that quarter ſeveral men well ſkilled in the Greek language, particularly a monk, Barlaam, and one Leo, or Leontius, with whom I was intimately acquainted, and of whom the firſt had been ſome time my ſcholar. In conſequence of this propoſal, he begged me to give him a recommendatory letter to you, as you have conſiderable influence in that part of the country. This requeſt I granted, in hopes that the young man, by his genius and talents, will afford you ſatisfaction equal to the ſervice which you may render to him." In his letter to Brunus, Petrarch expreſſes himſelf as follows: "He is a young man who wiſhes to ſee the world as I formerly did; but I never reflect on it without horror. He is deſirous of ſeeing Rome; and this deſire I cannot condemn, as I myſelf have ſo often viſited that city, and could ſtill reviſit it with pleaſure. I ſuſpect, however, that he will venture on a more extenſive ocean, and that he imagines to find a fortune where he will, perhaps, meet with a ſhipwreck. At any rate, he is deſirous, he ſays, of putting his fortune to a trial. I wiſh it may be favourable; ſhould it be adverſe, he is ſtill at liberty to return to my peaceful, though ſmall, haven; for I hang out a light, during the day as well as the night, to guide thoſe who quit me through youthful folly, and to enable them to find their way back. The ardour by which he is impelled muſt not be aſcribed ſo much to him as to his age, and is in itſelf commendable. If I am not much deceived, the young man loves me and virtue in general. He is unſteady, but modeſt; and deſerves that all good men ſhould contribute to his proſperity as far as they can."

From the letters of Petrarch, there is reaſon to believe, that John de Ravenna lived with him only about three years in all; and that he had not attained to the full age of manhood when he left him. It appears alſo, for this circumſtance is very obſcure, that after he quitted him, he wandered about a conſiderable time before he was ſo fortunate as to meet with a protector and patron, at whoſe houſe, as he wrote to Petrarch, he at laſt found a permanent aſylum. How long he remained with his patron, whom ſome believe to have been Cardinal Philip, and what happened to him till the death of Petrarch in 1374, and for ſome years after, is unknown. The literary monuments of the fourteenth and fifteenth centuries ſay nothing farther of him till his appearance at Padua; where, according to the teſtimony of Sicco (B), one of the moſt celebrated of his ſcholars, he not only taught the Roman Eloquence, but alſo the ſcience of moral philoſophy, with ſuch ſucceſs and applauſe, and improved his ſcholars ſo much by his life and example, that, according to univerſal opinion, he far excelled all the profeſſors of thoſe ſciences who had ever before appeared. That he was here of conſiderable ſervice in reviving the ſtudy of the Latin language, and of the works of the ancient Romans, was acknowledged by all his ſcholars, and is confirmed by the following teſtimony of Blondus (C).

"About the ſame period, Ravenna produced that learned

(B) Adoleſcens tum ego poetas, et inſtituta Tullii audiebam. Legebat tunc hac in civitate Padua, literarum nutrice, *Johannes Ravennas* vir et ſanctimonia morum, et ſtudio iſto excellens, atque ſi poteſt ſine invidia, dici ceteris, qui magiſtri artis hujus in terra Italia uſquam degerent et doctiſſimi haberentur, quantum recordari videor, omnium judicio præferendus. Hoc namque a præceptore non eloquentia modo, quam ex ordine legerit ſed mores etiam, ac quædam bene honeſteque vivendi ratio cum doctrina tum exemplis diſcebatur.—*Sicco Polentonus*, Ap. Mehus, l. c. p. 139.

(C) Blondi Flavii Forlivienſis Italia illuſtrata. Bas. 1559. fol. p. 346.

learned grammarian and rhetorician Johannes, of whom Leonardus Aretinus uſed to ſay, that he firſt introduced into Italy, after a long period of barbariſm, the ſtudy of the Latin language and eloquence, now ſo flouriſhing; a circumſtance which deſerves to be enlarged on in the preſent work. Thoſe well acquainted with Roman literature know, that after the periods of Ambroſe, Jerom, and Auguſtine, there were none, or very few, who wrote with any elegance, unleſs we add to theſe good writers, St Gregory, the venerable Bede, and St Bernard. Francis Petrarcha was the firſt who, with much genius, and ſtill greater care, recalled from the duſt the true art of poetry and of eloquence. He did not attain to the flowers of Ciceronian eloquence, with which many are adorned in the preſent century; but this was owing rather to a want of books than of talents. Though he boaſted of having found at Vercelli Cicero's letters to Lentulus, he was unacquainted with the books of that great Roman *De Oratore*, Quintilian's Inſtitutes, the *Orator*, the *Brutus*, and other writings of Cicero. John de Ravenna was known to Petrarch both in his youth and in his old age. He was not more converſant with the ancients than Petrarch; and, as far as I know, left no works behind him. By his excellent genius, however, and, as Leonardus Aretinus ſays, by the particular diſpenſation of God, he was the preceptor of this Leonardus, of Petrus Paulus Vergerius, of Annebonus de Padua, of Robert Roſſi, of James Angeli of Florence, of Poggius and Guarino of Verona, of Victorinus, Sicco, and other men of leſs note, whom he incited to the ſtudy of better knowledge, and to imitate Cicero, if he could not form them or inſtruct them completely.

"About the ſame time, Manuel Chryſoloras, a man as virtuous as learned, came from Conſtantinople to Italy, and inſtructed in the Greek language, partly at Venice and partly at Florence and Rome, all the before mentioned ſcholars of John de Ravenna. After he had continued this inſtruction for ſome years, thoſe unacquainted with the Greek language, and the ancient Greek writers, were conſidered in Italy as more ignorant than thoſe unacquainted with the Latin. A great many young men and youths were inflamed with an enthuſiaſtic deſire for the works of the ancient Greeks and Romans. At the time of the council of Conſtance, in the beginning of the fifteenth century, many of my countrymen endeavoured, by ſearching the neighbouring cities and convents, to diſcover ſome of the Roman manuſcripts which had been loſt. Poggius firſt diſcovered a complete copy of Quintilian, which was ſoon followed by the letters of Cicero to Atticus. As our youth applied to the ſtudy of theſe works with the utmoſt diligence, that celebrated grammarian and rhetorician Caſparinus de Bergamo, opened a ſchool at Venice, ſuperior to the former, and in which young perſons were encouraged to ſtudy the ancient languages and writers. About the ſame time flouriſhed Petrus Paulus Vergerus, Leonerdus Aretinus, Robert Roſſi, James Angeli, Poggius, and Nicolaus de Medici, whom Aretin had long inſtructed. Guarinus alſo had begun to inſtruct many at Venice, and Victorinus at Mantua, when Philip III. Duke of Milan, recalled Caſparinus as his ſubject, from Venice to Padua and Milan. The increaſing ſtudy of ancient literature was much promoted by Gerard Landriano biſhop of Lodi, diſcovering under ſome ruins an old copy of Cicero, written in characters ſcarcely legible, which, among other rhetorical writings of that great Roman, contained the whole books *De Oratore*, with his *Brutus* and *Orator*. This ſaved Caſparinus the trouble of ſupplying the books of Cicero *De Oratore*, as he had attempted to ſupply the works of Quintilian. As no one was found in all Milan who could read this old manuſcript of Cicero, an ingenious young man of Verona, named Caſmus, was ſo fortunate as firſt to tranſcribe the books *De Oratore*, and to fill all Italy with copies of a work which was univerſally ſought for with the utmoſt avidity. I myſelf, in my youth, when I went to Milan on the buſineſs of my native city, tranſcribed, with as much ardour as ſpeed, the *Brutus* of Cicero, and ſent copies of my tranſcription to Guarinus at Verona, and to Leonard Juſtiniani at Venice; by which means this work was ſoon diſperſed all over Italy. By theſe new works eloquence acquired new fire; and hence it happens, that in our age people ſpeak and write better than in the time of Petrarch. The ſtudy of the Greek language, beſides the abundance of new and uſeful knowledge which it diſcloſed, was attended with this great advantage, that many attempted to tranſlate Greek works into Latin, and thereby improved their ſtyle much more than they could have done without that practice. After this period, ſchools for teaching the ancient languages increaſed in Italy, and flouriſhed more and more. Moſt cities had ſchools of this kind; and it gives one pleaſure to obſerve, that the ſcholars excelled their maſters, not only when they left them, but even while they were under their tuition. Of the ſcholars of John de Ravenna, two of the oldeſt, Guarinus and Victorinus, the former at Venice, and the latter at Mantua, Verona, Florence, and Ferrara, inſtructed an immenſe number of pupils; and among theſe, the Princes of Ferrara and Mantua. George of Trebiſonde, when he lectured at Rome, had for his auditors, beſides Italians, many French, Spaniards, and Germans, among whom ſometimes there were men of rank and eminence. Franciſcus Philelphus, who had been taught at Conſtantinople by Chryſoloras himſelf, inſtructed a great many young men and youths in the Greek and Latin languages at Venice, Florence, Siena, Bologna, and, laſt of all, at Milan." In the above quotation, the ſhare which John de Ravenna had in reviving and diffuſing a knowledge, not only of the Roman, but alſo of the Grecian literature, is ſo clearly repreſented, that no farther teſtimony is neceſſary to eſtabliſh his claim to celebrity.

After John de Ravenna had taught at Padua, he removed for the like purpoſe to Florence; where, as appears, he inſtructed young people for ſome time, without being expreſsly invited by the government, and without being publicly paid for his labours. In the beginning of his reſidence at Florence, he ſeems to have been recommended by Colucius to the learned Charles de Malateſta. "There lives here at preſent (ſays Colucius, in one of his letters) a teacher of great merit, John de Ravenna.—He is (continues he) of mature age; irreproachable in his manners, and ſo diſpoſed in general, that if you receive him, as I hope and wiſh, among the number of your intimate friends, you will find him an agreeable and incomparable aſſiſtant to you in your labours and ſtudies. What can be more deſirable to you than to poſſeſs a man who will lucubrate and labour for you? and who, in a ſhort time, can communicate to you what you could not obtain by your own exertions without great difficulty. I do not know whether you will find his like in all Italy ; and I therefore wiſh, that, if you confide in my judgment, you will receive John de Ravenna in the room of your late learned friend James de Alegretti." It is not known whether John de Ravenna went to reſide with Malateſta or not. It is, however, certain, that the former, in 1397 (the ſame year in which Manuel Chryſoloras came to Florence), was invited thither by the magiſtrates of that city, with the promiſe of an annual ſalary, to inſtruct young people in the Roman language and eloquence ; that John de Ravenna, at the period when he entered into this honourable engagement, was 45 years of age ; and that the ſcholars of John de Ravenna were, at the ſame time, ſcholars of Chryſoloras. Saluratus Colucius, in all probability, was the cauſe of this invitation, as he was acquainted with the ſervices of John de Ravenna, and knew how to appreciate them. "We know (ſays he, in one of his letters to John de Ravenna), and all who reſpect you know alſo, that none of the moderns, or even ancients, approached ſo near to Cicero as you ; and that to the moſt wonderful beauty and powers of ſpeech, you join the deepeſt knowledge." John de Ravenna, like Chryſoloras, and moſt of the teachers of the Greek and Roman languages in the beginning of the fifteen century, was, no doubt, engaged at firſt only for a few years ; when theſe were elapſed, the engagement was renewed, perhaps for the laſt time, in 1412, and he was bound, beſides teaching the Roman eloquence, to read publicly, and explain in the cathedral, on feſtivals, the poems of Dante. John de Ravenna did not long ſurvive the above renewal of his engagement ; for an anonymous writer, who, in 1420, finiſhed *A Guide to Letter-writing, according to the Principles of John de Ravenna*," ſpeaks of his preceptor as of a man not then in exiſtence.

MALT. See Brewing (*Encycl.*), where a full account is given of Sir Robert Murray's method of malt-making, together with ſome valuable obſervations on malt by Mr Richardſon of Hull. In a late edition of this latter gentleman's *Theoretic Hints on Brewing*, we are told, that Mr Edward Rigby of Norwich is of opinion, that the mere exſiccation of corn is not the only object obtainable by drying it on the kiln, but that ſome portion of the ſaccharum of malt is the effect of that proceſs. "The operation of kiln drying the malt (ſays Mr Rigby) is as follows:—The grain is ſpread thick upon a floor made of flat bricks (*tiles*), or iron plates, which are full of perforations ; immediately under this floor is the oven or furnace, in which is a large fire made of *coaks*, cinders, or, in ſome places, billet wood ; a current of air, at the mouth of the furnace, keeps up the combuſtion of the coaks, and the air which is phlogiſticated by their burning, and which, in a common fire place, riſes up the chimney, paſſes, in this inſtance, through the apertures in the floor, and penetrates the whole ſtratum of malt before it can paſs into the external air. Under theſe circumſtances, it is evident, that the interſtices of the malt muſt be filled with phlogiſtic air ; and as the grain uſually remains in this ſituation about two days, it is obvious, that if it have the power of abſorbing phlogiſton, it certainly muſt do it when ſo long in contact with it. And that the malt does really imbibe ſome of this principle, is not only probable on the general ground of the truth of the preceding theory, but, I believe, it will be found, that the phlogiſticated air which riſes from the burning ſubſtances underneath, is corrected in paſſing through the malt ; for without its being meliorated by this or ſome other cauſe, it is evident that the air in the kiln-chamber, more eſpecially the lower ſtrata of it, muſt be noxious, and probably even ſo much ſo as to be unfit for reſpiration and combuſtion. But ſo far from this being the caſe, I am informed, that workmen will lie and ſleep many hours on the malt in this ſituation without ſuffering any inconvenience. And after mentioning this, it is ſcarcely neceſſary to add, that I find alſo, by experiment, that a candle will burn perfectly well in the air which is immediately on the ſurface of the malt.

"Were heat alone ſufficient for the purpoſe of completing the operation of malting, it certainly might be applied in a much more cheap way than is at preſent done ; for the floor on which the grain is laid might, unqueſtionably, be heated equally without there being perforations in it, as with them. In which caſe, one kind of fuel would be as good as another ; and, conſequently, the preſent expence of previouſly burning the coals, to convert them into coaks or cinders, might be ſaved.

"But, admitting that the application of phlogiſton to the malt, as well as heat, is requiſite in this operation, the neceſſity of theſe perforations becomes evident, and alſo the propriety of previouſly burning the coals in ſuch a way, that all the water, and thoſe other heterogeneous particles which compoſe ſmoke and ſoot, may be diſſipated ; for theſe, merely as ſuch, would obviouſly contribute little to the phlogiſtication of the malt, and would evidently impart ſome offenſive flavour, if not ſome obnoxious quality to it.

"Reaſoning from the above premiſes (Mr Rigby concludes), it would ſeem, that as all the farinaceous parts of the barley are ſeldom diſſolved in brewing, and the grains which are left have uſually the diſpoſition to become ſour, thereby manifeſting ſome of the acid principle to be ſtill exiſting in them, it is not improbable but ſome further ſaccharine matter might be obtained from the grain by another expoſure to phlogiſticated air, or, in other words, by being once more laid on the kiln."

This is indeed ſo far from being improbable, that we think it muſt infallibly be the caſe. Sugar, it is well known, conſiſts of oxygen, hydrogen, and carbon (ſee Chemistry in this *Supplement*, n° 466.) ; but from the diſpoſition of the grains to become ſour, it is plain, that after the proceſs of brewing they ſtill retain much oxygen ; and the azotic gas, which is here called phlogiſticated air, there is every reaſon to believe contains both hydrogen and carbon. Theſe, therefore, uniting with the oxygen of the grains, muſt make an addition to the ſaccharine matter. This has, indeed, been found to be the fact by Mr Richardſon, who, in conſequence of Mr Rigby's ſuggeſtion, was induced to brew a ſmall brewing of malt, of ten quarters only, and ſtopping the proceſs when, according to his general practice, one extract was ſtill due, he ordered the grains to be laid upon one of his malt-kilns, and cinders to be applied the ſame as for drying of malt. This was continued for two days and a half, when the grains, being perfectly dried, were put into ſacks, and, when cold, returned again into the maſh-tun. The event, in ſome meaſure, juſtified Mr

Mammalukes.

Rigby's expectation ; for the produce of fermentable matter was conſiderably more than he had reaſon to conclude would have been the caſe, had the extract been made in immediate ſucceſſion, as it would have been in the ordinary courſe of his practice. He attempts, indeed, to account for it in a way very different from ours ; but though we have the higheſt confidence in Mr Richardſon as an experienced brewer, we muſt ſometimes beg leave to think for ourſelves as chemiſts. Like a man of ſenſe, however, and a man of ſcience, he ſays, " I am ſo well ſatisfied with the event of this experiment, that I ſhall probably be inclined, on ſome future occaſion, to repeat it, in various ſtages of the proceſs. The fine lively froth on the ſurface of the wort, in the underback, added to its tranſparency and good flavour, are circumſtances which induce me to thank Mr Rigby for the hint, which, it is not improbable, may be applied to ſome uſeful purpoſe, in certain ſituations which ſometimes occur in the brewing trade."

MAMMALUKES, Mamalucs, *Mamaloucs*, or *Mamluks*, were a dynaſty that reigned for a conſiderable time in Egypt, and of which ſome account has been given in that article (*Encycl.*). A fuller account of them muſt, however, be acceptable to our readers, as, ſince the expedition of Buonaparte, they have attracted the attention of all Europe.

Antijacobin Review, nº 12. and *Brown's Travels.*

They were firſt introduced into Egypt, as we have already obſerved, by Saladine, who, when he had it in contemplation to beſiege Jeruſalem, very naturally endeavoured to collect the moſt forcible means to accompliſh ſo deſirable an end ; and, in conſequence, obſerving that the ancient inhabitants of Egypt were, from their effeminate mode of education, and the quiet and tranquil habits of their lives, much fitter for thoſe occupations in which they delighted, namely, the arts, merchandize, and mechanics, than military tactics and military toil, he reſolved, as little as poſſible, to employ or depend upon them.

This reſolution ſtimulating him to procure a hardier race of ſoldiers, he therefore commiſſioned agents to treat with the Circaſſians, by the Lake of Mæotis, near Tawrica Cherſoneſas, whence, about the year 1176, they purchaſed more than a thouſand ſlaves. Men inured to hardſhip, nurtured in the lap of toil and danger, and bred from their infancy to war, which was to them rather an inſtinct than a ſcience, as the continual incurſions of the Tartars rendered ſelf-defence, in their ſituation, abſolutely neceſſary.

Theſe ſlaves Saladine trained to military diſcipline, and, at the ſame time that he made them renounce Chriſtianity, had them inſtructed in the Mahometan religion ; and although he prohibited them from marrying, he allowed them an unbounded licence with reſpect to deſultory gallantry. What progreſs they made in the doctrines of the Alcoran, whether the tenets of that ſacred volume effectually eradicated all their firſt principles, is uncertain ; but it is certain, that in time they became excellent ſoldiers, and that the military glory of Saladine, which was feebly ſupported by the native Egyptians, expanded in the hands of the Mameloucs, who extended their conqueſts on every ſide, until, pervading the Holy Land, they entered in the plain of Aſkelon.

Theſe Mameloucs, who were continually adding to their numbers, in proceſs of time became naturalized to the country ; and, as it has been obſerved, they excelled the Egyptians in ſtrength of body, in military diſcipline, in their ſkill in horſemanſhip, and in courage ; ſo they, by the liberality of their generals, and the plunder of cities and provinces, alſo excelled them in wealth. In fact, their mode of education fitted them for the moſt dangerous and adventurous enterpriſes, and, from being the ſlaves, enabled them in time to become the maſters of even the Turks, by whom they had originally been purchaſed.

After the death of Saladine, who left the kingdom to his brother, they roſe to ſtill greater importance than they had acquired during his reign, and continued, if not abſolutely to govern, yet, like the Roman ſoldiers in the time of Pertinax, Alexander, and Valerian, to awe the monarch.

This influence continued through the reigns of five ſucceſſive Caliphs, until that of Melachſala, the laſt of the poſterity of Saladine, who being at war with the Arriſtians, and, at the ſame time, wiſhing to repreſs the enormous power of the Mameloucs, purchaſed ſlaves from all the ſurrounding countries, whom, in imitation of his anceſtor, he armed and appointed to defend his dominions. The event of this meaſure was exactly what might have been expected. Melachſala was, in conſequence of a conſpiracy betwixt his new and his old ſoldiers, ſlain; and Turquemenus, the leader of this mutiny and rebellion, hailed by the title of Great Sultan of Egypt. With him began the government of the Mameloucs, about the year 1250; which had the next year gathered ſuch ſtrength, that it was thought neceſſary, in order to repreſs thoſe exuberances to which new formed governments are liable, and bring it nearer to a ſyſtem, to cauſe the following articles, in the form of a charter, to be ſubſcribed to by their principal leaders, as an act of the whole people :—" 1ſt, That the Sultan ſhould be choſen from the body of Mameloucs; 2dly, That none ſhould be admitted into the order that were by birth either Jews or Turks, but only Chriſtian captives ; 3dly, That the native Egyptians ſhould not be permitted to uſe, or have, any weapons, except the inſtruments of agriculture."

Turquemenus, as is frequently the practice with thoſe that experience a ſudden elevation, endeavoured to kick down the ladder by which he had been raiſed ; or, in other words, his carriage was ſo haughty and diſdainful to his former companions, that he was by them, or rather by one of them named Clotho, ſuddenly ſlain ; for which the murderer was rewarded with his ſceptre. After him ſucceeded a long race of princes, many of whom were as eminent for their talents as for their valour ; among whom, the name of Caitbeius has been tranſmitted to us as that of the greateſt ſtateſman and general of his age ; but, as every one who conſiders the *materials* of which the government was compoſed, muſt rather wonder that it exiſted ſo long, than that it ſhould, through almoſt the whole courſe of its operation, be expoſed to all the various evils and diſtreſſes ariſing from a long train of ſedition and tumults, ſo he muſt lament that it ſhould expire in the reign of one of their wiſeſt and beſt monarchs : yet it is ſome conſolation to reflect, that Campſon, the laſt Sultan of the Mameloucs, was not *murdered by his own ſubjects*, but having for many years governed the kingdoms of Egypt, Judea, and Syria, in a manner that has excited the praiſe

of

of the hiſtoric pen, he, oppreſſed with age and diſeaſe, and encumbered with his armour, ſunk upon the field of battle, and, with his laſt breath, yielded the victory to the fortunate Selim.

With this monarch, who expired January 20, 1516, ended the government of the Mameloucs, after it had continued 276 years; for although an attempt was made by Tomumby to get himſelf declared Sultan, in which attempt he actually ſucceeded ſo far as to be inveſted with the title, yet he was ſoon after defeated by the victorious Selim. He was then forſaken by his troops, taken and executed; while the Mameloucs, broken and diſperſed, it was the policy of Selim to rally, and, by offers too tempting to be by them refuſed, engage in his ſervice. The uſe of theſe ſoldiers ſoon became ſufficiently apparent to the Turkiſh Emperors, to ſtimulate them to augment their number, enlarge their ſphere of action, and combine them cloſer to the ſtate, by the allowance of ſtill greater privileges and advantages than they had before enjoyed.

The Beys were ordained to be choſen from among them; and the Paſha, or chief governor for the Porte, was to ſhare his power with thoſe Beys, and even to continue in office no longer than ſhould be agreeable to their collective will. At firſt the power of the Paſha was very extenſive; but, by the intrigues and ambition of the Beys, it has been reduced almoſt to a cypher. It was rather of a civil than military nature. He was always preſident of the Divan, which was held in the caſtle where he reſided. But that council now commonly meets in the palace of one of the chief Beys, except when a firman or mandate is received from Conſtantinople, when the Beys are ſummoned to the caſtle, to hear the commands of the Porte. The few who attend, as ſoon as the reading is finiſhed, anſwer, as is uſual, "*Eſmana wa taana*," "We have heard, and we obey." On leaving the caſtle, their general voice is "*Eſmana wa awſina*," We have heard, and ſhall diſobey."

In the year 1791, Salah Aga, a ſlave of Murad Bey, was deputed from the government of Egypt to negociate their peace with the Porte. He carried preſents of horſes, rich ſtuffs, &c. A ſpontaneous tribute, which the Porte was in no condition to enforce, implied obligation on the part of the latter. He was well received, and afterwards was appointed *Waquil es Sultan*, agent or attorney to the Sultan in Cairo. It is probable, this office was given him to incline him to ſecond the efforts of the Court in diſuniting the Beys; but it was ineffectual. Theſe had formerly experienced the evils of diviſion, and now were united by common intereſt, grown rich, and well provided with ſlaves; ſo that no tribute has ſince that time found its way to Conſtantinople.

The Mameloucs remain, as they have ever been, military ſlaves, imported from Georgia, Circaſſia, and Mingrelia. A few have been priſoners, taken from the Auſtrians and Ruſſians, who have exchanged their religion for an eſtabliſhment. The Beys give general orders to their agents at Conſtantinople, to purchaſe a certain number every year; and many are brought to Egypt by private merchants on ſpeculation. When the ſupply proves inſufficient, or many have been expended, black ſlaves from the interior of Africa are ſubſtituted, and, if found docile, are armed and accoutred like the reſt.

Particular attention is paid to the education of theſe favoured ſlaves. They are inſtructed in every exerciſe of agility or ſtrength, and are, in general, diſtinguiſhed by the grace and beauty of their perſons. The gratitude of the diſciples is equal to the favour of their maſters, whom they never quit in the hour of danger. If they have a diſpoſition for learning, they are taught the uſe of letters, and ſome of them are excellent ſcribes; but the greater part neither can read nor write. A ſtriking example of which deficiency is obſervable in Murad Bey himſelf.

The inferior Mameloucs conſtantly appear in the military dreſs, and are commonly armed with a pair of piſtols, a ſabre, and a dagger. They wear a peculiar cap of a greeniſh hue, around which is wreathed a turban. The reſt of their dreſs reſembles that of other Mohamedan citizens, and is reſtricted to no particular colour; but another ſingularity is, their large drawers of thick Venetian cloth, of a crimſon colour, to which are attached their ſlippers of red leather. On horſeback they add to their arms a pair of large horſe piſtols, and the dubbus or battle axe. In battle, many of them wear an open helmet, and the ancient ring armour of interwoven links of ſteel, worn under part of their dreſs, and thus concealed. Theſe are dear; ſometimes coſting 500 piaſtres, or about L. 40. Some of them are made at Conſtantinople, others in Perſia. Their horſes are of the fineſt Arabian breed, and are often purchaſed at three or four purſes, L. 150 to L. 200 ſterling.

They have no pay, as they eat at a table in the houſe of their maſter the Bey, Caſhef, or other officer. Any military officer may purchaſe a ſlave, who becomes, *ipſo facto*, a Mamelouc. The name, from *malek*, to poſſeſs, implies merely a perſon who is the property of another. After a proper education, the candidate thus conſtituted a Mamelouc, receives a preſent of a horſe and arms from his maſter, together with a ſuit of clothes; which is renewed every year in the month Ramadan. The generoſity of their maſters, and rewards or extortions from others, afford them ſupplies of money, either for avarice or debauchery. Some of them, admitted to peculiar favour by the Beys, as chaſnadars, or purſe-bearers, &c. acquire great wealth. They are rather gay and thoughtleſs than inſolent, fond of ſhow, and unprincipled in their means of acquiring it. They ſeldom marry till they acquire ſome office.

Though born of Chriſtian parents, they ſeem highly ſatisfied with their condition, which they have been known to refuſe to exchange for freedom. The majority are regarded by the Arabs as little ſtrict in the principles or duties of Mohamediſm. It is worthy of remark, that though the Mameloucs, in general, be ſtrong and perſonable men, yet the few who marry very ſeldom have children. As the ſon, even of a Bey, is not honoured with any particular conſideration, the women, perhaps, procure abortions. Of eighteen Beys, with whoſe hiſtory Mr Browne was well acquainted, two only had any children living.

Hardy, capable of every fatigue, of undaunted courage, and eminent ſkill in horſemanſhip and the uſe of the ſabre, the Mameloucs may be regarded as by far the beſt troops in the Eaſt. But in a regular battle, conducted by manœuvres, and large or rapid movements, they are equally inferior to European troops.

Being diſtinguiſhed by favouritiſm or merit, the Mameloue becomes a Caſhef, and in time a Bey. The chief cauſe of preference ariſes from political adherence to ſome powerful leader.

The government of Cairo, and Egypt, in general, is veſted in 24 Beys; each of whom is nominally choſen by the remaining 23, but, in fact, appointed by one of the moſt powerful. The Yenk-tchery, Aga, and ſeveral other officers, are enumerated among the 24 Beys.

Beſides being governors of certain diſtricts of Egypt, ſeveral of the Beys receive other dignities from the Porte: Such are the Shech el Bellad or governor of the city; the Defterdar, or accountant-general; the Emir el Hadj, or leader of the ſacred caravan; and the Emir es Said, or governor of the Upper Egypt. Theſe two laſt offices are annual. Theſe officers have alſo revenues allotted them by the Porte, ill defined, and liable to much abuſe.

Of the other Beys, each appoints all officers and governors within his diſtrict, putting into it ſome ſlave of his own, who is compelled to render an account of the receipts, of which a great part paſſes to ſupport the grandeur of his maſter. An opulent Bey may have from 600 to 1000 purſes annually; the revenue of Murad Bey more than doubles that ſum. The inferior Beys may have 300 purſes, or L. 15,000.

Every Bey ſits in judgment on caſes of equity. Theſe perſonages are very obſervant of their reſpective juriſdictions; and no Bey will impriſon a man liberated by another. Though ſometimes too impetuous, they nevertheleſs diſplay great acuteneſs and knowledge of characters. This government, at leaſt, poſſeſſes every advantage of publicity, as every Bey is a magiſtrate.

MAN, has been conſidered in a great number of particulars under the title Man (*Encycl.*); but a reference was made from that article to the article *Varieties of the Human Species*, which was, after all, omitted entirely.

Perhaps enough has been ſaid on the varieties of the human ſpecies in the articles Complexion and Negro (*Encycl.*); but as infidel ignorance is perpetually pretending, that the diminutive Icelander, the ugly Eſquimaux, the woolly-headed Negro, and the copper-coloured American, could not have deſcended from one original pair, either of European complexion or of Hindoo ſymmetry—it may not be improper, in this place, to ſhew the weakneſs of this popular objection to the Moſaic hiſtory of the origin of man. This has been done in ſo ſatisfactory a manner by Profeſſor Blumenbach, that we have nothing to do but lay his obſervations before our readers, convinced, as we are, that they are intelligible to every capacity, and that they will carry conviction to all who are not the ſlaves of prejudice.

Phil. Mag. vol. iii. p. 284. "Some late writers on natural hiſtory (ſays the Profeſſor) ſeem doubtful whether the numerous diſtinct races of men ought to be conſidered as mere varieties, which have ariſen from degeneration, or as ſo many ſpecies altogether different. The cauſe of this ſeems chiefly to be, that they took too narrow a view in their reſearches; ſelected, perhaps, two races the moſt different from each other poſſible, and, overlooking the intermediate races that formed the connecting links between them, compared theſe two together; or, they fixed their attention too much on man, without examining other ſpecies of animals, and comparing their varieties and degeneration with thoſe of the human ſpecies. The firſt fault is, when one, for example, places together a Senegal negro and an European Adonis, and at the ſame time forgets that there is not one of the bodily differences of theſe two beings, whether hair, colour, features, &c. which does not gradually run into the ſame thing of the other, by ſuch a variety of ſhades, that no phyſiologiſt or naturaliſt is able to eſtabliſh a certain boundary between theſe gradations, and conſequently between the extremes themſelves.

"The ſecond fault is, when people reaſon as if man were the only organiſed being in nature, and conſider the varieties in his ſpecies to be ſtrange and problematical, without reflecting that all theſe varieties are not more ſtriking or more uncommon than thoſe with which ſo many thouſands of other ſpecies of organiſed beings degenerate, as it were, before our eyes."

As what we have ſaid under the articles Complexion and Negro may be ſufficient to warn mankind againſt the firſt error, and at the ſame time to refute it, we haſten to refute the ſecond by our author's compariſon between the human race and that of ſwine.

"More reaſons (ſays he) than one have induced me to make choice of ſwine for this compariſon; but, in particular, becauſe they have a great ſimilarity, in many reſpects, to man: not, however, in the form of their entrails, as people formerly believed, and therefore ſtudied the anatomy of the human body purpoſely in ſwine; ſo that, even in the laſt century, a celebrated diſpute, which aroſe between the phyſicians of Heidelberg and thoſe of Durlach, reſpecting the poſition of the heart in man, was determined, in conſequence of orders from government, by inſpecting a ſow, to the great triumph of the party which really was in the wrong. Nor is it becauſe in the time of Galen, according to repeated aſſertions, human fleſh was ſaid to have a taſte perfectly ſimilar to that of ſwine; nor becauſe the fat, and the tanned hides of both, are very like to each other; but becauſe both, in regard to the economy of their bodily ſtructure, taken on the whole, ſhew unexpectedly, on the firſt view, as well as on cloſer examination, a very ſtriking ſimilitude.

"Both, for example, are domeſtic animals; both *omnivora;* both are diſperſed throughout all the four quarters of the world; and both conſequently are expoſed, in numerous ways, to the principal cauſes of degeneration ariſing from climate, mode of life, nouriſhment, &c.; both, for the ſame reaſon, are ſubject to many diſeaſes, and, what is particularly worthy of remark, to diſeaſes rarely found among other animals than men and ſwine, ſuch as the ſtone in the bladder; or to diſeaſes excluſively peculiar to theſe two, ſuch as the worms found in meaſled ſwine.

"Another reaſon (continues he) why I have made choice of ſwine for the preſent compariſon is, becauſe the degeneration and deſcent from the original race are far more certain in theſe animals, and can be better traced, than in the varieties of other domeſtic animals. For no naturaliſt, I believe, has carried his ſcepticiſm ſo far as to doubt the deſcent of the domeſtic ſwine from the wild boar; which is ſo much the more evident, as it is well known that wild pigs, when caught, may be eaſily rendered as tame and familiar as domeſtic ſwine: and the contrary alſo is the caſe; for if the latter by any accident get into the woods, they as readily become wild again; ſo that there are inſtances of ſuch animals being ſhot for wild ſwine; and it has not been till they were opened, and found caſtrated, that people were led to a diſcovery of their origin, and how, and at what time, they ran away. It is well aſcertained, that, before the diſcovery of America by the Spaniards, ſwine were unknown in that quarter of the world, and that they were afterwards carried thither from Europe. All the varieties, therefore, through which this animal has ſince degenerated, belong, with the original European race, to one and the ſame ſpecies; and ſince no bodily difference is found in the human race, as will preſently appear, either in regard to ſtature, colour, the form of the cranium, &c. which is not obſerved in the ſame proportion among the ſwine race, while no one, on that account, ever doubts that all theſe different kinds are merely varieties that have ariſen from degeneration through the influence of climate, &c. this compariſon, it is to be hoped, will ſilence thoſe ſceptics who have thought proper, on account of theſe varieties in the human race, to admit more than one ſpecies.

"With regard to ſtature, the Patagonians, as is well known, have afforded the greateſt employment to anthropologiſts. The romantic tales, however, of the old travellers, who give to theſe inhabitants of the ſouthern extremity of America a ſtature of ten feet and more, are ſcarcely worth notice; and even the more modeſt relations of later Engliſh navigators, who make their height from ſix to ſeven feet, have been doubted by other travellers, who, on the ſame coaſt, ſought for ſuch children of Enoch in vain. But we ſhall admit every thing ſaid of the extraordinary ſize of theſe Patagonians by Byron, Wallis, and Carteret; the firſt of whom aſſigns to their chief, and ſeveral of his attendants, a height of not leſs than ſeven feet, as far as could be determined by the eye; the ſecond, who aſſerts that he actually meaſured them, gives to the greater part of them from 5 feet 10 inches to 6 feet; to ſome 6 feet 5 inches, and 6 feet 6; but to the talleſt, 6 feet 7 inches: and this account is confirmed by the laſt-mentioned of the above circumnavigators. Now, allowing this to be the caſe, it is not near ſuch an exceſs of ſtature as that obſerved in many parts of America among the ſwine, originally carried thither from Europe; and of theſe I ſhall mention in particular thoſe of Cuba, which are more than double the ſize of the original ſtock in Europe.

"The natives of Guinea, Madagaſcar, New Holland, New Guinea, &c. are black; many American tribes are reddiſh brown, and the Europeans are white. An equal difference is obſerved among ſwine in different countries. In Piedmont, for example, they are black. When I paſſed (ſays our author) through that country, during the great fair for ſwine at Salenge, I did not ſee a ſingle one of any other colour. In Bavaria, they are reddiſh brown; in Normandy, they are all white.

"Human hair is, indeed, ſomewhat different from ſwine's briſtles; yet, in the preſent point of view, they may be compared with each other. Fair hair is ſoft, and of a ſilky texture; black hair is coarſer, and among ſeveral tribes, ſuch as the Abyſſinians, Negroes, and the inhabitants of New Holland, it is woolly, and moſt ſo among the Hottentots. In the like manner, among the white ſwine in Normandy, as I was aſſured by an incomparable obſerver, Sulzer of Ronneburg, the hair on the whole body is longer and ſofter than among other ſwine; and even the briſtles on the back are very little different, but lie flat, and are only longer than the hair on the other parts of the body. They cannot, therefore, be employed by the bruſh makers. The difference between the hair of the wild boar and the domeſtic ſwine, particularly in regard to the ſofter part between the ſtrong briſtles, is, as is well known, ſtill greater.

"The whole difference between the cranium of a Negro and that of an European, is not in the leaſt degree greater than that equally ſtriking difference which exiſts between the cranium of the wild boar and that of the domeſtic ſwine. Thoſe who have not obſerved this in the animals themſelves, need only to caſt their eye on the figure which Daubenton has given of both.

"I ſhall paſs over (ſays our author) leſs national varieties which may be found among ſwine as well as among men, and only mention, that I have been aſſured by Mr Sulzer, that the peculiarity of having the bone of the leg remarkably long, as is the caſe among the Hindoos, has been remarked with regard to the ſwine in Normandy. 'They ſtand very long on their hind legs (ſays he, in one of his letters); their back, therefore, is higheſt at the rump, forming a kind of inclined plane; and the head proceeds in the ſame direction, ſo that the ſnout is not far from the ground.' I ſhall here add, that the ſwine, in ſome countries, have degenerated into races which in ſingularity far exceed every thing that has been found ſtrange in bodily variety among the human race. Swine with ſolid hoofs were known to the ancients, and large herds of them are found in Hungary, Sweden, &c. In the like manner, the European Swine, firſt carried by the Spaniards, in 1509, to the iſland of Cuba, at that time celebrated for its pearl fiſhery, degenerated into a monſtrous race, with hoofs which were half a ſpan in length."

From theſe facts, our author concludes, that it is abſurd to allow the vaſt variety of ſwine to have deſcended from one original pair, and to contend that the varieties of men are ſo many diſtinct ſpecies.

MANDING, a large ſtate in the interior of Africa, of which the only ſatisfactory account that we have is by Mr Park, who, for ſeveral months, was hoſpitably entertained in Kamalia, one of its towns, ſituated in 12° 40′ N. Lat. and 6° 40′ W. Long. The government of Manding appeared to our author to be a ſort of republic, or rather an oligarchy. Every town is indeed governed by a chief magiſtrate called Manſa, which uſually ſignifies king; but the chief power of the ſtate, in the laſt reſort, is lodged in the aſſembly of theſe manſas (A). The caſe, however, is different in other countries, which are occupied by people who have emigrated from Manding; for in all the Mandingo ſtates

---

(A) Mr Park, for the moſt part, writes with remarkable perſpicuity; but we are not ſure that here we have not miſtaken his meaning. He ſays, that the chief power of the ſtate is lodged in the aſſembly of that *whole body*; but we think, that by the whole body muſt be meant the body of *Manſas*, otherwiſe the government could not be called an oligarchy.

near the Gambia, the government is monarchical, tho' the power of the ſovereign is by no means unlimited.

As Mr Park's route was confined to a tract of country, bounded nearly by the 12th and 15th parallels of latitude, the climate throughout the whole was nearly the ſame as that of Manding, and extremely hot: Yet, where the country aſcended into hills, he found it comparatively cool and pleaſant; though none of the diſtricts which he traverſed could be called mountainous. About the middle of June, the hot and ſultry atmoſphere is agitated by violent guſts of wind (called *tornadoes*), accompanied with thunder and rain. Theſe uſher in what is denominated *the rainy ſeaſon;* which continues until the month of November. During this time, the diurnal rains are very heavy; and the prevailing winds are from the ſouth-weſt. The termination of the rainy ſeaſon is likewiſe attended with violent tornadoes; after which the wind ſhifts to the north-eaſt, and continues to blow from that quarter during the reſt of the year.

When the wind ſets in from the north-eaſt, it produces a wonderful change in the face of the country. The graſs ſoon becomes dry and withered; the rivers ſubſide very rapidly, and many of the trees ſhed their leaves. About this period is commonly felt the *harmattan*, a dry and parching wind, blowing from the north eaſt, and accompanied by a thick ſmoky haze; through which the ſun appears of a dull red colour. This wind, in paſſing over the great deſert of Sahara, acquires a very ſtrong attraction for humidity, and parches up every thing expoſed to its current. It is, however, reckoned very ſalutary, particularly to Europeans, who generally recover their health during its continuance. The truth of this our author experienced both at Kamalia and Piſania, when he had been brought to the very brink of the grave by ſickneſs.

Whenever the graſs is ſufficiently dry, the negroes ſet it on fire; but in Ludamar, and other Mooriſh countries, this practice is not allowed; for it is upon the withered ſtubble that the Moors feed their cattle until the return of the rains. The burning of the graſs in Manding exhibits a ſcene of terrific grandeur. "In the middle of the night (ſays Mr Park), I could ſee the plains and mountains, as far as my eye could reach, variegated with lines of fire; and the light reflected on the ſky, made the heavens appear in a blaze. In the day time, pillars of ſmoke were ſeen in every direction; while the birds of prey were obſerved hovering round the conflagration, and pouncing down upon the ſnakes, lizards, and other reptiles, which attempted to eſcape from the flames." This annual burning is ſoon followed by a freſh and ſweet verdure, and the country is thereby rendered more healthful and pleaſant.

Though many ſpecies of the edible roots, which grow in the Weſt India iſlands, are found in Africa, yet our traveller never ſaw, in any part of his journey, either the ſugar cane, the coffee, or the cocoa tree; nor could he learn, on inquiry, that they were known to the natives. The pine-apple, and the thouſand other delicious fruits which the induſtry of civilized man (improving the bounties of nature), has brought to ſo great perfection in the tropical climates of America, are here equally unknown. He obſerved, indeed, a few orange and banana trees, near the mouth of the Gambia; but whether they were indigenous, or were formerly planted there by ſome of the white traders, he could not poſitively learn.

Concerning property in the ſoil, it appeared to Mr Park, that the lands in native woods were conſidered as belonging to the king, or (where the government was not monarchical) to the ſtate. When any individual of free condition had the means of cultivating more land than he actually poſſeſſed, he applied to the chief man of the diſtrict, who allowed him an extenſion of territory, on condition of forfeiture if the lands were not brought into cultivation by a given period. The condition being fulfilled, the ſoil became veſted in the poſſeſſor; and, for aught that appeared, deſcended to his heirs.

The Mandingoes are a very gentle race of people; cheerful in their diſpoſitions, inquiſitive, credulous, ſimple, and fond of flattery. The men are commonly above the middle ſize, well ſhaped, ſtrong, and capable of enduring great labour; the women are good natured, ſprightly, and agreeable. The dreſs of both ſexes is compoſed of cotton cloth of their own manufacture; that of the men is a looſe frock, not unlike a ſurplice, with drawers which reach half way down the leg; and they wear ſandals on their feet, and white cotton caps on their heads. The womens dreſs conſiſts of two pieces of cloth, each of which is about ſix feet long and three broad; one of theſe they wrap round the waiſt, which, hanging down to the ancles, anſwers the purpoſe of a petticoat; the other is thrown negligently over the boſom and ſhoulders. Both men and women among the Mandingoes ſeem to have an invincible propenſity to commit depredations on the property of unprotected ſtrangers; whilſt ſuch is the good nature of thoſe poor heathens, that they will readily ſympathiſe in the ſufferings, relieve the diſtreſſes, and contribute to the perſonal ſafety, of the very ſtrangers whom they are bent upon plundering.

Among the Mandingoes, the parental and filial affection is remarkably ſtrong between the mother and her child; but not ſo between the father and his children. This, as Mr Park obſerves, is eaſily accounted for. The ſyſtem of polygamy, while it weakens the father's attachment, by dividing it among the children of different wives, concentrates all the mother's jealous tenderneſs to one point, the protection of her own offſpring. He perceived, with great ſatisfaction too, that the maternal ſolicitude extended, not only to the growth and ſecurity of the perſon, but alſo, in a certain degree, to the improvement of the mind of the infant; for one of the firſt leſſons, in which the Mandingo women inſtruct their children, is *the practice of truth.*

The Mandingo women ſuckle their children until they are able to walk of themſelves. Three years nurſing is not uncommon; and during this period, the huſband devotes his whole attention to his other wives. To this practice it is owing, that the family of each wife is ſeldom very numerous. Few women have more than five or ſix children. As ſoon as an infant is able to walk, it is permitted to run about with great freedom. The mother is not over ſolicitous to preſerve it from ſlight falls, and other trifling accidents. A little practice ſoon enables a child to take care of itſelf, and experience acts the part of a nurſe. As they advance in life, the girls are taught to ſpin cotton, and to beat corn, and are inſtructed in other domeſtic duties; and the

the boys are employed in the labours of the field. Both ſexes, whether Buſhreens or Kafirs, on attaining the age of puberty, are circumciſed. This painful operation is not conſidered by the Kafirs ſo much in the light of a religious ceremony, as a matter of convenience and utility. They have, indeed, a ſuperſtitious notion, that it contributes to render the marriage ſtate prolific.

When a young man takes a fancy to a young girl, and wiſhes to marry her, it is by no means conſidered as neceſſary that he ſhould make an overture to the girl herſelf. The firſt object is to agree with the parents, concerning the recompence to be given them for the loſs of the company and ſervices of their daughter. The value of two ſlaves is a common price, unleſs the girl is thought very handſome; in which caſe, the parents will raiſe their demand very conſiderably. If the lover is rich enough, and willing to give the ſum demanded, he then communicates his wiſhes to the damſel: but her conſent is by no means neceſſary to the match; for if the parents agree to it, and eat a few *kolla nuts*, which are preſented by the ſuitor as an earneſt of the bargain, the young lady muſt either have the man of their choice, or continue unmarried, for ſhe cannot afterwards be given to another. If the parents ſhould attempt it, the lover is then authoriſed, by the laws of the country, to ſeize upon the girl as his ſlave. At the celebration of a marriage, no religious ceremony ſeems to be practiſed. A ſelect number of people are indeed invited to the wedding, and feaſted; but conſummation conſtitutes the marriage; for towards the morning, the new married couple are always diſturbed by the women, who aſſemble to inſpect the nuptial ſheet (according to the manners of the ancient Hebrews, as recorded in Scripture), and dance round it. This ceremony is thought indiſpenſably neceſſary; nor is the marriage conſidered as valid without it.

The Mandingoes, and indeed all the negro ſtates, whether Mahomedan or Pagan, allow a plurality of wives. The conſequence is, that the wives frequently quarrel among themſelves. When this happens, the huſband decides between them; and ſometimes finds it neceſſary to adminiſter a little corporal chaſtiſement before tranquillity can be reſtored. But if any one of the ladies complains to the chief of the town, that her huſband has unjuſtly puniſhed her, and ſhewn an undue partiality to ſome other of his wives, the affair is brought to a public trial. In theſe *palavers*, however, which are conducted chiefly by married men, our author was informed, that the complaint of the wife is not always conſidered in a very ſerious light; and the complainant herſelf is ſometimes convicted of ſtrife and contention, and left without remedy. If ſhe murmurs at the deciſion of the court, the magic rod of *Mumbo Jumbo* ſoon puts an end to the buſineſs. See MUMBO JUMBO in this *Suppl.*

A child, among them, is named when it is ſeven or eight days old. The ceremony commences by ſhaving the infant's head; and a diſh called *dega*, made of pounded corn and ſour milk, is prepared for the gueſts. If the parents are rich, a ſheep or a goat is commonly added. This feaſt is called *ding koon lee*, "the child's head ſhaving." During Mr Park's ſtay at Kamalia, he was preſent at four different feaſts of this kind, and the ceremony was the ſame in each, whether the child belonged to a Buſhreen or a Kafir. The ſchoolmaſter, who officiated as prieſt on thoſe occaſions, and who is neceſſarily a Buſhreen, firſt ſaid a long prayer over the *dega*; during which, every perſon preſent took hold of the brim of the calabaſh with his right hand. After this, the ſchoolmaſter took the child in his arms, and ſaid a ſecond prayer; in which he repeatedly ſolicited the bleſſing of God upon the child, and upon all the company. When this prayer was ended, he whiſpered a few ſentences in the child's ear, and ſpit three times in its face; after which he pronounced its name aloud, and returned the infant to the mother. This part of the ceremony being ended, the father of the child divided the *dega* into a number of balls, one of which he diſtributed to every perſon preſent. And inquiry was then made, if any perſon in the town was dangerouſly ſick; it being uſual, in ſuch caſes, to ſend the party a large portion of the *dega*, which is thought to poſſeſs great medical virtues.

The Mandingoes have no artificial method of dividing time. They calculate the years by the number of *rainy ſeaſons*. They portion the year into *moons*, and reckon the days by ſo many *ſuns*. The day they divide into morning, mid-day, and evening; and further ſubdivide it, when neceſſary, by pointing to the ſun's place in the heavens. Our author frequently inquired of ſome of them, what became of the ſun during the night, and whether we ſhould ſee the ſame ſun, or a different one, in the morning? But that ſubject appeared to them as placed beyond the reach of human inveſtigation; they had never indulged a conjecture, nor formed any hypotheſis, about the matter. The moon, by varying her form, has more attracted their attention. On the firſt appearance of the new moon, which they look upon to be newly created, the Pagan natives, as well as Mahomedans, ſay a ſhort prayer; and this ſeems to be the only viſible adoration which the Kafirs offer up to the Supreme Being. This prayer is pronounced in a whiſper; the party holding up his hands before his face: its purport is to return thanks to God for his kindneſs through the exiſtence of the paſt moon, and to ſolicit a continuation of his favour during that of the new one. At the concluſion, they ſpit upon their hands, and rub them over their faces. Great attention is paid to the changes of this luminary in its monthly courſe; and it is thought very unlucky to begin a journey, or any other work of conſequence, in the laſt quarter. An eclipſe, whether of the ſun or moon, is ſuppoſed to be effected by witchcraft. The ſtars are very little regarded; and the whole ſtudy of aſtronomy appears to them as a uſeleſs purſuit, and attended to by ſuch perſons only as deal in magic.

Their notions of geography are equally puerile. They imagine that the world is an extended plain, the termination of which no eye has diſcovered; it being, they ſay, overhung with clouds and darkneſs. They deſcribe the ſea as a large river of ſalt water, on the farther ſhore of which is ſituated a country called *Tobaubo doo*; "the land of the white people." At a diſtance from Tobaubo doo, they deſcribe another country, which they allege is inhabited by cannibals of gigantic ſize, called *Koomi*.

Mr Park ſays he has converſed with all ranks and conditions of negroes on the ſubject of their faith, and that he can pronounce, without the ſmalleſt ſhadow of doubt, that the belief of one God, and of a future ſtate of reward and puniſhment, is entire and univerſal among them.

them. It is remarkable, however, that, except on the appearance of a new moon, as before related, the Pagan natives do not think it neceſſary to offer up prayers and ſupplications to the Almighty. They repreſent the Deity, indeed, as the creator and preſerver of all things; but in general they conſider him as a Being ſo remote, and of ſo exalted a nature, that it is idle to imagine the feeble ſupplications of wretched mortals can reverſe the decrees, and change the purpoſes, of unerring wiſdom. The concerns of this world, they believe, are committed by the Almighty to the ſuperintendance and direction of ſubordinate ſpirits, over whom they ſuppoſe that certain magical ceremonies have great influence. A white fowl, ſuſpended to the branch of a particular tree, a ſnake's head, or a few handfuls of fruit, are offerings which ignorance and ſuperſtition frequently preſent, to deprecate the wrath, or to conciliate the favour, of theſe tutelary agents.

The Mandingoes ſeldom attain extreme old age. At forty, moſt of them become grey haired, and covered with wrinkles; and but few of them ſurvive the age of fifty-five, or ſixty. Yet their diſeaſes appeared but few; fevers and fluxes being the moſt common, and the moſt fatal. For theſe they generally apply *ſaphies*, i. e. charms, to different parts of the body; though ſometimes, on the firſt attack of a fever, the patient is, with great ſucceſs, placed in a ſort of vapour bath. The other diſeaſes which prevail among the negroes, are the *yaws*, the *elephantiaſis*, and a *leproſy* of the very worſt kind, together with the *Guinea worm*, which they attribute to bad water.

When a perſon of conſequence dies, the relations and neighbours meet together, and manifeſt their ſorrow by loud and diſmal howlings. A bullock or goat is killed for ſuch perſons as come to aſſiſt at the funeral; which generally takes place in the evening of the ſame day on which the party died. The negroes have no appropriate burial places, and frequently dig the grave in the floor of the deceaſed's hut, or in the ſhade of a favourite tree. The body is dreſſed in white cotton, and wrapped up in a mat. It is carried to the grave, in the duſk of the evening, by the relations. If the grave is without the walls of the town, a number of prickly buſhes are laid upon it, to prevent the wolves from digging up the body; but our author never obſerved that any ſtone was placed over the grave as a monument or memorial.

With reſpect to employment, the men cultivate the ground, or catch fiſh in large rivers; while the women manufacture cotton cloth. It is only the ſpinning and the dyeing, however, that are performed by the women; for the web, which is ſeldom more than four inches broad, is wove by the men in a loom made exactly upon the ſame principle as that of Europe. As the arts of weaving, dyeing, ſewing, &c. may eaſily be acquired, thoſe who exerciſe them are not conſidered in Africa as following any particular profeſſion; for almoſt every ſlave can weave, and every boy can ſew. The only artiſts which are diſtinctly acknowledged as ſuch by the negroes, and who value themſelves on exerciſing appropriate and peculiar trades, are the manufacturers of leather and of iron. The firſt of theſe are called *Karrankea* (or as the word is ſometimes pronounced *Gaungay*). They are to be found in almoſt every town, and they frequently travel through the country in the exerciſe of their calling. They tan and dreſs leather with very great expedition, by ſteeping the hide firſt in a mixture of wood aſhes and water, until it parts with the hair; and afterwards by uſing the pounded leaves of a tree, called *goo*, as an aſtringent.

The manufacturers in iron are not ſo numerous as the *Karrankeas*; but they appear to have ſtudied their buſineſs with equal diligence. The negroes on the coaſt being cheaply ſupplied with iron from the European traders, never attempt the manufacturing of this article themſelves; but in the inland parts, the natives ſmelt this uſeful metal in ſuch quantities, as not only to ſupply themſelves from it with all neceſſary weapons and inſtruments, but even to make it an article of commerce with ſome of the neighbouring ſtates. During our author's ſtay at Kamalia, there was a ſmelting furnace at a ſhort diſtance from the hut where he lodged, and the owner and his workmen made no ſecret about the manner of conducting the operation; and readily allowed him to examine the furnace, and aſſiſt them in breaking the iron-ſtone. The proceſs it is needleſs to deſcribe; though it be proper to obſerve, that the maſs of metal obtained by it was rather ſteel than iron. Moſt of the African blackſmiths are acquainted alſo with the method of ſmelting gold, in which proceſs they uſe an alkaline ſalt, obtained from a ley of burnt corn-ſtalks evaporated to dryneſs. They likewiſe draw the gold into wire, and form it into a variety of ornaments, ſome of which are executed with a great deal of taſte and ingenuity.

The reader will obſerve, that in the extracts which we have made from Mr Park's intereſting travels, the terms African and Negro are frequently uſed as if all Africans and Negroes were Mandingoes. The reaſon is, that the Mandingoes were not only the moſt numerous tribe which he viſited, but were alſo ſpread over all that tract of country which he traverſed.

MANIANA, a ſmall negro kingdom lying between 12° and 14° North Lat. and between the meridian of Greenwich and 1° and 30′ Weſt Long. Its inhabitants, as Mr Park was informed by a variety of people in many different kingdoms, are remarkable for cruelty and ferocity; carrying their reſentment to their enemies ſo far as never to give quarter, and even indulging themſelves with banquets of human fleſh. Hence the inhabitants of Bambarra, who carried on with them a long and bloody war, and muſt of courſe be well aſcertained of the fact, call them *Ma dummulo*, which ſignifies meneaters.

MANURE is ſo eſſential to agriculture, that the want of it, or an improper manner of uſing it, is the principal cauſe of the ſterility of a country. We have therefore treated of manures and their action at ſome length in the article AGRICULTURE in the *Encyclopædia*; but as the theoretical part of that diſquiſition reſts in a great meaſure on the doctrine of phlogiſton, which is now exploded, it may not be improper to reſume the ſubject here. Experience however being, after all, the only guide which the farmer can ſafely and confidently follow, inſtead of amuſing our readers with theories of our own, we ſhall lay before them the obſervations of a man who ſeems to have united theory with practice.

"The uſe of manures (ſays M. Parmentier*) has been known in all ages, but we are yet far from having any clear and preciſe ideas of the nature of the juices which

---

* *Memoi of the R Society of griculture Paris.*

which are deſtined for the nouriſhment of vegetables, and of the manner in which they are tranſmitted to their organs. The writers on agriculture, who have endeavoured to explain theſe matters, perceiving ſalts in moſt plants, were perſuaded that theſe ſalts, by the help of water and heat, paſſed, in a ſaline form, through the vegetable filter. Theſe firſt philoſophers did not heſitate to conſider every thing that has been done by the induſtry of man, to improve the nature of land, and its productions, as merely forming reſervoirs of theſe ſalts, which they conſidered as the principle of fertility. This opinion was ſo well eſtabliſhed among the improvers of land, that, to this day, many of them have no object in view, in their operations, but to diſengage ſalts; and, when they attempt to explain certain phenomena which take place in their fields or orchards, they talk confidently about the *nitre of the air*, *of rain*, *of ſnow*, *of dew*, *and fogs*; of the *ſalts of the earth*, *of dung*, *of marle*, *of lime*, *of chalk*, &c. and make uſe of thoſe vague terms, *oil*, *ſulphur*, *ſpirit*, &c. which ought henceforward to be baniſhed from our elementary books on agriculture.

" Among the authors who have attacked, and combated with moſt ſucceſs, the opinion that the fruitfulneſs of ſoils, and the aliment of vegetables, reſide in ſaline ſubſtances, muſt be reckoned Eller and Wallerius. Theſe philoſophers examined, by every means which chymiſtry at that time could furniſh, the various kinds of earth proper for cultivation, and alſo thoſe ſubſtances which have always been conſidered as the moſt powerful manures, without being able to obtain, from any of them, any thing more than mere atoms of ſalt.

" Animated with the ſame zeal, and taking advantage of the inſtructions found in their writings, I thought it neceſſary to determine, by experience, whether, as has been aſſerted, there really exiſt neutral ſalts in earths; and alſo, whether thoſe earths are more fertile in proportion to the quantity of ſuch ſalts they contain. With this view, I lixiviated, by means of diſtilled water, many ſpecies of cultivated earths, taken in various ſtates, from freſh earth to that which had been impoveriſhed by the growth of ſeveral crops; I alſo tried dung, reduced more or leſs into the ſtate of mould; and likewiſe the moſt active manures, ſuch as the offal of animal ſubſtances rotted by putrefaction; but in none of theſe, however carefully analyzed, were found any ſalts in a free ſtate. They contain indeed the materials proper for forming ſalts, but if they contain any ready formed, it is merely by accident.

" The reſearches of Kraft, and thoſe of Alſton, were not attended with different reſults. Having ſown ſome oats in aſhes, not lixiviated, and in ſand ſtrongly impregnated with potaſh and with ſaltpetre, and having found that the oats did not grow, they concluded that neutral ſalts, and alkalies, not only retarded the growth of vegetables, but that they abſolutely prevented it. It is well known that in Egypt there are diſtricts where the earth is entirely covered with ſea-ſalt, and theſe diſtricts are quite barren. It is probably owing to this property of ſea-ſalt, that the Romans were accuſtomed to ſcatter large quantities of it over fields where any great crime had been committed, and of which they wiſhed to perpetuate the remembrance, by rendering the part barren for a certain time.

" The idea that ſalts had great influence in vegetation, ought to have been greatly weakened by the following ſimple reflection. Suppoſing that ſalts exiſted in garden mould, they would be very ſoon diſſolved by the rain, and carried away, towards the lower ſtrata of the earth, to a depth to which the longeſt roots would not reach. Indeed the famous experiment of Vanhelmont would have been ſufficient to have deſtroyed the above opinion, if it did not generally happen that we are no ſooner ſet free from one error than we fall into another not leſs extraordinary. The ſurpriſing effects of vegetation brought about by the overflowing of water, and in the neighbourhood of ſalt marſhes, and the infinite number of inhaling capillary tubes obſerved upon the ſurface of vegetables, led to an opinion that the air and water, abſorbed by the roots and leaves of plants, were only vehicles loaded with ſaline matter, analogous to the vegetables nouriſhed by them.

" To the experiment of Vanhelmont, which was repeated by many accurate obſervers, ſucceeded thoſe of modern philoſophers; from which it clearly appeared, that plants could grow, and produce fruit, in the air of the atmoſphere, and in diſtilled water, alſo in pure ſand, in powdered glaſs, in wet moſs or ſponge, in the cavity of fleſhy roots, &c. and that plants which had nothing but the above-mentioned fluids for their nouriſhment, gave, when ſubmitted to chymical analyſis, the ſame products as thoſe which had undergone their proceſs of vegetation in a ſoil perfectly well manured. It was alſo obſerved, that the moſt barren ſoils were rendered fertile when they were properly ſupplied with water by canals; and the efficacy of irrigation was repeatedly evinced in different ways: from theſe obſervations was formed the following ſyſtem, that water riſes in plants in the form of vapour, as in diſtillation; that air introduces itſelf into their pores; and that, if ſalts contribute to the fruitfulneſs of ſoils, it is only in conſequence of their containing the two fluids above mentioned in great abundance."

Our author, after making many experiments upon various ſoils and ſalts, and after attending minutely to the proceſs of vegetation, thinks himſelf warranted to maintain, " that ſaline ſubſtances have no ſenſible effects in promoting vegetation, except inaſmuch as they are of a deliqueſcent nature, have an earthy baſis eaſily decompoſed, and are uſed only in ſmall quantity. In thoſe circumſtances they have the power of attracting, from the immenſe reſervoir of the atmoſphere, the vapours which circulate in it; theſe vapours they retain, along with the moiſture that is produced from rain, ſnow, dew, fog, &c. which moiſture they prevent from running together in a maſs, or from being loſt, either by exhaling into the air of the atmoſphere, or by filtering itſelf through the inferior ſtrata of the earth, and thereby leaving the roots of vegetables dry; they diſtribute that moiſture uniformly, and tranſmit it, in a ſtate of great diviſion, to the orifices of the tubes deſtined to carry it into the texture of the plant, where it is afterwards to undergo the laws of aſſimilation. As every kind of vegetable manure poſſeſſes a viſcous kind of moiſture, it thereby partakes of the property of deliqueſcent ſalts. In ſhort, the preparation of land for vegetation has no other object in view but to divide the earthy particles, to ſoften them, and to give them a form capable of producing the above mentioned effects. It is ſufficient, therefore, that water, by its mixture

Manure.

with the earth and the manure, be divided, and ſpread out ſo as to be applied only by its ſurface, and that it keep the root of the plant always wet, without drowning it, in order to become the eſſential principle of vegetation. But as plants which grow in the ſhade, even in the beſt ſoil, are weakly, and as the greater part of thoſe which are made to grow in a place that is perfectly dark neither give fruit nor flowers, it cannot be denied that the influence of the ſun is of great importance in vegetable economy."

Such was the opinion which our author gave of the manner in which ſalts act in vegetation, at a time when it was not known that air and water (which had been ſo long conſidered as elements), far from being ſimple ſubſtances, are capable of being decompoſed by a great variety of operations both of nature and art; and nothing was wanting to complete his theory, but to know that air and water act their part in vegetation only in a ſtate of decompoſition; and that if earth well manured is a better matrix than water itſelf, it is becauſe ſuch earth has the power of converting the water into gaſes which are eaſily abſorbed, and which, while their abſorption takes place, communicate to the plants a motion and heat which they received when taking the form of gas, and which they loſe when they enter again into combination; whence it is natural to conclude, that this motion and this heat muſt neceſſarily develope themſelves in ſeeds, and maintain the vital action in plants.

What is a vegetable, conſidered chemically, according to the preſent ſtate of our knowledge? It is, ſay the chemiſts, a compound of hydrogen, oxygen, and carbon, the proportions of which vary according to the agents which have concurred to its developement, and according to the matrix which received and aſſimilated them, in order to create thoſe combinations which are varied to infinity, by their forms and properties, and known by the generic terms of ſalt, oil, and mucilage. It appears, therefore, needleſs to ſeek theſe combinations in the different ſubſtances which are uſed for manure, when we wiſh to determine the nature of them, and explain their manner of acting in vegetation; becauſe, ſuppoſing it true that theſe ſalts, theſe oils, or theſe mucilages, exiſt in their combined ſtate, nothing but their conſtituent elements, namely, hydrogen, oxygen, and carbon, can poſſibly have any action.

The ſuperiority of animal ſubſtances, as manures, and the remarkable luxuriance of thoſe plants which are watered with putrid water, prove inconteſtibly, that the putrid ſtate is favourable to vegetation, and that every ſubſtance which is liable to enter, to a certain degree, into that ſtate, contributes very powerfully thereto. The moſt aerated waters are, in this caſe, the moſt beneficial. It is obſerved that rain, particularly in ſtormy weather, quickens vegetation ſo much, that the gardeners in the neighbourhood of Paris are often obiged to drench their plants with water taken from their wells, which, in conſequence of its rawneſs, or its want of air, retards the vegetation of the plants; either becauſe it precipitates the meteoriſed or electrified water, or becauſe, by being mixed with the other water, it diminiſhes its fertilizing quality; whereas, in ſummer, this ſame well-water, by being expoſed to the ſun for ſome days, acquires a ſmell like that of ſtale eggs, loſes its rawneſs, and becomes very fit for accelerating vegetation. An atom of vegetable or animal matter is, at that time, ſufficient to bring about more quickly this ſtate of putrefaction; while theſe ſame ſubſtances, by being employed in certain proportions, far from acting as a leaven on the liquids which hold them in ſolution, preſerve thoſe liquids, or at leaſt make them more ſlow to change.

Salts and dung, therefore, are not merely decompoſed by the power of vegetation; by furniſhing the reſults of their decompoſition, they alſo act in the manner of leavens, the action of which is ſcarcely perceptible in cold or dry weather; but when they are heated by the ſun, and ſufficiently penetrated with moiſture, they very ſoon enter into a ſort of fermentation, ſuffering the various gaſes with which they are provided to eſcape. Thus manures may be conſidered as decompoſing inſtruments, provided by nature, and prepared by art, to act upon water ſo as to bring it to a proper ſtate of attenuation. The ſubſtances which enter into the compoſition of plants are, therefore, nothing but products of the decompoſition of air and water, and combinations of the conſtituent principles of theſe two fluids, determined by the power which preſides in the ſeed, and which thence has paſſed into the plant.

It is now eaſy to account for the effects of charcoal-powder, ſtraw, &c which are made uſe of to cover ground during long droughts with undoubted benefit: they are mechanical means of preventing the diſſipation of moiſture, and of determining it to take the form of thoſe gaſeous fluids which have ſuch powerful effect in vegetation. As water is compoſed of hydrogen and oxygen, it is not ſurpriſing that, when aſſiſted by the influence of the ſun, and that of electricity, it is capable of forming, almoſt by itſelf, the ſolids and fluids of vegetables; taking from the atmoſphere the carbon it ſtands in need of, to give them their moſt eſſential characters. We ſay their moſt eſſential characters; for thoſe terreſtrial plants which have grown in air and water do not abound in principles, and their offſpring, when they have any, is by no means vigorous. We ſee alſo, that plants which are naturally of an aquatic nature, have in general but little ſmell, becauſe the medium in which they live and grow furniſhes only a ſmall quantity of carbon, in proportion to the hydrogen and oxygen, which are the conſtituent principles of water. This is the reaſon why, in cold and wet years, flowers are leſs odoriferous, fruit leſs full of flavour, and more difficult to be preſerved. The germ of their reproduction is weak; and they are, if the expreſſion may be uſed, in a ſort of dropſy; that is to ſay, they are loaded with the principles which conſtitute water, and even with water itſelf.

Theſe obſervations, to which more might be added, may ſerve to explain why vegetation is ſlow and weak in a ſoil which is too much charged with ſaline matter, while it is rendered quick and vigorous by a ſmall quantity of this ſame matter; and why earth, which is perfectly lixiviated, and watered, from time to time, with diſtilled water only, is capable of giving to bitter plants their bitterneſs, to ſweet ones their ſweetneſs, to acid ones their acidity, to aromatic ones their ſpicineſs, and to poiſonous ones their deleterious qualities; in ſhort, why the inherent characters of plants are more ſtrongly marked, in proportion as the ſoil in which they grow is furniſhed with natural or mechanical means to produce a quantity of gas neceſſary to the formation of the ſubſtances on which thoſe characters depend.

If a nitrous or marine plant can, even when growing in a ſoil deſtitute of nitre or ſea-ſalt, occaſion the production of theſe ſalts, it muſt be allowed that ſuch plants would vegetate more ſtrongly, and contain more of ſuch ſalts, if they grew in ſoils more abounding in materials proper to form them. Thus, the different ſpecies of ſamphire, glaſſwort, ſea wrack, &c. flouriſh on the borders of the ſea, ſuch ſoils being ſtrongly impregnated with the fluids neceſſary to form the muriatic gas and ſea ſalt which enter into the compoſition of thoſe plants; while the ſun flower, pellitory, &c. ſucceed beſt in earth which is mixed with the ruins of old buildings, in which the materials for the production of nitrous gas, and even of nitre itſelf, are very abundant. In ſhort, the organization of theſe plants is a real elaboratory for forming the forementioned ſalts.

Thoſe plants which, for their vegetation, require the moſt aſſiſtance from the ſoil and manure, are very apt to contract a diſagreeable taſte, if either the ſoil or manure are capable of ſupplying the principles from which it is acquired. The claſs *tetradynamia*, particularly all ſorts of cabbages (which contain ſulphur ready formed), contract a bad taſte in a ſoil compoſed of mud and dung, becauſe theſe ſubſtances, as they are decompoſed, furniſh a great quantity of hepatic gas, or of ſulphuriſed hydrogen gas; yet plants of another claſs may grow in the ſame ſoil, cloſe by the cabbages, without partaking even in the ſmalleſt degree of the bad taſte of the latter. The plants laſt mentioned, when growing in hepatic gas, retain only ſo much of it as is ſufficient for the production of the ſubſtances of which they are formed; the overplus, which could not be aſſimilated, is thrown out by the excretory veſſels, after undergoing thoſe modifications which the digeſtive juices and organization of the plant, and the ſtate of the atmoſphere, have produced.

Thus we ſee that thoſe plants which abound moſt in oily, ſaline, and mucilaginous principles, are generally ſuch as require a ſoil well manured. Tobacco, for inſtance, gives forty pounds of alkaline ſalt or potaſh from every hundred weight of aſhes: this plant may, by being buried in the ground, be converted into a very powerful manure; while other plants, which thrive in a middling ſoil, and appear as vigorous, are, in general, ſuch as have not ſo great a quantity of principles in their compoſition, and when thrown on the dunghill, and left to rot, furniſh very little manure. From ſuch obſervations, it may perhaps not be impoſſible hereafter to judge, by the analyſis of a plant, not only whether it requires a large or a ſmall quantity of manure, but likewiſe what kinds of ſoil and manure are moſt fit to promote its vegetation: wild plants alſo may ſerve to ſhew the nature of the ſoil which they ſeem moſt to flouriſh in.

Beſides the phyſical action of manures, they have a very evident mechanical action. When mixed with earth, in a certain proportion, they not only render it more permeable to water, but the roots of plants can, with greater eaſe, acquire their proper ſize and form in it: in other caſes, manures tend to unite that earth which is too looſe, and, by rendering it more tenacious, they prevent the water from being loſt, and the roots from becoming dry. Thoſe manures which are called *warm* are ſuited to cold lands, not only becauſe they render them leſs compact, but alſo becauſe they take off a part of that moiſture which ſuch lands always have in too great quantity. Cold manures, on the other hand, by their viſcid quality, give tenacity to dry and hot ſoils, attracting and retaining, for a longer time, the moiſture which comes in their way. The nature of the ſoil muſt therefore determine what kind of manure it ſtands in need of, and alſo whether cultivating it by means of oxen or by horſes is preferable; for the manures produced from theſe two animals have thoſe oppoſite qualities which we have above deſcribed. By ſuch obſervations, we ſhall perhaps be able to reſolve a queſtion, reſpecting which the ſentiments of cultivators in many parts of the kingdom are much divided.

It cannot, however, be denied, that the earth is able of itſelf to ſerve as a baſis and ſupport to plants, and that it has an action more or leſs evident upon air, upon water, and upon dung. There is a well-known method of diſtinguiſhing clay from other earths; by merely breathing upon it, a ſmell is immediately perceived, ſufficiently ſtrong to ſhew that a decompoſition and freſh combination have taken place. In ſummer, after a drought of ſome days continuance, there always ariſes in the fields a particular ſmell during a ſhower of rain; and there is no kind of vegetable manure which, when mixed with earth, does not ſend forth a ſmell. This proves, that the nature of the ſoil muſt have an influence, not only upon air and upon water, but alſo upon the effect of manures; and that before we ſpeak of their power, we ſhould always ſpecify what kind of earth they were applied to; becauſe when manures and earth are mixed together, there enſues an action and reaction more or leſs favourable to vegetation.

Having examined to what degree air and water enter, in ſubſtance, into the veſſels of plants, and having ſhewn that the principal action of earth, of ſalts, and of manures, conſiſts in preparing, elaborating, and decompoſing theſe two fluids, and in giving to the products of their decompoſition the forms they require, to accompliſh the purpoſe of nature in vegetation, our author makes ſome obſervations upon the particular effects of certain ſubſtances uſed for improving land, ſuch as marl, lime, chalk, and wood aſhes; which are uſually applied either to an exhauſted ſoil, in order to reſtore it, or to a drooping plant, with a view to give it ſtrength. Of the efficacy of theſe ſubſtances no one doubts, but it does not appear that we are equally agreed reſpecting their manner of acting.

Marl (a manure whoſe effects are well known, and which is found to be of the greateſt benefit in thoſe diſtricts where it can be procured in ſufficient quantity) is capable of acting in the ſame manner as the moſt fertile ſoil, when the principles of which it is compoſed, namely, clay, ſand, calcareous earth, and magneſian earth, are juſtly proportioned to each other. But it is ſometimes compact and tenacious, becauſe it contains a ſuperabundant portion of clay, and at other times porous and friable, becauſe it contains too much ſand, and therefore is not in general fit for vegetation by itſelf. Theſe conſiderations ought always to be our guide when we mean to employ marl as a manure.

It has been ſuppoſed that *to marl* was a ſort of technical expreſſion, intended to denote the bringing together or dividing the earthy particles by means of clay or ſand. It appears to our author, that neither of the above operations can properly be called *marling;* becauſe, in either caſe, all we do is, to put the ſoil into a ſituation to receive and to profit by the influence of the atmoſphere, and that of the manures made uſe of. The peculiar principle of marl is, that part of it which, like lime, acts very powerfully upon the different aeriform fluids, is eaſily reduced to powder, efferveſces with acids, and ſends forth a quantity of air-bubbles when water is poured upon it. Now this matter, which in a particular manner does the office of manure, reſides neither in clay nor in ſand. Upon the proportion of it depends the duration of the fertility it produces; conſequently it is of importance, when we make uſe of marl, to know which of its conſtituent parts it contains in the greateſt proportion, otherwiſe in ſome caſes we ſhould only add one common kind of earth to another. Hence our author infers, that for a chalky ſoil clay is the proper manure, and that in ſuch a ſoil a clay bottom is of more value than a gold mine.

“ Wood-aſhes, as a manure, may be, in ſome reſpects, compared to marl; at leaſt they contain the ſame earths as thoſe which generally enter into the compoſition of marl, but they contain a greater quantity of ſaline ſubſtances, proceeding from the vegetables of which they are the reſidue, and from the proceſs made uſe of in their combuſtion; a proceſs which increaſes their activity, and ſhould render us careful in what manner and for what purpoſes we employ them. Wood aſhes, when ſcattered over fields, at proper times and in proper quantities, deſtroy weeds, and encourage the vegetation of good plants. But do the aſhes produce this effect by a ſort of corroſive power? I cannot (ſays our author) think it; for in that caſe all kinds of plants would indiſcriminately be acted upon by them, and to a certain degree deſtroyed.

“ Beſides, the aſhes of freſh wood are ſeldom employed until they have been lixiviated, in which ſtate they are deprived of their cauſtic principle; thoſe aſhes which are moſt commonly made uſe of for manure are produced either from wood that has been floated in water, or from turf, or from pit-coal, and contain little or no alkaline ſalt.

“ It appears much more probable that aſhes, when laid upon ground, deſtroy the weeds by a well-known effect, namely, by ſeizing with eagerneſs that moiſture which ſerved to produce thoſe weeds, and which in a ſuperabundant quantity is neceſſary to their exiſtence and ſupport. Whereas thoſe plants which have a firmer texture and a longer root, which are rendered ſtrong by age and by having withſtood the rigour of winter, and which are in fact the plants of which the fields are compoſed, do not ſuffer any damage from the application of the aſhes; but, on the contrary, by being freed from the ſuperfluous weeds which ſtifled them, and robbed them of a part of their ſuſtenance, they receive a quantity of nouriſhment proportioned to their wants. The ſtate of relaxation and languor to which they were reduced by a ſuperabundance of water, leaves them, the ſoil gets its proper conſiſtence, and the graſs, corn, &c. acquiring the ſtrength and vigour which is natural to them, ſoon overcome the moſs, ruſhes, and other weeds; thus a good crop, of whatever the field conſiſts of, is produced. It is in the above manner that wood aſhes act, whenever in the ſpring it is neceſſary to apply them to meadows, corn fields, &c. the plants of which are ſtifled and weakened by a luxuriant vegetation of weeds, the uſual conſequence of mild and wet winters.

“ When wood aſhes produce an effect different from what is above deſcribed, it is either becauſe they happen to contain too much alkaline ſalt, or that they are laid on the ground in too great quantity, or that the fields to which they are applied were not ſufficiently wet to reſtrain their action; for when they are ſcattered upon cold ſoils, and buried by the plough before the time of ſowing, they are, like lime, of great ſervice. The laſt-mentioned ſubſtance is very efficacious in other circumſtances; and there is a well-known method of uſing it, practiſed by the Germans, as follows: A heap of lime is formed by the ſide of a heap of poor earth, and water is poured upon the lime; the earth is then thrown over it, and becomes impregnated with the vapours which eſcape from the lime while it is ſlaked. The earth, after being thus aerated, may be ſeparated; and although no lime remains mixed with it, is, by the operation juſt deſcribed, rendered capable of giving a luxuriant vegetation to whatever plants may be put into it.

“ It is poſſible, therefore, to aerate earth as well as fluids; for this purpoſe, by mixing it with certain ſubſtances, during their decompoſition, we muſt attach to it the principles of which thoſe ſubſtances are compoſed; from which there reſults a matter ſo loaded with gas, as to form a more compound ſubſtance, and one which has acquired new properties. The Arabians, for example, who take great pains to improve their land, are accuſtomed to make large pits, which they fill with animals which happen to die: theſe pits they afterwards cover with calcareous or clayey earth; and after ſome time theſe earths, which of themſelves are ſterile, acquire the properties of the richeſt manures.

“ The foregoing obſervations may at leaſt be conſidered as proving, that thoſe ſubſtances which, when employed freſh and in too great quantity, are moſt prejudicial to vegetation, have, on the contrary, an advantageous effect, when they are previouſly made to undergo a fermentation; or when they are mixed with earth or water, in a proportion adapted to the end propoſed. The graſs of fields in which cattle or poultry go to feed, after the firſt or ſecond crop of hay, appears to be dried by the urine and dung of thoſe animals; as if fire had been applied to it; whereas theſe ſame excrementitious ſubſtances, when combined with earth, or diluted with water, are capable, without any other preparation, of performing the office of good manure.

“ But if animal ſecretions, when applied in ſubſtance to plants, were capable of acting upon them, as is affirmed, in ſuch a way as to corrode or burn them, how could ſeed which has been ſwallowed, and eſcaped the action of the digeſtive powers, be prolific when thrown out by the animal, after having remained ſo long in its dung? yet we often ſee oats, ſo circumſtanced, grow and produce ſeed. Is it not more conſiſtent with experience and obſervation to ſuppoſe, that theſe excrementitious ſubſtances, being ſtill endowed with animal heat, and with an organic motion, diffuſe round plants in vegetation a deleterious principle or inflammable gas, which deſtroys them; for ſoon after their application, the foliage of the plant grows yellow, dries up, and the plant withers, unleſs there happens a ſhower of rain which

which revives it. When theſe ſubſtances are diluted, by being mixed with water and earth, they loſe that principle which is ſo deſtructive to vegetable life, and an incipient fermentation augments their power as a manure, ſo that they may be immediately made uſe of without any apprehenſion of injury from their effects.

" It appears, therefore, that any operation upon excrementitious ſubſtances, by which they are dried and reduced to powder, cannot be practiſed without depriving thoſe ſubſtances of a great part of ſuch of their principles as are eaſily evaporated, and upon which their fluidity depends; theſe principles, when diluted with water, and confined by being mixed with earth, are capable of increaſing the produce of the ſoil. Such is the way in which the huſbandmen in Flanders make uſe of this kind of manure, in the cultivation of a kind of rape or cole ſeed, which is to them a very important branch of agricultural induſtry and commerce; and they never obſerve that the ſap carries up any of thoſe principles which give ſuch manure its offenſive ſmell; nor do they obſerve, that the fodder produced from fields ſo manured, whether eaten freſh or dry, is diſagreeable to their cattle. The excrements of all animals would be injurious to plants, if applied too freſh, or in too great quantity; and a gardener could not commit a greater fault, than to put more than a certain quantity of them into the water he means to make uſe of to water his young plants; in ſhort, this kind of manure is to be uſed in a very ſparing manner; and he that is too prodigal of it will find, to his coſt, that exceſs, even of that which is otherwiſe beneficial, becomes an evil.

" It muſt certainly be allowed, that excrementitious ſubſtances are a very advantageous manure for cold ſoils, and ſuited to moſt vegetable productions; a long experience of their effects over a large tract of country, and the acknowledged intelligence of the Flemiſh farmers, ought to be conſidered as ſufficient to overcome the prejudice that has been raiſed againſt this ſort of manure. Suppoſing that the bad effects which have been attributed to it, when uſed in the ſtate in which it is taken out of privies, &c. are not the offspring of a prejudiced imagination, they may have ariſen from its having been made uſe of at an improper time, or in too great quantity; or from its having been applied to a ſoil and for the cultivation of plants to which it was not adapted; for we know that the exceſs of any kind of manure changes the ſmell and taſte of plants, and the ſame effect is produced by watering them too frequently. Striking examples of this change are ſeen in the ſtrawberry and in the violet, when ſuch as have grown in the woods are compared to thoſe produced from ſome of our over-manured gardens; alſo in the lettuce, and ſome other plants, when thoſe raiſed for ſale by the gardeners about Paris are compared to thoſe of ſome particular kitchen gardens. In the markets of ſome cities, the carrots, turnips, and potatoes of the fields, are preferred to the ſame kind of roots cultivated by the gardeners (A); for though the laſt are of a larger ſize, they have not ſo good a flavour. Some vegetables, therefore, are like certain wild ſpecies of the animal kingdom; they reſiſt every kind of culture, as thoſe animals reſiſt every effort to tame them.

" Although experience has taught the Flemiſh farmers, that excrementitious ſubſtances are more active in their natural ſtate than when dried, yet it cannot be denied that drying them, and reducing them into powder, is ſometimes very advantageous, becauſe in that ſtate they are much leſs offenſive, are eaſily tranſported to any diſtance, and may be uſed when moſt convenient or moſt proper. In many cities the inhabitants pay to have their privies emptied: in other places, thoſe who empty them pay for their contents; and it would aſtoniſh any one to be told how great a revenue is produced in the city of Liſle in Flanders by the ſale of this kind of manure. I am, however (ſays our author), far from thinking that it is right, in all caſes, to employ it in the above mentioned ſtate of concentration; it would be better, in my opinion, to follow the example of the Flemiſh farmers, who uſe it the firſt year for the cultivation of plants for oil, or for hemp or flax; and the ſecond year for the beſt kinds of grain: thus obtaining two crops, inſtead of one, without any farther preparation of the land. What is ſaid above may be applied alſo to the manures produced from the dung of cattle, poultry, &c. (particularly to pigeons dung, the moſt powerful manure of its kind), all which, by being dried and powdered before they are uſed, loſe a great portion of their activity. From theſe obſervations another fact may be deduced, namely, that manure ſhould not be taken from the place where it has been thrown together until the ſeaſon of the year and the ſtate of the land are ſuch that it may be put into the ground as ſoon as it is brought to it. In ſome diſtricts a very injurious cuſtom prevails of carrying the manure into the fields, and leaving it there formed into ſmall heaps, expoſed for ſome days to the elements; during which time, either the ſun and wind dry up its natural moiſture, leaving a maſs which is much leſs active; or the rain diſſolves and carries away the extractive part impregnated with the ſalt. This kind of brine, which is the moſt powerful part of the manure, penetrates the earth to a conſiderable depth, and ſhews (by the thick tufts which ariſe in thoſe places, and which produce more ſtraw than grain) that manure ought to be put into the ground as ſoon as it is brought to it, becauſe it then poſſeſſes its full force and effect, and conſequently would be then uſed to the greateſt advantage.

" We have always at hand the means of compoſing, from a great variety of vegetable and animal ſubſtances, ſuch manures as, when brought into a proper ſtate, and mixed with land, contribute to its fertility. Chemiſtry alſo offers to us a number of ſubſtances, which, although when uſed ſeparately they tend to diminiſh the fertiliſing quality of the earth, are yet capable, by being combined, of forming excellent manures; ſuch, for inſtance, is that ſaponaceous combination which is produced from a mixture of potaſh, oil, and earth. What an advantage it would be, if, inſtead of being ſparing of manure, the inhabitants of the country would endeavour to increaſe the number of theſe reſources, and to render them more beneficial, by employing them in a

more

(A) We believe they are univerſally preferable.

Manure, Maouana.

more effectual manner. How many years had paſſed before it was known that the refuſe of apples and pears, after they are preſſed (and which uſed to be thrown away as uſeleſs), is capable of forming as valuable a manure, in cyder and perry countries, as the refuſe of grapes does in wine countries."

From what has been obſerved, our author concludes, that manures act, in many circumſtances, like medicines, and conſequently that the ſame ſort of manure cannot be adapted to every ſituation, and every kind of ſoil; we muſt therefore take care to make proper diſtinctions between them. Whoever ſhall pretend that any particular kind of manure may be uſed, with equal benefit, in graſs land, corn-fields, vineyards, orchards, kitchen gardens, &c. ought to be claſſed amongſt thoſe quacks who undertake to cure all perſons with the ſame remedy, without any regard to their age, conſtitution, &c. It is probably from not having paid ſufficient attention to the forementioned diſtinctions, that ſome authors have found fault with particular manures, while others have ſpoken too highly in their favour. He thinks, however, and we agree with him, that we are ſtill in want of a courſe of comparative experiments upon the various kinds of manures, conſidered according to their influence with reſpect to different ſoils, ſituations, and productions. If this part of rural economy were better underſtood, we ſhould perhaps ſee many places in a ſtate of cultivation, which, on account of the bad quality of their ſoil, have hitherto reſiſted all our endeavours to render them fertile.

Perhaps it would not be proper to diſmiſs this ſubject without noticing Mr Middleton's obſervations on various kinds of manure, which were publiſhed in the Tranſactions of the Society of Arts for the year 1799. This gentleman agrees with Mr Parmentier in recommending the *excrementitious matter of privies* as the moſt powerful of all manures on ſome kinds of ſoil; but he differs from him, and we believe from moſt writers on agriculture, when he affirms, that *wood aſhes*, when ſpread on the graſs in February or March, are of very little ſervice, and that the aſhes of *coal* and even of *peat* are of none upon any kind of land. He likewiſe affirms *ſoot* to be of very little value as a manure, *ſoapmakers waſte* to be of none, or rather to be hurtful; and he ſeems to conſider *malt-duſt*, including the duſt from the malt-kilns, to be, after the ſoil of privies, one of the moſt powerful manures. He affirms, from his own experience, that, with reſpect to fertiliſing power, the ſoil of privies, compared with farm-yard dung, is in the proportion of five to one.

MAOUANA, one of that cluſter of iſlands in the South Sea which were diſcovered by M. Bougainville, and by him named Navigator's Iſlands. It was viſited by La Perouſe in 1787, who deſcribes it as exceedingly rich in every animal and vegetable production neceſſary to the ſuſtenance of man. The two frigates which he commanded had no ſooner approached the ſhore, than he diſcovered at the bottom of each creek a number of villages, from whence came innumerable canoes, laden with hogs, cocoa nuts, and other fruits, which were purchaſed for glaſs ware. This was in the evening; and next morning the commerce was renewed in the moſt friendly manner. As early as the dawn of day, the iſlanders had ſurrounded the two frigates with 200 canoes full of different kinds of proviſion, which they would exchange only for beads—in their eſtimation diamonds of the firſt water. Axes, cloth, and all other articles of commerce, they diſdained. Abounding in real bleſſings, they were deſirous of obtaining ſuperfluities alone.

Maouana.

Two boats, filled with empty caſks, were ſent aſhore for freſh water; and Perouſe himſelf accompanied them in his pinnace. A line of ſoldiers was poſted between the beach and the Indians, who amounted to about 200, including a great many women and children. The French commander prevailed upon them all to ſit down under cocoa trees, that were not more than eight toiſes diſtant from the ſhips boats. Each of them had by him fowls, hogs, parrots, pigeons, or fruit, and all wiſhed to ſell them at once, which occaſioned ſome confuſion.

The women, ſome of whom were very pretty, offered their favours, as well as their fowls and fruit, to all thoſe who had beads to give them; and ſoon tried to paſs through the line of ſoldiers, who oppoſed but a feeble reſiſtance to their attempts. Europeans who have made a voyage round the world, eſpecially Frenchmen, have no arms to ward off ſimilar attacks. Accordingly the fair ſavages found little difficulty in breaking the ranks; the men then approached; and the confuſion was growing general; when Indians, who ſeemed to be chiefs, made their appearance with ſticks in their hands, and reſtored order, every one returning to his poſt, and the traffic beginning anew, to the great ſatiſfaction of both buyers and ſellers.

While all this was paſſing with the greateſt tranquillity, and the caſks were filling with water, Perouſe thought he might venture to the diſtance of 200 yards to viſit a charming village, ſituated in the midſt of a wood, or rather of an orchard, all the trees of which were loaded with fruit. The houſes were placed upon the circumference of a circle, of about 150 toiſes in diameter, the interior forming a vaſt open ſpace, covered with the moſt beautiful verdure, and ſhaded by trees, which kept the air delightfully cool. Women, children, and old men, accompanied him, and invited him into their houſes. They ſpread the fineſt and freſheſt mats upon a floor formed of little choſen pebbles, and raiſed about two feet above the ground, in order to guard againſt humidity. He went into the handſomeſt of theſe huts, which probably belonged to a chief; and great was his ſurpriſe to ſee a large cabin of lattice-work, as well executed as any of thoſe in the environs of Paris. The beſt architect could not have given a more elegant curve to the extremities of the ellipſis that terminated the building; while a row of pillars, at five feet diſtance from each other, formed a complete colonnade round the whole. The pillars were made of trunks of trees very neatly wrought, and between them were fine mats laid over one another with great art, like the ſcales of a fiſh, and drawing up and down with cords, like our Venetian blinds. The reſt of the houſe was covered with leaves of the cocoa palm.

This charming country combines the advantages of a ſoil fruitful without culture, and of a climate which renders clothing unneceſſary. The trees that produce the bread-fruit, the cocoa-nut, the banana, the guava, and the orange, hold out to theſe fortunate people an abundance of wholeſome food; while the fowls, hogs, and dogs, which live upon the ſurplus of theſe fruits, afford them an agreeable variety of viands. What cold imagination could ſeparate the idea of happineſs from ſo

Maouana, Maſon.

ſo enchanting a place! But Maouana is not the abode of innocence. No arms were indeed perceived; but the bodies of the Indians, covered over with ſcars, proved that they were often at war, or elſe quarrelling among themſelves; while their features announced a ferocity that was not perceptible in the countenances of the women. Nature had, no doubt, ſtamped this character on their faces, by way of ſhewing, that the half ſavage, living in a ſtate of anarchy, is a more miſchievous being than the moſt ferocious of the brute creation.

Of their ferocity and their treachery, Perouſe had too ſoon the moſt complete evidence. M. de Langle, the ſecond in command, went aſhore for freſh water, accompanied by ſixty Frenchmen, officers, ſailors, and ſoldiers. They were received with an air of good humour by crowds of people waiting on the beach with immenſe quantities of fruit and hogs; but this calm was of ſhort duration. The Indians picked a quarrel with them, pelted them with ſtones, thrown with great dexterity and with equal force; and it was with difficulty that, of the ſixty-one, forty-nine reached the ſhips, many of whom were ſeverely wounded. Among the killed were De Langle, and Lamanon the naturaliſt (See LAMANON in this *Suppl.*). Perouſe deſcribes the men of Maouana as of gigantic ſtature, and of great muſcular ſtrength. See *NAVIGATORS Iſlands* in this *Suppl.*

MASON (the Rev. William) was a man of ſuch eminence both as a poet and as a ſcholar, that a more particular account of his life and of his ſtudies ſhould be publiſhed than our ſcanty materials enable us to give. He was born at Hull, where his father poſſeſſed the vicarage of St Trinity; but where he received his ſchool education we have not been able to learn. At the proper time he was admitted into St John's College, Cambridge; where he took the degrees of B. A. and M. A. and in 1747, he obtained a fellowſhip in Pembroke Hall. It was there that he contracted an intimate friendſhip with Gray the poet, and with Mr Hurd, now Biſhop of Worceſter. When the former of theſe gentlemen died, Mr Maſon took upon himſelf the office of editor of his works and guardian of his fame; and upon the promotion of the latter to the ſee of Litchfield and Coventry, he expreſſed his ſatisfaction in ſome beautiful verſes, which we read at the time, but do not recollect where.

In 1754 he entered into holy orders, and was patronized by the then Earl of Holderneſs, who obtained for him the appointment of chaplain to the king, and preſented him with the valuable rectory of Aſton in Yorkſhire. He was ſome time afterwards made precentor of York Cathedral, when he publiſhed a ſmall volume of church muſic, which has alternately met with oppoſition and applauſe. In our opinion ſome of his anthems are unrivalled.

It was natural for the precentor of a cathedral church, who was likewiſe a poet, to turn his attention to ſacred muſic; and Maſon had been a poet from his early years. His *Elfrida* and *Caractacus*, two tragedies on the Grecian model, were both publiſhed before the year 1757. Theſe two dramas, in the opinion of Dr Hurd, do honour to modern poetry, and are, according to him, a ſufficient proof of the propriety of reviving the chorus on the Britiſh ſtage. In this ſentiment few critics, we believe, will agree with his Lordſhip; but the tragedies have certainly great merit, and

Maſon.

tranſcend perhaps every poem of the ſame caſt in our own or any other modern tongue. In the firſt, the language is elegant and ſweet; in the latter, it is daring and ſublime. The author himſelf always conſidered the former as the moſt perfect; and Johnſon, whoſe critical judgment will not be raſhly queſtioned, ſeems to have been of the ſame opinion. Johnſon's partiality to Oxford, as is well known, made him embrace every opportunity of turning into ridicule Cambridge men and Cambridge poems; but while he boaſted of having ſpent hours in burleſquing Caractacus for the amuſement of his Oxford friends, he confeſſed that Elfrida was too beautiful to be hurt by ridicule. The voice of the public, however, ſeems to give the preference to the latter, and to conſider it as ſtanding, like Dryden's celebrated ode, without a rival. In both are ſentiments and expreſſions which would do honour to the genius of Shakeſpeare; and Caractacus, in the Greek verſion of Mr Glaſs, would not have diſgraced an Athenian theatre.

Beſides his two tragedies, Mr Maſon publiſhed many other poems. His Engliſh Garden is univerſally read and admired, being unqueſtionably the fineſt poem of the kind that has appeared ſince the days of Thomſon; though ſome have affected to conſider it as treating the ſubject rather with profeſſional ſkill than with poetical genius. That there are in it a few proſaic expreſſions we ſhall not controvert; for ſuch ſeem inſeparable from didactic poetry; but, taken as a whole, where ſhall we find its equal? His elegies, particularly that on the death of his wife, and that on the demiſe of Lady Coventry, have been generally read and extolled, though not more than they deſerve, as ſuperior in claſſic elegance to any thing of the kind in the Engliſh tongue, and expreſſing a manlineſs and tenderneſs of the pathetic, rarely found in the moſt poliſhed elegies of Roman writers. The ſplendor of genius, and accuracy of judgement, conſpicuous in his dramas, are equally diſplayed in his character as a lyric writer. His quarry was bold and impetuous, and he never ſwept the ground with an ignominious flight. In his Sappho and Phaon he has happily imitated the ſtyle of Dryden and Metaſtaſio; and at his death he was employed on a poem in which he propoſed to meaſure his ſtrength with Dryden.

We have reaſon to believe that this ingenious man was not only a poet and a muſical performer, but the inventor of the faſhionable inſtrument the Piano Forte. We cannot indeed at preſent bring evidence of this fact; but we have inſtituted ſuch inquiries as, we hope, ſhall enable us to aſcertain the truth under the article *PIANO Forte*.

Poetry and muſic, and the duties of his office, might be ſuppoſed to have employed all his time; but, unfortunately, he caught the alarm which in 1769 was ſpread over the nation by the expulſion of Mr Wilkes from the Houſe of Commons, and immediately inrolled himſelf among the ſupporters of the *Bill of Rights*. The deciſion of the Houſe, which pronounced Mr Lutteral duly elected in oppoſition to Mr Wilkes, he conſidered as a groſs violation of the rights of the people; and though he ſurely did not approve of the conduct of the exiled member, he joined with other freeholders in Yorkſhire in a petition to the king that he would diſſolve the parliament.

Being now leagued with the oppoſition, he joined in ſome violent clamours for a parliamentary reform. In the

the year 1779, when the city of London, and ſome other commercial towns, agreed to preſent their petitions to parliament for a more economical expenditure of the public money, and a more equal repreſentation of the people, Mr Maſon came forward, and took an active part in promoting theſe deſigns, as one who was convinced of their importance and neceſſity. When the county of York aſſembled, on the 30th of December 1779, and reſolved unanimouſly, "that a committee of correſpondence ſhould be appointed, for the effectually promoting the object of the petition then agreed to, and alſo to prepare a plan of *aſſociation* to ſupport that laudable reform, and ſuch other meaſures as may conduce to reſtore the *freedom of parliament*," he was choſen upon the committee, and was conſulted with, or aſſiſted in drawing up thoſe various high-ſpirited reſolutions and addreſſes to the public, for which the Yorkſhire committee was ſo celebrated; and which was afterwards generally adopted by the other aſſociated bodies of reformers. This part of his conduct is ſurely entitled to no praiſe. Thinking as we do of the parliamentary reformers, we cannot but regret that a man of Mr Maſon's talents and virtues ſhould have embarked in their dangerous purſuits; and though we perceived leſs hazard in thoſe purſuits than we do, we ſhould ſtill conſider them as unſuitable to the character of a clergyman. Our author, however, was of a different opinion. In reply to a cenſure paſſed by a dignified clergyman on the political conduct of himſelf and ſome of his reverend brethren, he publiſhed, without his name indeed, a ſpirited defence of their proceedings and deſigns in ſome of the country papers. The York committee, too, at its next meeting, reſolved, "that a Proteſtant, by entering into holy orders, does not abandon his civil rights;" they alſo reſolved, "that the thanks of the committee be given to thoſe reverend gentlemen who, thus preferring the public good to their own private emoluments, have ſtood forth the firm friends to the true intereſts of their country."

Mr Maſon, however, ſhowed, by his ſubſequent conduct, that however earneſtly he might wiſh for what he doubtleſs conſidered as an expedient reform in the commons-houſe of Parliament, he was firmly attached to the Britiſh conſtitution. He was indeed a whig; but he was a whig of the old ſchool. In the beginning of 1794, when the reformers had betrayed the principles of French democrates, he deſerted them, and ranged himſelf under the banners of the ſervants of the crown; and for this conduct, which was certainly conſiſtent, he has been plentifully traduced by our Jacobin journaliſts as an alarmiſt, who not only deſerted his old friends, but aſcribed to them a certain degree of guilt and political depravity.

The death of this great and good man, which happened in April 1797, was occaſioned neither by age nor by inveterate diſeaſe. As he was ſtepping into his chariot, his foot ſlipped, and his ſhin grazed againſt the ſtep. This accident had taken place ſeveral days before he paid the proper attention to it; and on April the 3d a mortification enſued, which, in the ſpace of forty-eight hours, put a period to his life.

That he was a ſcholar and a poet of high eminence is univerſally acknowledged; and we are aſſured, that his poſthumous works, when publiſhed, will not detract from his living fame. In private life, though he affected perhaps too much the faſtidious manners of Mr Gray, whoſe genius he eſtimated with a degree of enthuſiaſm amounting almoſt to idolatry, his character was diſtinguiſhed by philanthropy and the moſt fervid friendſhips; and he may be conſidered as a man who merits to be ranked with the ableſt ſupporters of Britiſh liberty and Britiſh morals.

FREE MASONRY, is a ſubject which, after the copious detail given in the *Encyclopædia* of its lodges, and wardens, and grand maſters, we ſhould not have reſumed in this place, but to warn our countrymen againſt the pernicious ſuperſtructures which have been raiſed by the French and Germans on the ſimple ſyſtem of Britiſh maſonry.

Much falſehood is current reſpecting the origin and antiquity of the maſonic aſſociations. That the Dionyſiacs of Aſia Minor were a ſociety of architects and engineers, who had the excluſive privilege of building temples, ſtadia, and theatres, under the myſterious tutelage of Bacchus, ſeems to be unqueſtionable. "We are alſo certain, that there was a ſimilar trading aſſociation during the dark ages in Chriſtian Europe, which monopolized the building of great churches and caſtles, and enjoyed many privileges under the patronage of the various ſovereigns. Circumſtances (ſays Dr Robiſon), which it would be tedious to enumerate and diſcuſs, continued this aſſociation longer in Britain than on the continent;" but there is no good evidence, that, anterior to the year 1648, any man ſought admiſſion into it, who was not either a builder by profeſſion, or at leaſt ſkilled in the ſcience of architecture. At that period, indeed, Mr Aſhmole, the famous antiquary (ſee ASHMOLE, *Encycl.*), was admitted into a lodge at Warrington, together with his father-in-law Colonel Mainwaring; and theſe are the firſt diſtinct and unequivocal inſtances that we have in Britain of men unconnected with the operative maſons being received into their myſterious fraternity. The ſecrecy, however, of the lodges, made them fit places for the meetings of the royaliſts; and accordingly many royaliſts became free maſons. "Nay, the ritual of the maſter's degree ſeems to have been formed, or perhaps twiſted from its original inſtitution, ſo as to give an opportunity of ſounding the political principles of the candidate, and of the whole brethren preſent. For it bears ſo eaſy an adaptation to the death of the king, to the overturning of the venerable conſtitution of the Engliſh government of three orders by a mean democracy, and its re-eſtabliſhment by the efforts of the loyaliſts, that this would ſtart into every perſon's mind during the ceremonial, and could hardly fail to ſhew, by the countenances and behaviour of the brethren, how they were affected."

This ſuppoſition receives much countenance from the well known fact, that "Charles II. was made a maſon, and frequented the lodges. It is not unlikely, that beſides the amuſement of a vacant hour, which was always agreeable to him, he had pleaſure in meeting with his loyal friends, and in the occupations of the lodge, which recalled to his mind their attachment and ſervices. His brother and ſucceſſor James II. was of a more ſerious and manly caſt of mind, and had little pleaſure in the frivolous ceremonies of maſonry. He did not frequent the lodges. But, by this time, they were the reſort of many perſons who were not of the profeſſion, or members of the trading corporation. This circumſtance,

ſtance, in all probability, produced the denominations of *free* and *accepted* maſons. A perſon who has the privilege of working at any incorporated trade, is ſaid to be a *freeman* of that trade. Others were *accepted* as brethren, and admitted to a kind of honorary freedom; as is the caſe in many other trades and incorporations, without having (as far as we can learn for certain) a legal title to earn a livelihood by the exerciſe of it."

It was not till ſome years after this period that the lodges made open profeſſion of the cultivation of general benevolence, and that the grand aim of the fraternity was to enforce the exerciſe of all the ſocial virtues. The eſtabliſhment of a fund for the relief of unfortunate brethren did not take place till the very end of the laſt century; and we may preſume, that it was brought about by the warm recommendations of ſome benevolent members, who would naturally enforce it by addreſſes to their aſſembled brethren. Hence the probable origin of thoſe philanthropic diſcourſes, which are occaſionally delivered in the lodges by one of the brethren as an official taſk.

The boaſted philanthropy of maſons ſerves, however, another purpoſe. The inquiſitive are always prying and teazing, eager to diſcover the ſecrets of their neighbours; and hence the brethren are induced to ſay, that univerſal beneficence is the great aim of the order, for it is the only point on which they are at liberty to ſpeak. They forget, that univerſal beneficence and philanthropy are inconſiſtent with the excluſive and monopolizing ſpirit of an aſſociation, which not only confines its benevolence to its own members (like any other charitable aſſociation), but hoards up in its boſom ineſtimable ſecrets, whoſe natural tendency, they ſay, is to form the heart to this generous and kind conduct, and inſpire us with love to all mankind. The profane world cannot ſee the beneficence of concealing from public view a principle or a motive which ſo powerfully induces a maſon to be good and kind. The brother ſays, that publicity would rob it of its force; and we muſt take him at his word: and our curioſity is ſo much the more excited, to learn what are the ſecrets which have ſo ſingular a quality, for they muſt be totally unlike the principles of ſcience, which produce their effects only when made public.

From this account of maſonry, it would appear to have been at firſt a loyal aſſociation, and as ſuch it was carried over from England to the continent; for all the maſons abroad profeſs to have received their myſteries from Great Britain. It was firſt tranſported into France by the zealous adherents of King James, who, together with their unfortunate maſter, took refuge in that country; and it was cultivated by the French in a manner ſuited to the taſte and habits of that highly poliſhed and frivolous people. To the three ſimple Britiſh degrees of *apprentice*, *fellow-craft*, and *maſter*, they gradually added degrees innumerable, all decorated with ſtars and ribbons; and into their lodges they introduced the impieties and ſeditious doctrines of Voltaire and the other philoſophiſts. Indeed, if the account which the Abbé Barruel gives of maſonry be juſt, it muſt be admitted, that even the ſecrets of the moſt ancient lodges, though in one ſenſe harmleſs and juſt, are ſo expreſſed, that they may be eaſily twiſted to very dangerous purpoſes. This author was advanced by a few friends to the degree of maſter, without being obliged to take the oath of ſecrecy; and being furniſhed with the ſigns, he got admiſſion into a lodge, where he heard the ſecret regularly communicated, with all the ordinary forms, to an apprentice. "It would be uſeleſs, ſays he, to deſcribe the ceremonials and trials on ſuch occaſions; for in the firſt degrees, they are nothing more than the play of children. The grand object was the communication of the famous ſecret, when the candidate was ordered to approach nearer to the venerable. At that moment, the brethren, who had been armed with ſwords for the occaſion, drawing up in two lines, held their ſwords elevated, leaning the points towards each other, and formed what in maſonry is called the *arch of ſteel*. The candidate paſſed under this arch to a ſort of altar elevated on two ſteps, at the fartheſt end of the lodge. The maſter, ſeated in an arm chair, or a ſort of throne, behind this altar, pronounced a long diſcourſe on the inviolability of the ſecret which was to be imparted, and on the danger of breaking the oath which the candidate was going to take. He pointed to the naked ſwords, which were always ready to pierce the breaſt of the traitor; and declared to him that it was impoſſible to eſcape their vengeance. The candidate then ſwore, "that rather than betray the ſecret, he conſented to have his head cut off, his heart and entrails torn out, and his aſhes caſt before the winds." Having taken the oath, the maſter ſaid the following words to him: "My dear brother, the ſecret of maſonry conſiſts in theſe words, EQUALITY AND LIBERTY; *all men are equal and free; all men are brethren.*" The maſter did not utter another ſyllable, and every body embraced the new *brother equal and free.* The lodge broke up, and we gayly adjourned to a maſonic repaſt."

In the Britiſh lodges, the author admits, that no other interpretation is given to this famous ſecret, than that, as all men are children of one common parent, and creatures of the ſame God, they are in duty bound to love and help each other as brethren; but he contends, that in France it was differently interpreted; and he ſupports his opinion by the following arguments:

On the 12th of Auguſt 1792, Louis XVI. was carried a priſoner to the tower of the *temple*, ſo called becauſe it formerly belonged to the knights templars. On that day, the rebel aſſembly decreed, that to the date of *liberty* the date of *equality* ſhould be added in future in all public acts; and the decree itſelf was dated the fourth year of *liberty*, the firſt year and firſt day of *equality*. It was on that day, for the firſt time, that the ſecret of free-maſonry was made public; that ſecret ſo dear to them, and which they preſerved with all the ſolemnity of the moſt inviolable oath. At the reading of this famous decree, they exclaimed, "We have at length ſucceeded, and France is no other than an immenſe lodge. The whole French people are free maſons, and the whole univerſe will ſoon follow their example."

"I witneſſed (ſays our author) this enthuſiaſm; I heard the converſations to which it gave riſe; I ſaw maſons, till then the moſt reſerved, who freely and openly declared, 'Yes, at length the grand object of free-maſonry is accompliſhed, EQUALITY and LIBERTY; *all men are equal and brothers; all men are free.* That was the whole ſubſtance of our doctrine, the object of our wiſhes, *the whole of our grand ſecret!*"

This is a very ſerious charge againſt the original ſecret of maſonry, as it was underſtood in France ; and though the author does not bring it directly againſt the ſame ſecret as underſtood in Britain, he yet ſeems to ſay, that in *all* lodges, the following queſtion is put to the candidate before he is entruſted with any ſecret :— " Brother, are you diſpoſed to execute all the orders of the grand-maſter, though you were to receive contrary orders from a king, an emperor, or any other ſovereign whatever ?" And as the brother is obliged to promiſe this unlimited obedience, it is eaſy to conceive how much a traiterous conſpiracy may be promoted by means of maſon lodges. The allegorical ſtory which is told at the conferring of the degree of maſter, is capable of various and even contrary interpretations ; for though in this country it was originally rendered ſubſervient to the purpoſes of the royaliſts, in the occult lodges on the continent it has been made the vehicle of treaſon and impiety.

When the degree of maſter-maſon is to be conferred, the lodge is hung round with black. In the middle is a coffin covered with a pall, the brethren ſtanding round it in attitudes denoting ſorrow and revenge. When the new adept is admitted, the maſter relates to him the following hiſtory or fable :

" Adoniram preſided over the payment of the workmen who were building the temple by Solomon's orders. They were three thouſand workmen. That each one might receive his due, Adoniram divided them into three claſſes, apprentices, fellow-crafts, and maſters. He entruſted each claſs with a word, ſigns, and a gripe, by which they might be recogniſed. Each claſs was to preſerve the greateſt ſecrecy as to theſe ſigns and words. Three of the fellow-crafts, wiſhing to know the word, and by that means obtain the ſalary, of maſter, hid themſelves in the temple, and each poſted himſelf at a different gate. At the uſual time when Adoniram came to ſhut the gates of the temple, the firſt of the three met him, and demanded the *word of the maſters ;* Adoniram refuſed to give it, and received a violent blow with a ſtick on his head. He flies to another gate, is met, challenged, and treated in a ſimilar manner by the ſecond : flying to the third door, he is killed by the fellow-craft poſted there, on his refuſing to betray the word. His aſſaſſins buried him under a heap of rubbiſh, and marked the ſpot with a branch of acacia.

" Adoniram's abſence gave great uneaſineſs to Solomon and the maſters. He is ſought for every where : at length one of the maſters diſcovers the corpſe, and, taking it by the finger, the finger parted from the hand ; he took it by the wriſt, and it parted from the arm ; when the maſter, in aſtoniſhment, cried out, *Mac Benac ;* which the craft interprets by " *the fleſh parts from the bones.*"

" Leſt Adoniram ſhould have revealed the *word*, the maſters convened and agreed to change it, and to ſubſtitute the words *Mac Benac ;* ſacred words, that free-maſons dare not pronounce out of the lodges, and there each only pronounces one ſyllable, leaving his neighbour to pronounce the other."

The hiſtory finiſhed, the adept is informed, that the object of the degree he has juſt received is to recover the word loſt by the death of Adoniram, and to revenge this martyr of the maſonic ſecrecy. The generality of maſons, looking upon this hiſtory as no more than a fable, and the ceremonies as puerile, give themſelves very little trouble to ſearch farther into theſe myſteries.

Theſe ſports, however, aſſume a more ſerious aſpect when we arrive at the degree of elect (*Elu*). This degree is ſubdivided into two parts ; the firſt has the revenging of Adoniram for its object, the other to recover the *word*, or rather the ſacred doctrine which it expreſſed, and which has been loſt.

In this degree of elect, all the brethren appear dreſſed in black, wearing a breaſt-piece on the left ſide, on which is embroidered a death's head, a bone, and a poignard, encircled by the motto of *Conquer or die.* The ſame motto is embroidered on a ribband which they wear in ſaltier. Every thing breathes death and revenge. The candidate is led into the lodge blindfolded, with bloody gloves on his hands. An adept with a poignard in his hand threatens to run him through the heart for the crime with which he is accuſed. After various frights, he obtains his life, on condition that he will revenge the father of maſonry in the death of his aſſaſſin. He is ſhewn to a dark cavern. He is to penetrate into it ; and they call to him, Strike all that ſhall oppoſe you ; enter, defend yourſelf, and avenge our maſter ; at that price you ſhall receive the degree of elect. A poignard in his right hand, a lamp in his left, he proceeds ; a phantom oppoſes his paſſage ; he hears the ſame voice repeat, Strike, avenge Hiram, there is his aſſaſſin. He ſtrikes, and the blood flows.—Strike off his head, the voice repeats ; and the head of the corpſe is lying at his feet. He ſeizes it by the hair (A), and triumphantly carries it back as a proof of his victory ; ſhows it to each of the brethren, and is judged worthy of the new degree.

Our author ſays, that he has queſtioned divers maſons whether this apprenticeſhip to ferocity and murder had never given them the idea, that the head to be cut off was that of kings ; but they all affirmed that ſuch an idea had never occurred to them till the French revolution had convinced them of the fact. At this indeed we are not ſurpriſed. The aſſaſſin of Hiram is no where ſaid to have been a king ; and why ſhould the young elect have ſuppoſed, that when ſtabbing that aſſaſſin, he was training to be a regicide ? The ceremony, however, is certainly ferocious in the higheſt degree, and obviouſly calculated to reconcile the maſons of the occult lodges to the practice of aſſaſſination at the command of their ſuperiors ; and when it is remembered, that they are bound to pay obedience to thoſe unſeen ſuperiors even againſt their lawful ſovereigns, the atrocities of the revolution would naturally make them interpret this ſhocking ceremony as it is interpreted by the Abbé.

It was the ſame with reſpect to the religious part of this degree, where the adept is at once pontiff and ſacrificer with the reſt of the brethren. Veſted in the ornaments of the prieſthood, they offer bread and wine, according to the order of Melchiſedec. The ſecret object of this ceremony is to re-eſtabliſh religious equality, and to exhibit all men equally prieſts and pontiffs, to recal the brethren to natural religion, and to perſuade them that the religion of Moſes and of Chriſt had violated religious equality and liberty by the diſtinction

---

(A) The reader may eaſily conceive that this corpſe is no more than a mannikin containing bladders full of blood.

of prieſts and laity. It was the revolution again which opened the eyes of many of the adepts, who then owned that they had been dupes to this impiety, as they had been to the regicide eſſay in the former part.

Our author treats the fraternity of the occult lodges through the higher degrees of Scotch maſonry, thoſe of the Roſicrucians, and that of the knights Kadoſch; and ſums up his account in the following terms:

“ In the two firſt degrees, that is to ſay, in thoſe of *apprentice* and *fellow-craft*, the ſect begins by throwing out its equality and liberty. After that, it occupies the attention of its novices with puerile games of fraternity or maſonic repaſts; but it already trains its adepts to the profoundeſt ſecrecy by the moſt frightful oaths.

“ In that of *maſter*, it relates the allegorical hiſtory of Adoniram, who is to be avenged; and of the *word*, which is to be recovered.

“ In the degree of *elect*, it trains the adepts to vengeance, without pointing out the perſon on whom it is to fall. It carries them back to the time of the patriarchs, when, according to them, men knew no religion but that of nature, and when every body was equally prieſt and pontiff. But it had not as yet declared that all religion revealed ſince the time of the patriarchs was to be thrown aſide.

“ This laſt myſtery is only developed in the Scotch degrees. There the brethren are declared free: The word ſo long ſought for is, Deiſm; it is the worſhip of Jehovah, ſuch as was known to the philoſophers of nature. The true maſon becomes the pontiff of Jehovah; and ſuch is the grand myſtery by which he is extricated from that darkneſs in which the prophane are involved.

“ In the degree *Roſæ Crucis*, he who wreſted the *word*, who deſtroyed the worſhip of Jehovah, is Chriſt himſelf, the author of Chriſtianity; and it is on the Goſpel and on the Son of Man that the adept is to avenge the brethren, the pontiffs of Jehovah.

“ At length, on his reception as Kadoſch, he learns that the aſſaſſin of Adoniram is the king, who is to be killed to avenge the grand maſter Molay, and the order of the maſons ſucceſſors of the knights templars. The religion which is to be deſtroyed to recover the *word*, or the true doctrine, is the religion of Chriſt, founded on revelation. This word in its full extent is *equality* and *liberty*, to be eſtabliſhed by the total overthrow of the altar and the throne.

“ Such are the incipient degrees, the proceſs, and the whole ſyſtem of maſonry; it is thus that the ſect, by its gradual explanation of its twofold principle of *equality* and *liberty*, of its allegory of the founder of maſonry to be avenged, of the word to be recovered, leading the adepts from ſecret to ſecret, at length initiates them into the whole Jacobinical code of revolution.”

If this account of maſonry be not greatly exaggerated, what are we to think of thoſe men among ourſelves, who, ſince the publication of the Abbé Barruel's book and Dr Robiſon's, have diſplayed a zeal for the propagation of their myſteries, by which they ſeemed not to be formerly actuated, and to which the importance of the buſineſs that, by their own account, is tranſacted in the lodges, cannot be thought to bear an adequate proportion? It is not enough to ſay that Britiſh maſonry is harmleſs, and that the *equality* and *liberty* taught in our lodges are the equality and liberty taught in the bible. Without directly queſtioning this aſſertion, we only beg leave to put our countrymen in remembrance, that French and German maſonry, as it was derived from Britain, muſt have been originally as harmleſs as our own; and to call their attention to the monſtrous ſuperſtructures of impiety and rebellion which in theſe countries have been raiſed upon our foundation. Have there been no ſymptoms of ſedition and irreligion among us, ſince the commencement of the French revolution, that we ſhould be ſo confident that the equality and liberty of our lodges will never degenerate into the equality and liberty of the French Jacobins? This cannot be ſaid; for it has been proved, that there are ſeveral occult lodges in Britain; and what ſecurity have we, or what ſecurity can we receive, that their number will not increaſe? The legiſlature indeed has lately laid ſome ſalutary reſtraints on the meetings of maſons; but ſuch is the nature of theſe meetings, that nothing can effectually ſecure us againſt the introduction of the higher myſteries, but the voluntary ſhutting up for a time of all lodges. This has been done by the honeſt maſons in Germany; and why may it not be done by the maſons in Britain? The fund for the relief of poor brethren may ſurely be managed without ſecrecy; the ſigns and gripe may be communicated without the *word*, or exacting a promiſe of implicit obedience; and the relinquiſhing of the joys of a ſocial hour would be no great ſacrifice to the peace of a country.

But is Britiſh maſonry really ſo harmleſs as the younger maſons wiſh us to believe? The writer of theſe reflections was never initiated in its myſteries, and therefore cannot, from his own knowledge, ſay what is their tendency; but he has no heſitation to affirm, becauſe he believes himſelf able to demonſtrate, that it is groſsly immoral to promiſe implicit obedience to unknown ſuperiors, or to ſwear that one will keep inviolate a ſecret, to the nature of which he is an abſolute ſtranger. He hopes, indeed, and is inclined to believe, that, in the decent lodges of Britain, the candidate is aſſured, before he is required to take the oath, that the ſecret to be communicated, and the obedience which he is to pay, militate in no reſpect againſt the civil government or the religion of his country; but ſtill if the ſecret contain information of value, it is, in his opinion, ſinful to keep it a ſecret; and he cannot conceive upon what principle a native of Britain can promiſe unlimited obedience to any human being. The myſteries of maſonry muſt relate to ſomething which is either important and laudable; frivolous, though innocent; or dangerous and immoral. To confine to a ſect any information which is laudable and important, is ſurely not to act the part of genuine philanthropiſts; to adminiſter the moſt tremendous oaths in the midſt of frivolous amuſements, is to violate one of the moſt ſacred precepts of our holy religion; and, as no man will pretend to vindicate dangerous and immoral myſteries, maſonry appears, in every point in which it can be placed, an aſſociation which no good Chriſtian will think himſelf at liberty to encourage.

MASUAH (See MASSUAH, *Encycl.*) is in latitude 15° 35′ 5″ north, and in longitude 39° 36′ 30″ eaſt of Greenwich. On the 22d of September 1769 Mr Bruce found the variation of the needle at Maſuah to be 12° 48′ weſt.

MATMAI, or MATSUMAI, is the largeſt of the Kurile iſlands; and if it be not independent, is tributary

Mayorga, Mayow.

to Japan. The capital town of the ſame name, Matmai, is ſituated on the ſea-ſhore, on the ſouth-weſt ſide. It was built and is inhabited by the Japaneſe. It is a fortified place, furniſhed with artillery, and defended by a numerous garriſon. The iſland of Matmai is the place of exile for perſons of diſtinction at Japan: it is ſeparated from that empire by only a narrow channel, but which is conſidered as dangerous, becauſe the capes, which project on both ſides, render the navigation difficult The people are ſaid to be ſenſible to friendſhip, hoſpitable, generous, and humane.

MAYORGA (Martin de). See *Don Martin*, &c. in this *Suppl.*

MAYOW (John), whoſe diſcoveries in chemiſtry have aſtoniſhed the ſcientific part of the public, deſcended, ſays Wood, from a genteel family living at *Bree* in the county of *Cornwall*. His father was probably a younger ſon, bred to buſineſs; for our author was born in Fleet-ſtreet, London, in the pariſh of St Dunſtan's in the Weſt. At what ſchool he received the rudiments of his education, a circumſtance which the biographers of men eminent in the republic of letters ſhould never omit, we have not been able to learn; but on the 27th of September 1661, when he had juſt completed his 16th year, he was admitted a ſcholar of Wadham college, Oxford. Some time afterwards, on the recommendation of Henry Coventry, Eſq; one of the ſecretaries of ſtate, he was choſen probationer fellow of All-ſouls college. As Wood informs us that he had here a *Legiſt's place*, an expreſſion by which we underſtand a law fellowſhip, it is not wonderful that he took his degrees in the civil law, though phyſic and the phyſical ſciences were the favourite objects of his ſtudy. He was indeed an eminent phyſician, practiſing both in London and in Bath, but in the latter city chiefly in the ſummer months, till the year 1679, when he died, ſome time during the month of September, in the houſe of an apothecary in York-ſtreet, Covent Garden, and was buried in the church of that pariſh He had been married, ſays Wood, a little before his death, not altogether to his content; and indeed he muſt have been very diſcontented, if he choſe to die in the houſe of a friend rather than in his own. He publiſhed, "Tractatus quinque medico phyſici, 1. De ſalnitro; 2. De reſpiratione; 3. De reſpiratione fœtus in utero et ovo; 4. De motu muſculari et ſpiritibus animalibus; 5. De Rachitide." Theſe were publiſhed together in 8vo at Oxford, in 1674; but there is an edition of two of them, "De reſpiratione," and "De Rachitide," publiſhed together at Leyden in 1671.

The fame of this author has been lately revived and extended by Dr Beddoes, who publiſhed, in 1790, "Chemical Experiments and Opinions, extracted from a work publiſhed in the laſt century," 8vo; in which he gives to Mayow the higheſt credit as a chemiſt, and aſcribes to him ſome of the greateſt modern diſcoveries reſpecting air, giving many extracts from the three firſt of his treatiſes. His chief diſcovery was, that oxygen gas, to which he gave the name of *fire air*, exiſts in the nitrous acid, and in the atmoſphere; which he proved by ſuch deciſive experiments, as to render it impoſſible to explain how Boyle and Hales could avoid availing themſelves, in their reſearches into air, of ſo capital a diſcovery. Mayow alſo relates his manner of paſſing aeriform fluids under water, from veſſel to veſſel, which is generally believed to be a new art. He did not collect dephlogiſticated air in veſſels, and transfer it from one jar to another, but he proved its exiſtence by finding ſubſtances that would burn in vacuo, and in water when mixed with nitre; and after animals had breathed and died in veſſels filled with atmoſpheric air, or after fire had been extinguiſhed in them, there was a reſiduum which was the part of the air unfit for reſpiration, and for ſupporting fire; and he further ſhewed, that nitrous acid cannot be formed, but by expoſing the ſubſtances that generate it to the atmoſphere. Mayow was undoubtedly no common man, eſpecially ſince, if the above dates are right, he was only 34 at the time of his death. But he was not ſo unknown as Dr Beddoes ſuppoſed; for ſince the repetition of the ſame diſcovery by Prieſtley and Scheele, reference has frequently been made by chemiſts to Mayow as the original inventor; thus allowing to him a ſpecies of merit, to which he has perhaps but a doubtful claim, and which, if that claim be well founded, muſt certainly be ſhared between him and Dr Hooke. See HOOKE in this *Supplement*.

Mean, Meaſure

MEAN, in general. See *Encycl.*

Arithmetical Mean, is half the ſum of the extremes. So 4 is an arithmetical mean between 2 and 6, or between 3 and 5, or between 1 and 7; alſo an arithmetical mean between a and b is $\frac{a+b}{2}$, or $\frac{1}{2}a+\frac{1}{2}b$.

Geometrical Mean, commonly called a mean proportional, is the ſquare root of the product of the two extremes; ſo that, to find a mean proportional between two given extremes, multiply theſe together, and extract the ſquare root of the product. Thus, a mean proportional between 1 and 9, is $\sqrt{1\times9}=\sqrt{9}=3$; a mean between 2 and $4\frac{1}{2}$ is $\sqrt{2\times4\frac{1}{2}}=\sqrt{9}=3$ alſo; the mean between 4 and 6 is $\sqrt{4\times6}=\sqrt{24}$; and the mean between a and b is $\sqrt{ab}$.

Harmonical Mean. See *Harmonical Proportion*, Encycl.

Mean and Extreme Proportion, or *Extreme and Mean Proportion*, is when a line or any quantity is ſo divided that the leſs part is to the greater, as the greater is to the whole.

Mean Anomaly of a Planet, is an angle which is always proportional to the time of the planet's motion from the aphelion or perihelion, or proportional to the area deſcribed by the radius vector; that is, as the whole periodic time in one revolution of the planet, is to the time paſt the aphelion or perihelion, ſo is 360° to the mean anomaly. See ANAMOLY, *Encycl.*

Mean Conjunction or *Oppoſition*, is when the mean place of the ſun is in conjunction, or oppoſition, with the mean place of the moon in the ecliptic.

Mean Diſtance of a Planet from the Sun, is an arithmetical mean between the planet's greateſt and leaſt diſtances.

Mean Motion, is that by which a planet is ſuppoſed to move equably in its orbit; and it is always proportional to the time.

Mean Time, or *Equal Time*, is that which is meaſured by an equable motion, as a clock; as diſtinguiſhed from apparent time, ariſing from the unequal motion of the earth or ſun.

UNIVERSAL or PERPETUAL MEASURE, is a kind of of meaſure unalterable by time or place, to which the meaſures of different ages and nations might be reduced, and by which they may be compared and eſtimated. Such a meaſure would be very uſeful if it could be attained; ſince, being uſed at all times, and in all places, a great deal of confuſion and error would be avoided.

It has been attempted, at different times and in different countries, more eſpecially by the French, who, ſince the commencement of their revolutionary government, have laboured hard to obtrude their innovations in arts and ſcience, as well as in politics, upon all nations. Propoſals, however, have been made by ſoberer men for a ſtandard both of weights and of meaſures for all nations; and ſome of the moſt rational of theſe ſhall be noticed under the word WEIGHTS in this *Supplement*.

MECHANICS.—Our readers will recollect that in the article PHYSICS, *Encycl.* we propoſed to diſtinguiſh by the term *Mechanical Philoſophy* that part of natural ſcience which treats of the local motions of bodies, and the cauſes of thoſe phenomena. And, although all the changes which we obſerve in material nature are accompanied by local motion, and, when completely explained, are the effects (perhaps very remote) of thoſe powers of matter which we call *moving forces*, and of thoſe alone, yet, in many caſes, this local motion is not obſerved, and we only perceive certain ultimate reſults of thoſe changes of place. This is the caſe (for example) in the ſolution of a grain of ſilver in a phial of aquafortis. In the beginning of the experiment, the particles of ſilver are contained in a ſmall ſpace at the bottom of the phial; but they are finally raiſed from the bottom, and uniformly diſſeminated over the whole fluid. If we fix our attention ſteadily on one particle, and trace it in its whole progreſs, we contemplate nothing but a particle of matter acted on by moving forces, and yielding to their action. Could we ſtate, for every ſituation of the particle, the direction and intenſity of the moving force by which it is impelled, we could conſtruct a figure, or a formula, which would tell us the preciſe direction and velocity with which it changes its place, and we could delineate its path, and tell the time when it will arrive at that part of the veſſel where it finally reſts in perfect equilibrium. Newton having done all this in the caſe of bodies acted on by the moving force called gravity, has given us a complete ſyſtem of mechanical aſtronomy. The philoſopher who ſhall be as fortunate in aſcertaining the paths and motions of the particles of ſilver, till the end of this experiment, will eſtabliſh a ſyſtem of the mechanical ſolution of ſilver in aquafortis; and the theorems and formulæ which characteriſe this particular moving force, or this modification of force, ſtating the laws of variation by a change of diſtance, will be the complete theory of this chemical fact. It is this modification of moving force which is uſually (but moſt vaguely) called the *chemical affinity*, or the *elective attraction of ſilver and aquafortis*.

But, alas! we are, as yet, far from having attained this perfection of chemical knowledge. All that we have yet diſcovered is, that the putting the bit of ſilver into the ſpirit of ſalt will not give occaſion to the exertion of this moving force; and we expreſs this obſervation, by calling that unknown force (unknown, becauſe we are ignorant of the law of its action) an *affinity*, an *elective* attraction. And we have obſerved many ſuch elections, and have been able to claſs them, and to tell on what occaſions they will or will not be exerted; and this ſcrap of the complete theory becomes a moſt valuable acquiſition, and the claſſification of thoſe ſcraps a moſt curious, and extenſive, and important ſcience. The chemical philoſopher has alſo the pleaſure of ſeeing gradual approaches made by ingenious men to the complete mechanical explanation of theſe unſeen motions and their cauſes, of which he has arranged the ultimate reſults.

The ordinary chemiſt, however, and even many moſt acute and penetrating enquirers, do not think of all theſe motions. Familiarly converſant with the reſults, they conſider them as principles, and as topics to reaſon from. They think a chemical phenomenon ſufficiently explained, when they have pointed out the affinity under which it is arranged. Thus they aſcribe the propagation of heat to the expanſive nature of fire, and imagine that they conceive clearly how the effect is produced. But if a mathematical philoſopher ſhould ſay, "What is this which you call an expanſive fluid? Explain to me diſtinctly, in what manner this property which you call expanſiveneſs operates in producing the propagation of heat."—We imagine that the chemiſt would find himſelf put to a ſtand. He will then, perhaps for the firſt time, try to form a diſtinct conception of an expanſive fluid, and its manner of operation. He will naturally think of air, and will reflect on the manner in which air actually expands or occupies more room; and he will thus contemplate local motion and mechanical preſſure. He will find, too late, that this gives him no aſſiſtance; becauſe the phenomena which he has been accuſtomed to explain by the expanſiveneſs of fluids have no reſemblance whatever to what we ſee reſult from the actual expanſion of air. Experience has made him acquainted with many effects which the air produces during its expanſion; but they are of a totally different kind from thoſe which he thought that he had ſufficiently explained by the expanſiveneſs of fire. The only reſemblance he obſerves is, that the air and the heat, which were formerly perceived only in a ſmall ſpace, now appear in a much larger ſpace. The mathematician now deſires him to tell in what manner he conceives this expanſiveneſs, or this actual expanſion of air or gas. The chemiſt is then obliged to conſider the air or gas as conſiſting of atoms or particles, which muſt be kept in their preſent ſituation by an external force, the moſt familiar of all to his imagination, namely, preſſure; and all preſſures are equally fit. Preſſure is a moving force, and can only be oppoſed to ſuch another moving force; therefore expanſiveneſs ſuppoſes, that the particles are under the influence of ſomething which would ſeparate them from each other, if it were not oppoſed by ſomething *perfectly of the ſame kind*. It cannot be oppoſed by greenneſs, nor by loudneſs, nor by fear, but only by what is competent to the production of motion; and it may be oppoſed by any *ſuch* natural power; therefore by gravity, or by magnetiſm, or electricity, or corpuſcular attraction, or by an elective attraction. The chemiſt, being thus led to the contemplation of the phenomenon in its moſt ſimple ſtate, can now judge with ſome diſtinctneſs, what is the nature of thoſe powers with which expanſiveneſs can

be

be brought to co-operate or combine. And only now will he be able to ſpeculate on the means for explaining the propagation of heat; and he will perceive, that the general laws of motion, and of the action of moving forces (doctrines which we comprehended under the title of DYNAMICS, *Suppl.*), muſt be reſorted to for a *complete* explanation of all chemical phenomena. The ſame may be ſaid of the phenomena perceived in the growth of vegetables and animals. All of them lead us ultimately to the contemplation of an atom, which is characteriſed by being ſuſceptible of local motion, and requires for this purpoſe the agency of what we call a moving force.

We would diſtinguiſh this particular OBJECT of our CONTEMPLATION (conſiſting of two conſtituent parts, the atom and the force, related, in fact, to each other by conſtant conjunction) by the term MECHANISM. We conceive it to be the characteriſtic of what we call MATTER; and we would conſider it as the moſt ſimple MECHANICAL PHENOMENON. We are diſpoſed to think, that this moving force is as ſimple and uniform as the atom to which it is related; and we would aſcribe the inconceivable diverſity of the moving forces which we ſee around us to combinations of this univerſal force exerted by many atoms at once; and therefore modified by this combination, in the very ſame manner as we frequently ſee thoſe ſeemingly different moving forces combine their influence on a ſenſible maſs of tangible matter, giving it a ſenſible local motion. Having formed ſuch notions, we would ſay that we do not conceive either the atom or the force as being matter, but the two thus related. And we would then ſay, that whatever object of contemplation does not ultimately lead us to this complex notion is IMMATERIAL; meaning by the epithet nothing more than the negation of this particular character of the object. It is equivalent to ſaying, that the phenomenon does not lead the mind to the conſideration of an atom actuated by a moving force; that is, moved, or prevented from moving, by an oppoſite preſſure or force.

Such is the extenſion which the diſcoveries of laſt century have enabled us to give to the uſe of the term mechaniſm, mechanical action, mechanical cauſe, &c.

The Greeks, from whom we have borrowed the term, gave it a much more limited meaning; confining it to thoſe motions which are produced by the intervention of machines. Even many of the naturaliſts of the preſent day limit the term to thoſe motions which are the *immediate* conſequences of impulſe, and which are caſes of ſenſible motion. Thus the chemiſt ſays, that printers ink is a mechanical fluid, but that ink for writing is a chemical fluid. We make no objection to the diſtinction, becauſe chemiſtry is really a vaſt body of real and important ſcience, although we have, as yet, been able to claſs only very complicated phenomena, and are far from the knowledge of its elements. This diſtinction made by the chemiſts is very clear, and very proper to be kept in view; but we ſhould be at a loſs for a term to expreſs the analogy which is perceivable between theſe ſenſible motions and the hidden motions which obtain even in the chemical phenomena, unleſs we give mechaniſm a ſtill greater extenſion than the effects of percuſſion or impulſion.

Mechanics, in the ancient ſenſe of the word, conſiders only the energy of *organa*, machines. The authors who have treated the ſubject ſyſtematically, have obſerved, that all machines derive their efficacy from a few ſimple forms and diſpoſitions, which may be given to that piece of matter called the *tool*, ’Οργανον, or *machine*, which is interpoſed between the workman or natural agent, and the taſk to be performed, which is always ſomething to be moved, in oppoſition to reſiſting preſſures. To thoſe ſimple forms they have given the name of MECHANICAL POWERS, ſimple powers, ſimple machines.

The machine is interpoſed for various reaſons.

1. In order to enable a natural power, having a certain determinate intenſity, which cannot be increaſed, to balance or overcome another natural power, acting with a greater intenſity. For this purpoſe, a piece of ſolid matter is interpoſed, connected in ſuch a manner with firm ſupports, that the preſſure exerted on the impelled point by the power occaſions the excitement of a preſſure at the working point, which is equal or ſuperior to the reſiſtance, ariſing from the work, to the motion of that point. Thus, if a rod three feet long be ſupported at one foot from the end to which the reſiſtance of two pounds is applied, and if a preſſure of one pound be applied to the other end of the rod, perpendicular to its length, the coheſive forces which connect the particles of the rod will all be excited, in certain proportions, according to their ſituation, and the ſupported point will be made to preſs on its ſupport as much as three pounds would preſs on it; and a preſſure in the oppoſite direction will be excited at the working point, equal to the preſſure of two pounds. The reſiſtance will therefore be balanced, and it will be overcome by increaſing the natural power acting on the long diviſion of the rod. This is called a LEVER. Toothed wheels and pinions are a perpetual ſucceſſion of levers in one machine or mechanical power.

2. The natural power may act with a certain velocity which cannot be changed, and the work requires to be performed with a greater velocity. A machine is interpoſed, moveable round a fixed ſupport, and the diſtances of the impelled and working points are taken in the proportion of the two velocities. Then are we certain, that when the power acts with its natural velocity, the working point is moving with the velocity we deſire.

3. The power may act only in one unchangeable direction, and the reſiſtance muſt be overcome in another direction. As when a quantity of coals muſt be brought from the bottom of a pit, and we have no power at command but the weight of a quantity of water. We let the water pull down one end of a lever, either immediately or by a rope, and we hang the coals on the other end, while the middle point is firmly ſupported. This lever may be made perpetual, by lapping the ropes round a cylinder which turns round an axis firmly ſupported. This is a FIXED PULLEY. We can ſet unequal powers in oppoſition, by lapping each rope round a different cylinder, having the ſame axis. This is a WINDLASS or GIN. All theſe forms derive their energy from the lever virtually contained in them.

Any of theſe three purpoſes may be gained by the interpoſition of a ſolid body in another way. Inſtead of being ſupported in one point, round which it is moveable, it may be ſupported by a ſolid path, along which it is impelled, and by its ſhape it thruſts the reſiſting body out of its way. This is the caſe with the WEDGE when it is employed to force up a ſwagging joiſt, or preſs things ſtrongly together. If this wedge be lapped or formed round an axis, it becomes a SCREW or a SPIRAL WIPER. This is alſo the operation of the balance wheel of a horizontal or cylinder watch. The oblique face of the tooth is a wedge, which thruſts the edge of the cylinder out of its way The pallet of a clock or watch is alſo a wedge, acted on in the oppoſite direction.

Theſe are the different forms in which a ſolid body is interpoſed as a mechanic power. All are reducible to the lever and the wedge.

But there are other mechanic powers beſides thoſe now mentioned. The carmen have a way of lowering a caſk of liquor into a cellar, by paſſing a rope under it, making the end faſt to ſome ſtake cloſe to the ground, and bringing the other end of the rope round the caſk, and thus letting it ſlip down in the bight of the rope. In this proceſs they feel but half of its weight, the other half being ſupported by the end of the rope that is faſtened to the ſtake. This is called a PARBUCKLE by the ſeamen. A hanging pulley is quite the ſame with this more artleſs method. The weight hangs by the axis of the pulley, and each half of the hanging rope carries half of the weight, and the perſon who pulls one of them upwards acts only againſt half of the weight, the other being carried by the hook to which the ſtanding rope is faſtened. This mechanical power does not (as is commonly imagined) derive its efficacy from the pulley's turning round an axis. If it were made faſt, or if the tackle rope merely paſſed through a loop of the rope which carries the weight, it would ſtill require only half of the weight acting on the running rope to balance it. The uſe of the motion round an axis is merely to avoid a very great friction. When the two hanging parts of the rope are not parallel, but inclined in any angle, the force neceſſary for balancing the weight is to the weight as the ſide is to the diagonal of the parallelogram formed by the directions of the three ropes. Varignon calls this the FUNICULAR MACHINE or power. Our ſailors call it the SWIGG.

We may employ the *quaqua verſum* preſſure of fluidity with great effect as a mechanic power. Thus, in the hydroſtatic bellows deſcribed by Graveſande, § 1451, and by Deſaguilliers, the weight of a few ounces of water is made to raiſe ſeveral hundred pounds. In like manner, Dr Wallis of Oxford, by blowing with a pipe into a bladder, raiſed 64 pounds lying on it. Otto Guericke of Magdeburgh made a child balance, and even overcome, the pull exerted by the emperor's ſix coach horſes, by merely ſucking the air from below a piſton. Mr Bramah, ironmonger in Piccadilly, London, has lately obtained a patent for a machine acting on this principle as a preſs*. A piſton of one-fourth of an inch in diameter, forces water into a cylinder of 12 inches diameter, and by this intervention raiſes the piſton of the cylinder. A boy, acting with the fourth part of his ſtrength on the ſmall piſton by means of a lever, raiſes 42 tons, or 94,080 libs, preſſing on the great piſton. It is very ſurpriſing, that this application of the *quaqua verſum* preſſure of fluids has been overlooked for more than a century, although the principle has been inculcated and lectured on by every itinerant teacher, and illuſtrated by the above mentioned experiments of Graveſande and Wallis; nay, it has been expreſsly taught as a mechanic power of great efficacy by the Profeſſor of Natural Philoſophy at Edinburgh every ſeſſion of the college for theſe twenty years paſt, but he never thought of putting it in practice. It forms a moſt compendious machine of prodigious power, and is ſuſceptible of the greateſt ſtrength. If the ſame multiplication of power be attempted by toothed wheels, pinions, and racks, it is ſcarcely poſſible to give ſtrength enough to the teeth of the racks, and the machine becomes very cumberſome and of great expence. But Mr Bramah's machine may be made abundantly ſtrong in very ſmall compaſs. It only requires very accurate execution. We give it all praiſe; but Mr Bramah is miſtaken when he publiſhes it as the invention or diſcovery of a new mechanic power: for it has been familiar to every ſtudent of mechanics and hydroſtatics ever ſince Boyle's firſt publication of his hydroſtatic paradoxes.

MEDICAL JURISPRUDENCE. See *MEDICINA Forenſis* in this *Suppl.*

MEDICI, is the name of an illuſtrious family in Florence, which contributed more than perhaps any other family whatever to the revival of letters in Europe. To trace this family from its origin, or even to give biographical ſketches of all the great men whom it produced, would occupy by far too great a part of our work; for, during ſome centuries, almoſt every individual of the houſe of Medici was diſtinguiſhed among his contemporaries. That houſe, after having rendered itſelf memorable in the annals of Florence, for oppoſing the encroachments of the nobles on the liberties of the people, had loſt much of its influence under the ariſtocratic government of the Albizi, when it was raiſed to a rank ſuperior to what it had ever held, by

Giovanni de MEDICI, who was born in the year 1360. This man determined to reſtore his family to ſplendour; but, conſcious of his critical ſituation, ſurrounded as he was by powerful rivals and enemies, he affected rather a ſecure privacy than a dangerous popularity. Even when raiſed to the office of gonfalonier, or generaliſſimo of the republic, he carefully avoided any deſire of partaking in the magiſtracy, and ſeemed to be entirely engroſſed by merchandize, which he extended from the Eaſt throughout Europe. This conduct, as on one hand it threw his enemies off their guard, on the other, enabled him to acquire an immenſe fortune, of which he made a proper diſpoſition amongſt all ranks of people.

Many, even of the ruling party, either gained by his liberality, or pleaſed with his amiable and retired conduct, propoſed to the ſeigniory to admit him into the magiſtracy; and though the propoſal met with great oppoſition, it was carried in the affirmative.

It was by raſhly declaring for the plebeians againſt the nobles that an anceſtor of Giovanni's had loſt to his family their rank in the ſtate. Giovanni, reſolving not to ſplit on the ſame rock, continued to affect privacy and retirement, accepting any office in the ſtate with the utmoſt appearance of reluctance, and never attending at the Palazzo, unleſs particularly ſent for by the ſeigniory. Riſing by theſe means in the eſteem of the people, his enemies became, of courſe, unpopular; and having obtained a decided ſuperiority over his opponents, he now ventured to procure, that thoſe taxes which the nobles had exacted with the utmoſt ſeverity and partiality from the people alone, ſhould be levied upon

---

* e MA- C ERY s S. l.

Medici.

upon the two firſt orders, in common with the plebeians; and that a law ſhould be ordained, by which perſonal property might be taxed.

The nobles ſeeing, with the deepeſt concern, their conſequence ſo ſenſibly wounded, and their power ſo much diminiſhed, held ſeveral conſultations in private how they might effect his ruin; but their want of unanimity prevented any thing deciſive from being carried into execution. The people, alarmed for the ſafety of their leader and patron, offered him the ſovereignty, which his relations and friends urged him to accept; but this his prudence forbad him to take, as with the title of lord he would have gained alſo that of tyrant. Thus, by his ſingular prudence, he died poſſeſſed of all the power of the ſtate, with the affectation of being the moſt diſintereſted citizen in the commonwealth. His death happened in the year 1428.

Giovanni was graceful in his perſon, and his affability to all eſtabliſhed his character for moderation. His extenſive knowledge and pleaſantry made his company eagerly ſought. As all his actions were placid and ſerene, he was not in want of that trumpet of ſedition, popular declamation, which he never attempted. Much to his honour, his elevation was not procured even by the baniſhment of a ſingle individual; a circumſtance until then unknown in Florence, where every new adminiſtration was marked with the ruin of families, and by ſcaffolds ſtained with blood.

"The maxims (ſays Mr Roſcoe) which, uniformly purſued, raiſed the houſe of Medici to the ſplendour which it afterwards enjoyed, are to be found in the charge given by this venerable old man, on his deathbed, to his two ſons Coſmo and Lorenzo. 'I feel (ſaid he) that I have lived the time preſcribed me. I die content, leaving you, my ſons, in affluence and in health, and in ſuch a ſtation, that, whilſt you follow my example, you may live in your native place honoured and reſpected. Nothing affords me more pleaſure than the reflection, that my conduct has given offence to no one; but that, on the contrary, I have endeavoured to ſerve all perſons to the beſt of my abilities. I adviſe you to do the ſame. With reſpect to the honours of the ſtate, if you would live with ſecurity, accept only ſuch as are beſtowed on you by the laws, and the favour of your fellow-citizens; for it is the exerciſe of that power which is obtained by violence, and not of that which is voluntarily given, that occaſions hatred and contention."

Medici (Coſmo de), the eldeſt ſon of the preceding, was born in 1389. During the life-time of his father, he had engaged himſelf deeply, not only in the extenſive commerce by which the family had acquired its wealth, but in the weightier matters of government. When Giovanni died he was in the prime of life; and though his complexion was ſwarthy, he had an agreeable perſon, was well made, of a proper ſtature, and in converſation united a happy intermixture of gravity with occaſional ſallies of pleaſantry and repartee. His conduct was uniformly marked by urbanity and kindneſs to the ſuperior ranks of his fellow-citizens, and by a conſtant attention to the intereſts and the wants of the lower claſs, whom he relieved with unbounded generoſity. By theſe means he acquired numerous and zealous partizans of every denomination; but he rather conſidered them as pledges for the continuance of the power which he poſſeſſed, than as inſtruments to be employed in extending it to the ruin and ſubjugation of the ſtate. An interchange of reciprocal good offices was the only tie by which the Florentines and the Medici were bound; and perhaps the long continuance of this connection may be attributed to the very circumſtance of its being in the power of either of the parties at any time to have diſſolved it.

Medici.

But the prudence and moderation of Coſmo could not repreſs the ambitious deſigns of thoſe rival families, who wiſhed to poſſeſs or to ſhare his authority. In the year 1433, Rinaldo de Albizi, at the head of a powerful party, carried the appointment of the magiſtracy. At that time Coſmo had withdrawn to his ſeat in the country, to avoid the diſturbances which he ſaw likely to enſue; but at the requeſt of his friends he returned to Florence, where he was led to expect ſuch a union of parties, as might at leaſt preſerve the peace of the city. No ſooner did he make his appearance in the palace, where his preſence had been requeſted, on pretence of his being intended to ſhare in the adminiſtration of the republic, than he was ſeized upon by his adverſaries, and committed to priſon.

The conſpirators were divided in their opinions as to the diſpoſal of their priſoner. Moſt of them inclined to follow the advice of Peruzzi, who recommended taking him off by poiſon. Coſmo, confined in the Alberzettino, a room in one of the turrets of the Palazzo, could hear this dreadful conſultation, which was determining, not in what manner he ſhould be tried, but in what manner he ſhould be put to death; and finding that he was to die by an infuſion of poiſon ſecretly adminiſtered to him, a ſmall portion of bread was the only food which he thought proper to take.

Coſmo lived in this manner four days; and, ſhut up from all his kindred and friends, he ſoon expected to be numbered with the dead; but here, as it ſometimes happens, he found relief where leaſt expected, from the man who had been engaged to take him off. Malavolta, the keeper of the priſon, either from compunction, diſſatisfaction, or the youth and misfortunes of the illuſtrious ſufferer, relented; and inſtead of purſuing any criminal intentions againſt the life of Coſmo, after upbraiding him with entertaining ſo unworthy an opinion of him, declared that his fears were entirely groundleſs. To convince him of this, he ſat down, and partook of every thing the priſoner choſe to eat of. The expreſſions of gratitude, together with his moſt engaging manners, and great promiſes, entirely won Malavolta, who, to ingratiate himſelf ſtill farther in the good opinion of Coſmo, invited Fargaccio, the moſt celebrated wit in Florence, to dine with him the next day, from the idea that his ſprightly mirth would contribute to lighten his misfortunes.

In the mean time, his brother Lorenzo, and his couſin Averardo, having raiſed a conſiderable body of men in Romagna and other neighbouring diſtricts, and being joined by the commander of the troops of the republic, approached towards Florence to his relief. The apprehenſion, however, that the life of Coſmo might be endangered, if they ſhould proceed to open violence, induced them to abandon their enterpriſe. At length Rinaldo and his adherents obtained a decree of the magiſtracy, by which Coſmo was baniſhed to Padua for ten years, his brother to Venice for five years; and ſeveral

veral of their relations and adherents ſhared the ſame fate.

Coſmo received this determination of his judges with a compoſure that gained him the compaſſion and the admiration of many of his moſt inveterate enemies. He would gladly have left the city purſuant to his ſentence; but he was detained by his enemies till their authority ſhould be eſtabliſhed: and it was not till he thought of bribing the gonfalonier, and another creature of Rinaldo's, that he was privately taken from his confinement, and conducted out of Florence.

Padua, to which he was confined by his ſentence, was in the dominions of Venice; but before he could reach that place, he received a deputation from the ſenate, the purport of which was to condole with him for his misfortunes, and to promiſe him their protection and aſſiſtance in whatever he ſhould deſire. He experienced the treatment of a prince rather than that of an exile. Nor were that wiſe people without good reaſons for ſuch a conduct. Venice had long regarded Florence as her rival in commerce, and hoped, by conferring upon Coſmo the moſt flattering diſtinctions, to prevail upon him to reſide there in future; prudently ſuppoſing, that the manufactories of Florence, and the great commerce the Medici had carried on throughout Italy, and extended far beyond it to the wealthieſt kingdoms in Europe, would become their own by enrolling him amongſt their ſubjects.

The readineſs with which Coſmo had given way to the temporary clamour raiſed againſt him, and the reluctance which he had ſhewn to renew thoſe rencounters which had ſo often deluged the ſtreets of Florence with blood, gained him new friends, even during his exile. The utmoſt exertions of his antagoniſts could not long prevent the choice of ſuch magiſtrates as were known to be attached to the cauſe of the Medici; and no ſooner did they enter on their office, than Coſmo and his brother were recalled, and Rinaldo with his adherents were compelled to quit the city. This event took place about a year after the baniſhment of Coſmo.

The ſubſequent conduct of this great man (for great all allow him to have been) has been painted in different colours by different writers. Mr Noble, after Machiavel, compares his cruelties to his fallen foes with thoſe of Sylla and Octavius to the partizans of Marius and Brutus; whilſt Roſcoe repreſents his conduct as in a high degree amiable and generous. It appears to us evident, from his own words, that he had exerciſed ſome cruelties on his exiled enemies; for when one of them wrote to him, that "the hen was hatching," he replied, "She will have but a bad time of it, ſo far from her neſt." When ſome other exiles acquainted him that "they were not aſleep," he anſwered, "he could eaſily believe that, for he thought he had ſpoiled their ſleeping." At another time, ſome of the citizens remonſtrated with him upon the odiouſneſs of his conduct in baniſhing ſo many perſons; telling him, "the republic would be extremely weakened, and God offended, by the expulſion of ſo many good and pious men as he was ſending into baniſhment." His anſwer was, "It would be better for the republic to be weakened than utterly ruined; that two or three yards of fine cloth made many a one look like a good man; but that ſtates were not to be governed or maintained by counting a ſtring of beads, and mumbling over a few *Pater noſters*."

From this time the life of Coſmo de Medici was an almoſt uninterrupted ſeries of proſperity. His misfortunes had taught him, that the affectation of grandeur is more dangerous in a free ſtate than uſurpation. He adopted, therefore, the dreſs, behaviour, and manners, of a private citizen. His clothes were of the ſame faſhion and materials as the reſt of the Florentines. In the ſtreets he walked alone and unguarded. His table was ſupplied from what his eſtate of Mugello produced, nor had he one ſervant more than was abſolutely neceſſary; thus endeavouring to unite the character of a prince with that of a merchant, and a private perſon in a republic.

Whilſt he rejected all offices in the magiſtracy, no buſineſs was tranſacted without its being firſt ſettled at Mugello: nor did he contract any alliances but with the ſons and daughters of the citizens of Florence; yet all foreign princes and courts paid his children the reſpect due only to thoſe of ſovereigns; and the family of Coſmo received educations equal to thoſe of the greateſt potentates.

A proper judgment may be formed of his immenſe traffic, and the prodigious advantages accruing from it: For though a private citizen of Florence only, yet he poſſeſſed at one time more money than what was in all the treaſuries of the different ſovereigns in Europe. When Alfonſo king of Naples leagued with the Venetians againſt Florence, Coſmo called in ſuch immenſe debts from thoſe places, as deprived them of reſources for carrying on the war. During the conteſt between the houſes of York and Lancaſter, he furniſhed Edward IV. with a ſum of money ſo great, that it might almoſt be conſidered as the means of ſupporting that monarch on the throne.

In his public and private charities, in the number and grandeur of the edifices he erected, not only in Florence, but in the moſt diſtant parts of the world, and in the foundations which he endowed, he ſeemed to more than vie with majeſty. He ſupplied moſt of the exigencies of the ſtate from his private purſe; and there were few citizens that had not experienced his liberality, and many without the leaſt application, particularly the nobles.

But in nothing did his munificence produce ſo much good to the world, or acquire ſuch honour to himſelf, as when it was exerted for the promotion of ſcience, and the encouragement of learned men; and upon nothing did Coſmo delight ſo much to exert it. The ſtudy of the Greek language had been introduced into Italy towards the latter part of the preceding century; but it had again fallen into neglect. After a ſhort interval, an attempt was made to revive it, by the intervention of Emanuel Chryſoloras, a noble Greek, who taught that language at Florence, and other cities of Italy, about the beginning of the 15th century. His diſciples, who were numerous and reſpectable, kept the flame alive till it received new aid from other learned Greeks, who were driven from Conſtantinople by the dread of the Turks, or by the total overthrow of the Eaſtern Empire. To theſe illuſtrious foreigners, as well as to the learned Italians, who ſhortly became their ſucceſsful rivals, even in the knowledge of their national hiſtory and language, Coſmo afforded the moſt liberal ſupport and protection. The very titles of the works of ancient authors, which were brought to light by his munificence, would extend this article beyond its proper limits. Such, indeed, was the eſtimation in which theſe works were then held in Italy, that a manuſcript of the hiſtory of Livy, ſent by Coſmo de Medici to Alfonſo king of Naples, with whom he was at variance, conciliated the breach between them.

As the natural diſpoſition of Coſmo led him to take an active part in collecting the remains of the ancient Greek and Roman writers, ſo he was enabled by his wealth, and by his extenſive mercantile intercourſe with different parts of Europe and of Aſia, to gratify a paſſion of this kind beyond any other individual. To this end he laid injunctions on all his friends and correſpondents, as well as on the miſſionaries and preachers who travelled into the remoteſt countries, to ſearch for and procure ancient manuſcripts, in every language, and on every ſubject. The ſituation of the Eaſtern Empire, then falling into ruins, afforded him an opportunity of obtaining many ineſtimable works in the Hebrew, Greek, Chaldaic, Arabic, and other eaſtern languages. From theſe beginnings aroſe the celebrated library of the Medici; which, after various viciſſitudes of fortune, and frequent and conſiderable additions, has been preſerved to the preſent times under the name of the *Bibliotheca Mediceo Laurentiana*.

Nor was Coſmo a mere collector of books, he was himſelf, even in old age, a laborious ſtudent. Having been ſtruck with the ſublime ſpeculations of Plato, which he had heard detailed in lectures by a Greek monk, who had come from Conſtantinople to the council of Florence, he determined to found an academy for the cultivation of that philoſophy. For this purpoſe he ſelected Marſilio Ficino, the ſon of his favourite phyſician, and deſtined him, though very young, to be the ſupport of his future eſtabliſhment. The education of Ficino was entirely directed to the Platonic philoſophy; nor were the expectations which Coſmo had formed of him diſappointed. The Florentine academy was ſome years afterwards eſtabliſhed with great credit, and was the firſt inſtitution in Europe for the purſuit of ſcience, detached from the ſcholaſtic method then univerſally adopted. It is true, the fanciful doctrines of Plato are as remote from the purpoſes of life as the ſubtleties of Ariſtotle; but, by dividing the attention of the learned between them, the dogmas of the Stagyrite were deprived of that ſervile reſpect which had ſo long been paid to them, and men learned by degrees to think for themſelves.

The foſtering hand of Coſmo was held out to art as well as to ſcience; and architecture, ſculpture, and painting, all flouriſhed under his powerful protection. The countenance ſhewn by him to theſe arts was not ſuch as their profeſſors generally receive from the great. It was not conceded as a bounty, nor received as a favour, but appeared in the friendſhip and equality that ſubſiſted between the artiſt and his patron; and the ſums of money, which Coſmo expended on pictures, ſtatues, and public buildings, appear almoſt incredible.

Coſmo now approached the period of his mortal exiſtence; but the faculties of his mind remained unimpaired. About twenty days before he died, he ſent for Ficino, and enjoined him to tranſlate from the Greek the treatiſe of Xenocrates on death. Calling into his chamber his wife and his ſon Piero, he entered into a narrative of all his public tranſactions; in which he gave a full account of his extenſive mercantile connections, and adverted to the ſtate of his domeſtic concerns. To Piero he recommended a ſtrict attention to the education of his ſons; and requeſted, that his funeral might be conducted with as much privacy as poſſible. He died on the firſt of Auguſt 1464, at the age of 75 years, deeply lamented by a great majority of the citizens of Florence. Their eſteem and gratitude had indeed been fully ſhewn ſome time before, when, by a public decree, he was honoured with the title of *Pater Patriæ*, an appellation which was inſcribed on his tomb; and which, as it was founded, ſays Roſcoe, on real merit, has ever ſince been attached to the name of Coſmo de Medici.

Medici (Lorenzo de), juſtly ſtyled the *magnificent*, was the grandſon of Coſmo, and about 16 years of age when his grandfather died. His father Piero de Medici, though poſſeſſed of more than ordinary talents, as well as of a very conſiderable ſhare of worth, was, from various circumſtances, little qualified to maintain the influence which his family had gained in the republic of Florence. From very early life he had been tortured by the gout; and almoſt uninterrupted pain had made him peeviſh. Such a diſpoſition was not calculated to retain the affections of the giddy Florentines, or to perſuade republicans that they were free, while they ſubmitted to the government of a ſingle individual. All this Coſmo had foreſeen, and had done what wiſdom could do to preſerve to his family that aſcendency in the republic which he had himſelf acquired. He exhorted Piero to beſtow the utmoſt care on the education of his ſons, of whoſe capacity he expreſſed a high opinion; he recommended to him Diotiſalvo Neroni, a man whom he had himſelf raiſed from obſcurity to an eminent rank, as a counſellor, in whoſe wiſdom and fidelity he might place the utmoſt confidence: and to bind the inhabitants of Florence to the houſe of Medici by the ſtrongeſt of all ties, he had diſtributed among them, under the denomination of loans, immenſe ſums, which he knew they would not ſoon be able to repay.

Piero paid the utmoſt deference to the dying injunctions of his father. He had himſelf an ardent love of letters; and under the eye of the venerable Coſmo, he had given his two ſons, Lorenzo and Juliano, the beſt poſſible domeſtic education. In the Greek language, in ethics, and in the principles of the Ariſtotelian philoſophy, Lorenzo, the eldeſt, had the advantage of the precepts of the learned Argyropylus (A), and in thoſe of the Platonic ſect he was ſedulouſly inſtructed by Marſilio Ficino (ſee Ficinus, *Encycl.*); but for his moſt valuable accompliſhments he was not indebted to any preceptor. To complete his education, however, it was judged expedient that he ſhould viſit ſome of the principal courts of Italy; and very ſoon after the death of his grandfather, he repaired to Rome, Bologna, Ferrara, Venice, and Milan, where he gained the eſteem of all whoſe eſteem was of value.

(A) This man had fled from Conſtantinople, when it was taken by the Turks, to Florence, where he was protected by Coſmo de Medici.

Thus attentive was Piero to the advice of his father with reſpect to the education of his eldeſt ſon; nor was he leſs attentive to it in the choice of his principal counſellor. He intruſted the whole of his affairs into the hands of Neroni, and gave him Coſmo's accounts to peruſe and ſettle. That ambition, which perhaps had lain lurking in this man's mind, was now called forth, and he baſely formed the ſcheme of ruining the ſon of his patron, by building upon his misfortunes his own future grandeur. For this purpoſe, he lamented the abſolute neceſſity there was for an immediate call upon thoſe who were indebted to Piero as Coſmo's repreſentative; telling him, that a delay might ſubject him to the greateſt inconveniences. Piero conſented, though with reluctance, to his ſuppoſed friend's advice. The reſult was ſuch as Neroni expected. Thoſe who were friends of the father became enemies of the ſon; and had not Piero diſcovered the ſnare, and deſiſted from ſuch rigorous proceedings, he might have found, when too late, that in ſupporting the character of the merchant, he had forgotten that of the ſtateſman; for all the citizens of Florence were his debtors.

Soon after this, an attempt was made to aſſaſſinate Piero, by a powerful party which had always been inimical to the houſe of Medici; but it was defeated by Lorenzo, who diſplayed on that occaſion a ſagacity and promptitude of mind which would have done honour to the oldeſt ſtateſman. A few of the conſpirators were declared enemies to the ſtate, and condemned to baniſhment; but by far the greater part of them were pardoned on the ſolicitation of Lorenzo, who declared, that "he only knows how to conquer, who knows how to forgive."

In the year 1469 Piero de Medici died; and Lorenzo ſucceeded to his authority as if it had been a part of his patrimony, being requeſted by the principal inhabitants of Florence, that he would take upon himſelf the adminiſtration of the republic in the ſame manner that his grandfather and father had done.

In the month of December 1470, a league was ſolemnly concluded between the pope, the king of Naples, the duke of Milan, and the Florentines, againſt Mahomet II. who had vowed not to lay down his arms till he had aboliſhed the religion of Chriſt, and extirpated all his followers. The pope, however (Paul II.), died on the 26th of July 1471; and Sixtus IV. ſucceeding to the chair of St Peter, Lorenzo was deputed from Florence to congratulate him on his elevation. Two more oppoſite characters can hardly be conceived than thoſe of Sixtus and Lorenzo. The former was cruel, treacherous, and ſordid; the latter was merciful, candid, and generous. Yet ſuch inſtances of mutual good will took place between them on this occaſion, that Lorenzo, who, under the direction of his agents, had a bank eſtabliſhed at Rome, was formally inveſted with the office of treaſurer of the Holy See.

Piſa had been under the dominion of Florence from the year 1406, and it had acquired ſome celebrity on account of its academy, which had exiſted almoſt two centuries. That academy, however, had fallen into decay; and, in the year 1472, the Florentines reſolved to reſtore it to its priſtine ſplendour. Five citizens, of whom Lorenzo de Medici was one, were appointed to ſuperintend the execution of their purpoſe; but Lorenzo, who was the projector of the plan, undertook the chief management of it; and, in addition to 6000 florins annually granted by the ſtate, expended, in effecting his purpoſe, a large ſum of money from his private fortune. In doing this, he only imitated the example of his father and grandfather; for in the courſe of 37 years, reckoning from the return of Coſmo from baniſhment, this illuſtrious family had expended on works of charity or public utility upwards of 660,000 florins. "Some perſons (ſaid Lorenzo) would perhaps be better pleaſed to have a part of it in their purſe; but I conceive that it has been of great advantage to the public, and well laid out, and am therefore perfectly ſatisfied."

In the year 1474, Lorenzo incurred the diſpleaſure of the pope for oppoſing ſome of his encroachments on the petty princes of Italy; and the revenge planned by Sixtus was of ſuch a nature as would have diſgraced, we do not ſay a Chriſtian biſhop, but the rudeſt ſavage. He began by depriving Lorenzo of the office of treaſurer of the Roman See, which he gave to the Pazzi, a Florentine family, who, as well as the Medici, had a public bank at Rome. By this ſtep he ſecured the intereſt of the Pazzi, who, it is probable, were to govern Florence under the pope, when Lorenzo and Juliano de Medici ſhould be cut off, and their friends and adherents driven from the republic. The principal agent engaged in the undertaking was Franſeſco Salviati archbiſhop of Piſa, to which rank he had lately been promoted by Sixtus, in oppoſition to the wiſhes of the Medici. The other conſpirators were Giacopo Salviati, brother to the archbiſhop; Giacopo Poggio, one of the ſons of the celebrated Poggio Bracciolini (ſee POGGIUS, *Encycl.*); Barnardo Bandini, a daring libertine, rendered deſperate by the conſequence of his exceſſes; Giovanni Battiſti Monteſicco, who had diſtinguiſhed himſelf as general of the pope's armies; Antonio Maffei, a prieſt of Volterra; and Stephano de Bagnona, one of the apoſtolic ſcribes; with ſeveral others of inferior note. The cardinal Riario, then at Piſa, was likewiſe an inſtrument in the conſpiracy; but he can hardly be conſidered as an agent, for he was kept ignorant of what was going on, and enjoined only to obey whatever directions he might receive from the archbiſhop of Piſa.

The aſſaſſination of the illuſtrious youths was fixed for Sunday, April 26. 1478; the place the cathedral of Florence, at the moment the hoſt was to be elevated; and their murder was to be the ſignal for ſeizing and expelling from the walls of the city all their relations and friends. What a tranſaction this for one who preſumed to ſtyle himſelf the vicar of Chriſt, the common father of Chriſtendom, to patronize!

The fatal day arrived, and Lorenzo was already in the church; but Juliano remained at home, occaſioned by a ſlight indiſpoſition. The conſpirators, determining not to loſe one of their victims, went to invite, to intreat him, to go. They embraced (B), and led him, by a tender violence, to the cathedral. The ſignal was

---

(B) The aſſaſſins embraced Juliano, to diſcover whether he wore any ſecret armour, that they might know where to ſtrike with the ſureſt aim.

given by the elevation of the conſecrated wafer; and whilſt the people fell upon their knees to adore, the aſſaſſins roſe, and, as was concerted, two of them, Franciſco Pazzi and Barnardo Bandini, fell upon Juliano. The latter directed his poignard ſo truly, that it entered into the boſom of the unoffending youth, and he fell mortally wounded at his feet.

In a moment, as muſt be ſuppoſed, all was confuſion. Lorenzo, alarmed, put himſelf in a poſture of defence, when, in an inſtant, Antonio of Volterra, and Stephano a prieſt, the dependant of the archbiſhop, who, upon Giovanni Battiſti's declining the infamous taſk, undertook his deſtruction, ruſhed upon him as their deſtined prey. The conteſt continued ſome time. Lorenzo had received a wound in his neck, and ſeemed to contend for his life in vain; but a ſervant, whom he had lately relieved from priſon, inſpired by gratitude, heroically threw himſelf between his beloved lord and his aſſaſſins, receiving in his body thoſe weapons that were aimed at the breaſt of Lorenzo. This fidelity ſaved him; for by one vigorous effort he broke from Antonio and Stephano, and with a few friends ruſhed into the ſacriſty, ſhutting the doors behind them, which were of braſs. Apprehenſions being entertained, that the weapon which had wounded him was poiſoned, a young man ſucked the wound, endangering his own life to ſave that of Lorenzo.

The rage of the people to ſee one of their favourites expiring, and the other covered with blood, was inexpreſſible. The cardinal Riario found it difficult to ſave his life at that altar which he had ſtained by ſo horrid a deed, and to which he then fled for protection.

Whilſt this infamous ſcene was acting in the cathedral, others of the conſpirators were attempting to ſeize the Palazzo; but with no better ſucceſs. The archbiſhop Salviatti, who had undertaken to head them, gave the magiſtrates ſuſpicion by thoſe violent emotions which agitated his whole frame. The nine ſenators who compoſed the magiſtracy, including the gonfalonier, who had been appointed by, and were, in other words, the privy council of the Medici, immediately attacked thoſe who intended to have ſurpriſed them; and Salviatti and his followers had no ſooner gained the ſecond floor, than they found themſelves priſoners.

Jacobo Pazzi ſoon appeared in the ſtreet, proclaiming, with exultation, the murder of Juliano; and inviting the Florentines to free themſelves from the Medicean ſlavery; but perceiving that he was not joined by the people, the magiſtrates ſent off 100 horſe to the reſcue of Lorenzo. This was the more to be commended, becauſe they continued to be aſſaulted by the conſpirators, who, finding their ſituation deſperate, forced themſelves to the ground floor, determining, if poſſible, to ſeize the Palazzo. The magiſtrates, with their attendants, acted with ſuch reſolution and valour, that as often as they gained an entrance, they drove them back, killing ſome of the aſſailants upon the ſpot, others they threw out of the windows upon the pavement; and to ſtrike an awe into thoſe that were without, they had the boldneſs and virtue to hang the archbiſhop from one of the windows, dreſſed as he was in his pontifical robes, with Poggio, another of the chief conſpirators. Florence reſounded in every part with the exclamation—Medici, Medici! down with their enemies!

Lorenzo was liberated from that part of the cathedral to which he had fled, and conveyed home in triumph, where his wounds were attended to, and where he found himſelf ſurrounded by his moſt valuable friends, to whom he was endeared by the ſhocking occurrences of the day. His partizans, however, did not ſpend their time only in lamentations for the death of one of the brothers, and exultations for the preſervation of the other; they united in purſuing the conſpirators, ſparing none that fell into their hands. Jacobo Pazzi was taken flying with his forces into Romania, and immediately hung. An officer of the pope's, who commanded a brigade under count Hirronimo, had alone the favour of decapitation. Bandini fled privately to Piſa, thence to Naples, and, laſtly, to Conſtantinople; but Mahomet, to oblige Lorenzo, ſeized, and ſent him back; and he was hung out of the ſame window from which the archbiſhop had ſuffered. An embaſſy was ſent from Florence to thank the ſultan in the name of the republic.

Throughout the whole of this juſt but dreadful retribution, Lorenzo had exerted all his influence to reſtrain the indignation of the populace. He entreated that they would reſign to the magiſtrates the taſk of aſcertaining and of puniſhing the guilty, leſt the innocent ſhould be incautiouſly involved in deſtruction; and his appearance and admonitions had an inſtantaneous effect. By his moderation, and even kindneſs to the relatives of the conſpirators, he ſought to obliterate the remembrance of paſt diſturbances; and by his interference, even the ſurvivors of the Pazzi were reſtored to their honours, of which they had been deprived by a decree of the ſtate.

The generoſity and moderation of Lorenzo had no effect on the temper of Sixtus, who ſolemnly excommunicated him, the gonfalonier, the magiſtrates, and their immediate ſucceſſors; and in the bull which he iſſued on this occaſion, he ſtyles Lorenzo de Medici "the child of iniquity, and the nurſling of perdition!" Not content with this ebullition of reſentment, he ſuſpended the biſhops and clergy of the Florentine territories from the exerciſe of their ſpiritual functions; thus laying the whole republic under an interdict. This had been a formidable weapon in the hands of his predeceſſors, who had, by means of it, overawed the moſt powerful monarchs; but the general character of Sixtus was ſo infamous, and his preſent injuſtice ſo manifeſt, that by the exertions of the biſhop of Arezzo, a convocation was held in the cathedral church of Florence, in which Sixtus was accuſed of *fornication* and *adultery*, with other infamous vices; declared to be the principal inſtigator of the conſpiracy againſt the Medici; and the ſentence of excommunication which he had fulminated againſt Lorenzo and the Florentine magiſtrates was called in direct terms, the "execrable malediction of a damned judge (*maledictam maledictionem damnatiſſimi judicis*)!

How ſuch language could be reconciled to the notions which then prevailed of the ſanctity of the pope, and the plenitude of his power it is needleſs to inquire; but the reader will not be ſurpriſed that the prelates, who made uſe of it, paid no regard to the interdict of Sixtus. The pontiff, however, did not relax from his purpoſe. Whilſt he brandiſhed with one hand the ſpiritual weapon, which the Florentines treated with ſuch contempt, in the other, he graſped a temporal ſword, which he now openly, as he had before ſecretly, aimed at the breaſt of Lorenzo. At his inſtigation the king of Naples

diſpatched

diſpatched an envoy to Florence, to require the citizens to baniſh Lorenzo from the Tuſcan territories, if they would not incur the vengeance both of him and of the pope. Theſe threats produced not the intended effect; for the Florentines avowed their firm reſolution to ſuffer every extremity, rather than betray the man whom they conſidered as guardian of the republic. War therefore was commenced; and the republic was on the point of being ruined, when Lorenzo taking advantage of a truce, threw himſelf, with a reſolution not to be equalled, into the hands of the king of Naples. He judged, perhaps, that any ſtipulations for his perſonal ſafety would be uſeleſs with a prince who had ſported with honour, juſtice, mercy, and the moſt ſolemn treaties. But, whilſt all viewed him as a victim who had devoted himſelf to ſave his country, he, by perſuaſive eloquence, obtained of this crafty perfidious monarch a ſeparate peace, and returned to Florence crowned with a ſucceſs that no one thought poſſible, and where he was received as its tutelar deity. The pope, however, continued inflexible, till a deſcent of the Turks upon Italy reſtored him to his ſenſes, and made him willing to receive the ſubmiſſion of Florence, and reconcile its inhabitants to the church.

Soon after the termination of the hoſtilities between Sixtus and the republic of Florence, Lorenzo began to unfold plans for ſecuring the peace of Italy, which confer the higheſt honour on his political life. To counterpoiſe all the jarring intereſts of the petty ſtates of which that country was compoſed, to reſtrain the powerful, ſuccour the weak, and to unite the whole in one firm body which might be able, on the one hand, ſucceſsfully to oppoſe the formidable power of the Turks, and, on the other, to repel the incurſions of the French and Germans, were the important ends which this great man propoſed to accompliſh. But before he engaged in theſe momentous undertakings, he had further perſonal dangers to encounter. By the inſtigation of Cardinal Riario, and ſome Florentine exiles, one Battiſta Fraſcobaldi, with only two aſſiſtants, undertook to aſſaſſinate him in the church of the Carmeli, on the feſtival of the aſcenſion 1481; but the plot was diſcovered, the conſpirators executed, and Lorenzo henceforth ſeldom went abroad without being ſurrounded by a number of tried friends.

Lorenzo was now at liberty to proſecute his benevolent purpoſes; and after contributing to the expulſion of the Turks from Italy, he ſet himſelf in good earneſt to ſupport the weak ſtates againſt the encroachments of the more powerful. This neceſſarily embroiled the republic at one time with the pope, at another with the king of Naples; now with the Venetians, and then with the Duke of Milan: but when ſome exclaimed againſt him as being too precipitate in involving the republic in dangerous and expenſive wars, he explained to them the neceſſity of maintaining the balance of power, if they would preſerve the independence of their own ſtate; and ſo completely had he made himſelf maſter of this ſubject, that he convinced the moſt incredulous of the propriety of his meaſures, which, in 1488, introduced general tranquillity into Italy.

At this period, the city of Florence was at its higheſt degree of proſperity. The vigilance of Lorenzo had ſecured it from all apprehenſions of external attack; and his acknowledged diſintereſtedneſs and moderation had almoſt extinguiſhed that ſpirit of internal diſſenſion for which it had been ſo long remarkable. The Florentines gloried in their illuſtrious citizen, and were gratified by numbering in their body a man who wielded in his hands the fate of nations, and attracted the reſpect and admiration of all Europe.

Yet amidſt public affairs ſo intricate and ſo momentous, ſuch was the capacity of this man's mind, and ſuch his verſatility of genius, that, for the greater part of his life, he carried on a commerce as extenſive as that of his grandfather, whilſt he afforded ſtill greater encouragement to learning and learned men. Coſmo had greatly promoted the ſtudy of the ancient languages and ancient philoſophy. Lorenzo did the ſame thing: but he did much more; he encouraged the cultivation of his own tongue, which had been neglected ſince the age of Petrarca; and by ſetting a great example himſelf, he produced a race of Italian poets, which have hardly been ſurpaſſed in any age or nation. To enumerate even the names of the elegant ſcholars whom he patroniſed, would extend this article far beyond its limits. In the academy of Piſa, of which mention has been already made, the ſtudies were chiefly confined to the Latin language, and to thoſe ſciences of which it was the principal vehicle. At Florence the Greek tongue was taught under the ſanction of a public inſtitution, either by native Greeks or learned Italians, whoſe ſervices were procured by the diligence of Lorenzo de Medici, and repaid by his bounty. He placed Michael Angelo at the head of an academy, which he erected for painting and ſculpture, furniſhing it with the beſt models of antiquity. He built and endowed a public library, and ſent Laſcaris, of imperial deſcent, to Conſtantinople more than once, to procure Greek manuſcripts. For father Moriano, the orator, a monaſtery was built; and Florence owed many of her fineſt edifices to him. Politiano and Ficino were among his moſt intimate friends; and it is not perhaps too much to ſay, that he did more for letters and ſcience and art than any other individual that ever exiſted. His own acquirements in learning were great; and his poetry, of which the reader will find many ſpecimens in the elegant work of Roſcoe, was exquiſite.

Is it ſurpriſing, when we examine Lorenzo's character, that all Italy, all Chriſtendom, even the Mahometans, gave him the moſt flattering marks of approbation, and ſtrove who ſhould oblige him moſt, by preſenting him with whatever was rare and valuable? His palace was conſtantly filled with men famous in every elegant, every uſeful ſcience, and the neighbouring princes flocked to it as to the temple of wiſdom. The celebrated prince of Mirandola, on his account, choſe Florence for his reſidence, and died there.

To a moſt engaging perſon was added each grace, and every accompliſhment. He was the favourite of the ladies, the envy of the men, and the admiration of both. The ſtateſman of his time; unrivalled in chivalry; one of the moſt eminent orators that the world has produced. His poetic merit, with his judgment in, and patronage of that art, procured him the title of "Father of the Muſes." In liberality to his fellow-citizens, as well as in every other reſpect, except as a general, he exceeded even Cæſar himſelf; and had not peace been his dear delight, his talents would have made him a conſummate commander. Yet with all theſe ſuperior

perior accompliſhments, he did not think it beneath him to indulge in amuſements which perſons, leſs wiſe, would have thought an impeachment of their underſtanding, and he would often ſeek pleaſure in his nurſery, ſpending hours there in all the frivolous pranks of childiſh diverſion. In fine, "the gravity of his life, if compared with its levity, muſt make him appear as a compoſition of two different perſons, incompatible, and, as it were, impoſſible to be joined with the other."

Lorenzo, like moſt other great men, had wiſhed to ſpend his laſt years in the tranquillity of retirement. He therefore at an early period wound up his mercantile concerns, and divided his time between the cares of the republic at Florence, and the cultivation of his eſtates in the country. He wiſhed even to diveſt himſelf of all public concerns, and get his ſecond ſon Giovanni admitted into holy orders at the age of ſeven years, that he might be fit for eccleſiaſtical preferment before he ſhould be deprived of the protection of his father. The young eccleſiaſtic, who afterwards made ſuch a figure as Leo X. was accordingly appointed by Louis XI. of France, abbot of Fonte Dolac, before he was eight years of age; and by Innocent VIII. a cardinal, when he was little more than thirteen. This added much to the influence of the family, not only in the Tuſcan ſtates, but through all Italy; and Lorenzo having introduced his eldeſt ſon into public life, and accompliſhed a marriage between him and the daughter of a noble family at Rome, thought he might commit the affairs of the republic in a great meaſure to Piero, and indulge his own taſte in the converſation of his learned friends. This dream of felicity however was not realized. Early in the year 1492, he was attacked by a diſeaſe, under which he had long laboured, with ſuch violence, that on the 8th of April he died in the midſt of his weeping friends, after having taken of them, one by one, an affectionate farewel, and given to his ſon Piero much ſalutary counſel, which he thought not fit to follow.

The character of this great and good man is developed in the detail which we have given of his conduct through life: But it may not be improper to add, that ſuch was the love and veneration of the citizens to him, that the phyſician, who had attended him on his deathbed, afraid to return to Florence, left the houſe in a ſtate of diſtraction, and plunged himſelf into a well. Throughout the reſt of Italy the death of Lorenzo was regarded as a public calamity of the moſt alarming kind. Of the arch which ſupported the political fabric of that country he had long been conſidered as the centre, and his loſs ſeemed to threaten the whole with immediate deſtruction. When Ferdinand king of Naples was informed of the event, he exclaimed, "This man has lived long enough for his own glory, but too ſhort a time for Italy."

MEDICINA FORENSIS, is a phraſe uſed in Germany to denote thoſe parts of anatomical and phyſiological knowledge, which enable phyſicians and ſurgeons to decide certain cauſes as judges in courts of juſtice. In that country it has long been law and cuſtom (if we miſtake not, by the Caraline code of Charles V.) to refer caſes of *poiſoning*, *child murder*, *rape*, *pregnancy*, *impotency*, *ideotiſm*, &c. to the medical faculty, which, in the univerſities and ſome other great towns, is conſtituted into a kind of court for the trial of ſuch queſtions. In this country there are no ſuch courts; but in criminal trials medical gentlemen are often called upon to deſcribe the ſymptoms of *poiſoning*, *child-murder*, *rape*, &c. and therefore it becomes them to obtain an accurate knowledge of theſe ſymptoms, and to ſtore their memories with a number of minute facts, to which they may have occaſion to appeal when giving their evidence.

The importance of this ſubject induced the profeſſor of the inſtitutes of phyſic in the univerſity of Edinburgh to reſolve lately to read an annual courſe of lectures on MEDICAL JURISPRUDENCE. This, we doubt not, will prove a valuable courſe; for though it is hardly conceivable that, under the head *medical juriſprudence*, any *knowledge* can be communicated which a well educated phyſician would not neceſſarily have acquired, without attending ſuch a courſe; yet it is very obvious, that the recollection of the young phyſician may receive great aid from his liſtening to the well arranged lectures of an accurate profeſſor. From theſe lectures he may ſtore his mind with a collection of aphoriſms which ſhall be always ready on the day of examination; or the lectures themſelves may be delivered in queſtions and anſwers with all the formalities of a criminal court.

We have heard it obſerved, that to attend a courſe of ſuch lectures would be of the utmoſt advantage to all who may be called upon to ſerve as jurymen in criminal trials; but of the truth of this obſervation we are more than doubtful. Perſons who are only *half* inſtructed are always conceited of their own attainments; and men not acquainted with anatomy and phyſiology cannot be *more* than half inſtructed by the ableſt courſe poſſible to be given of medical juriſprudence. Such perſons indeed can hardly avoid miſtaking the ſenſe of the profeſſor's language, however perſpicuous that language may be. Of this we had lately a very ſtriking inſtance. A gentleman, by no means illiterate, though a ſtranger to anatomical and phyſiological ſcience, was expatiating to the writer of this article upon the general importance of medical juriſprudence, a courſe of which, he ſaid, he had attended for the ſole purpoſe of qualifying himſelf for diſcharging the important duties of a juryman. Upon being aſked what he had learned? he replied, that he had been taught, among other things which we thought frivolous, to diſcern, from the ſymptoms of *hanging*, whether the dead man had been hanged by *himſelf* or by *another*. We need not ſurely obſerve, that no ſuch leſſon was ever taught in any univerſity, or by any medical lecturer; but it is worthy of conſideration, whether lectures on medical juriſprudence may not have the moſt pernicious effects on the minds of men ſo little qualified as this gentleman to profit by them. To the regularly educated phyſician and ſurgeon ſuch lectures may prove uſeful; to the plain citizen, not ſkilled in anatomy and phyſiology, they muſt prove dangerous; as their only tendency is to make him deſpiſe the evidence given before him by the regular phyſician or ſurgeon; to place implicit confidence in his own ſuperficial knowledge; and thus to decide at random on the life or death of his fellow-creature:

A little learning is a dangerous thing;
Drink deep, or taſte not the Pierian ſpring.

MEDINA, the capital of the kingdom of Woolli in Africa, is ſituated in 13° 40′ N. Lat. and 12° 40′ W. Long. It is a place of conſiderable extent, and may contain from 800 to 1000 houſes. It is fortified in the

edusa,
egame-
ter.

common African manner, by a ſurrounding high wall built of clay, and an outward fence of pointed ſtakes and prickly buſhes; but the walls are neglected, and the outward fence has ſuffered conſiderably from the active hands of buſy houſewives, who pluck up the ſtakes for firewood. Mr Park paſſed through it on his route eaſtward, and was treated with much kindneſs both by the king and the people. The good old ſovereign warned him of the dangers he was about to encounter, and endeavoured to perſuade him to relinquiſh all thoughts of his journey eaſtward; but when he could not prevail, he gave him a guide, who conducted him in ſafety to Koojar, the frontier town of the kingdom towards Bondou, from which it is ſeparated by an intervening wilderneſs of two days journey. Here our author was preſented, by way of refreſhment, with a liquor which taſted ſo much like the ſtrong beer of his native country (and very good beer too), as to induce him to inquire into its compoſition; and he learned, with ſome degree of ſurpriſe, that it was actually made from corn which had been previouſly malted, much in the ſame manner as barley is malted in Great Britain: a root yielding a grateful bitter was uſed in lieu of hops, the name of which he forgot; but the corn which yields the wort is the *holcus ſpicatus* of botaniſts.

Plate XXVI.

MEDUSA. In addition to the different ſpecies of this genus of vermes deſcribed in the *Encyclopædia*, that which is repreſented in two different attitudes, fig. 1. and 2. and which ſtrongly reſembles a bagpipe in ſhape, may be worthy of notice. It is merely a white tranſparent veſicle, furniſhed with ſeveral blue tentacles yellowiſh at their extremity; its long tail, which is alſo blue, appears to be compoſed of a number of ſmall glandulous grains, flattened and united together by a gelatinous membrane. The upper part of the veſicle exhibits a kind of ſeam with alternate punctures of three different ſizes; its elongated part, which may be conſidered as the head of the animal, is terminated by a ſingle trunk, the exterior edge of which is fringed with 25 or 26 tentacles, much ſmaller than thoſe which originate from the inſertion of its long tail, and the number of which ſometimes amounts to 30. By means of theſe laſt, the diameter of which it is capable of increaſing at pleaſure by forcing in a little of the air from its body, it fixed itſelf to the ſide of the veſſel, in which it was placed, in ſuch a manner as that the extremity of ſome of its tentacles occupied a ſurface of two or three lines from its body. The moſt moveable part of the veſicle is its elongation, or the head of the animal, as it is by means of this that it performs its different motions. The rounded ſubſtance, marked by the letter P, is ſituated in the centre of the larger tentacles, which are firmly fixed to the body of the animal near its tail; and is only an aſſemblage of a few minute gelatinous globules, from the middle of which ariſe other larger globules, with a ſmall peduncle, about the middle of which is fixed a curved bluiſh coloured body, which is repreſented magnified in two poſitions at R. Martiniere, the naturaliſt, who accompanied Perouſe in his voyage round the world, met with this animal in about the 20th degree of lat. and 179° of long. eaſt from Paris.

MEGAMETER, a name ſometimes given to the MICROMETER, which ſee, *Encycl.*

Mehall,
Meninſki.

MEHALL, in the language of Bengal, a place or diſtrict.

MENINSKI (Franciſcus), a moſt celebrated German orientaliſt, was born in Lorraine, then ſubject to the emperor, in the year 1623; and for copiouſneſs of learning, elegance of genius, and profound knowledge of languages, particularly thoſe of the Eaſt, proved undoubtedly one of the principal ornaments of the age in which he lived. He ſtudied at Rome under Giattino. When he was about 30, his love of letters induced him to accompany the Poliſh ambaſſador to Conſtantinople, where he ſtudied the Turkiſh language under Bobovius and Ahmed, two very ſkilful teachers. So ſucceſsful was he in this ſtudy, that when he had been there only two years, the place of firſt interpreter to the Poliſh embaſſy at the Porte was promiſed to him. When the place became vacant, he was accordingly appointed to it, and obtained ſo much credit by his conduct, that, after a time, he was ſent for into Poland, and again ſent out with full powers as ambaſſador to the Porte. For his able execution of this office, he was further honoured, by being naturalized in Poland; on which occaſion he added the Poliſh termination of *ſki* to his family name, which was Menin. Being deſirous afterwards to extend his ſphere of action, he went to the court of the emperor as interpreter of oriental languages in 1661. Here alſo, as in other inſtances, his talents and behaviour obtained the higheſt approbation; on which account he was not only ſent as interpreter to ſeveral imperial ambaſſadors at the Porte, but was intruſted in many important and confidential ſervices; and, in 1669, having paid a viſit to the holy ſepulchre at Jeruſalem, was made one of the knights of that order. After his return to Vienna he was advanced to further honours; being made one of the counſellors of war to the emperor, and firſt interpreter of oriental languages. At Vienna he died at the age of 75, in the year 1698. His great work, 1. The "Theſaurus linguarum orientalium," was publiſhed at Vienna in 1680, in 4 vols folio; to which was added, in 1687, another volume, intitled, "Complementum Theſauri linguarum orientalium, ſeu onomaſticum Latino-Turcico-Arabico Perſicum." The former volumes having become extremely ſcarce, partly on account of the deſtruction of a great part of the impreſſion, in the ſiege of Vienna by the Turks in 1683, a deſign was formed ſome time ago in England of reprinting the work, by a ſociety of learned men, among whom was Sir William Jones. But as this undertaking, probably on account of the vaſt expence which muſt have been incurred, did not proceed, the empreſs queen Maria Thereſa, who had heard of the plan, took it upon herſelf, and with vaſt liberality furniſhed every thing neceſſary for its completion. In conſequence of this, it was begun to be ſplendidly republiſhed at Vienna in 1780, with this title: "Franciſci a Meſgnien Meninſki Lexicon Arabico-Perſico-Turcicum, adjecta ad ſingulas voces et Phraſes interpretatione Latinâ, ad uſitatiores, etiam Italicâ." Of this edition only two vols folio are yet publiſhed, extending no farther than *zal*, the ninth letter of the Arabic alphabet, which is about a third of the whole. The delay of the reſt is much to be lamented. In this edition, ſay the editors, the Lexicon of Meninſki may be ſaid to be increaſed, diminiſhed, and amended. *Increaſed*, becauſe many Arabic and Perſian words are added, from Wankuli and Ferhengi, the beſt Arabic and Perſic lexicographers whom the Eaſt has produced; and from Herbelot are inſerted the names of kingdoms, cities, and rivers, as well as phraſes in common uſe among the Turks, &c. *Diminiſhed*, becauſe many uſeleſs ſynonyma are omitted, which rather puzzled than aſſiſted the ſtudent; as well as all the French, Poliſh, and German interpretations, the Latin being conſidered as ſufficient for all men of learning. *Amended*, with reſpect to innumerable typographical errors; which, however, from a work of this nature, no care can perhaps altogether exclude. The other works of Meninſki were occaſioned chiefly by a violent conteſt between him and a man named J. B. Podeſta, in which much acrimony was employed on both ſides. Theſe it is hardly worth while to enumerate, but they may all be ſeen in the account of his life from which this article is taken (A). It ſhould be obſerved, however, that in 1674, Podeſta publiſhed a book, intitled, "Prodromus novi linguarum orientalium collegii, juſſu Aug. &c. erigendi, in Univ. Viennenſi;" to which Meninſki oppoſed, 2. "Meninſkii Antidotum in Prodromum novi ling. orient. collegii, &c." 4to. But ſuch was the credit of his antagoniſt in the univerſity, that ſoon after there came out a decree in the name of the rector and conſiſtory, in which that antidote of Meninſki's is proſcribed and prohibited, for ſix ſpecific reaſons, as impious and infamous. Meninſki was defended againſt this formidable attack by a friend, in a ſmall tract, intitled, "Veritas defenſa, ſeu juſtitia cauſæ Dn. F. de M. M. [Meninſki] contra infame decretum Univerſitatis Viennenſis, Anno 1674, 23 Novembris, &c. ab Amico luci expoſita, Anno 1675," in which this friend expoſes, article by article, the falſehood of the decree, and exclaims ſtrongly againſt the arts of Podeſta. This tract is in the Britiſh Muſeum. Podeſta was oriental ſecretary to the emperor, and profeſſor of thoſe languages at Vienna; but is deſcribed in a very ſatirical manner by the defender of Meninſki. "Podeſta, natura Semi-Italus, ſtatura nanus, cæcutiens, balbus, imo bardus repertus, aliiſque vitiis ac ſtultitiis plenus, adeoque ad diſcendas linguas orientales inhabilis." A liſt of the works of Podeſta is, however, given by the late editors of Meninſki.

MERCHETTA, or *Marchetta Mulierum*, is commonly ſuppoſed to have been a right which, during the prevalence of the feudal ſyſtem, the lord had of paſſing the firſt night after marriage with his female villain. This opinion has been held by the greater part of our antiquarians; and we have adopted it in our hiſtory of Scotland publiſhed in the *Encyclopædia*. It appears, however, to be a miſtake. That there was a cuſtom called *merchetta mulierum*, which prevailed not only in England, Scotland, Wales, and the iſle of Guernſey, but alſo on the continent, is indeed a fact unqueſtionable; but Mr Aſtle has clearly proved, that, inſtead of being an adulterous connection, the *merchetta* was a compact between the lord and his vaſſal for the redemption of an *offence* committed by that vaſſal's *unmarried* daughter. He admits, however, that it denoted likewiſe a fine paid by a *ſokeman* or a *villain* to his lord, for a licence to marry his daughter to a free man; and that if the vaſſal gave her away without obtaining ſuch a licence, he was liable to pay a heavier fine. He quotes two authorities in ſupport of his opinion from Bracton; one of which we ſhall tranſcribe, as being alone complete evidence.

Archæologia, vol. xii.

"Ric. Burre tenet unum meſuagium et debet telliagium ſectam curiæ, et *merchet*, hoc modo, *quod ſi maritare voluerit filiam ſuam cum quodam libero homine, extra villam, faciet pacem domini pro maritagio, et ſi eam maritaverit alicui cuſtumario villæ, nihil debuit pro maritagio.*"

"The probable reaſon of the cuſtom (ſays Mr Aſtle) appears to have been this. Perſons of low rank, reſiding on an eſtate, were either *aſcripti glebæ*, or were ſubjected to ſome ſpecies of ſervitude ſimilar to the *aſcripti glebæ*. They were bound to reſide on the eſtate, and to perform ſeveral ſervices to the lord. As women neceſſarily followed the reſidence of their huſbands, the conſequence was, that when a woman of low rank married a ſtranger, the lord was deprived of part of his live ſtock; he therefore required a fine to indemnify him for the loſs of his property." Further particulars on the *merchetta* are to be found in the Appendix to vol. 1ſt of *Sir David Dalrymple's Annals of Scotland.*

MERIDIAN Line, an arch, or part of the meridian of the place, terminated each way by the horizon. Or, a meridian line is the interſection of the plane of the meridian of the place with the plane of the horizon, often called a north-and-ſouth line, becauſe its direction is from north to ſouth.

In the article Astronomy (*Encycl.*), n° 376 and 377, we have given two methods of drawing a meridian line; but it may be proper to add, in this place, the following improvement of the former of theſe from Dr Hutton's Mathematical Dictionary. "As it is not eaſy (ſays the Doctor) to determine preciſely the extremity of the ſhadow, it will be beſt to make the ſtile flat at the top, and to drill a ſmall hole through it, noting the lucid point projected by it on the ſeveral concentric circles, inſtead of marking the extremity of the ſhadow itſelf on theſe circles."

We ſhall give another method of drawing a meridian line from the ſame valuable dictionary.

"Knowing the ſouth quarter pretty nearly, obſerve the altitude FE of ſome ſtar on the eaſt ſide of it, and not far from the meridian HZRN: then, keeping the quadrant firm on its axis, ſo as the plummet may ſtill cut the ſame degree, direct it to the weſtern ſide of the meridian, and wait till you find the ſtar has the ſame altitude as before, as *fe*. Laſtly, biſect the angle EC*e*, formed by the interſection of the two planes in which the quadrant has been placed at the time of the two obſervations, by the right line HR, which will be the meridian ſought."

Plat
XXX

Magnetical Meridian, is a great circle paſſing thro' or by the magnetical poles; to which meridians the magnetical needle conforms itſelf. See Magnetism, *Suppl.*

MESOLABE, or Mesolabium, a mathematical inſtrument invented by the ancients, for finding two mean

---

(A) We have taken this article from the Biographical Dictionary; the editors of which took it from the life of Meninſki prefixed to the new edition of his great work.

mean proportionals mechanically, which they could not perform geometrically. It conſiſts of three parallelograms, moving in a groove to certain interſections. Its figure is deſcribed by Eutocius, in his Commentary on Archimedes. See alſo Pappus, lib. 3.

MESO-Logarithm, a term uſed by Kepler to ſignify the logarithms of the coſines and cotangents.

MESURATA, a ſeaport of the kingdom of Tripoli, in Africa. A caravan proceeds from this place to Fezzan, and other interior parts toward the ſouth of Africa. It is 260 miles north of Mourzook. E. lon. 15. 5. N. lat. 31. 3.

METALLIC Tractors. See Perkinism in this *Suppl.*

METONIC Cycle, called alſo the *Golden Number*, and *Lunar Cycle*, or *Cycle of the Moon*, that which was invented by Meton the Athenian; being a period of 19 years. See Cycle, *Encycl.*

MHA Rajah, the higheſt title of Hindoos.

MICROCOUSTICS, or Microphones, inſtruments contrived to magnify ſmall ſounds, as microſcopes do ſmall objects.

MICROCOSMIC Salt. See Chemistry-*Index*, *Suppl.*

MIDDLE Latitude, is half the ſum of two given latitudes; or the arithmetical mean, or the middle between two parallels of latitude. Therefore,

If the latitudes be of the ſame name, either both north or both ſouth, add the one number to the other, and divide the ſum by 2; the quotient is the middle latitude, which is of the ſame name with the two given latitudes. But

If the latitudes be of different names, the one north and the other ſouth; ſubtract the leſs from the greater, and divide the remainder by 2, ſo ſhall the quotient be the middle latitude, of the ſame name with the greater of the two.

MIDSUMMER-Day, is held on the 24th of June, the ſame day as the nativity of St John the Baptiſt is held.

MILK, or Milkyet, property in Bengal.

Mills.

MILLS of various kinds are deſcribed in the article Mechanics (*Encycl.*); and he who ſhall ſtudy that article, together with *Water-Works*, and Machinery, in this *Supplement*, will have a ſufficient knowledge of the principles upon which mills muſt be conſtructed ſo as that they may produce their proper effects. The ſubject is introduced into this place merely to put it into the power of our countrymen to adopt, if they ſhall think fit, the improvements which have been made in the machinery of flour mills in America.

The chief of theſe conſiſt in a new application of the ſcrew, and the introduction of what are called elevators, the idea of which was evidently borrowed from the chain pump. The ſcrew is made by ſticking ſmall thin pieces of board, about three inches long and two wide, into a cylinder, ſo as to form the ſpiral line. This ſcrew is placed in a horizontal poſition, and by turning on its axis it forces wheat or flour from one end of a trough to the other. For inſtance, in the trough which receives the meal immediately coming from the ſtones, a ſcrew of this kind is placed, by which the meal is forced on, to the diſtance of ſix or eight feet, perhaps, into a reſervoir; from thence, without any manual labour, it is conveyed to the very top of the mill by the elevators, which conſiſt of a number of ſmall buckets of the ſize of tea cups, attached to a long band that goes round a wheel at the top, and another at the bottom of the mill. As the band revolves round the wheels, theſe buckets dip into the reſervoir of wheat or flour below, and take their loads up to the top, where they empty themſelves as they turn round the upper wheel. The elevators are incloſed in ſquare wooden tubes, to prevent them from catching in any thing, and alſo to prevent duſt. By means of theſe two ſimple contrivances no manual labour is required from the moment the wheat is taken to the mill till it is converted into flour, and ready to be packed, during the various proceſſes of ſcreening, grinding, ſifting, &c.

That this is a conſiderable improvement is obvious; and we are not without hopes that it may be adopted. The licentiouſneſs of an Engliſh mob has indeed perſecuted an Arkwright, expelled the inventor of the fly-ſhuttle from his native country, and by ſuch conduct prevented the re-erection of the Albion mills, and the general eſtabliſhment of ſaw-mills through the kingdom; but their ſovereignty perhaps will not be rouſed by ſo eaſy and ſimple a contrivance as this to leſſen the quantity of manual labour. For an account of the Dutch oil-mill, which was ſomehow omitted in its proper place in the *Encyclopædia*, ſee *Oil-Mill* in this *Supplement*.

MINERALOGY

IS a ſcience, the object of which is the deſcription and arrangement of *inorganic bodies* or *minerals*; or of *all* the bodies which belong to our globe, excepting *animal* and *vegetable* ſubſtances.

Since the publication of the article Mineralogy, *Encycl.* ſcarcely a ſingle day has paſſed without the diſcovery of ſome new mineralogical fact, or the detection of ſome old and unſuſpected error. Theſe improvements cannot be overlooked in the preſent *Supplement*. But they are ſo numerous in every part of the ſcience, that we can hardly notice them without giving a pretty complete view of the preſent ſtate of mineralogy. This will ſcarcely occupy more room, and muſt be much more uſeful as well as entertaining, than an undigeſted maſs of annotations and remarks. We undertake this taſk the more readily, becauſe in the article Mineralogy in the *Encyclopædia*, the improvements of Mr Werner and his diſciples, to which the ſcience is indebted for a great part of its preſent accuracy, have been entirely overlooked.

2
Object.

The object of mineralogy is twofold. 1. To *deſcribe* every mineral with ſo much accuracy and preciſion, that it may be eaſily diſtinguiſhed from every other mineral; 2. To *arrange* them into a ſyſtem in ſuch a manner that every mineral may be eaſily referred to its proper place, and that a perſon may be able, merely by the help of the ſyſtem, to diſcover the *name* of any mineral whatever. When theſe two objects are accompliſhed, mineralogy, ſtrictly ſo called, is completed. But were we to ſtop here, the utility of the ſcience, if it would be entitled to the name of ſcience, could hardly be conſidered as very great. We muſt therefore apply *chemiſtry* to diſcover the ingredients of which minerals are compoſed, and to detect, if poſſible, the laws which theſe ingredients have obſerved in their combination. Thus we ſhall really extend our knowledge of inorganic nature, and be enabled to apply that knowledge to the improvement of almoſt every art and manufacture.

3 Diviſion of the article. Mineralogy naturally divides itſelf into three parts. The *firſt* treats of the method of deſcribing minerals; the *ſecond*, of the method of arranging them; and the *third* exhibits them in a ſyſtem deſcribed and arranged according to the rules laid down in the two firſt parts. Theſe three parts ſhall be the ſubjects of the following chapters; and we ſhall finiſh the article with a chapter on the chemical analyſis of minerals.

Chap. I. Of the Deſcription of Minerals.

Nothing, at firſt ſight, appears eaſier than to deſcribe a mineral, and yet, in reality, it is attended with a great deal of difficulty. The mineralogical deſcriptions of the ancients are ſo looſe and inaccurate, that many of the minerals to which they allude cannot be aſcertained; and conſequently their obſervations, however valuable in themſelves, are often, as far as reſpects us, altogether loſt. It it obvious, that to diſtinguiſh a mineral from every other, we muſt either mention ſome peculiar property, or a collection of properties, which exiſt together in no other mineral. Theſe properties muſt be deſcribed in terms rigidly accurate, which convey preciſe ideas of the very properties intended, and of no other properties. The ſmalleſt deviation from this would lead to confuſion and uncertainty. Now it is impoſſible to deſcribe minerals in this manner, unleſs there be a peculiar term for each of their properties; and unleſs this term be completely underſtood. Mineralogy therefore muſt have a language of its own; that is to ſay, it muſt have a *term* to denote every mineralogical property, and each of theſe terms muſt be accurately defined. The language of mineralogy was invented by the celebrated Werner of Freyberg, and firſt made known to the world by the publication of his treatiſe on *the external characters of minerals*. Of this language we ſhall give a view in the following general deſcription of the properties of minerals (A).

4 Properties of minerals. The properties of minerals may be divided into two claſſes. 1*ſt*, Properties diſcoverable without deſtroying the texture of the mineral; 2*d*, Properties reſulting from the action of other bodies on it. The firſt claſs has, by Werner and his diſciples, been called *external* properties, and by ſome French writers *phyſical*; the ſecond claſs has been called *chemical*.

The *external* properties may be arranged under the following heads:

1 Figure.
2 Surface.
3 Tranſparency.
4 Colour.
5 Scratch.
6 Luſtre.
7 Hardneſs.
8 Ductility.
9 Fracture.
10 Texture.
11 Structure.
12 Fragments.
13 Feel.
14 Sound.
15 Smell.
16 Taſte.
17 Gravity.
18 Magnetiſm.
19 Electricity.

5 Figure. I. By FIGURE is meant the ſhape or form which a mineral is obſerved to have. The *figure* of minerals is either *regular*, *particular*, or *amorphous*. 1. Minerals which aſſume a regular figure are ſaid to be cryſtallized *. The *ſides* of a cryſtal are called *faces*; the ſharp line formed by the inclination of two faces is called an *edge*; and the corner, or angle, formed by the meeting of ſeveral edges in one point, is called a *ſolid angle*, or ſimply *an angle*. Thus a cube has ſix faces, twelve edges, and eight angles. 2. Some minerals, though not cryſtallized, affect a *particular* figure. Theſe particular figures are the following: *Globular*, like a globe; *oval*, like an oblong ſpheriod; *ovate*, like an egg; *cheeſe-ſhaped*, a very flattened ſphere; *almond-ſhaped*, like an almond; *lenticular*, like a double convex lenſe, compreſſed and gradually thinner towards the edges; *cuneiform*, like a wedge; *nodulous*, having depreſſions and protuberances like a potatoe; *botryoidal*, like grapes cloſely preſſed together; *dentiform*, longiſh and tortuous, and thicker at the bottom than the top; *wireform*, like a wire; *capillary*, like hair, finer than the preceding; *retiform*, threads interwoven like a net; *dendritic*, like a tree, having branches iſſuing from a common ſtem; *ſhrubform*, branches not ariſing from a common ſtem; *coraloidal*, branched like coral; *ſtalactitical*, like iſicles; *clavated*, like a club, long, and thicker at one end than another; *faſciform*, long ſtraight cylindrical bodies, united like a bundle of rods; *tubular*, cylindrical and hollow. 3. When minerals have neither a regular nor particular ſhape, they are ſaid to be *amorphous*.

6 Surface. II. By SURFACE is meant the appearance of the external ſurface of minerals. The *ſurface* is either *uneven*, compoſed of ſmall unequal elevations and depreſſions; *ſcabrous*, having very ſmall *ſharp* and rough elevations, more eaſily felt than ſeen; *druſy*, covered with very minute cryſtals; *rough*, compoſed of very minute *blunt* elevations, eaſily diſtinguiſhable by the feel; *ſcaly*, compoſed of very minute thin ſcale-like leaves; *ſmooth*, free from all inequality or roughneſs; *ſpecular*, having a ſmooth poliſhed ſurface like a mirror; or *ſtreaked*, having elevated, ſtraight, and parallel lines. This laſt character is confined to the *ſurface* of cryſtals. The *ſtreaks* are either *tranſverſe*; *longitudinal*; *alternate*, in different directions on different faces; *plumoſe*, running from a middle rib; or *decuſſated*, croſſing each other.

7 Tranſparency. III. By TRANSPARENCY is meant the proportion of light which minerals are capable of tranſmitting. They are *tranſparent* or *pellucid*, when objects can be ſeen diſtinctly through them; *diaphanous*, when objects are ſeen

* See CHEMISTRY, Part III. ch. iv. Supp

(A) The fulleſt account of Werner's external characters which we have ſeen in the Engliſh language, has been given by Dr Townſon in his *Philoſophy of Mineralogy*. We have availed ourſelves of this book, in order to exhibit ſome of the lateſt improvements of Werner and his diſciples. The reader may alſo conſult *Werner's Treatiſe*, publiſhed at Leipſic in 1774; or the *French tranſlation* publiſhed at Dijon in 1790. See alſo *Romé de Liſle*. *Des caracters exterieur des mineraux*. And *Hauy Jour. d'hiſt. Nat.* II. 56.

ternal racters.

ſeen through them indiſtinctly; *ſubdiaphanous*, when light paſſes but in ſo ſmall a quantity that objects cannot be ſeen through them (B); *opaque*, when no light is tranſmitted.

When opaque minerals become tranſparent in water, they are called *hydrophanous*. When objects are ſeen double through a tranſparent mineral, it is ſaid to *refract doubly*.

8 lour.

IV. The colours of minerals may be reduced to eight claſſes.

1. *Whites*.

Snow white. Pure white.

Reddiſh white. White with a light tint of red.

Yellowiſh white. White with a light tint of yellow.

Silver white. Yellowiſh white with a metallic luſtre.

Greyiſh white. White with a light tint of black.

Greeniſh white. White with a light tint of green.

Milk white. White with a light tint of blue.

Tin white. Milk white of a metallic luſtre.

2. *Greys*.

Bluiſh grey. Grey with a little blue.

Lead grey. Bluiſh grey with a metallic luſtre.

Pearl grey. Light grey with a ſlight mixture of violet blue.

Smoke grey. Dark grey with a little blue and brown.

Greeniſh grey. Light grey tinged with green.

Yellowiſh grey. A light grey tinged with yellow.

Steel grey. A dark grey with a light tint of yellow and a metallic luſtre.

Black grey. The darkeſt grey with a tint of yellow.

3. *Blacks*.

Greyiſh black. Black with a little white.

Browniſh black. Black with a tint of brown.

Black. Pure black.

Iron black. Pure black with a ſmall mixture of white and a metallic luſtre.

Bluiſh black. Black with a tint of blue.

4. *Blues*.

Indigo blue. A dark blackiſh blue.

Pruſſian blue. The pureſt blue.

Azure blue. A bright blue with ſcarce a tint of red.

Smalt blue. A light blue.

Violet blue. A mixture of azure blue and carmine.

Lavender blue. Violet blue mixed with grey.

Sky blue. A light blue with a ſlight tint of green.

5. *Greens*.

Verdigris green. A bright green of a bluiſh caſt.

Seagreen. A very light green, a mixture of verdigris green and grey.

Beryl green. The preceding, but of a yellowiſh caſt.

Emerald green. Pure green.

Graſs green. Pure green with a tint of yellow.

Apple green. A light green formed of verdigris green and white.

Leek green. A very dark green with a caſt of brown.

Blackiſh green. The darkeſt green, a mixture of leek green and black.

Piſtachio green. Graſs green, yellow and a little brown.

External Characters.

Olive green. A pale yellowiſh green with a tint of brown.

Aſparagus green. The lighteſt green, yellowiſh with a little brown and grey.

6. *Yellows*.

Sulphur yellow. A light greeniſh yellow.

Braſs yellow. The preceding, with a little leſs green and a metallic luſtre.

Lemon yellow. Pure yellow.

Gold yellow. The preceding with a metallic luſtre.

Honey yellow. A deep yellow with a little reddiſh brown.

Wax yellow. The preceding, but deeper.

Pyritaceous. A pale yellow with grey.

Straw yellow. A pale yellow, a mixture of ſulphur yellow and reddiſh grey.

Wine yellow. A pale yellow with a tint of red.

Ochre yellow. Darker than the preceding, a mixture of lemon yellow with a little brown.

Iſabella yellow. A pale browniſh yellow, a mixture of pale orange with reddiſh brown.

Orange yellow. A bright reddiſh yellow, formed of lemon yellow and red.

7. *Reds*.

Aurora red. A bright yellow red, a mixture of ſcarlet and lemon yellow.

Hyacinth red. A high red like the preceding, but with a ſhade of brown.

Brick red. Lighter than the preceding; a mixture of aurora red and a little brown.

Scarlet red. A bright and high red with ſcarce a tint of yellow.

Copper red. A light yellowiſh red with the metallic luſtre.

Blood red. A deep red, a mixture of crimſon and ſcarlet.

Carmine red. Pure red verging towards a caſt of blue.

Cochineal red. A deep red; a mixture of carmine with a little blue and a very little grey.

Crimſon red. A deep red with a tint of blue.

Fleſh red. A very pale red of the crimſon kind.

Roſe red. A pale red of the cochineal kind.

Peach bloſſom red. A very pale whitiſh red of the crimſon kind.

Mordoré. A dark dirty crimſon red; a mixture of crimſon and a little brown.

Browniſh red. A mixture of blood red and brown.

8. *Browns*.

Reddiſh brown. A deep brown inclining to red.

Clove brown. A deep brown with a tint of carmine.

Yellowiſh brown. A light brown verging towards ochre yellow.

Umber brown. A light brown, a mixture of yellowiſh brown and grey.

Hair brown. Intermediate between yellow brown and clove brown with a tint of grey.

Tombac brown. A light yellowiſh brown, of a metallic luſtre, formed of gold yellow and reddiſh brown.

(B) After Mr Kirwan, we have denoted theſe three degrees of tranſparency by the figures 4, 3, 2. When a mineral is ſubdiaphanous only at the edges, that is denoted by the figure 1. Opacity is ſometimes denoted by 0.

External Characters. Liver brown. A dark brown; blackiſh brown with a tint of green.

Blackiſh brown. The darkeſt brown.

Colours, in reſpect of intenſity, are either *dark*, *deep*, *light*, or *pale*. When a colour cannot be referred to any of the preceding, but is a mixture of two, this is expreſſed, by ſaying, that the prevailing one *verges* towards the other, if it has only a ſmall tint of it; *paſſes* into it, if it has a greater.

9 Streak. V. By the SCRATCH or STREAK, is meant the mark left when a mineral is ſcratched by any hard body, as the point of a knife. It is either *ſimilar*, of the ſame colour with the mineral; or *diſſimilar*, of a different colour.

10 Luſtre. VI. LUSTRE, is the gloſs or brightneſs which appears on the external ſurface of a mineral, or on its internal ſurface when freſh broken. The firſt is called *external*, the ſecond *internal* luſtre. Luſtre is either *common*, that which moſt minerals poſſeſs; *ſilky*, like that of ſilk or mother-of-pearl; *waxy*, like that of wax; *greaſy*, like that of greaſe; or *metallic*, like that of metals.

As to the degree, the greateſt is called *ſplendent*, the next *ſhining*, the third *dulliſh*; and when only a few ſcattered particles ſhine, the luſtre is called *dull* (c).

11 Hardneſs. VII. We have uſed figures to denote the comparative HARDNESS of bodies; for an explanation of which, we refer to the article CHEMISTRY, Vol. I. p. 224. of this *Supplement*.

12 Ductility and brittleneſs. VIII. With reſpect to DUCTILITY and BRITTLENESS, minerals are either *malleable*; *ſectile*, capable of being cut without breaking, but not malleable; *flexile*, capable of being bent, and when bent retaining their ſhape; or *elaſtic*, capable of being bent, but recovering their former ſhape. Minerals deſtitute of theſe properties are *brittle*. Brittle minerals, with reſpect to the eaſe with which they may be broken, are either *very tough*, *tough*, *fragile*, or *very fragile*.

13 Fracture. IX. By FRACTURE is meant the freſh ſurface which a mineral diſplays when broken. It is either *flat*, without any general elevation or depreſſion; or *conchoidal*, having wide extended roundiſh hollows and gentle riſings. When theſe are not *very* evident, the fracture is called *flat* conchoidal; when they are ſmall, it is called *ſmall* conchoidal; and when of great extent, *great* conchoidal.

The fracture may alſo be *even*, free from all aſperities; *uneven*, having many ſmall, ſharp, abrupt, irregular elevations and inequalities; and from the ſize of theſe, this fracture is denominated *coarſe*, *ſmall*, or *fine*; *ſplintery*, having ſmall, thin, half detached, ſharp edged ſplinters, according to the ſize of which this fracture is donominated *coarſe* or *fine*; or *rugged*, having many very minute ſharp hooks, more ſenſible to the hand than the eye.

14 Texture. X. By TEXTURE is meant the internal ſtructure or diſpoſition of the matter of which a mineral is compoſed, which may be diſcovered by breaking it. The texture is either *compact*, without any diſtinguiſhable parts, or the appearance of being compoſed of ſmaller parts; *earthy*, compoſed of very minute *almoſt* imperceptible rough parts; *granular*, compoſed of ſmall ſhapeleſs grains; *globuliform*, compoſed of ſmall ſpherical bodies; *fibrous*, compoſed of fibres which may be *long*, *ſhort*, *ſtraight*, *crooked*, *parallel*, *divergent*, *ſtellated*, *faſciculated*, or *decuſſated*; *radiated*, conſiſting of long narrow flattiſh lamellæ; or *lamellar* or *foliated*, conſiſting of ſmooth continued plates covering each other: theſe plates may be either *ſtraight*, *crooked*, or *undulating*.

Extern Characte

15 Structur XI. The STRUCTURE OR COMPOUND TEXTURE is the manner in which the parts that form the texture are diſpoſed. It is either *ſlaty*, in ſtraight layers like ſlate; *teſtaceous*, in incurvated layers; *concentric*, in concentric layers; or *columnar*, in columns.

The *texture* and *ſtructure* may at firſt view appear the ſame; but in reality they are very different. Thus common ſlate has often the *ſlaty ſtructure* and *earthy texture*. The texture of pitcoal is compact, but its ſtructure is often ſlaty.

16 Fragme XII. By FRAGMENTS is meant the ſhape of the pieces into which a mineral breaks when ſtruck with a hammer. They are either *cubic*; *rhomboidal*; *wedgeſhaped*; *ſplintery*, thin, long, and pointed; *tabular*, thin, and broad, and ſharp at the corners, as common ſlate; or *indeterminate*, without any particular reſemblance to any other body. The *edges* of indeterminate fragments are either *very ſharp*, *ſharp*, *ſharpiſh*, or *blunt*.

17 Feel. XIII. By the FEEL of minerals is meant the ſenſation which their ſurfaces communicate when handled. The feel of ſome minerals is *greaſy*, of others *dry*, &c.

18 Sound XIV. Some minerals when ſtruck give a *clear* SOUND, as common ſlate; others a *dull* ſound.

The SMELL, TASTE, SPECIFIC GRAVITY, and MAGNETISM of minerals, require no explanation.

With reſpect to ELECTRICITY, ſome minerals become electric when *heated*, others when *rubbed*, others cannot be rendered electric. The electricity of ſome minerals is *poſitive* or *vitreous*, of others *negative* or *reſinous*.

As for the CHEMICAL properties of minerals, they have been already explained in the article CHEMISTRY, which makes a part of this *Supplement*. And for the deſcription of the blow-pipe, and the manner of uſing it, we refer the reader to a treatiſe on that ſubject prefixed to the article MINERALOGY in the *Encyclopædia*.

CHAP. II. OF THE ARRANGEMENT OF MINERALS.

MINERALS may be arranged two ways, according to their external characters, and according to their chemical compoſition. The firſt of theſe methods has been called an *artificial* claſſification; the ſecond, a *natural* one. The firſt is indiſpenſably neceſſary for the ſtudent of nature; the ſecond is no leſs indiſpenſable for the proficient who means to turn his knowledge to account. Without the firſt, it is impoſſible to diſcover the *names* of minerals; and without the ſecond, we muſt remain ignorant of their uſe.

Almoſt every ſyſtem of mineralogy hitherto publiſhed, at leaſt ſince the appearance of Werner's *external characters*, has attempted to combine theſe two arrangements, and to obtain at one and the ſame time the advantages peculiar to each. But no attempt of this kind has hitherto ſucceeded. Whether this be owing to any thing impoſſible in the undertaking, or to the preſent

---

(c) Theſe four degrees have been denoted by Kirwan by the figures 4, 3, 2, 1, and no luſtre by 0. We have imitated him in the preſent article.

tificial
ſtem.

Artificial
Syſtem.

preſent imperfect ſtate of mineralogy, as is more probable, we do not take upon us to determine. But ſurely the want of ſucceſs, which has hitherto attended all attempts to combine the two arrangements, ought to ſuggeſt the propriety of ſeparating them. By adhering ſtrictly to one language, the trouble of ſtudying two different ſyſtems would be entirely prevented. They would throw mutual light upon each other: the artificial ſyſtem would enable the ſtudent to diſcover the *names* of minerals; the natural would enable him to arrange them, and to ſtudy their properties and uſes.

The happy arrangement of Cronſtedt, together with the ſubſequent improvements of Bergman, Werner, Kirwan, Hauy, and other celebrated mineralogiſts, has brought the *natural* ſyſtem of mineralogy to a conſiderable degree of perfection. But an *artificial* ſyſtem is ſtill a deſideratum; for excepting Linnæus, whoſe ſucceſs was precluded by the ſtate of the ſcience, no one has hitherto attempted it. Though we are very far from thinking ourſelves ſufficiently qualified for undertaking ſuch a taſk, we ſhall nevertheleſs venture, in the next chapter, to ſketch out the rudiments of an artificial ſyſtem. The attempt, at leaſt, will be laudable, even though we ſhould fail.

CHAP. III. ARTIFICIAL SYSTEM.

19
ficial
s.

MINERALS may be divided into ſix claſſes:

1. Minerals that cannot be fuſed by the blow-pipe *per ſe*.

2. Minerals fuſible *per ſe* by the blow-pipe.

3. Minerals fuſible by the blow-pipe *per ſe* when expoſed to the blue flame, but not when expoſed to the yellow flame.

4. Minerals fuſible *per ſe* by the blow-pipe; and when in fuſion, partly evaporating in a viſible ſmoke.

5. Minerals which totally evaporate before the blow-pipe.

6. Minerals totally ſoluble in muriatic acid with effervescence, the ſolution colourleſs.

Under theſe heads we ſhall arrange the ſubjects of the mineral kingdom.

CLASS I. INFUSIBLE.

ORDER I. Specific gravity from 16 to 12.

GENUS I. Colour whitiſh iron grey.

Species 1. Native platinum.

ORDER II. Sp. gr. 8.5844 to 7.006.

GENUS I. Attracted by the magnet.

Sp. 1. Native iron.

GENUS II. Not attracted by the magnet.

Sp. 1. Native copper.

Flexible and malleable. Colour uſually red.

Sp. 2. Wolfram.

Brittle. Colour uſually brown or black.

ORDER III. Sp. gr. from 6.4509 to 5.8.

GENUS I. Forms a blue glaſs with microcoſmic ſalt, which becomes colourleſs in the yellow, but recovers its colour in the blue flame.

Sp. 1. Tungſtat of lime.

GENUS II. Forms with microcoſmic ſalt a permanently coloured bead.

Sp. 1. Sulphuret of cobalt.

ORDER IV. Sp. gr. from 4.8 to 4.5.

GENUS I. Tinges borax dark green.

Sp. 1. Common magnetic iron ſtone.

GENUS II. Tinges borax reddiſh brown.

Sp. 1. Grey ore of manganeſe.

ORDER V. Sp. gr. from 4.4165 to 3.092. Infuſible with fixed alkalies.

GENUS I. Hardneſs 20.

Sp. 1. Diamond.

GENUS II. Hardneſs 15 to 17. Cauſes ſingle refraction.

Sp. 1. Teleſia.

Sp. 2. Corundum.

GENUS III. Hardneſs 13. Single refraction.

Sp. 1. Ruby.

Cryſtallizes in octohedrons.

GENUS IV. Hardneſs 12. Single refraction.

Sp. 1. Chryſoberyl.

GENUS V. Hardneſs 12. Cauſes double refraction. Becomes electric when heated.

Sp. 1. Topaz.

GENUS VI. Hardneſs 10 to 16. Double refraction. Sp. gr. 4.2 to 4.165.

Sp. 1. Zircon.

GENUS VII. Hardneſs 6 to 9. Feels greaſy.

Sp. 1. Cyanite.

GENUS VIII. Hardneſs 9 to 10. Feel not greaſy. Double refraction. Sp. gr. 3.283 to 3.285.

Sp. 1. Chryſolite.

GENUS IX. Hardneſs 12. Infuſible with borax. Colour of large maſſes black, of thin pieces deep green.

Sp. Ceylanite.

(Phoſphat of lime.)

ORDER VI Sp. gr. from 2.9829 to 1.987. Infuſible with fixed alkalies.

GENUS I. Hardneſs 12.

Sp. 1. Emerald.

GENUS II. Hardneſs 10.

Sp. 1. Jade.

GENUS III. Hardneſs 6 to 7. Somewhat tranſparent.

Sp. 1. Phoſphat of lime.

Before the blow-pipe becomes ſurrounded with a luminous green vapour.

GENUS IV. Hardneſs 6. Opaque.

Sp. 1. Micarelle.

GENUS V. Stains the fingers. Colour lead grey.

Sp. 1. Plumbago.

Spaniſh wax rubbed with plumbago does not become electric; or if it does, the electricity is negative. Streak lead grey even on earthen ware.

ORDER VII. Sp. gr. from 4.7385 to 4.569. Fuſible with fixed alkalies.

GENUS I. Stains the fingers. Colour lead grey.

Sp. 1 Molybdena.

Spaniſh wax rubbed with molybdena becomes poſitively electric. Streak on earthen ware yellowiſh green.

ORDER VIII. Sp. gr. from 4.1668 to 2.479. Fuſible with fixed alkalies.

* Hardneſs from 10 to 12.

Artificial Syſtem.

Genus I. Uſually white. Cryſtals dodecahedrons. Double refraction. Fracture imperfectly conchoidal or ſplintery. Brittle.
Sp. 1. Quartz.

Genus II. Uſually dark brown. Fracture perfectly conchoidal. Brittle. Eaſily breaks into ſplinters.
Sp. 1. Flint.

Genus III. Not brittle. Fracture even or imperfectly conchoidal.
Sp. 1. Chalcedony.
Sp. 2. Jaſper.

Genus IV. Forms with potaſs a violet glaſs, with ſoda or borax a brown glaſs, with microcoſmic ſalt a honey yellow glaſs. Colour green. Amorphous.
Sp. 1. Chryſopraſium.

Genus V. Tinges ſoda red. The colour diſappears before the blue flame, and returns before the yellow flame.
Sp. 1. Oxyd of manganeſe and barytes.
Sp. 2. Black ore of manganeſe.
Sp. 3. Carbonat of manganeſe.
(*Brown ore of iron. Red ore of iron.*)
** Hardneſs 9 to 3.

Genus VI. Flexible and elaſtic in every direction.
Sp. 1. Elaſtic quartz.

Genus VII. Emits white flakes before the blow-pipe.
Sp. 1. Blende.

Genus VIII. Becomes electric when heated.
Sp. 1. Calamine.

Genus IX. Tinges borax green. Blackens before the blow-pipe.
Sp. 1. Mountain blue.
Colour blue.
Sp. 2. Green carbonat of copper.
Colour green.

Genus X. Tinges borax green. Becomes attractable by the magnet by the action of the blow-pipe.
Sp. 1. Brown iron ore.
Colour brown.
Sp. 2. Red iron ore.
Colour red.

Genus XI. Tinges borax ſmutty yellow. Becomes browniſh black before the blow-pipe.
Sp. 1. Carbonat of iron.

Genus XII. Feels greaſy.
Sp. 1. Steatites.
(*Black ore of Manganeſe. Carbonat of manganeſe. Mica.*)

ORDER IX. Sp. gr. from 2.39 to 1.7.

Genus I. Luſtre glaſſy.
Sp. 1. Opal.
Sp. 2. Hyalite.

Genus II. Luſtre greaſy.
Sp. 1. Pitchſtone.

Genus III. Luſtre waxy or pearly.
Sp. 1. Staurolite.

Class II. FUSIBLE.

ORDER I. Sp. gr. from 19 to 10.

Genus I. Colour Yellow.
Sp. 1. Native gold.

Genus II. Colour white.
Sp. 1. Native Silver.

Genus III. Colour yellowiſh white.
Sp. 1. Alloy of ſilver and gold.

ORDER II. Sp. gr. from 7.786 to 4.5.

Genus I. Flexible and malleable.
Sp. 1. Sulphuret of ſilver.
** Brittle.

Genus II. Tinges borax white.
Sp. 1. Tinſtone.

Genus III. Tinges borax green.
Sp. 1. Sulphuret of copper.
Colour bluiſh grey.
Sp. 2. Chromat of lead.
Colour aurora red.
Sp. 3. Purple copper ore.
Colour purple.

Genus IV. Tinges borax faint yellow. Becomes black when expoſed to the vapour of ſulphuret of ammonia.
Sp. 1. Galena.
Colour bluiſh grey. Luſtre metallic. Fragments cubic.
Sp. 2. Black lead ore.
Colour black. Luſtre metallic.
Sp. 3. Lead ochre.
Colour yellow, grey, or red. Luſtre 0.
Sp. 4. Carbonat of lead.
Colour white. Luſtre waxy.
Sp. 5. Phoſphat of lead.
Uſually green. Luſtre waxy. After fuſion by the blow-pipe cryſtallizes on cooling.
Sp. 6. Molybdat of lead.
Colour yellow. Streak white. Luſtre waxy.

ORDER III. Sp. gr. from 4.35 to 3.
* Hardneſs 14 to 9.

Genus I. Melts without frothing into a grey enamel.
Sp. 1. Garnet.
Colour red.

Genus II. Melts into a browniſh enamel.
Sp. 1. Shorl.
Colour black. Opaque.

Genus III. Froths and melts into a white enamel.
Sp. 1. Tourmaline.
Becomes electric by heat.

Genus IV. Froths and melts into a greeniſh black enamel.
Sp. 1. Baſaltine.

Genus V. Froths amd melts into a black enamel.
Sp. 1. Thallite.
Colour dark green.
Sp. 2. Thumeiſtone.
Colour clove brown.
** Hardneſs 5 to 8.

Genus VI. Melts into a tranſparent glaſs.
Sp. 1. Fluat of lime.
Powder phoſphoreſces when thrown on a hot iron.

Genus VII. Melts into a black glaſs.

ificial tem.

Artificial Syſtem.

Sp. 1. Hornblende.

Genus VIII. Melts into a black bead with a ſulphureous ſmell, and depoſits a blue oxyd on the charcoal.

Sp. 1. Sulphuret of tin.

Genus IX Melts into a brown glaſs. Tinges borax violet.

Sp. 1. Aſbeſtoid.

Colour green.

Genus X. Melts into a brown (?) glaſs. When fuſed with potaſs, and diſſolved in water, the ſolution becomes of a fine orange yellow.

Sp. 1. Chromat of iron.

Genus XI. Before the blow-pipe yields a bead of copper.

Sp. 1. Red oxyd of copper.

(Sulphuret of copper.)

ORDER IV. Sp. gr. from 2.945 to 2.437.

Genus I. Compoſed of ſcales.

Sp. 1. Talk.

Feels greaſy. Spaniſh wax rubbed by it becomes poſitively electric.

Genus II. Compoſed of thin plates, eaſily ſeparable from each other.

Sp. 1. Mica.

Plates flexible and elaſtic, may be torn but not broken. Spaniſh wax rubbed by it becomes negatively electric.

Sp. 2. Stilbite.

Plates ſomewhat flexible. Colour pearl white. Powder renders ſyrup of violets green. Froths and melts into an opaque white enamel.

Sp. 3. Lepidolite.

Colour violet. Powder white with a tint of red. Froths and melts into a white ſemitranſparent enamel full of bubbles.

Genus III. Texture foliated.

Sp. 1. Felſpar.

Fragments rhomboidal. Hardneſs 9 to 10.

Sp. 2. Leucite.

Always cryſtallized. White. Powder renders ſyrup of violets green. Hardneſs 8 to 10.

Sp. 3. Argentine felſpar.

Always cryſtallized. Two faces dead white, two ſilvery white.

Sp. 4. Prehnite.

Colour green. Froths and melts into a brown enamel.

Genus IV. Texture fibrous. Fibres eaſily ſeparated.

Sp. 1. Aſbeſtus.

Feels ſomewhat greaſy.

Genus V. Texture ſtriated.

Sp. 1. Ædelite.

Abſorbs water. Froths and melts into a frothy maſs.

Genus VI. Texture earthy or compact.

Sp. 1. Lazulite.

Froths and melts into a yellowiſh black maſs. If previouſly calcined, gelatinizes with acids.

Sp. 2. Borat of lime.

Tinges the flame greeniſh, froths and melts into a yellowiſh enamel garniſhed with ſmall projecting points. If the blaſt be continued, theſe dart off in ſparks.

ORDER V. Sp. gr. from 2.348 to 0.68.

Genus I. Hardneſs 10.

Sp. 1. Obſidian.

Colour blackiſh, in thin pieces green.

Genus II. Hardneſs 6 to 8.

Sp. 1. Zeolite.

Gelatinizes with acids. Becomes electric by heat.

Genus III. Hardneſs 3 to 4.

Sp. 1. Amianthus.

Feels greaſy. Texture fibrous.

Sp. 2. Mountain cork.

Elaſtic like cork.

Class III. FUSIBLE by the BLUE FLAME, INFUSIBLE by the YELLOW.

Genus I. Sp. gr. from 4.43 to 4.4.

Sp. 1. Sulphat of barytes.

Genus II. Sp. gr. from 3.96 to 3.51.

Sp. 1. Sulphat of ſtrontites.

Genus III. Sp. gr. from 2.311 to 2.167.

Sp. 1. Sulphat of lime.

Class IV. FUSIBLE, and partly EVAPORATING.

ORDER I. Sp. gr. from 10 to 5.

Genus I. Colour white or grey. Luſtre metallic.

* Sp. gr. 9 to 10.

Sp. 1. Native amalgam.

Tinges gold white. Creaks when cut.

Sp. 2. Alloy of ſilver and antimony.

Powder greyiſh black.

** Sp. gr. from 6 467 to 5.309.

Sp. 3. Sulphuret of biſmuth.

Melts when held to the flame of a candle.

Sp. 4. Dull grey cobalt ore.

Streak bluiſh grey. Hardneſs 10. When ſtruck, emits an arſenical ſmell. Luſtre ſcarcely metallic.

Genus II. Colour red, at leaſt of the ſtreak.

Sp. 1. Red ſilver ore.

Burns with a blue flame.

Sp. 2. Hepatic mercurial ore.

Does not flame, but gives out mercury before the blow-pipe.

Genus III. Colour blue.

Sp. 1. Blue lead ore.

Burns with a blue flame and ſulphureous ſmell, and leaves a button of lead.

Genus IV. Colour yellowiſh green.

Sp. 1. Phoſphat and arſeniat of lead combined.

When fuſed by the blow-pipe, cryſtallizes on cooling.

Genus V. Colour uſually that of copper. Sp. gr.

Artificial Syſtem.

gr. 6.6084 to 6.6481.
Sp. 1. Sulphuret of nickel.
Exhales before the blow-pipe an arſenical ſmoke.

ORDER II. Sp. gr. from 4.6 to 3.44.
Genus I. Colour grey.
Sp. 1. Grey ore of antimony.
Burns with a blue flame, and leaves a white oxyd.
Sp. 2. Grey copper ore.
Crackles before the blow-pipe.
Genus II. Colour yellow.
Sp. 1. Pyrites.
Burns with a blue flame and ſulphureous ſmell, and leaves a browniſh bead.
Sp. 2. Yellow copper ore.
Melts into a black maſs.

Class V. EVAPORATING.

ORDER I. Sp. gr. 13.6.
Genus I. Fluid.
Sp. 1. Native mercury.

ORDER II. Sp. gr. from 10 to 5.419.
Genus I. Colour red.
Sp. 1. Native cinnabar.
Genus II. Colour white or grey. Luſtre metallic.
Sp. 1. Native biſmuth.
Melts into a white bead, and then evaporates in a yellowiſh white ſmoke. Sp. gr. 9 to 9.5.
Sp. 2. Native antimony.
Melts and evaporates in a grey ſmoke. Sp. gr. 6.6 to 6.8.
Sp. 3. Native arſenic.
Evaporates without melting, and gives out a garlic ſmell.

ORDER III. Sp. gr. from 4.8 to 3.33.
Genus I. Colour red.
Sp. 1. Red antimonial ore.
Melts with a ſulphureous ſmell. Sp. gr. 4.7.
Sp. 2. Realgar.
Melts with a garlic ſmell. Sp. gr. 3.384.
Genus II. Colour yellow.
Sp. 1. Orpiment.

Class VI. SOLUBLE with EFFERVESCENCE in MURIATIC ACID.

Natural Syſtem.

Genus I. Sp. gr. from 4.338 to 4.3.
Sp. 1. Carbonat of barytes.
Genus II. Sp. gr. from 3.66 to 3.4.
Sp. 1. Carbonat of ſtrontites.
Genus III. Sp. gr. from 2.8 to 1 or under.
Sp. 1. Carbonat of lime.

We have purpoſely avoided giving names to the claſſes, orders, and genera; becauſe a more careful examination will doubtleſs ſuggeſt many improvements in the arrangement, and an artificial ſyſtem ought to be brought to a great degree of perfection before its claſſes, orders, and genera, be finally ſettled.

We have excluded from this arrangement all thoſe bodies which in the following ſyſtem are arranged under the claſs of combuſtibles; becauſe there can ſcarcely be any difficulty in diſtinguiſhing them both from the other claſſes and from one another. For ſimilar reaſons we have excluded the claſs of ſalts.

Chap. IV. Natural System.

Avicenna, a writer of the 11th century, divided minerals into four claſſes; ſtones, ſalts, inflammable bodies, and metals (D). This diviſion has been, in ſome meaſure, followed by all ſucceeding writers. Linnæus, indeed, the firſt of the moderns who publiſhed a ſyſtem of mineralogy, being guided by the external characters alone, divided minerals into three claſſes, *petræ*, *mineræ*, *foſſilia*: but Avicenna's claſſes appear among his orders. The ſame remark may be made with reſpect to the ſyſtems of Wallerius, Wolſterdorf, Cartheuſer, and Juſti, which appeared in ſucceſſion after the firſt publication of Linnæus's *Syſtema Naturæ*, in 1736. At laſt, in 1758, the ſyſtem of Cronſtedt appeared. He reinſtated the claſſes of Avicenna in their place; and his ſyſtem was adopted by Bergman, Kirwan, Werner, and the moſt celebrated mineralogiſts who have written ſince. We alſo ſhall adopt his claſſes, with a few ſlight exceptions; becauſe we are not acquainted with any other diviſion which is intitled to a preference.

20 Natural claſſes.

We ſhall therefore divide this treatiſe into four claſſes. I. Stones. II. Salts. III. Combuſtibles. IV. Ores.

The firſt claſs comprehends all the minerals which are compoſed chiefly or entirely of earths; the ſecond, all the combinations of acids and alkalies which occur in the mineral kingdom; the third, thoſe minerals which are capable of combuſtion, and which conſiſt chiefly of ſulphur, carbon, and oil; the fourth, the mineral bodies which are compoſed chiefly of metals.

Class I. EARTHS and STONES.

WE ſhall divide this claſs into three orders. The firſt order ſhall comprehend all chemical combinations of earths with each other; the ſecond order, chemical combinations of earths with acids; and the third order, mechanical mixtures of earths or ſtones. All the minerals belonging to the firſt order exhibit the ſame homogeneous appearance to the eye as if they were ſimple bodies. We ſhall therefore, for want of a better name, call the firſt order *ſimple*; the ſecond order we ſhall diſtinguiſh by the epithet of *ſaline*; and the third we ſhall call

---

(D) Corpora mineralia in quatuor ſpecies dividuntur, ſcilicet in lapides, et in liqueſactiva, ſulphurea, et ſales. Et horum quædam ſunt raræ ſubſtantiæ et debilis compoſitionis, et quædam fortis ſubſtantiæ, et quædam ductibilia, et quædam non. *Avicenna de congelatione et conglutinatione lapidum*, Cap. 3. *Theatrum Chemicum*, t. iv. p. 997.

Ea s and nes. call *aggregates*; becauſe moſt of the minerals belonging to it conſiſt of various *ſimple ſtones*, cemented, as it were, together.

Order I. SIMPLE STONES.

1 Cr ſtedt's ge a. CRONSTEDT divided this order into nine genera, correſponding to nine earths; one of which he thought compoſed the ſtones arranged under each genus. The names of his genera were, *calcareæ*, *ſiliceæ*, *granatinæ*, *argillaceæ*, *micaceæ*, *fluores*, *aſbeſtinæ*, *zeolithicæ*, *magneſiæ*. All his earths were afterwards found to be compounds, except the firſt, ſecond, fourth, and ninth. Bergman, therefore, in his Sciagraphia, firſt publiſhed in 1782, 2 Im oved. reduced the number of genera to five; which was the number of primitive earths known when he wrote. Since that period three new earths have been diſcovered. Accordingly, in the lateſt ſyſtems of mineralogy, the genera belonging to this order amount to eight. Each genus is named from an earth; and they are arranged in the neweſt Wernerian ſyſtem, which we have ſeen, as follows:

1. Jargon genus.
2. Siliceous genus.
3. Glucina genus.
4. Argillaceous genus.
5. Magneſian genus.
6. Calcareous genus.
7. Barytic genus.
8. Strontian genus.

Mr Kirwan, in his very valuable ſyſtem of mineralogy, has adopted the ſame genera. Under each genus, thoſe ſtones are placed, which are compoſed chiefly of the earth which gives a name to the genus, or which at leaſt are ſuppoſed to poſſeſs the characters which diſtinguiſh that earth.

3 Si efici- en. A little conſideration will be ſufficient to diſcover that there is no natural foundation for theſe genera. Moſt ſtones are compoſed of two, three, or even four ingredients; and, in many caſes, the proportion of two or more of theſe is nearly equal. Now, under what genus ſoever ſuch minerals are arranged, the earth which gives it a name muſt form the ſmalleſt part of their compoſition. Accordingly, it has not been ſo much the chemical compoſition, as the external character, which has guided the mineralogiſt in the diſtribution of his ſpecies. The genera cannot be ſaid properly to have any character at all, nor the ſpecies to be connected by any thing elſe than an arbitrary title. This defect, which muſt be apparent in the moſt valuable ſyſtems of mineralogy, ſeems to have ariſen chiefly from an attempt to combine together an artificial and natural ſyſtem. As we have ſeparated theſe two from each other, it becomes neceſſary for us to attend more accurately to the natural diſtribution of genera than has hitherto been done. We have accordingly ventured to form new genera for this order, and we have formed them according to the following rules.

4 N genera. The only ſubſtances which enter into the minerals belonging to this order, in ſuch quantity as to deſerve attention, are the following:

Alumina,
Silica,
Magneſia,
Lime,
Barytes,
Glucina,
Zirconia,
Oxyd of iron,
Oxyd of chromum,
Potaſs,

All thoſe minerals which are compoſed of the *ſame* ingredients we arrange under the *ſame* genus. According to this plan, there muſt be as many genera as there are varieties of combinations of the above ſubſtances exiſting in nature. The varieties in the *proportion* of the ingredients conſtitute ſpecies. We have not impoſed names upon our genera, but, in imitation of Bergman *, have denoted each by a ſymbol. This ſymbol is compoſed of the firſt letter of every ſubſtance which enters in any conſiderable quantity into the compoſition of the minerals arranged under the genus denoted by it. Thus, ſuppoſe the minerals of a genus to be compoſed of *alumina*, *ſilica*, and *oxyd of iron*, we denote the genus by the ſymbol *aſi*. The letters are arranged according to the proportion of the ingredients; that which enters in the greateſt proportion being put firſt, and the others in their order. Thus the genus *aſi* is compoſed of a conſiderable proportion of alumina, of a ſmaller proportion of ſilica, and contains leaſt of all of iron. By this contrivance, the ſymbol of a genus contains, within the compaſs of a few letters, a pretty accurate deſcription of its nature and character. Where the proportions of the ingredients vary in the ſame genus ſo much, that the letters which conſtitute its ſymbol change their place, we ſubdivide the genus into parts; and whenever the minerals belonging to any genus become too numerous, advantage may be taken of theſe ſubdiviſions, and each of them may be formed into a ſeparate genus. At preſent this ſeems unneceſſary (E).

* *Opuſc.* iv. 231.

The following is a view of the different genera belonging to this order, denoted each by its ſymbol. Every genus is followed by the ſpecies included under it; and the whole are in the order which we mean to follow in deſcribing them:

I. A.
    Teleſia,
    Corundum,
    Native alumina.
II. AMC.
    Ruby.
III. AIM.
    Ceylanite,
IV. S.
    Quartz,
    Elaſtic quartz,
    Flint,
    Opal,
    Pitchſtone,
    Chryſopraſium.
V. 1. AS.
    Topaz,
    Sommite,
    Shorlite.
  2. SA.
    Rubellite,
    Hornſlate,
    Hornſtone,
    Chalcedony,
    Jaſper,
    Tripoli.
VI. 1. ASI.
    Micarell,
    Shorl,
    Granatite,
  2. SAI.
    Tourmaline,
    Argentine felſpar,
    Mica,
    Talc,
    Baſaltine,
    Hornblende,
    Obſidian,
    Petrilite,
    Felſite.
VII. SAP.
    Felſpar,
    Lepidolite,
    Leucite.
VIII. SAG.
    Emerald.
IX. SAB.
    Staurolite.
X. 1. ASL.
    Chryſoberyl.
  2. SAL.
    Hyalite,
    Ædelite.
  3. SAWL.

(E) We need hardly remark, that the laſt three genera of Werner belong to the ſecond order of the firſt claſs of this treatiſe.

3. SAWL.
    Zeolite,
    Stilbite,
    Analcime.
4. SLA.
    Lazulite.
XI. SALI.
    Garnet,
    Thumerſtone,
    Prehnite,
    Thallite.
XII. 1. AMS.
    Cyanite.
  2. MSA.
    Serpentine.
XIII. MSAI.
    Potſtone,
    Chlorite.
XIV. SLAM.
    Siliceous ſpar.
XV. SAMLI.
    Argillite.
XVI. SM.
    Kiffekill,
    Steatites.
XVII. MSI.
    Chryſolite,
    Jade.
XVIII. SML.
    Aſbeſtus,
    Aſbeſtinite.
XIX. 1. SILM.
    Pyroxen,
    Aſbeſtoid.
  2. SMIL.
    Æctinolite.
XX. SL.
    Shiſtoſe horneſtone.
XXI. ZS.
    Zircon.

25
G. I. A.
Teleſia.

GENUS I. A.

SPECIES 1. Teleſia (F).

Oriental ruby, *ſapphire*, and *topaz* of mineralogiſts.—*Rubis d'orient* of De Liſle.

Three ſtones, diſtinguiſhed from each other by their colour, have long been held in high eſtimation on account of their hardneſs and beauty. Theſe ſtones were known among lapidaries by the names of *ruby*, *ſapphire*, and *topaz*, and the epithet *oriental* was uſually added, to diſtinguiſh them from other three, known by the ſame names and the ſame colours, but very inferior in hardneſs and beauty. Mineralogiſts were accuſtomed to conſider theſe ſtones as three diſtinct ſpecies, till Romé de Liſle obſerved that they agreed in the form of their cryſtals, their hardneſs, and moſt of their other properties. Theſe obſervations were ſufficient to conſtitute them one ſpecies; and accordingly they were made one ſpecies by Romé de Liſle himſelf, by Kirwan, and ſeveral other modern mineralogical writers. But this ſpecies was deſtitute of a proper name, till Mr Hauy, whoſe labours, diſtinguiſhed equally by their ingenuity and accuracy, have contributed not a little to the progreſs of mineralogy, denominated it *teleſia*, from the Greek word τελεσιος, which ſignifies *perfect*.

The teleſia is found in the Eaſt Indies, eſpecially in Pegu and the iſland of Ceylon; and it is moſt commonly cryſtallized. The cryſtals are of no great ſize: Their *primitive* form, according to Mr Hauy, is a regular ſix-ſided priſm, diviſible in directions parallel both to its baſes and its ſides; and conſequently giving for the form of its primitive nucleus, or of its *integrant molecule*, an equilateral three ſided priſm *. The moſt uſual variety is a dodecahedron, in which the teleſia appears under the form of two very long ſlender ſix-ſided pyramids, joined baſe to baſe †. The ſides of theſe pyramids are iſoſceles triangles, having the angle at their vertex 22° 54′, and each of thoſe at the baſe 78° 48′ (G). The inclination of a ſide of one pyramid to a contiguous ſide of the other pyramid is 139° 54′ †. In ſome ſpecimens the ſummits of the pyramids are wanting, ſo that the cryſtal has the appearance of a ſix-ſided priſm, ſomewhat thicker in the middle than towards the extremities *. The three alternate angles at each extremity of this priſm are alſo ſometimes wanting, and a ſmall triangular face inſtead of them, which renders the baſes of the ſuppoſed priſm nine-ſided. The inclination of each of theſe ſmall triangles to the baſe is 122° 18′ ‡. For figures of theſe cryſtals we refer the reader to Romé de Liſle and Hauy *.

* Ann de Chim. xvii. 313.
† Plate XXXVI. fig. 1.
† Ibid and Romé de Liſle, ii. 315.
* Fig. 2.
‡ Hauy, ib
* Ibid.

The texture of the teleſia is foliated, and the joints are parallel to the baſe of the priſm †. Its luſtre varies from 3 to 4 (H). Tranſparency uſually 3 or 4, ſometimes only 2. It cauſes only a ſingle refraction. Specific gravity from 4. to 4.288. Hardneſs from 15 to 17. It is either colourleſs, or red, yellow or blue. Theſe colours have induced lapidaries to divide the teleſia into the three following varieties.

† Hauy.

Variety 1. Red teleſia.
Oriental ruby.

Colour carmine red, ſometimes verging towards violet. Sometimes various colours appear in the ſame ſtone, as red and white, red and blue, orange red. Hardneſs 17. Sp. gr. 4.288.

Variety 2. Yellow teleſia.
Oriental topaz.

Colour golden yellow. Tranſp. 4. Hardneſs 15. Sp gr. 4.0106.

Variety 3. Blue teleſia.
Oriental ſapphyr.

Colour Berlin blue, often ſo very faint that the ſtone appears almoſt colourleſs. Tranſp. 3, 4, 2. Hardneſs 17. Sp. gr. 3 991 to 4 083 ‡. This variety is not probably the ſame with the ſapphyr of the ancients. Their ſapphyr was diſtinguiſhed by gold-coloured ſpots, none of which are to be ſeen in the ſapphyr of the moderns ‖.

‡ Grevill Nicholſon Jour. iii
‖ Hill's Theophraſtus, περι των λιθων p. 100.

A ſpecimen of this laſt variety, analyſed by Mr Klaproth, was found to contain in 100 parts,

98.5 alumina,
1.0 oxyd of iron,
0.5 lime,

100.0 *.

* Beiträg i. 81.

The colouring matter of all theſe varieties is, according to Bergman's experiments, iron, in different ſtates of oxydation. He found that the topaz contained .06, the ruby .1, and the ſapphyr .02 of that metal †. But when theſe experiments were made, the analyſis of ſtones was not arrived at a ſufficient degree of perfection to enſure accuracy. No concluſion, therefore, can be drawn from theſe experiments, even though we were certain that they were made upon the real varieties of teleſia.

† Bergm ii. 96.

SPECIES

(F) See *Kirwan's Mineralogy*, I. 250.—*Gmelin's Syſtema Naturæ of Linnæus*, III. 170.—*Romé de Liſle's Cryſtallographie*, II. 212.—*Bermanni Opuſcula*, II. 72.

(G) In ſome inſtances, the angle at the vertex is 31°, thoſe at the baſe 74° 30′, and the inclination of two triangles 122° 36′. See *Hauy*, *ibid*.

(H) When the *kind* of luſtre is not ſpecified, as in the preſent inſtance, the *common* is always meant.

dum.

SPECIES 2. Corundum (1).

Corundum of Gmelin—*Adamantine ſpar* of Klaproth and Kirwan—*Corindon* of Hauy—*Corivindum* of Woodward.

This ſtone, though it appears to have been known to Mr Woodward, may be ſaid to have been firſt diſtinguiſhed from other minerals by Dr Black. In 1768, Mr Berry, a lapidary in Edinburgh, received a box of it from Dr Anderſon of Madras. Dr Black aſcertained, that theſe ſpecimens differed from all the ſtones known to Europeans; and, in conſequence of its hardneſs, it obtained the name of *adamantine ſpar*. Notwithſtanding this, it could ſcarcely be ſaid to have been known to European mineralogiſts till Mr Greville of London, who has done ſo much to promote the ſcience of mineralogy, obtained ſpecimens of it, in 1784, from India, and diſtributed them among the moſt eminent chemiſts, in order to be analyſed. Mr Greville alſo learned, that its Indian name was Corundum. It is found in Indoſtan, not far from the river Cavery, which is ſouth from Madras, in a rocky matrix, of conſiderable hardneſs, partaking of the nature of the ſtone itſelf *. It occurs alſo in China; and a ſubſtance, not unlike the matrix of corundum, has been found in Teree, one of the weſtern iſlands of Scotland †.

The corundum is uſually cryſtallized. Its primitive form, diſcovered by Mr Hauy ‡ and the Count de Bournon *, is a rhomboidal parallelopiped, whoſe ſides are equal rhombs, with angles of 86° and 94°, according to Bournon, or whoſe diagonals are to each other as $\surd 17$ to $\surd 15$, according to Hauy; which is very nearly the ſame thing †. The moſt common variety, for the primitive form has never yet been found, is the regular ſix-ſided priſm, the alternate angles of which are ſometimes wanting ‖, and the triangular faces, which occupy their place, are inclined to the baſe at an angle of 122° 34′ ‡. Sometimes the corundum is cryſtallized in the form of a ſix-ſided pyramid, the apex of which is generally wanting. For a deſcription and figure of theſe, and all the other varieties of corundum hitherto obſerved, we refer the reader to the diſſertation of the Count de Bournon on the ſubject *.

The texture of the corundum is foliated, and the natural joints are parallel to the faces of the primitive rhomboidal parallelopiped. Luſtre, when in the direction of the laminæ, 3; when broken acroſs, 0. Opake, except when in very thin pieces. Hardneſs 15. Sp. gr. from 3.710 to 4.180 †. Colour grey, often with various ſhades of blue and green.

According to the analyſis of Klaproth, the corundum of India is compoſed of

89.5 alumina,
5.5 ſilica,
1.25 oxyd of iron,
———
96.25 ‡.

A ſpecimen from China of

84.0 alumina,
6.5 ſilica,
7.5 oxyd of iron,
———
98.0 ‖.

Notwithſtanding the quantity of ſilica and of iron which theſe analyſes exhibit in the corundum, we have been induced to include it in the preſent genus, on account of the ſtrong reſemblance between it and the third variety of teleſia. The ſtriking reſemblance between the cryſtals of teleſia and corundum will appear evident, even from the ſuperficial deſcription which we have given; and the obſervations of De Bournon * render this reſemblance ſtill more ſtriking. It is not improbable, therefore, as Mr Greville and the Count de Bournon have ſuggeſted, that corundum may be only a variety of teleſia, and that the ſeeming difference in their ingredients is owing to the impurity of thoſe ſpecimens of corundum which have hitherto been brought to Europe. Let not the difference which has been found in the primitive form of theſe ſtones be conſidered as an inſuperable objection, till the ſubject has been again examined with this preciſe object in view; for nothing is eaſier than to commit an overſight in ſuch difficult examinations.

27
Native alumina.

SPECIES 3. Native alumina (K).

This ſubſtance has been found at Halles in Saxony in compact kidney-form maſſes. Its conſiſtence is earthy. Luſtre 0. Opaque. Hardneſs 4. Brittle. Sp. gr. moderate. Feels ſoft, but meagre. Adheres very ſlightly to the tongue. Stains very ſlightly. Colour pure white. Does not readily diffuſe itſelf in water.

It conſiſts of pure alumina, mixed with a ſmall quantity of carbonat of lime, and ſometimes of ſulphat of lime †.

28
G. II. AMC.
Ruby.

GENUS II. AMC.

SPECIES 1. Ruby (L).

Spinel and *balaſs Ruby* of Kirwan—*Ruby* of Hauy—*Rubis ſpinelle octoedre* of De Liſle—*Spinellus.* of Gmelin.

This ſtone, which comes from the iſland of Ceylon, is uſually cryſtallized. The primitive form of its cryſtals is a regular octohedron, compoſed of two four-ſided pyramids applied baſe to baſe, each of the ſides of which is an equilateral triangle ‡ (M). In ſome caſes two oppoſite ſides of the pyramids are broader than the other two; and ſometimes the edges of the octohedron are wanting, and narrow faces in their place. For figures and deſcriptions of theſe, and other varieties of theſe cryſtals, we refer the reader to *Romé de Liſle* and the *Abbé Eſtner* *.

The texture of the ruby is foliated. Its luſtre is 3. Tranſp. 3.4. It cauſes a ſingle refraction. Hardneſs 13. Sp. gr. 3.570 † to 3.625 ‡. Colour red; if deep, the ruby is uſually called *balaſs*; if pale roſy, *ſpinell*.

C c 2 The

* rrow Gre- Ni- n's ii.

† ville, ibi

‡ . de No i. 262.

* hol- Jour. I.

† . 3.

‖ . 4.

‡ Bour- no

* e alſo . Jour. in. No i. 262.

† proth. alſo Gre- Ni- n's iii. 11.

‡ iträge, i.

‖ *Ibid.* i. 73.

* *Nicholſon's Jour.* iii. 9.

† *Schreber.*

‡ *Fig.* 5.

* *Cryſtall.* ii. 226. *Eſtner's Miner.* 7.

† *Klaproth.*

‡ *Hatchett and Greville.*

---

(1) See *Kirwan's Mineralogy*, I.—*Klaproth in Beob. der Berlin*, VIII. 295. and *Beiträge*, I. 47.—*Mr Greville* and the *Count de Bournon* in the *Philoſophical Tranſactions* 1798, p. 403. and in *Nicholſon's Journal*, II. 540. and III. 5.—*Mr Hauy Jour. de Phyſ.* XXX. 193. and *Jour. de Min.* N° XXVIII. 262.

(K) See *Kirwan's Mineralogy*, I. 175, and *Schreber*. 15. *Stück*, p. 209.

(L) See *Kirwan's Min.* I. 253.—*Romé de Liſle*, II. 224.—*Klaproth Beob. der Berlin*, III. 336. and *Beitrage*, II. 1.—*Vauquelin Ann. de Chim.* XXVII. 3. and XXXI. 141.

(M) We ſhall afterwards diſtinguiſh this octohedron either by the epithet *regular* or *aluminiform*, becauſe it is the well known form of cryſtals of alum.

The ruby, according to the analyſis of Vauquelin, is compoſed of

86.00 alumina,
8.50 magneſia,
5.25 chromic acid.

99.75 *

The ancients ſeem to have claſſed this ſtone among their hyacinths †.

* Ann. de Chim. xxvii. 15.
† Plinii, l. 37. c. 9.

29 G. III. AIM. Ceylanite.

GENUS III. AIM.

SPECIES 1. Ceylanite.

The mineral denominated *ceylanite*, from the iſland of Ceylon, from which it was brought into Europe, had been obſerved by Romé de Liſle ‡; but was firſt deſcribed by La Metherie in the Journal de Phyſique for January 1793.

‡ Cryſtallog. iii. 180. Note 21.

It is moſt commonly found in rounded maſſes; but ſometimes alſo cryſtallized. The primitive form of its cryſtals is a regular octohedron: it commonly occurs under this form, but more commonly the edges of the octohedron are wanting, and ſmall faces in their place ‡.

‡ Hauy, Jour. de Min. N° xxxviii. 264.

The fracture of the ceylanite is conchoidal *. Its internal luſtre is glaſſy. Nearly opaque, except when in very thin pieces. Hardneſs 12. Sp. gr. from 3.7647† to 3.793‡. Colour of the maſs, black; of very thin pieces, deep green. Powder, greeniſh grey. According to the analyſis of Deſcotils the ceylanite is compoſed of

68 alumina,
16 oxyd of iron,
12 magneſia,
2 ſilica.

98 §

* Ibid. 263
† Hauy.
‡ Deſcotils.
§ Ann. de Chim. xxiii. 113.

30 G. IV. S. Quartz.

GENUS IV. S.

SPECIES 1. Quartz ||.

This ſtone, which is very common in moſt mountainous countries, is ſometimes cryſtallized, and ſometimes amorphous. The primitive form of its cryſtals, according to Mr Hauy, is a rhomboidal parallelopiped; the angles of whoſe rhombs are 93° 22′, and 86° 38′; ſo that it does not differ much from a cube *. The moſt common variety is a dodecahedron ‡, compoſed of two ſix-ſided pyramids, applied baſe to baſe, whoſe ſides are iſoſceles triangles, having the angle at the vertex 40°, and each of the angles at the baſe 70°; the inclination of a ſide of one pyramid to the contiguous ſide of the other pyramid is 104°. There is often a ſix-ſided priſm interpoſed between the two pyramids, the ſides of which always correſpond with thoſe of the pyramids ||. For a deſcription and figure of the other varieties of quartz cryſtals, and for a demonſtration of the law which they have followed in cryſtallizing, we refer the reader to *Romé de Liſle* † and *Mr Hauy* ‡.

|| Kirwan's Min. i. 241.
* Jour de Min, N° xxviii. 255.
‡ Fig. 6.
|| Fig. 7.
† Cryſtal. ii. 71.
‡ Mem. Par. 1786, p. 78. See alſo Lametherie, Jour. de Phyſ. xlii. 470.

The texture of quartz is more or leſs foliated. Fracture, conchoidal or ſplintery. Its luſtre varies from 3 to 1, and its tranſparency from 4 to 1; and in ſome caſes it is opaque. It cauſes a double refraction. Hardneſs, from 10 to 11. Sp. gr. from 2.64 to 2.67, and in one variety 2.691. Its colour is exceedingly various; a circumſtance which has induced mineralogiſts to divide it into numerous varieties. Of theſe the following are the chief:

1. Pure colourleſs, perfectly tranſparent cryſtallized quartz, having much the appearance of artificial cryſtal; known by the name of *rock cryſtal.*

2. Quartz leſs tranſparent, and with a ſplintery fracture, has uſually been diſtinguiſhed by the name of *quartz*, and ſeparated from rock cryſtal. As there is no occaſion for this ſeparation, we have, in imitation of Mr Hauy, choſen the word quartz for the *ſpecific name*, comprehending under it all the varieties.

3. Blood red quartz; formerly called *compoſtella hyacinth*, and by Hauy *quartz hematoide.* It owes its colour to oxyd of iron. The mineral known to mineralogiſts by the name of *ſinople*, and conſidered by them as a variety of *jaſper*, has been diſcovered by Dolomieu to be merely this variety of quartz in an amorphous ſtate *.

4. Yellow quartz; called falſe topaz.

5. Roſy red quartz; called Bohemian ruby.

For a fuller enumeration of theſe varieties, we refer the reader to *Smeiſſer's Mineralogy* †, *Kirwan's Mineralogy* ‡, and Gmelin's edition of the *Syſtema Naturæ* of Linnæus §. This laſt writer, however, has arranged ſeveral minerals under quartz which do not belong to it.

* Jour. de Min. N° xxviii. 255
† i. 89.
‡ i. 244.
§ iii. 194.

Pure quartz is compoſed entirely of ſilica; but ſome of the varieties of this ſpecies are contaminated with metallic oxyds, and with a ſmall quantity of other earths.

31 Elaſtic quartz.

SPECIES 2. Elaſtic Quartz (N).

This ſingular ſtone is moderately elaſtic, and flexible in every direction. Texture, earthy. Luſtre, 0 or 1. Hardneſs, 9. Brittle. Sp. gr. 2.624. Colour, greyiſh white. Phoſphoreſces when ſcraped with a knife in the dark. The ſpecimen analyſed by Mr Klaproth contained

96.5 ſilica,
2.5 alumina,
5 oxyd of iron,

99.5 †

† Beiträge ii. 116.

32 Flint.

SPECIES 3. Flint (O).

Pyromachus — Pierre a fuſil — Silex of Hauy.

This ſtone, which has become ſo neceſſary in modern war, is found in pieces of different ſizes, and uſually of a figure more or leſs globular, commonly among chalk, and often arranged in ſome kind of order. In Saxony it is ſaid to have been found cryſtallized in hexahedrons, compoſed of two low three-ſided pyramids applied baſe to baſe *.

* Gmelin's Syſtema Naturæ, iii. 183.

Its texture is compact. Its fracture, ſmooth conchoidal. Luſtre, external 0, the ſtones being always covered by a white cruſt; internal 1, inclining to greaſy. Tranſp. 2; when very thin, 3. Hardneſs, 10 or 11. Sp. gr. from 2.58 to 2.63. Colour varies from honey yellow to browniſh black. Very brittle, and ſplits into ſplinters in every direction. Two pieces of flint rubbed ſmartly together phoſphoreſce, and emit a peculiar odour. When heated it decrepitates, and becomes white and opaque. When expoſed long to the air

---

(N) *Kirwan's Min.* I. 316.—*Gerhard Mem. Berlin*, 1783, 107.—*Klaproth's Beitrage* 2 *Band.* 113. See alſo *Jour. de Phyſ.* XLI. 91.

(O) *Kirwan's Min.* I. 301.—*Dolomieu Jour de Min.* N° XXXIII. 693. and *Salivet, ibid.* 713. Theſe laſt gentlemen give the only accurate account of the method of making gun flints.

air it often becomes covered with a white cruſt. A ſpecimen of flint analyſed by Klaproth contained

98.00 ſilica,
.50 lime,
.25 alumina,
0.25 oxyd of iron,
1.00 water.

100.00 [†]

Another ſpecimen analyſed by Dolomieu was compoſed of
97 ſilica,
1 alumina and oxyd of iron,
2 water.

100 [‡]

The white cruſt with which flint is enveloped, conſiſts of the ſame ingredients, and alſo a little carbonat of lime. Dolomieu diſcovered that water is eſſential to flint; for when it is ſeparated by heat the ſtone loſes its properties [§].

The manufacture of gun flints is chiefly confined to two or three departments in France. The operation is exceedingly ſimple: a good workman will make a 1000 flints in a day. The whole art conſiſts in ſtriking the ſtone repeatedly with a kind of mallet, and bringing off at each ſtroke a ſplinter, ſharp at one end and thicker at the other. Theſe ſplinters are afterward ſhaped at pleaſure, by laying the line at which it is wiſhed they ſhould break, upon a ſharp iron inſtrument, and then giving it repeatedly ſmall blows with a mallet. During the whole operation the workman holds the ſtone in his hand, or merely ſupports it on his knee [||].

SPECIES 4. Opal (p).

This ſtone is found in many parts of Europe. It is uſually amorphous. Its fracture is conchoidal, commonly ſomewhat tranſparent. Hardneſs from 6 to 10. Sp. gr. from 1.7 to 2.66. The lowneſs of its ſpecific gravity, in ſome caſes, is to be aſcribed to accidental cavities which the ſtone contains. Theſe are ſometimes filled with drops of water. Some ſpecimens of opal have the property of emitting various coloured rays, with a particular effulgency, when placed between the eye and the light. The opals which poſſeſs this property, are diſtinguiſhed by lapidaries by the epithet *oriental*; and often by mineralogiſts by the epithet *nobilis*. This property rendered the ſtone much eſteemed by the ancients.

Variety 1. Opal edler—*Opalus nobilis*.

Luſtre glaſſy, 3. Tranſp. 3 to 2. Hardneſs, 6 to 8. Colour, uſually light bluiſh white, ſometimes yellow or green. When heated it becomes opaque, and ſometimes is decompoſed by the action of the atmoſphere. Hence it ſeems to follow, that water enters eſſentially into its compoſition. A ſpecimen of this variety, analyſed by Klaproth, contained

90 ſilica,
10 water.

100 [¶]

Variety 2. Semi-opal.

Fracture, imperfectly conchoidal. Luſtre, glaſſy 2. Tranſp. 2 to 3. Hardneſs, 7 to 9. Its colours are very various, greys, yellows, reds, browns, greens of different kinds.

Specimens of this variety ſometimes occur with rifts: theſe readily imbibe water, and therefore adhere to the tongue. Theſe ſpecimens ſometimes become tranſparent when ſoaked in water, by imbibing that fluid. They are then called *hydrophanes*.

Variety 3. Cat's eye [*].

This variety comes from Ceylon, and is ſeldom ſeen by European mineralogiſts till it has been poliſhed by the lapidary. Mr Klaproth has deſcribed a ſpecimen which he received in its natural ſtate from Mr Greville of London. Its figure was nearly ſquare, with ſharp edges, a rough ſurface, and a good deal of brilliancy. Its texture is imperfectly foliated. Luſtre greaſy, 2. Tranſp. 3 to 2. Hardneſs 10. Sp. gr. 2.56 to 2.66. Colour, grey; with a tinge of green, yellow or white: or brown, with a tinge of yellow or red. In certain poſitions it reflects a ſplendid white, as does the eye of a cat; hence the name of this ſtone.

Two ſpecimens, analyſed by Klaproth, the firſt from Ceylon, the other from Malabar, were compoſed of

95.00	94.50 ſilica,
1.75	2.00 alumina,
1.50	1.50 lime,
0.25	0.25 oxyd of iron.
98.5 [*]	98.25 [†].

SPECIES 5. Pitchſtone [§].

34 Pitchſtone.

Menelites.

This ſtone, which occurs in different parts of Germany, France, and other countries, has obtained its name from ſome reſemblance which it has been ſuppoſed to have to pitch. It is moſt uſually in amorphous pieces of different ſizes; and it has been found alſo cryſtallized in ſix-ſided priſms, terminated by three-ſided pyramids.

Its texture is conchoidal and uneven, and ſometimes approaches the ſplintery. Luſtre greaſy, from 3 to 1. Tranſp. 2 to 1, ſometimes 0. Hardneſs 8 to 10. Exceedingly brittle; it yields even to the nail of the finger. Sp. gr. 2.049 to 2.39. Its colours are numerous, greyiſh black, bluiſh grey, green, red, yellow of different ſhades. Sometimes ſeveral of theſe colours appear together in the ſame ſtone. A ſpecimen of pitchſtone from Meſnil-montant near Paris [*], analyſed by Mr Klaproth, contained

85.5 ſilica,
11.0 air and water,
1.0 alumina,
.5 iron,
.5 lime and magneſia.

98.5 [†]

SPECIES 6. Chryſopraſium (q).

35 Chryſopraſium.

This mineral, which is found in different parts of Germany, particularly near Koſemütz in Sileſia, is always amorphous. Its fracture is either even or inclining to the ſplintery. Scarcely any luſtre. Tranſp. 2 to 3. Hardneſs 10 to 12. Sp. gr. 2.479. Colour, green. In a heat of 130° Wedgewood it whitens and becomes opaque.

A

[*] Kirwan's Min i. 301. Klaproth, Beiträge, i. 90.

[*] Beiträge, i. 94.
[†] Ibid. p. 96.

[§] Kir Min. i. 292 — Daubanton, Mem. Par. 1787, p. 86.

[*] See Jour. de Phyſ. xxxi. 219.

[†] Beiträge, ii. 169.

(p) *Kirwan's Min.* I. 289.—*Hauy, Jour. d'Hiſt. Nat.* II. 9. *Delius. Nouv. Jour. de Phyſ.* I. 45.
(q) *Kirwan's Min.* I.—*Lehmann. Mem. Berlin.* 1755. *p.* 202.—*Klaproth Beitrage*, II. 127.

Earths and Stones.

A ſpecimen of this ſtone, analyſed by Mr Klaproth, contained

96.16 ſilica,
1.00 oxyd of nickel,
0.83 lime,
0.08 alumina,
0.08 oxyd of iron.
98.15 ‡

‡ Beiträge, ii. 133.

36 G. V. 1 AS. Topaz.

GENUS V. 1. AS.

SPECIES 1. Topaz (R).

Occidental ruby, topaz, and ſapphyr.

The name *topaz* has been reſtricted by Mr Hauy to the ſtones called by mineralogiſts occidental ruby, topaz, and ſapphyr; which, agreeing in their cryſtallization and moſt of their properties, were arranged under one ſpecies by Mr Romé de Liſle. The word *topaz*, derived from an iſland in the Red Sea (s), where the ancients uſed to find topazes, was applied by them to a mineral very different from ours. One variety of our topaz they denominated *chryſolite.*

The topaz is found in Saxony, Bohemia, Siberia, and Brazil, mixed with other minerals in granite rocks.

It is commonly cryſtallized. The primitive form of its cryſtals is a priſm whoſe ſides are rectangles, and baſes rhombs, having their greateſt angles 124° 22′, and the integral molecule has the ſame form*; and the height of the priſm is to a ſide of the rhomboidal baſes as 3 to 2‡. The different varieties of topaz cryſtals hitherto obſerved, amount to 6. Five of theſe are eight-ſided priſms, terminated by four-ſided pyramids, or wedge-ſhaped ſummits, or by irregular figures of 7, 13, or 15 ſides‖; the laſt variety is a twelve-ſided priſm, terminated by ſix-ſided pyramids wanting the apex. For an accurate deſcription and figure of theſe varieties we refer the reader to Mr Hauy †.

* Hauy, Jour. de Min. N° xxviii, 287.
‡ Fig. 8.
‖ Fig. 9.
† Jour. de Min. ibid.

The texture of the topaz is foliated. Its luſtre is from 2 to 4. Tranſp. from 2 to 4. It cauſes a double refraction. Hardneſs 12 to 14. Sp. gr. from 3.5311 to 3.564. The Siberian and Brazil topazes, when heated, become poſitively electrified on one ſide, and negatively on the other §. It is infuſible by the blow-pipe. The yellow topaz of Brazil becomes red when expoſed to a ſtrong heat in a crucible; that of Saxony becomes white by the ſame proceſs. This ſhews us, that the colouring matter of theſe two ſtones is different.

§ Hauy, ibid.

The colour of the topaz is various, which has induced mineralogiſts to divide it into the following varieties:

1. Red topaz, of a red colour inclining to yellow; called *Brazilian* or *occidental ruby.*

2. Yellow topaz, of a golden yellow colour, and ſometimes alſo nearly white; called *occidental* or *Brazil topaz.* The powder of this and the following variety cauſes ſyrup of violets to aſſume a green colour ‖.

‖ Vauquelin, Jour. de Min N° xxix. 165.

3. *Saxon topaz.* It is of a pale wine yellow colour, and ſometimes greyiſh white.

4. *Aigue marine.* It is of a bluiſh or pale green colour.

5. *Occidental ſapphyr.* It is of a blue colour; and ſometimes white.

Simple Stones.

A ſpecimen of white Saxon topaz, analyſed by Vauquelin, contained

68 alumina,
31 ſilica.
99 ¶

¶ Jour. de Min N° xxiv. 3.

37 Sommite.

SPECIES 2. Sommite.

This ſtone was called ſommite by La Metherie, from the moutain Somma, where it was firſt found. It is uſually mixed with volcanic productions. It cryſtallizes in ſix-ſided priſms, ſometimes terminated by pyramids. Colour white. Somewhat tranſparent. Sp. gr. 3.2741. Infuſible by the blow-pipe. According to the analyſis of Vauquelin, it is compoſed of

49 alumina,
46 ſilica,
2 lime,
1 oxyd of iron.
98 *

* Ibid. N° xxviii. 27

38 Shorlite.

SPECIES 3. Shorlite †.

This ſtone, which received its name from Mr Klaproth, is generally found, in irregular oblong maſſes or columns, inſerted in granite. Its texture is foliated. Fracture uneven. Luſtre 2. Tranſparency 2 to 1. Hardneſs 9 to 10. Sp. gr. 3.53. Colour greeniſh white, or ſulphur yellow. Not altered by heat. According to the analyſis of Klaproth, it is compoſed of

† Kirwan Min. i. 28

50 alumina,
50 ſilica.
100

39 G V. 2. 1 Rubellite.

GENUS V. 2 SA.

SPECIES 4. Rubellite (T).

Red ſhorl of Siberia.

This ſtone is found in Siberia mixed with white quartz. It is cryſtallized in ſmall needles, which are grouped together and traverſe the quartz in various directions. Texture fibrous. Fracture even, inclining to the conchoidal. Tranſparency 2; at the edges 3. Hardneſs 10. Brittle. Sp. gr. 3.1. Colour crimſon, blood or peach red. By expoſure to a red heat it becomes ſnow white; but loſes none of its weight. It tinges ſoda blue, but does not melt with it.

According to the analyſis of Mr Bindheim, it is compoſed of

57 ſilica,
35 alumina,
5 oxyds of iron and manganeſe.
97

40 Hornſlate

SPECIES 5. Hornſlate (U).

Shiſtoſe porphyry.

This ſtone, which occurs in mountains, is generally amorphous; but ſometimes alſo in columns. Structure

---

(R) *Kirwan's Min.* I. 254.—*Pott. Mem. Berlin*, 1747, *p.* 46.—*Margraf, ibid.* 1776. *p.* 73. and 160.—*Henkel. Act. Acad. Nat. Cur.* IV. 316.

(S) It got its name from τοπαζω, *to ſeek;* becauſe the iſland was often ſurrounded with fog, and therefore difficult to find. See *Plinii lb.* 37. *c.* 8.

(T) *Kirwan's Min* I. 288. *Bindheim. Crell's Annals*, 1792 *p.* 320.

(U) *Kirwan's Min.* I. 307.—*Wiegleb. Crell's Annals*, 1787. 1 *Band.* 302.—See alſo *Reuſs. Samml. Natur. Hiſt. Aufsäze, p* 207.

Ear and St es.

ture ſlaty. Texture foliated. Fracture uneven and ſplintery; ſometimes approaching the conchoidal. Luſtre 0. Tranſparency 1 or 0. Hardneſs about 10. Sp. gr. from 2.512 to 2.7. Colour different ſhades of *grey*, from *aſh* to *bluiſh* or *olive green*. Melts at 145° Wedgewood into an enamel. A ſpecimen, analyſed by Wedgewood, contained

73.0	ſilica,
23.9	alumina,
3.5	iron.
100.4	

Hor one.

SPECIES 6. Hornſtone (x).

Petroſilex—Chert.

This ſtone, which makes a part of many mountains, is uſually amorphous; but, as Mr Kirwan informs us, it has been found cryſtallized by Mr Beyer on Schneeberg. Its cryſtals are ſix ſided priſms, ſometimes terminated by pyramids; hexahedrons, conſiſting of two three-ſided pyramids applied baſe to baſe; and cubes, or ſix-ſided plates *. Its texture is foliated. Fracture ſplintery, and ſometimes conchoidal. Luſtre 0. Tranſparency 1 to 2. The cryſtals are ſometimes opaque. Hardneſs 7 to 9. Sp. gr. 2.532 to 2.653. Colour uſually dark blue: but hornſtone occurs alſo of the following colours; grey, red, blue, green, and brown of different ſhades †.

According to Kirwan, it is compoſed of

72	ſilica,
22	alumina,
6	carbonat of lime.
100 ‡	

* K wan, i. 3

† S eiſ- fer's Min. 3. 1

‡ Ib p. 305

Cha do- ny.

SPECIES 7. Chalcedony.

This ſtone is found abundantly in many countries, particularly in Iceland and the Faro iſlands. It is moſt commonly amorphous, ſtalactitical, or in rounded maſſes; but it occurs alſo cryſtallized in ſix ſided priſms, terminated by pyramids, or more commonly in four or ſix ſided pyramids, whoſe ſides are convex. Surface rough. Fracture more or leſs conchoidal. Luſtre 1. Somewhat tranſparent. Hardneſs 10 to 11. Sp. gr. 2.56 to 2.665. Not brittle.

According to Bergman, the chalcedony of Faroe is compoſed of

84	ſilica,
16	alumina, mixed with iron.
100	

Variety 1. Common chalcedony.

Fracture even, inclining to conchoidal. Tranſparency 2 to 3; ſometimes 1. Its colours are various; it is moſt commonly greyiſh, with a tint of yellow, green, blue, or pearl; often alſo white, green, red, yellow, brown, black, or dotted with red. When ſtriped white and black, or brown, alternately, it is called *onyx*; when ſtriped white and grey, it is called *chalcedonix*. Black or brown chalcedony, when held between the eye and a ſtrong light, appears dark red.

Variety 2. Cornelian.

Fracture conchoidal. Tranſparency 3 to 1; often cloudy. Its colours are various ſhades of red, brown, and yellow. Several colours often appear in the ſame maſs. To this variety belong many of the ſtones known by the name of *Scotch pebbles*.

Simple Stones.

43 Jaſper.

SPECIES 8. Jaſper (y).

This ſtone is an ingredient in the compoſition of many mountains. It occurs uſually in large amorphous maſſes, and ſometimes alſo cryſtallized in ſix ſided irregular priſms. Its fracture is conchoidal. Luſtre from 2 to 0. Either opaque, or its tranſparency is 1. Hardneſs 9 to 10. Sp. gr. from 2.5 to 2.82. Its colours are various. When heated, it does not decripitate. It ſeems to be compoſed of ſilica and alumina, and often alſo contains iron.

Variety 1. Common jaſper.

Sp. gr. from 2.58 to 2.7. Its colours are, different ſhades of white, yellow, red, brown, and green; often variegated, ſpotted, or veined, with ſeveral colours.

Variety 2. Egyptian pebble.

This variety is found chiefly in Egypt. It uſually has a ſpheroidal or flat rounded figure, and is enveloped in a coarſe rough cruſt. It is opaque. Hardneſs 10. Sp. gr. 2.564. It is chiefly diſtinguiſhed by the variety of colours, which always exiſt in the ſame ſpecimen, either in concentric ſtripes or layers, or in dots or dentritical figures These colours are, different browns and yellows, milk white, and iſabella green; black alſo has been obſerved in dots.

Variety 3. Striped jaſper.

This variety is alſo diſtinguiſhed by concentric ſtripes or layers of different colours: theſe colours are, yellow, browniſh red, and green. It is diſtinguiſhed from the laſt variety by its occurring in large amorphous maſſes, and by its fracture, which is nearly even.

44 Tripoli.

SPECIES 9. Tripoli.

This mineral is found ſometimes in an earthy form, but more generally indurated. Its texture is earthy. Its fracture often ſomewhat conchoidal. Luſtre 0. Generally opaque. Hardneſs 4 to 7. Sp. gr. 2.080 to 2.529. Abſorbs water. Feel, harſh dry. Hardly adheres to the tongue. Takes no poliſh from the nail. Does not ſtain the fingers Colour generally pale yellowiſh grey, alſo different kinds of yellow, brown, and white.

It contains, according to Haaſſe, 90 parts of ſilica, 7 alumina, and 3 of iron. A mineral belonging to this ſpecies was analyſed by Klaproth, and found to contain

66.5	ſilica,
7.0	alumina,
2.5	oxyd of iron,
1.5	magneſia,
1.25	lime,
19.	air and water.
97·75	

45 G. VI. I. ASI. Micarell.

GENUS VI. I. ASI.

SPECIES 1. Micarell *.

This name has been given by Mr Kirwan to a ſtone which former mineralogiſts conſidered as a variety of mica. It is found in granite. Its texture is foliated, and

* Kirwan's Min i. 212.

(x) *Kirwan's Min.* I. 303.—*Baumer Jour. de Phyſ.* II. 154. and *Mónnet*, *ibid.* 331.—*Wiegleb. Crell's Annals*, 1788, *p.* 45 and 135.

(y) *Kirw. Min.* I. 309.—*Borral Hiſt. Natur. de Corſe.*—*Henkel Act. Acad. Nat. Curios.* V. 339.

and it may be ſplit into thin plates. Luſtre metallic, 3. Opaque. Hardneſs 6. Sp. gr. 2.980. Colour browniſh black. At 153° Wedgewood, it melts into a black compact glaſs, the ſurface of which is reddiſh †.

† Kirw. ibid.

A ſpecimen analyſed by Klaproth contained

63.00	alumina,
29.50	ſilica,
6.75	iron.
99.25	

46 Shorl.

SPECIES 2. Shorl ‡.

‡ Ibid. i. 265.

No word has been uſed by mineralogiſts with leſs limitation than *ſhorl*. It was firſt introduced into mineralogy by Cronſtedt, to denote any ſtone of a columnar form, conſiderable hardneſs, and a ſpecific gravity from 3 to 3.4. This deſcription applied to a very great number of ſtones. And ſucceeding mineralogiſts, though they made the word more definite in its ſignification, left it ſtill ſo general, that under the deſignation of *ſhorl* almoſt 20 diſtinct ſpecies of minerals were included.

Mr Werner firſt defined the word *ſhorl* preciſely, and reſtricted it to one ſpecies of ſtones. We uſe the word in the ſenſe aſſigned by him.

Shorl is found abundantly in mountains, either maſſive or cryſtallized, in three or nine ſided priſms, often terminated by three ſided ſummits. The ſides of the cryſtals are longitudinally ſtreaked. Its texture is foliated. Its fracture conchoidal. Luſtre 2. Opaque. Hardneſs 10. Sp. gr. 2.92 to 3.212. Colour black. Streak grey. It does not become electric by heat. When heated to redneſs, its colour becomes browniſh red; and at 127° Wedgewood, it is converted into a browniſh compact enamel *. According to Wiegleb, it is compoſed of

* Ibid. i. 266.

41.25	alumina,
34.16	ſilica,
20.00	iron,
5.41	mangane ſe.
100.82 †	

† Crell's Beiträge, 1. Bandes. 4 Stück, p. 21.

47 Granatite.

SPECIES 3. Granatite.

Staurotide of Hauy—*Pierre de Croix* of De Liſle—*Staurolithe* of Lametherie.

We have adopted from Mr Vauquelin the term *granatite* to denote this ſtone, becauſe all the other names are ambiguous, having been applied to another mineral poſſeſſed of very different properties.

Granatite is found in Galicia in Spain, and Britanny in France. It is always cryſtallized in a very peculiar form; two ſix-ſided priſms interſect each other, either at right angles or obliquely ‡. Hence the name *croſsſtone*, by which it was known in France and Spain *. Mr Hauy has proved, in a very ingenious manner, that the primitive form of the granatite is a rectangular priſm, whoſe baſes are rhombs, with angles of 129½° and 50½°; and that the height of the priſm is to the greater diagonal of a rhomb as 1 to 6; and that its integrant molecules are triangular priſms, ſimilar to what would be obtained by cutting the primitive cryſtal in two, by a plane paſſing vertically through the ſhorter diagonal of the rhomboidal baſe. From this ſtructure he has demonſtrated the law of the formation of the cruciform varieties *. The colour of granatite is greyiſh or reddiſh brown.

‡ Fig. 10.

* Romé de Liſle, ii. 435.

* Ann. de Chim. vi. 142.

According to the analyſis of Vauquelin, it is compoſed of

47.06	alumina,
30.59	ſilica,
15.30	oxyd of iron,
3.00	lime.
95.95 †	

† Ibid. xx 106.

48 G. VI. 2. SAI. Tourmaline.

GENUS VI. 2. SAI.

SPECIES 4. Tourmaline (z).

This ſtone was firſt made known in Europe by ſpecimens brought from Ceylon; but it is now found frequently forming a part of the compoſition of mountains. It is either in amorphous pieces, or cryſtallized in three or nine ſided priſms, with four-ſided ſummits.

Its texture is foliated: Its fracture conchoidal. Internal luſtre 2 to 3. Tranſparency 3 to 4; ſometimes only 2 (A). Cauſes only ſingle refraction *. Hardneſs 9 to 11. Sp. gr. 3.05 to 3.155. Colour brown, often ſo dark that the ſtone appears black; the brown has alſo ſometimes a tint of green, blue, red, or yellow.

* Hauy, Jour. de Min. No xxviii. 2

When heated to 200° Fahrenheit, it becomes electric; one of the ſummits of the cryſtal negatively, the other poſitively †. It reddens when heated; and is fuſible *per ſe* with intumeſcence into a white or grey enamel.

† Æpinu

A ſpecimen of the tourmaline of Ceylon, analyſed by Vauquelin, was compoſed of

40	ſilica,
39	alumina,
12	oxyd of iron,
4	lime,
2.5	oxyd of mangane ſe,
97.5 ‡.	

‡ Ann. d Chim. xx 105.

49 Argenti felſpar.

SPECIES 5. Argentine felſpar §.

§ Kirw i. 327.

This ſtone was diſcovered by Mr Dodun in the black mountains of Languedoc. It is either amorphous, or cryſtallized in rhomboidal tables, or ſix or eight ſided priſms. Its texture is foliated. Fragments rectangular. Laminæ inflexible. Internal luſtre 4. Tranſparency 2. Colour white; two oppoſite faces of the cryſtals are ſilver white, two others dead white. Hardneſs of the ſilvery laminæ 6, of the reſt 9. Brittle. Sp. gr. 2.5. When the flame of the blow-pipe is directed againſt the edges of the cryſtal (ſtuck upon glaſs), it eaſily melts into a clear compact glaſs; but when the flame is directed againſt the faces, they preſerve their luſtre, and the edges alone ſlowly melt.

According to the analyſis of Dodun, it is compoſed of

46	ſilica,
36	alumina,
16	oxyd of iron,
98	

When this ſtone is expoſed to the atmoſphere, it is apt

(z) *Kirw.* I. 271.—*Berg.* II. 118. and V. 402.—*Gerhard. Mem. Berlin*, 1777, p. 14.—*Hauy Mem. Par.* 1784, 270.—*Wilſon Phil. Tranſ.* XLI. 308.—*Æpinus. Recueil ſur la Tourmaline.* See alſo *La Porterie. Le Saphir, l'Oeil de Chat, et la Tourmaline de Ceylon demaſqués.*

(A) And when black only 1.

Ear and
St es.

apt to decay: Its ſurface becomes irideſcent, and at laſt changes to ochre yellow: Its ſpecific gravity is 2.3 or 2.212; and when breathed upon, it gives out an earthy ſmell.

M a.

SPECIES 6. Mica ‖.

‖ K v. i.
2 0 Gme-
lin, v.
Com etro
pol. 549.

This ſtone forms an eſſential part of many mountains, and has been long known under the names of *glacies mariæ* and *Muſcovy glaſs*. It conſiſts of a great number of thin laminæ adhering to each other, ſometimes of a very large ſize. Specimens have been found in Siberia nearly 2¼ yards ſquare (B).

It is ſometimes cryſtallized: Its primitive form is a rectangular priſm, whoſe baſes are rhombs, with angles of 120° and 60°†: Its integrant molecule has the ſame form. Sometimes it occurs in rectangular priſms, whoſe baſes alſo are rectangles, and ſometimes alſo in ſhort ſix-ſided priſms †; but it is much more frequently in plates or ſcales of no determinate figure or ſize *.

† F 11.

† F 12.

* H y,
Jou le
Mi N°
xxv 296.

Its texture is foliated. Its fragments flat. The lamellæ flexible, and ſomewhat elaſtic. Luſtre metallic, from 3 to 4. Tranſparency of the laminæ 3 or 4, ſometimes only 2 (C). Hardneſs 6. Very tough. Often abſorbs water. Sp. gr. from 2.6546 to 2.9342. Feels ſmooth, but not greaſy. Powder feels greaſy. Colour, when pureſt, ſilver white or grey; but it occurs alſo yellow, greeniſh, reddiſh, brown, and black. Mica is fuſible by the blow-pipe into a white, grey, green, or black, enamel; and this laſt is attracted by the magnet (D). Spaniſh wax rubbed by it becomes negatively electric *.

* I .

A ſpecimen of mica, analyſed by Vauquelin, contained

50.00	ſilica,
35.00	alumina,
7.00	oxyd of iron,
1.35	magneſia,
1.33	lime,
94.68 †.	

† I 302.

Mica has long been employed as a ſubſtitute for glaſs. A great quantity of it is ſaid to be uſed in the Ruſſian marine for panes to the cabin windows of ſhips; it is preferred, becauſe it is not ſo liable as glaſs to be broken by the agitation of the ſhip.

I
lc.

SPECIES 7. Talc ‡.

‡ I w. i.
15 -Pott
M Berl.
17 p 65.

This ſtone has a very ſtrong reſemblance to mica, and was long conſidered as a mere variety of that mineral. It occurs ſometimes in ſmall looſe ſcales, and ſometimes in an indurated form; but it has not hitherto been found cryſtallized.

Its texture is foliated. The lamellæ are flexible, but not elaſtic. Its luſtre is from 2 to 4. Tranſparency from 2 to 4. Hardneſs 4 to 6. Sp. gr. when indurated, from 2.7 to 2.8. Feels greaſy. Colour moſt commonly whitiſh or greeniſh. Spaniſh wax rubbed with it becomes *poſitively* electric §.

§ H y,
Jo de
M N°
xx .291.

Variety 1. Scaly talc.

Talcite of Kirwan.

This variety occurs under the form of ſmall ſcales, ſcarcely cohering. Luſtre 3 to 4. Very light. Adheres to the fingers. When rubbed upon the ſkin, it gives it a gloſs. Colour white, with a ſhade of red or green; ſometimes leek green.

Simple
Stones.

Variety 2. Common talc.

Venetian talc.

This variety often occurs in oblong nodules. Luſtre, nearly metallic, 4. Tranſparency 2 to 3; when very thin 4. Hardneſs 4 to 5. Colour white, with a ſhade of green or red; or apple green, verging towards ſilver white. By tranſmitted light green.

Variety 3. Shiſtoſe talc.

Its ſtructure is ſlaty. Fracture hackly and long ſplintery. Eaſily crumbles when rubbed in the fracture. External luſtre 2 to 3; internal, 1; but ſometimes, in certain poſitions, 3. Colour grey, with a ſhade of white, green or blue. Becomes white and ſcaly when expoſed to the air.

A ſpecimen of *common talc*, analyſed by Mr Chenevix, contained

48.0	ſilica,
37.0	alumina,
6.0	oxyd of iron,
1.5	magneſia,
1.5	lime,
5.0	water,
99.0 *.	

* *Ann. de Chim.* xxviii. 200.

52
Baſaltine.

SPECIES 8. Baſaltine †.

Baſaltic hornblende of Werner—*Actinote* of Hauy—*Zillertite* of Lametherie—*Shorl priſmatique hexagone* of Sauſſure.

† *Kirw.* i. 219.

This ſtone is found commonly in baſaltic rocks; hence its name, which we have borrowed from Mr Kirwan. It is cryſtallized, either in rhomboidal priſms, or ſix or eight ſided priſms, terminated by three-ſided pyramids. Its texture is foliated. Its fracture uneven. Luſtre 3. Tranſparency, when in very thin plates, 1. Hardneſs from 9 to 10. Sp. gr. 3.333. Colour black, dark green, or yellowiſh green. Streak white. Tranſmits a reddiſh yellow light. Before the blow-pipe, it melts into a greyiſh coloured enamel, with a tint of yellow †. A ſpecimen, ſeemingly of this ſtone, analyſed by Bergman, contained

† *Le Lievre, Jour. de Min* N° xxviii. 269.

58	ſilica,
27	alumina,
9	iron,
4	lime,
1	magneſia,
99 ‡.	

‡ *Berg.* iii. 207.

53
Hornblende.

SPECIES 9. Hornblende ¶.

Amphibole of Hauy (E).

¶ *Kirw.* i. 213.

This ſtone enters into the compoſition of various mountains. Its texture is very conſpicuouſly foliated. Fracture conchoidal. Fragments often rhomboidal. Luſtre 2. Opaque. Hardneſs 5 to 9. Tough. Sp. gr. 2.922 to 3.41. Colour black, blackiſh green, olive green

---

(B) *Hiſt. General de Voyages*, T. XVIII. 272, quoted by Hauy *Jour. de Min.* N° XXVIII. 299.

(C) Black mica is often nearly opaque.

(D) *Hauy, ibid.* p. 295. Bergman, however, found pure mica infuſible *per ſe*; and this has been the caſe with all the ſpecimens of Muſcovy glaſs which we have tried.

(E) We ſuſpect, that under this name Mr Hauy comprehends *ſhorl* alſo.

green, or leek green. Streak greeniſh. It neither becomes electric by friction nor heat [*]. Before the blow-pipe it melts into a black glaſs. A ſpecimen of black hornblende, analyſed by Mr Hermann, was compoſed of

37	ſilica,
27	alumina,
25	iron,
5	lime.
3	magneſia,
97 [†]	

54 Reſplendent hornblende.

SPECIES 10. Reſplendent Hornblende.

There are two minerals which Werner conſiders as varieties of hornblende, and Mr Kirwan as conſtituting a diſtinct ſpecies. Theſe, till future analyſes decide the point, we ſhall place here under the name of reſplendent hornblende, the name given them by Mr Kirwan; and we ſhall deſcribe them ſeparately.

Variety 1. Labradore hornblende.

Texture, curved foliated. Luſtre, in ſome poſitions, 0; in others metallic, and from 3 to 4. Opaque. Hardneſs 8 to 9. Sp. gr. from 3.35 to 3.434. Colour, in moſt poſitions, greyiſh black; in others, it reflects a ſtrong iron grey, ſometimes mixed with copper red.

Variety 2. Shiller ſpar [*].

Texture foliated. Luſtre metallic, 4. Tranſparency, in thin pieces, 1. Hardneſs 8 to 9. Sp. gr. 2.882. Colour green, often with a ſhade of yellow; alſo golden yellow. In ſome poſitions it reflects white, grey, or yellow. At 141° Wedgewood, hardened into a porcelain maſs. A ſpecimen, analyzed by Gmelin, was compoſed of

43.7	ſilica,
17 9	alumina,
23.7	iron,
11.2	magneſia.
96.5 [†]	

It has been found in the Hartz, ſtuck in a ſerpentine rock.

55 Obſidian.

SPECIES 11. Obſidian [‖].

Iceland agate.

This ſtone is found either in detached maſſes, or forming a part of the rocks which compoſe many mountains. It is uſually inveſted with a grey or opaque cruſt. Its fracture is conchoidal. Its internal luſtre 3. Tranſparency 1. Hardneſs 10. Sp. gr. 2.348. Colour black or greyiſh black; when in very thin pieces, green. It melts into an opaque grey maſs. According to Bergman, it is compoſed of

69	ſilica,
22	alumina,
9	iron.
100 [§].	

56 Petrilite.

SPECIES 12. Petrilite [*].

Cubic felſpar.

This ſtone is found in the maſs of mountains. It is amorphous. Texture foliated. Fracture ſplintery. Fragments cubic, or inclining to that form; their faces unpoliſhed. Luſtre 2. Tranſparency partly 2, partly 1. Hardneſs 9. Sp. gr. 3 081. Colour reddiſh brown. Does not melt at 160° Wedgewood.

57 Felſite.

SPECIES 13. Felſite [†].

Compact felſpar.

This ſtone alſo forms a part of many mountains, and is amorphous. Texture ſomewhat foliated. Fracture uneven, approaching to the ſplintery. Luſtre 1. Tranſparency ſcarce 1. Hardneſs 9. Colour azure blue, and ſometimes brown and green. Streak white. Before the blow-pipe, whitens and becomes rifty; but is infuſible *per ſe*.

58 G. VII. SAP. Felſpar.

GENUS VII. SAP.

SPECIES 1. Felſpar [‡].

This ſtone forms the principal part of many of the higheſt mountains. It is commonly cryſtallized. Its primitive form, according to De Liſle, is a rectangular priſm, whoſe baſes are rhombs, with angles of 65° and 115° [†]. Sometimes the edges of the priſm are wanting, and faces in their place; and ſometimes this is the caſe alſo with the acute angles of the rhomb. For a deſcription and figure of theſe, and other varieties, we refer the reader to *Romé de Liſle* [*], *Mr Hauy* [†], and *Mr Pini* [‡].

Its texture is foliated. Its croſs fracture uneven. Fragments rhomboidal, and commonly ſmooth and poliſhed on four ſides. Luſtre of the poliſhed faces often 3. Tranſparency from 3 to 1. Hardneſs 9 to 10. Sp. gr. from 2.437 to 2.7. Gives a peculiar odour when rubbed. It is made electric with great difficulty by friction. Fuſible *per ſe* into a more or leſs tranſparent glaſs. When cryſtallized, it decrepitates before the blow-pipe.

Variety 1. Pure Felſpar.

Moon ſtone—Adularia.

This is the pureſt felſpar hitherto found. It occurs in Ceylon and Switzerland; and was firſt mentioned by Mr Sage. Luſtre nearly 3. Tranſparency 2 to 3. Hardneſs 10. Sp. gr. 2.559. Colour white; ſometimes with a ſhade of yellow, green, or red. Its ſurface is ſometimes irideſcent.

Variety 2. Common Felſpar.

Luſtre of the croſs fracture 0; of the fracture, in the direction of the laminæ, from 3 to 1. Tranſparency 2 to 1. Colour moſt commonly fleſh red; but often bluiſh grey, yellowiſh white, milk white, browniſh yellow; and ſometimes blue, olive green, and even black.

Variety 3. Labradore felſpar.

This variety was diſcovered on the coaſt of Labradore by Mr Wolfe; and ſince that time it has been found in Europe. Luſtre 2 to 3. Tranſparency from 1 to 3. Sp. gr. from 2.67 to 2.6925. Colour grey. In certain poſitions, ſpots of it reflect a blue, purple, red, or green colour.

Variety 4. Continuous felſpar.

This variety moſt probably belongs to a different ſpecies; but as it has not hitherto been analyſed, we did not think ourſelves at liberty to alter its place.

It is found in large maſſes. Texture earthy. Fracture uneven, ſometimes ſplintery. Luſtre 0. Tranſparency 1. Hardneſs 10. Sp. gr. 2.609. Colour reddiſh grey, reddiſh yellow, fleſh red.

A ſpecimen of green felſpar from Siberia, analyſed by Vauquelin, contained

62.83	ſilica,
17.02	alumina,
16.00	potaſs,
3.00	lime,
1.00	oxyd of iron.
99.85 [‖]	

---

[*] Hauy, Jour. de Min. N° xxviii. 267.

[†] Beob. der Berlin, 5. Band 317.

[*] Kirw. i. 221.

[†] Bergbaukunde, 1 Band. p. 92.

[‖] Kirw. i. 264.

[§] Berg. iii. 204.

[*] Kirw. i. 325.

[†] Kirw. i. 326.

[‡] Kirw. i. 316. and Jour. de Phyſ. paſſim.

[†] Fig. 13. and 14.

[*] Cryſtall. ii. 461.

[†] Mem. Par. 1784, p. 273.

[‡] Sur de Nouvelle Cryſtalliſation, &c. 8

[‖] Ann. Chim. x

Simple Stones.

SPECIES 2. Lepidolite (F).

Lilalite.

This ſtone appears to have been firſt obſerved by the Abbé Poda, and to have been firſt deſcribed by De Born §. Hitherto it has only been found in Moravia in Germany, and Sudermania in Sweden *. There it is mixed with granite in large amorphous maſſes. It is compoſed of thin plates, eaſily ſeparated, and not unlike thoſe of mica †. Luſtre, pearly 3. Tranſparency between 1 and 2. Hardneſs 4 to 5. Not eaſily pulveriſed ‡. Sp. gr. from 2.816 ‖ to 2.8549 ¶. Colour of the maſs, violet blue; of the thin plates, ſilvery white. Powder white, with a tint of red §. Before the blowpipe, it froths, and melts eaſily into a white ſemitranſparent enamel, full of bubbles. Diſſolves in borax with effervescence, and communicates no colour to it *. Effervesces ſlightly with ſoda, and melts into a maſs ſpotted with red. With microcoſmic ſalt, it gives a pearl coloured globule †.

This ſtone was firſt called lilalite from its colour, that of the *lily*. Klaproth, who diſcovered its component parts, gave it the name of *lepidolite* (G).

It is compoſed of

53	ſilica,
20	alumina,
18	potaſs,
5	fluat of lime,
3	oxyd of manganeſe,
1	oxyd of iron.
100 ‡	

SPECIES 3. Leucite ‖.

Veſuvian of Kirwan—*White garnet* of Veſuvius.

This ſtone is uſually found in volcanic productions, and is very abundant in the neighbourhood of Veſuvius. It is always cryſtallized. The primitive form of its cryſtals is either a cube or a rhomboidal dodecahedron, and its integrant molecules are tetrahedrons; but the varieties hitherto obſerved are all polyhedrons: The moſt common has a ſpheroidal figure, and is bounded by 24 equal and ſimilar trapeziods †; ſometimes the faces are 12, 18, 36, 54, and triangular, pentagonal, &c. For a deſcription and figure of ſeveral of theſe, we refer the reader to Mr Hauy ‖. The cryſtals vary from the ſize of a pin head to that of an inch.

The texture of the leucite is foliated. Its fracture ſomewhat conchoidal. Luſtre 3; when in a ſtate of decompoſition 0. Tranſparency 3 to 2; when decompoſing 0. Hardneſs 8 to 10; when decompoſing 5 to 6. Sp. gr. 2.4648. Colour white, or greyiſh white (H). Its powder cauſes ſyrup of violets to aſſume a green colour *.

It is compoſed, as Klaproth has ſhewn, of

54	ſilica,
23	alumina,
22	potaſs.
99 (I)	

It was by analyſing this ſtone that Klaproth diſcovered the preſence of potaſs in the mineral kingdom; which is not the leaſt important of the numerous diſcoveries of that accurate and illuſtrious chemiſt.

Leucite is found ſometimes in rocks which have never been expoſed to volcanic fire; and Mr Dolomieu has rendered it probable, from the ſubſtances in which it is found, that the leucite of volcanoes has not been formed by volcanic fire, but that it exiſted previouſly in the rocks upon which the volcanoes have acted, and that it was thrown out unaltered in fragments of theſe rocks §.

§ *Jour. de Min.* N° xxxix. 177.

GENUS VIII. SAG.

61 G. VIII. SAG Emerald.

SPECIES 1. Emerald (K).

This ſtone has hitherto been only found cryſtallized. The primitive form of its cryſtals is a regular ſix-ſided priſm; and the form of its integrant molecules is a triangular priſm, whoſe ſides are ſquares, and baſes equilateral triangles *. The moſt common variety of its cryſtals is the regular ſix-ſided priſm, ſometimes with the edges of the priſm, or of the baſes, or the ſolid angles, or both wanting ‡, and ſmall faces in their place †. The ſides of the priſm are generally channelled.

* *Hauy, Jour. de Min.* N° xix. 72.

‡ Fig. 16.

† *Romé de Liſle*, ii. 245. and *Hauy, ibid.*

Its texture is foliated. Its fracture conchoidal. Luſtre uſually from 3 to 4. Tranſparency from 2 to 4. Cauſes a double refraction. Hardneſs 12. Sp. gr. 2.65 to 2.775. Colour green. Becomes electric by friction, but not by heat. Its powder does not phoſphoreſce when thrown on a hot iron †. At 150° Wedgewood it melts into an opaque coloured maſs. According to Dolomieu, it is fuſible *per ſe* by the blow-pipe ‡.

† *Dolomieu, Jour. de Min.* N° xviii. 19.

‡ *Ibid.*

This mineral was formerly ſubdivided into two diſtinct ſpecies, the *emerald*, and *beryl* or *aqua marina*. Hauy demonſtrated, that the emerald and beryl correſponded exactly in their ſtructure and properties, and Vauquelin found that they were compoſed of the ſame ingredients; henceforth, therefore, they muſt be conſidered as varieties of the ſame ſpecies.

The variety formerly called *emerald* varies in colour from the pale to the perfect green. When heated to 120° Wedgewood, it becomes *blue*, but recovers its colour when cold. A ſpecimen, analyſed by Vauquelin, was compoſed of

64.60	ſilica,
14.00	alumina,
13.00	glucina,
3.50	oxyd of chromum,
2.56	lime,
2.00	moiſture or other volatile ingredient.
99.66 ‖	

‖ *Ann. de Chim.* xxvi. 264.

The *beryl* is of a greyiſh green colour, and ſometimes blue, yellow, and even white: ſometimes different colours appear in the ſame ſtone §. It is found in Ceylon, different parts of India, Brazil, and eſpecially in Siberia and Tartary, where its cryſtals are ſometimes a foot long ¶.

§ *Dolomieu, ibid.*

¶ *Ibid.*

(F) *Kirw.* I. 208.—*Karſten. Beob. der Berlin*, 5 *Band.* 71.—*Klaproth Beiträge*, I. 279. and II. 191.

(G) That is, *ſcale ſtone*, or ſtone compoſed of ſcales: From λεπις, *the ſcale of a fiſh*, and λιθος, *a ſtone*.

(H) Hence the name leucite, from λευκος, *white*.

(I) See *Jour. de Min.* N° XXVII. 194. and 201. and *Klaproth's Beiträge*, II. 39.

(K) *Kir.* I. 247. and 248.—*Dolomieu. Magazin Encyclopædique*, II. 17. and 145.; and *Jour. de Min.* N° XVIII. 19.—*Klaproth Beiträge*, II. 12.

long. A ſpecimen of beryl, analyſed by Vauquelin, contained

69 ſilica,
13 alumina,
16 glucina,
1.5 oxyd of iron.

99.5 ||

|| Ann. de Chim. xxviii. 168.

It was by analyſing this ſtone that Vauquelin diſcovered the earth which he called *glucina*.

62
G. IX. SAB.
Staurolite.

GENUS IX. SAB.

SPECIES I. Staurolite *.

* Kirw. i. 282.

Andreolite of Lametherie and Hauy—*Hyacinthe blanche cruciforme*, var. 9. of Romé de Liſle.

This ſtone has been found at Andreaſberg in the Hartz. It is cryſtallized, and the form of its cryſtals has induced mineralogiſts to give it the name of *croſs-ſtone*. Its cryſtals † are two four-ſided flattened priſms, terminated by four-ſided pyramids, interſecting each other at right angles: the plane of interſection paſſing longitudinally through the priſms (L).

† Fig. 17.

Its texture is foliated. Its luſtre waxy, 2. Tranſparency from 1 to 3. Hardneſs 9. Brittle. Sp. gr. 2.355 to 2.361. Colour milk white. When heated ſlowly, it loſes 0 15 or 0.16 parts of its weight, and falls into powder. It efferveſces with borax and microcoſmic ſalt, and is reduced to a greeniſh opaque maſs. With ſoda it melts into a frothy white enamel. When its powder is thrown on a hot coal, it emits a greeniſh yellow light †.

† Hauy, Jour. de Min. N° xxviii. 280.

A ſpecimen analyſed by Weſtrum was compoſed of

44 ſilica,
20 alumina,
20 barytes,
16 water.

100

Klaproth found the ſame ingredients, and nearly in the ſame proportions ‡.

‡ Beiträge, ii. 80.

A variety of ſtaurolite has been found only once, which has the following peculiarities.

Its luſtre is pearly, 2. Sp. gr. 2.361. Colour browniſh grey. With ſoda it melts into a purpliſh and yellowiſh frothy enamel. It is compoſed, according to Weſtrum, of

47.5 ſilica,
12.0 alumina,
20.0 barytes,
16.0 water,
4.5 oxyds of iron and mangaueſe.

100.0

63
G. X. ASL.
Chryſoberyl.

GENUS X. I. ASL.

SPECIES I. Chryſoberyl *.

* Kirw. i. 261.

Oriental chryſolite of jewellers—*Cymophane* of Hauy.

Hitherto this ſtone has been found only in Brazil, the iſland of Ceylon, and as ſome affirm near Nortſchink in Siberia. Werner firſt made it a diſtinct ſpecies, and gave it the name which we have adopted. It is uſually found in round maſſes about the ſize of a pea, but it is ſometimes alſo cryſtallized. The primitive form of its cryſtals is a four-ſided rectangular priſm, whoſe height is to its breadth as √3 to 1, and to its thickneſs as √2 to 1 †. The only variety hitherto obſerved is an eight-ſided priſm, terminated by ſix ſided ſummits ‡. Two of the faces of the priſm are hexagons, two are rectangles, and four trapeziums; two faces of the ſummits are rectangles, and the other four trapeziums. Sometimes two of the edges of the priſm are wanting, and ſmall faces in their place †.

† Fig. 18.
‡ Fig. 19.
† Hauy, Jour. de Min. N° xxi. 5.

Its texture is foliated. Laminæ parallel to the faces of the priſm. Luſtre 3 to 4. Tranſparency 3 to 4. Cauſes ſingle refraction. Hardneſs 12. Sp. gr. from 3.698 ‡ to 3.7961 ||. Colour yellowiſh green, ſurface ſparkling. It is infuſible by the blow pipe *per ſe*, and with ſoda.

‡ Werner.
|| Hauy.

A ſpecimen of chryſoberyl, analyſed by Klaproth, was compoſed of

71.5 alumina,
18.0 ſilica,
6.0 lime,
1.5 oxyd of iron.

97.0 §

§ Beiträg i. 102.

64
G. X. 2. SAL.
Hyalite.

GENUS X. 2. SAL.

SPECIES 2. Hyalite *.

* Kirw. 296.

This ſtone is frequently found in trap. It occurs in grains, filaments, and rhomboidal maſſes. Texture foliated. Fracture uneven, inclining to conchoidal. Luſtre glaſſy (M), 2 to 3. Tranſparency 2 to 3; ſometimes, tho' ſeldom, it is opaque. Hardneſs 9. Sp. gr. 2.11 †. Colour pure white. Infuſible at 150° Wedgewood; but it yields to ſoda ‡. According to Mr Link, it is compoſed of

† Kirwa
‡ Id.

57 ſilica,
18 alumina,
15 lime.

90 and a very little iron ||.

|| Crell's nals, 179 2 Band.

65
Ædelite.

Species 3. Ædelite *.

* Kirw. 276.

This ſtone has hitherto been found only in Sweden at Moſſeberg and Ædelfors. From this laſt place Mr Kirwan, who firſt made it a diſtinct ſpecies, has given it the name which we have adopted. It was firſt mentioned by Bergman †. Its form is tuberoſe and knotty. Texture ſtriated; ſometimes reſembles quartz. Luſtre from 0 to 1. Sp. gr. 2.515 after it has abſorbed water ‡. Colour light grey, often tinged red; alſo yellowiſh brown, yelloviſh green and green. Before the blow-pipe it intumeſces and forms a frothy maſs. Acids convert it into a jelly §. A ſpecimen from Moſſeberg, analyſed by Bergman, contained

† Opuſc. 101.
‡ See Kirwan's M i. 276.
§ Berg. i 227.

69 ſilica,
20 alumina,
8 lime,
3 water.

100 ||

|| Opuſc. 101.

A ſpecimen from Ædelfors yielded to the ſame chemiſt

62 ſilica,
18 alumina,
16 lime,
4 water.

100 ¶.

¶ Ibid.

GENUS

(L) See *Gillot*, *Jour. de Phyſ.* 1793, p. 1 and 2.

(M) Hence probably the name *hyalite*, which was impoſed by Werner from 'υαλις, *glaſs*, and λιθος, *a ſtone*.

ths and tones.

Simple Stones.

Genus X. 3. sawl.

species 4. Zeolite (n).

66 .X. 3. sawl. .eolite.

This ſtone was firſt deſcribed by Cronſtedt in the Stockholm Tranſactions for 1756. It is found ſometimes amorphous and ſometimes cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are ſquares. The moſt common variety is a long four ſided priſm, terminated by low four ſided pyramids*.

* Iauy, r. de n. Nº . 86.

Its texture is ſtriated or fibrous. Its luſtre is ſilky, from 3 to 1. Tranſparency from 2 to 4; ſometimes 1. Hardneſs 6 to 8; ſometimes only 4. Abſorbs water. Sp. gr. 2.07 to 2.3. Colour white, often with a ſhade of red or yellow; ſometimes brick red, green, blue. When heated, it becomes electric like the tourmaline†. Before the blow-pipe it froths (o), emits a phoſphoreſcent light, and melts into a white ſemitranſparent enamel, too ſoft to cut glaſs, and ſoluble in acids. In acids it diſſolves ſlowly and partially without effervescence; and at laſt, unleſs the quantity of liquid be too great, it is converted into a jelly.

† auy, ibid. xxviii.

A ſpecimen of zeolite (p), analyſed by Vauquelin, contained

53.00	ſilica,
27.00	alumina,
9.46	lime,
10.00	water.
99.46‡.	

‡ id. Nº .576.

species 5. Stilbite.

67 lbite.

This ſtone was firſt formed into a diſtinct ſpecies by Mr Hauy. Formerly it was conſidered as a variety of zeolite.

The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rectangles. It cryſtallizes ſometimes in dodecahedrons, conſiſting of a four-ſided priſm with hexagonal faces, terminated by four-ſided ſummits, whoſe faces are oblique parallelograms; ſometimes in ſix-ſided priſms, two of whoſe ſolid angles are wanting, and a ſmall triangular face in their place*.

* auy, r. de . Nº 86.

Its texture is foliated. The laminæ are eaſily ſeparated from each other; and are ſomewhat flexible. Luſtre pearly, 2 or 3 (q). Hardneſs inferior to that of zeolite, which ſcratches ſtilbite. Brittle. Sp. gr. 2.500†. Colour pearl white. Powder bright white, ſometimes with a ſhade of red. This powder, when expoſed to the air, cakes and adheres as if it had abſorbed water. It cauſes ſyrup of violets to aſſume a green colour. When ſtilbite is heated in a porcelain crucible, it ſwells up and aſſumes the colour and ſemitranſparency of baked porcelain. By this proceſs it loſes 0.185 of its weight. Before the blow-pipe it froths like borax, and then melts into an opaque white coloured enamel §.

† uy, ibid. xxviii.

§ uquelin, Nº x. 161.

According to the analyſis of Vauquelin, it is compoſed of

52.0	ſilica,
17.5	alumina,
9.0	lime,
18.5	water.
97.0‖	

‖ Ibid. 164.

species 6. Analcime.

68 Analcime.

This ſtone, which was diſcovered by Mr Dolomieu, is found cryſtallized in the cavities of lava. It was firſt made a diſtinct ſpecies by Mr Hauy. Mineralogiſts had formerly confounded it with zeolite.

The primitive form of its cryſtals is a cube. It is ſometimes found cryſtallized in cubes, whoſe ſolid angles are wanting, and three ſmall triangular faces in place of each; ſometimes in polyhedrons with 24 faces. It is uſuall ſomewhat tranſparent. Hardneſs about 8; ſcratches glaſs ſlightly. Sp. gr. above 2. When rubbed, it acquires only a ſmall degree of electricity, and with difficulty (r). Before the blow-pipe it melts without frothing, into a white ſemitranſparent glaſs*.

* Hauy, Jour. de Min. Nº xiv. 86. and xxviii. 278.

Genus X. 4. sla.

species 7. Lazulite†.

69 G.X.4.sla. Lazulite.

This ſtone, which is found chiefly in the northern parts of Aſia, has been long known to mineralogiſts by the name of *lapis lazuli*. This term has been contracted into *lazulite* by Mr Hauy; an alteration which was certainly proper, and which therefore we have adopted.

† Kirw. i. 283.

Lazulite is always amorphous. Its texture is earthy. Its fracture uneven. Luſtre 0. Opaque, or nearly ſo. Hardneſs 8 to 9. Sp. gr. 2.76 to 2.945‡. Colour blue (s); often ſpotted white from ſpecks of quartz, and yellow from particles of pyrites.

‡ Briſſon.

It retains its colour at 100° Wedgewood; in a higher heat it intumeſces, and melts into a yellowiſh black maſs. With acids it effervesces a little, and if previouſly calcined, forms with them a jelly.

Margraff publiſhed an analyſis of lazulite in the Berlin Memoirs for 1758. His analyſis has ſince been confirmed by Klaproth, who found a ſpecimen of it to contain

46.0	ſilica,
14.5	alumina,
28.0	carbonat of lime,
6.5	ſulphat of lime,
3.0	oxyd of iron,
2.0	water.
100.0§	

§ Beiträge, i. 196.

Genus XI. sali.

species 1. Garnet (t).

70 G.XI. sali. Garnet.

This ſtone is found abundantly in many mountains. It is uſually cryſtallized. The primitive form of its cryſtals

---

(n) *Kirw.* I. 278.—*Guettard*, IV. 637.—*Bucquet*, *Mem. Sav. Etrang.* IX. 576.—*Pelletier*, *Jour. de Phyſ.* XX. 420.

(o) Hence the name *zeolite*, given to this mineral by Cronſtedt; from ζεω, *to ferment*, and λιθος, *a ſtone*.

(p) Dr Black was accuſtomed to mention, in the courſe of his lectures, that Dr Hutton had diſcovered *ſoda* in zeolite. This diſcovery has not hitherto been verified by any other chemical mineralogiſt.

(q) Hence the name given to this mineral by Hauy, *ſtilbite*, from στιλβω, *to ſhine*.

(r) Hence the name *analcime* given it by Hauy, from αναλκις, *weak*.

(s) Hence the name *lazulite*, from an Arabian word *azul*, which ſignifies *blue*.

(t) *Kirw.* I. 258.—*Gerhard*, *Diſquiſitio phyſico-chymica Granatorum*, &c.—*Paſumot*, *Jour. de Phyſ.* III. 442.—*Wiegleb*, *Ann. de Chim.* I. 231.

cryſtals is a dodecahedron whoſe ſides are rhombs, with angles of 78° 31′ 44″, and 120° 28′ 16″. The inclination of the rhombs to each other is 120°. This dodecahedron may be conſidered as a four ſided priſm, terminated by four-ſided-pyramids *. It is diviſible into four parallelopipeds, whoſe ſides are rhombs; and each of theſe may be divided into four tetrahedrons, whoſe ſides are iſoſceles triangles, equal and ſimilar to either of the halves into which the rhomboidal faces of the dodecahedron are divided by their ſhorter diagonal. The integrant molecules of garnet are ſimilar tetrahedrons †. Sometimes the edges of the dodecahedron are wanting, and ſmall faces in their place; and ſometimes garnet is cryſtallized in polyhedrons, having 24 trapezoidal faces. For a deſcription and figure of theſe, and other varieties of garnet, we refer to *Romé de Liſle* and *Hauy* ‡.

* Fig. 20.

* *De Liſle*, ii 322 and *Hauy*, *Ann. de Chim.* xvii. 305.

† *Hauy*, *ibid.* 306.

‡ *Ibid.*

The texture of garnet, as Bergman firſt ſhewed, is foliated ‖. Its fracture commonly conchoidal. Internal luſtre from 4 to 2. Tranſparency from 2 to 4; ſometimes only 1 or 0. Cauſes ſingle refraction §. Hardneſs from 10 to 14. Sp. gr. 3.75 to 4.188. Colour uſually red. Often attracted by the magnet. Fuſible *per ſe* by the blow pipe.

‖ *Opuſc.* ii. 9.

§ *Hauy, Jour. de Min.* N° xxviii. 260.

Variety 1. Oriental garnet (U).

Internal luſtre 3 to 4. Tranſparency 4. Hardneſs 13 to 14. Sp. gr. 4 to 4.188. Colour deep red, inclining to violet (X).

Variety 2. Common garnet.

Fracture uneven, inclining to the conchoidal. Internal luſtre 2 to 3. Tranſparency from 3 to 0. Hardneſs 10 to 11; ſometimes only 9. Sp. gr. 3.75 to 4. Colour commonly deep red, inclining to violet; ſometimes verging towards black or olive; ſometimes leek green, brown, yellow.

Variety 3. Amorphous garnet.

Structure ſlaty. Luſtre 2. Tranſparency 2 to 1. Hardneſs 11 to 12. Sp. gr. 3.89. Colour browniſh or blackiſh red. Found in Sweden, Switzerland, and the Eaſt Indies.

A ſpecimen of oriental garnet, analyſed by Klaproth, contained

35.75	ſilica,
27.25	alumina,
36.00	oxyd of iron,
0.25	oxyd of manganeſe.
99.25*	

* *Beiträge*, ii. 26.

A ſpecimen of red garnet, analyſed by Vauquelin, contained

52.0	ſilica,
20.0	alumina,
17.0	oxyd of iron,
7.7	lime.
96.7†	

† *Jour. de Min.* N° xliv. 575.

A ſpecimen of black garnet yielded to the ſame chemiſt

43	ſilica,
16	alumina,
20	lime,
16	oxyd of iron,
4	moiſture.
99‡.	

‡ *Ibid.* 573.

Mr Klaproth found a ſpecimen of Bohemian garnet, compoſed of

40.00	ſilica,
28.50	alumina,
16.50	oxyd of iron,
10.00	magneſia,
3.50	lime,
.25	oxyd of manganeſe.
98.75¶	

¶ *Beiträge*, ii. 21.

SPECIES 2. Thumerſtone*.

71 Thumerſtone.

Yanolite of Lametherie—*Axinite* of Hauy.

This ſtone was firſt deſcribed by Mr Schreber, who found it near Balme d'Auris in Dauphiné, and gave it the name of *ſhorl violé* †. It was afterwards found near Thum in Saxony, in conſequence of which Werner called it *thumerſtone*.

* *Kirw.* i. 273.—*Pelletier, Jour. de Phyſ.* xxvi. 66.

† *De Liſle*, ii. 353.

It is ſometimes amorphous; but more commonly cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are parallelograms with angles of 101° 32′ and 78° 28′ ‡. The moſt uſual variety is a flat rhomboidal parallelopiped, with two of its oppoſite edges wanting, and a ſmall face in place of each §. The faces of the parallelopiped are generally ſtreaked longitudinally.

‡ *Hauy, Jour. de Min* N° xxviii. 264.

§ Fig. 21.

§ *De Liſle*, *ibid.*

The texture of thumerſtone is foliated. Its fracture conchoidal. Luſtre 2. Tranſparency, when cryſtallized, 3 to 4; when amorphous, 2 to 1. Cauſes ſimple refraction ‖. Hardneſs 10 to 9. Sp. gr. 3.2956. Colour clove brown; ſometimes inclining to red, green, grey, violet, or black. Before the blow-pipe it froths like zeolite, and melts into a hard black enamel. With borax it exhibits the ſame phenomena, or even when the ſtone is ſimply heated at the end of a pincer ¶.

‖ *Hauy*, *ibid.*

¶ *Vauquelin, Jour. de Min.* N° xxiii. 1.

A ſpecimen of thumerſtone, analyſed by Klaproth, contained

52.7	ſilica,
25.6	alumina,
9.4	lime,
9.6	oxyd of iron with a trace of manganeſe.
97.3*	

* *Beiträge* ii. 126.

A ſpecimen, analyſed by Vauquelin, contained

44	ſilica,
18	alumina,
19	lime,
14	oxyd of iron,
4	oxyd of manganeſe.
99†	

† *Jour. de Min. ibid.*

SPECIES 3. Prehnite (Y).

72 Prehnite

Though this ſtone had been mentioned by Sage †, Romé de Liſle *, and other mineralogiſts, Werner was the firſt who properly diſtinguiſhed it from other minerals, and made it a diſtinct ſpecies. The ſpecimen which he examined was brought from the Cape of Good Hope by Colonel Prehn; hence the name *prehnite*, by which he diſtinguiſhed it. It was found near Dumbarton by Mr Grotche †; and ſince that time it has been obſerved in other parts of Scotland.

† *Miner.* 231.

* *Cryſtall.* ii. 275.

† *Ann. de Chim.* i. 2

It

(U) This ſeems to be the *carbuncle* (ανθραξ) of Theophraſtus, and the *carbunculus garamanticus* of other ancient writers. See *Hill's Theophraſtus* περι λιθων, p. 74 and 77.

(X) Hence, according to many, the name *garnet* (in Latin *granatus*), from the reſemblance of the ſtone in colour to the bloſſoms of the pomegranate.

(Y) *Kirw.* I. 274.—*Haſſenfratz, Jour. de Phyſ.* XXXII. 81.—*Sage, ibid.* XXXIV. 446.—*Klaproth, Beob. der Berlin, 2 Band.* 211. And *Ann. de Chim.* I. 201.

Ea i and nes

It is both amorphous and cryſtallized. The cryſtals are in groups, and confuſed: they ſeem to be four-ſided priſms with dihedral ſummits ‡. Sometimes they are irregular ſix ſided plates, and ſometimes flat rhomboidal parallelopipeds.

Its texture is foliated. Fracture uneven. Internal luſtre pearly, ſcarcely 2. Tranſparency 3 to 2. Hardneſs 9 to 10. Brittle. Sp. gr. 2.6969 ‖. Colour apple green, or greeniſh grey. Before the blow-pipe it froths more violently than zeolite, and melts into a brown enamel. A ſpecimen of prehnite, analyſed by Klaproth, was compoſed of

43.83	ſilica,
30.33	alumina,
18.33	lime,
5.66	oxyd of iron,
1.16	air and water.
99.31 §	

‡ ly, Jo de M N° xx . 277.

‖ y, ibid.

Whereas Mr Haſſenfratz found in another ſpecimen

50.0	ſilica,
20.4	alumina,
23.3	lime,
4.9	iron,
.9	water,
.5	magneſia.
100.0 ¶	

§ n. de Ch i. 20

¶ l and Jo de Ph N° xx 81.

SPECIES 4. Thallite.

3 T llite

Green ſhorl of Dauphiné of De Liſle*—*Delphinite* of Sauſſure.

This ſtone is found in the fiſſures of mountains; and hitherto only in Dauphiné and on Chamouni in the Alps.

It is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe baſes are rhombs with angles of 114° 37′, and 65° 23′ †. The moſt uſual variety is an elongated four-ſided priſm (often flattened), terminated by four-ſided incomplete pyramids §; ſometimes it occurs in regular ſix-ſided priſms ‡. The cryſtals are often very ſlender.

Its texture appears fibrous. Luſtre inconſiderable. Tranſparency 2 to 3, ſometimes 4; ſometimes nearly opaque. Cauſes ſingle refraction. Hardneſs 9 to 10. Brittle. Sp. gr. 3.4529 to 3.46. Colour dark green (z). Powder white or yellowiſh green, and feels dry. It does not become electric by heat. Before the blow-pipe, froths and melts into a black ſlag. With borax melts into a green bead ‖.

* ſtallog. ii. 1.

† y, J de N° xx 271.

§ . 22.

‡ é de Li ibid. an Hauy, J de M N° xx 415.

‖ y, and D ils, ibi

A ſpecimen of thallite, analyſed by Mr Deſcotils, contained

37	ſilica,
27	alumina,
17	oxyd of iron,
14	lime,
1.5	oxyd of mangancſe.
96.5 §	

§ N° xx 420.

GENUS XII. I. AMS.

SPECIES 1. Cyanite*.

Sappare of Sauſſure.

Simple Stones.

74 G. XII AMS. Cyanite.

This ſtone was firſt deſcribed by Mr Sauſſure, the ſon, who gave it the name of *ſappare* †. It is commonly found in granite rocks. The primitive form of its cryſtals is a four-ſided oblique priſm, whoſe ſides are inclined at an angle of 103°. The baſe forms with one ſide of the priſm an angle of 103°; with another, an angle of 77°. It is ſometimes cryſtallized in ſix-ſided priſms ‡.

Its texture is foliated. Laminæ long. Fragments long, ſplintery. Luſtre pearly, 2 to 3. Tranſparency of the laminæ 3. Cauſes ſingle refraction ‖. Hardneſs 6 to 9. Brittle. Sp. gr. from 3.092 to 3.622 §. Feels ſomewhat greaſy. Colour milk white, with ſhades of ſky or pruſſian blue (A); ſometimes bluiſh grey; ſometimes partly bluiſh grey, partly yellowiſh or greeniſh grey.

* *Kirw.* i. 209.—*Sage, Jour. de Phyſ.* xxxv. 39.

† *Jour. de Phyſ* xxxiv. 213.

‡ *Hauy, Jour. de Min.* N° xxviii. 282.

‖ *Hauy, ibid.*

§ *Kirwan.*

Before the blow-pipe it becomes almoſt perfectly white; but does not melt. According to the analyſis of Sauſſure, it is compoſed of

66.92	alumina,
13.25	magneſia,
12.81	ſilica,
5.48	iron,
1.71	lime.
100.17 ¶	

¶ *Jour. de Phyſ. ibid.*

Cyanite has alſo been analyſed by Struvius and Hermann, who agree with Sauſſure as to the ingredients; but differ widely from him and one another as to the proportions.

Struvius.	Hermann.	
5.5	30	alumina,
30.5	39	magneſia,
51.5	23	ſilica,
5.0	2	iron,
4.0	3	lime
96.5*	97†	

* *Crell's Annals*, 1790.

† *Ibid.*

GENUS XII. 2. MSA.

SPECIES 2. Serpentine (B).

75 G. XII. 2. MSA Serpentine.

This ſtone is found in amorphous maſſes. Its fracture is ſplintery. Luſtre 0. Opaque. Hardneſs 6 to 7. Sp. gr. 2.2645 to 2.709. Feels rather ſoft, almoſt greaſy. Generally emits an earthy ſmell when breathed upon. Its colours are various ſhades of green, yellow, red, grey, brown, blue: commonly one or two colours form the ground, and one or more appear in ſpots or veins (C).

Before the blow-pipe it hardens and does not melt.

A ſpecimen of ſerpentine, analyſed by Mr Chenevix, contained

34.5	magneſia,
28.0	ſilica,
23.0	alumina,
4.5	oxyd of iron,
0.5	lime,
10.5	water.
101.0*	

* *Ann. de Chim.* xxviii 199.

GENUS

(z) Hence the name *thallite* given it by Lametherie, from θαλλος, *a green leaf*.

(A) Hence the name *cyanite*, impoſed by Werner.

(B) *Kirw.* I. 156.—*Margraf, Mem. Berlin*, 1759, p. 3.—*Bayen, Jour. de Phyſ.* XIII. 46.—*Mayer, Crell's Annals*, 1789, II. 416.

(C) Hence the name *ſerpentine*, given to the ſtone from a ſuppoſed reſemblance in colours to the ſkin of ſerpent.

76
G. XIII.
MSAI.
Potſtone.

GENUS XIII. MSAI.

SPECIES 1. Potſtone†.

† Kirw. i. 155.

This ſtone is found in neſts and beds, and is always amorphous. Its ſtructure is often ſlaty. Texture undulatingly foliated. Luſtre from 1 to 3. Tranſparency from 1 to 0; ſometimes 2. Hardneſs 4 to 6. Brittle. Sp. gr. from 2.8531 to 3.023. Feels greaſy. Sometimes abſorbs water. Colour grey with a ſhade of green, and ſometimes of red or yellow; ſometimes leek green; ſometimes ſpeckled with red.

Potſtone is not much affected by fire; and has therefore been made into utenſils for boiling water; hence its name.

According to Wiegleb, the potſtone of Como contains

38	magneſia,
38	ſilica,
7	alumina,
5	iron,
1	carbonat of lime,
1	fluoric acid.
90	

77
Chlorite.

SPECIES 2. Chlorite*.

* Kirw. i. 147.

This mineral enters as an ingredient into different mountains. It is ſometimes amorphous, and ſometimes cryſtallized in oblong, four-ſided, acuminated cryſtals. Its texture is foliated. Its luſtre from 0 to 2. Opaque. Hardneſs from 4 to 6; ſometimes in looſe ſcales. Colour green.

Variety 1. Farinaceous chlorite.

Compoſed of ſcales ſcarcely cohering, either heaped together, or inveſting other ſtones. Feels greaſy. Gives an earthy ſmell when breathed on. Difficult to pulveriſe. Colour graſs green; ſometimes greeniſh brown; ſometimes dark green, inclining to black. Streak white. When the powder of chlorite is expoſed to the blow-pipe it becomes brown. Before the blow-pipe, farinaceous chlorite froths and melts into a dark brown glaſs; with borax it forms a greeniſh brown glaſs*.

* Vauquelin, Jour. de Min. N° xxxix. 167.

Variety 2. Indurated chlorite.

This variety is cryſtallized. Luſtre 1. Hardneſs 6. Feel meage. Colour dark green, almoſt black. Streak mountain green.

Variety 3. Slaty chlorite.

Structure ſlaty. Fragments flatted. Internal luſtre 1 to 2. Hardneſs 5. Colour greeniſh grey, or dark green inclining to black. Streak mountain green.

A ſpecimen of the firſt variety, analyſed by Vauquelin, contained

43.3	oxyd of iron,
26.0	ſilica,
15.5	alumina,
8.0	magneſia,
2.0	muriat of potaſs,
4.0	water.
98.8†	

† Ann. de Chim. xxx. 106.

A ſpecimen of the ſame variety yielded Mr Hœpner

12.92	oxyd of iron,
37.50	ſilica,
4.17	alumina,
43.75	magneſia,
1.66	lime.
100.0‡	

‡ Sauſſure's Voyages, ii. 133.

A ſpecimen of the ſecond variety, analyſed by the ſame chemiſt, contained

10.15	oxyd of iron,
41.15	ſilica,
6.13	alumina,
39.47	magneſia,
1.50	lime,
1.50	air and water.
99.9 §	

§ Crell's Annals, 1790, p. 56.

On the ſuppoſition that theſe analyſes are accurate, the enormous difference between them is a demonſtration that chlorite is not a chemical combination, but a mechanical mixture.

78
G. XIV.
SLAM.
Siliceous ſpar.

GENUS XIV. SLAM.

SPECIES 1. Siliceous ſpar (D).

This ſtone has been found in Tranſylvania. It is cryſtallized in 4 or 6 ſided priſms, channelled tranſverſely, and generally heaped together. Its texture is fibrous. Its luſtre ſilky, 2. Its colours white, yellow, green, light blue. According to Bindheim, it contains

61.1	ſilica,
21.7	lime,
6.6	alumina,
5.0	magneſia,
1.3	oxyd of iron,
3.3	water.
99.0 *	

* Berg. vi. 104.

79
G. XV.
SAMLI.
Argillite

GENUS XV. SAMLI.

SPECES 1. Argillite†.

† Kirw. i. 234.

Argillaceous ſhiſtus—Common ſlate.

This ſtone conſtitutes a part of many mountains.

Its ſtructure is ſlaty. Its texture foliated. Fracture ſplintery. Fragments often tabular. Luſtre moſt commonly ſilky, 2; ſometimes 0. Tranſparency from 0 to 1. Hardneſs from 5 to 8. Sp. gr. from 2.67 to 2.88. Does not adhere to the tongue. Gives a clear ſound when ſtruck. Often imbibes water. Streak white or grey. Colour moſt commonly grey, with a ſhade of blue, green, or black; ſometimes purpliſh, yellowiſh, mountain green, brown, bluiſh black; ſometimes ſtriped or ſpotted with a darker colour than the ground.

It is compoſed, according to Kirwan, of ſilica, alumina, magneſia, lime, oxyd of iron. In ſome varieties the

---

(D) Is this the *tremolite* of Lowitz from the lake Baikal in Siberia? If ſo, the name of the genus ought to be SLM; for he found it to contain no alumina. According to his analyſis, it was compoſed of

52	ſilica,
20	lime,
12	carbonat of lime,
12	magneſia,

the lime is wanting. Several varieties contain a conſiderable quantity of carbonaceous matter.

GENUS XVI. SLACMI.

SPECIES 1. Smaragdite.

This ſtone was called *ſmaragdite* by Mr Sauſſure, from ſome reſemblance which it has to the emerald. Its texture is foliated. The laminæ are inflexible. Fracture even. Hardneſs 7. Colour in ſome caſes fine green, in others it has the grey colour and metallic luſtre of mica: it aſſumes all the ſhades of colour between theſe two extremes †.

According to the analyſis of Vauquelin, it is compoſed of

50.0	ſilica,
13.0	lime,
11.0	alumina,
7.5	oxyd of chromum.
6.0	magneſia,
5.5	oxyd of iron,
1.5	oxyd of copper.
94.5 ‡	

GENUS XVII. SM.

SPECIES 1. Kiffekil*.

Myrſen—Seafroth.

This mineral is dug up near Konie in Natolia, and is employed in forming the bowls of Turkiſh tobacco pipes. The ſale of it ſupports a large monaſtery of derviſes eſtabliſhed near the place where it is dug. It is found in a large fiſſure ſix feet wide, in grey calcareous earth. The workmen aſſert, that it grows again in the fiſſure †, and puffs itſelf up like froth (E). This mineral, when freſh dug, is of the conſiſtence of wax; it feels ſoft and greaſy; its colour is yellow; its ſp. gr. 1.600 ‡: when thrown on the fire it ſweats, emits a fetid vapour, becomes hard, and perfectly white.

According to the analyſis of Klaproth, it is compoſed of

50.50	ſilica,
17.25	magneſia,
25.00	water,
5.00	carbonic acid,
.50	lime.
98.25 §	

SPECIES 2. Steatites (F).

Though this mineral was noticed by the ancients, little attention was paid to it by mineralogiſts, till Mr Pott publiſhed his experiments on it in the Berlin Memoirs for 1747.

It is uſually amorphous, but ſometimes it is cryſtallized in ſix-ſided priſms. Its texture is commonly earthy, but ſometimes foliated. Luſtre from 0 to 2. Tranſparency from 0 to 2. Hardneſs 4 to 7. Sp. gr. from 2.61 to 2.794 *. Feels greaſy. Seldom adheres to the tongue. Colour uſually white or grey; often with a tint of other colours; the foliated commonly green. Does not melt *per ſe* before the blow-pipe.

Simple Stones.

Variety 1. Semi-indurated ſteatites.

Texture earthy. Fracture ſometimes coarſe ſplintery. Luſtre 0. Tranſparency 0, or ſcarce 1. Hardneſs 4 to 5. Abſorbs water. Takes a poliſh from the nail. Colour white, with a ſhade of grey, yellow, or green; ſometimes pure white; ſometimes it contains dendritical figures; and ſometimes red veins.

Variety 2. Indurated ſteatites.

Fracture fine ſplintery, often mixed with imperfectly conchoidal. External luſtre 2 to 1, internal 0. Tranſparency 2. Often has the feel of ſoap. Abſorbs water. Colour yellowiſh or greeniſh grey; often veined or ſpotted with deep yellow or red.

Variety 3. Foliated or ſtriated ſteatites.

The texture of this variety is uſually foliated; ſometimes ſtriated. Fragments cubiform. Luſtre 3. Tranſparency 2 to 1. Hardneſs 6 to 7. Colour leek green, paſſing into mountain green or ſulphur yellow. Streak pale greeniſh grey. When heated to redneſs, it becomes grey; and at 147° Wedgewood, it forms a grey porous porcelain maſs*.

* *Kirwan*, i. 155.

A ſpecimen of ſteatites, analyſed by Klaproth, contained

59.5	ſilica,
30.5	magneſia,
2.5	iron,
5.5	water,
98.0 †.	

† *Beiträge*, ii. 179.

A ſpecimen of white ſteatites, analyſed by Mr Chenevix, contained

60.00	ſilica,
28.50	magneſia,
3.00	alumina,
2.50	lime,
2.25	iron.
96.25 ‡	

‡ *Ann. de Chim.* xxviii. 200.

GENUS XVIII. MSI.

SPECIES 1. Chryſolite (G).

Peridot of the French—*Topaz* of the ancients.

53 G. XVIII. MSI. Chryſolite.

The name *chryſolite* was applied, without diſcrimination, to a great variety of ſtones, till Werner defined it accurately, and confined it to that ſtone which the French chemiſts diſtinguiſh by the appellation of *peridot*. This ſtone is the *topaz* of the ancients; their chryſolite is now called *topaz* §.

§ *Plinii*, lib. 37. c. 8.

Chryſolite is found ſometimes in unequal fragments, and ſometimes cryſtallized †. The primitive form of its cryſtals is a right angled parallelopiped ‡, whoſe length, breadth, and thickneſs, are as 5, $\sqrt{8}$, $\sqrt{5}$*.

† Fig. 23.

‡ Fig. 24.

* *Hauy, Jour. de Min.* N° xxviii. 281.

The texture of the chryſolite is foliated. Its fracture conchoidal. Its internal luſtre from 2 to 4. Its tranſparency from 4 to 2. Cauſes double refraction. Hardneſs

---

The carbonat of lime was only mechanically interpoſed between the fibres of the ſtone. See *Pallas, Neu. Nord. Beiträge, 6 Band*, p. 146.

(E) Hence the name *kiff-kil*, or rather *keff-kelli*, "clay froth," or "light clay."

(F) *Kirw.* I. 151.—*Pott, Mem. Berlin*, 1747, p. 57.—*Wiegleb, Jour. de Phyſ.* XXIX. 60.—*Lavoiſier, Mem. Par.* 1778, 433.

(G) *Kirw.* I. 262.—*Cartheuſer, Min.* 94.—*Dolomieu, Jour. de Min.* N° xxix. 365.—*La Metherie, Nouv. Jour. de Phyſ.* I. 397.

Hardneſs 9 to 10. Brittle. Sp. gr. from 3.265 to 3.45. Colour green. It is infuſible at 150°, but loſes its tranſparency, and becomes blackiſh grey†. With borax it melts without efferveſcence into a tranſparent glaſs of a light green colour. Infuſible with microcoſmic ſalt ‡ and fixed alkali §.

Variety 1. Common chryſolite.

Found in Ceylon, and South America, and in Bohemia, amidſt ſand and gravel ‖. Luſtre 3 to 4. Tranſparency 4 to 3. Colour yellowiſh green, ſometimes verging to olive green, ſometimes to pale yellow.

Variety 2. Olive chryſolite—*Olivine* ¶,

Found commonly among traps and baſalts; ſometimes in ſmall grains, ſometimes in pretty large pieces; but it has not been obſerved in cryſtals. Luſtre 2 to 3. Tranſparency 3 to 2. Colour olive green.

The firſt variety, according to the analyſis of Klaproth, is compoſed of

41.5	magneſia,
38.5	ſilica,
19.0	oxyd of iron.
99.0 †	

According to that of Vauquelin, it is compoſed of

51.5	magneſia,
38.0	ſilica,
9.5	oxyd of iron.
99.0 ‡	

The ſecond variety, according to the analyſis of Klaproth, is compoſed of

37.58	magneſia,
50.00	ſilica,
11.75	oxyd of iron,
.21	lime.
99.54 §.	

84 Jade.

SPECIES 2. Jade (H).

This ſtone was formerly called *lapis niphriticus*, and was much celebrated for its medical virtues. It is found in Egypt, China, America, and in the Siberian and Hungarian mountains. It is ſometimes adhering to rocks, and ſometimes in detached round pieces.

Its ſurface is ſmooth. Its fracture ſplintery. External luſtre 0, or ſcarce 1; internal waxy, 1. Tranſparency from 2 to 1. Hardneſs 10. Not brittle. Sp. gr. from 2.95 to 2.9829; or, according to Sauſſure, to 3.389. Feels greaſy. Looks as if it had imbibed oil. Colour dark leek green, or verging towards blue; in ſome prominencies inclining to greeniſh or bluiſh white. When heated it becomes more tranſparent and brittle, but is infuſible *per ſe*. According to Hœpſner, it is compoſed of

47	ſilica,
38	carbonat of magneſia,
9	iron,
4	alumina,
2	carbonat of lime,
100	

This is the ſtone which the inhabitants of New Zealand make into hatchets and other cutting inſtruments.

85 G. XIX. SML. Aſbeſtus.

GENUS XIX. SML.

SPECIES 1. Aſbeſtus (I).

This mineral was well known to the ancients. They even made a kind of cloth from one of the varieties, which was famous among them for its incombuſtibility. It is found abundantly in moſt mountainous countries, and no where more abundantly than in Scotland.

It is commonly amorphous. Its texture is fibrous. Its fragments often long ſplintery. Luſtre from 0 to 2; ſometimes 3, and then it is metallic. Tranſparency from 0 to 2. Hardneſs from 3 to 7. Sp. gr. from 2.7 to 0.6806. Abſorbs water. Colour uſually white or green. Fuſible *per ſe* by the blow-pipe.

Variety 1. Common aſbeſtus.

Luſtre 2 to 1. Tranſparency 1. Hardneſs 6 to 7. Sp. gr. 2.577 to 2.7. Feels ſomewhat greaſy. Colour leek green; ſometimes olive or mountain green; ſometimes greeniſh or yellowiſh grey. Streak grey. Powder grey.

Variety 2. Flexible aſbeſtus.

Amiantus.

Compoſed of a bundle of threads ſlightly cohering. Fibres flexible. Luſtre 1 to 2, ſometimes 3. Tranſparency 1 to 2, ſometimes 0. Hardneſs 3 to 4. Sp. gr. before it abſorbs water, from 0.9088 to 2.3134; after abſorbing water, from 1.5662 to 2.3803†. Feels greaſy. Colour greyiſh or greeniſh white; ſometimes yellowiſh or ſilvery white, olive or mountain green, pale fleſh red, and mountain yellow.

Variety 3. Elaſtic aſbeſtus.

Mountain cork.

This variety has a ſtrong reſemblance to common cork. Its fibres are interwoven. Luſtre commonly 0. Opaque. Hardneſs 4. Sp. gr. before abſorbing water, from 0.6806 to 0.9933; after abſorbing water, from 1.2492 to 1.3492. Feels meagre. Yields to the fingers like cork, and is ſomewhat elaſtic. Colour white; ſometimes with a ſhade of red or yellow; ſometimes yellow or brown.

A ſpecimen of the firſt variety from Dalecarlia, analyſed by Bergman, contained

63.9	ſilica,
16.0	carbonat of magneſia,
12.8	carbonat of lime,
6.0	oxyd of iron,
1.1	alumina.
99.8 *	

A ſpecimen of the ſecond variety yielded to the ſame chemiſt

64.0	ſilica,
17.2	carbonat of magneſia,
13.9	carbonat of lime,
2.7	alumina,
2.2	oxyd of iron.
100.0 ‡	

A ſpecimen of the third variety contained, according to the ſame analyſis,

56.2	ſilica,
26.1	carbonat of magneſia,
12.7	carbonat of lime,
3.0	iron,
2.0	alumina.
100.0 ‖	

Twelve

(H) *Kirw.* I. 171.—*Bartolin, De Lapide Nephritico.—Lehmann, Nov. Comm. Petropol.* X. 381.—*Hæpfner, Hiſt. Nat. de la Suiſſe*, I. 251.

(I) *Kirw.* I. 159.—*Bergman*, IV. 160.—*Plot, Phil. Tranſ.* XV. 1051.—*Nebel, Jour. de Phyſ.* II. 62.—*Ibid.* III. 367.

† *Kir. Min.* i. 263.

‡ *Vauquelin, Ann. de Chim.* xxi. 97.

§ *Kirw. ibid.*

‖ *Coquebert, Jour. de Min.* Nº xxii. 20.

¶ *Kirwan's Min.* i. 263.—*Le Lievre, Jour. de Phyſ.* xxx. 397.

† *Klaproth's Beiträge*, i. 103.

‡ *Ann. de Chim. ibid.*

§ *Beiträge*, i. 112.

† *Biſſon.*

* *Opuſc.* iv. 170.

‡ *Ibid.* p. 163.

‖ *Ibid.* p. 170.

tones.

ꝑuſc. iv.

Twelve different ſpecimens of aſbeſtus, analyſed by Bergman, yielded the ſame ingredients, differing a little in their proportions †.

86 eſtinite.

SPECIES 2. Aſbeſtinite (K)

This ſtone is amorphous. Texture foliated or broad ſtriated. Luſtre ſilky, 3. Tranſparency 1 to 2. Hardneſs 5 to 6. Sp. gr. from 2.806 to 2.880. Colour white, with ſhades of red, yellow, green, or blue. At 150° Wedgewood it melts into a green glaſs.

87 XX. 1. LM oxen.

GENUS XX. 1. SILM.

SPECIES 1. Pyroxen.

This ſtone is found abundantly in lava and other volcanic productions (L). It is always cryſtallized. The primitive form of its cryſtals is an oblique angled priſm, whoſe baſes are rhombs with angles of 92° 18′, and 37° 42′ ‡. It generally cryſtallizes in eight ſided priſms, terminated by dihedral ſummits ‖. Its texture is foliated. Hardneſs 9. Colour black; ſometimes green. Powder greeniſh grey *. Commonly attracted by the magnet †. Scarcely fuſible by the blow pipe ‡. With borax it melts into a yellowiſh glaſs, which appears red while it is hot §.

‡ auy, r. de n. N° iii. 269. ‖ e Liſle, 98. auquelin. erber. e Lievre. auquelin.

According to the analyſis of Vauquelin, it is compoſed of

52.00	ſilica,
14.66	oxyd of iron,
13.20	lime,
10.00	magneſia,
3.33	alumina,
2.00	oxyd of manganeſe.
95.19 ‖	

‖ our. de n N° ix. 172.

88 eſtoid.

SPECIES 2. Aſbeſtoid *.

* irwan, 56.

This ſtone has obtained its name from its ſimilarity to common aſbeſtus. It is amorphous. Its texture is foliated or ſtriated. Its luſtre common or glaſſy, from 2 to 3. Tranſparency from 0 to 1. Hardneſs 6 to 7. Sp. gr. from 3 to 3.31. Colour olive or leek green; when decompoſing, brown. Before the blowpipe it melts *per ſe* into a brown globule. With borax it forms a violet coloured globule verging towards hyacinth †. According to the analyſis of Mr Macquart, it is compoſed of

acquart, . de n. xxii.

46	ſilica,
20	oxyd of iron,
11	lime,
10	oxyd of manganeſe,
8	magneſia.
95 ‡	

‡ id.

There is a variety of this ſpecies which Kirwan calls metalliform aſbeſtoid. Its luſtrè is ſemimetallic, 3. Opaque. Hardneſs 8 to 9. Sp. gr. 3.356. Colour grey, ſometimes inclining to red *.

* irwan's i. 167.

Simple Stones.

89 G. XX. 2. SMIL. Shorlaceous actinolite.

GENUS XX. 2. SMIL.

SPECIES 3. Shorlaceous actinolite (M).

This ſtone cryſtallizes in four or ſix ſided priſms, thicker at one end than the other; hence it has been called by the Germans *ſtrahlſtein*, "arrow-ſtone." The cryſtals ſometimes adhere longitudinally. Fracture hackly. External luſtre glaſſy, 3 to 4; internal, 1 to 2. Tranſparency from 2 to 3; ſometimes 1. Hardneſs from 7 to 10. Sp. gr. 3.023 to 3.45. Colour leek or dark green.

This ſtone is often the matrix of iron, copper, and tin ores.

90 Lamellar actinolite.

SPECIES 5. Lamellar actinolite.

This ſtone reſembles hornblende. It is amorphous. Texture foliated. Luſtre various in different places. Tranſparency 0, or ſcarce 1. Sp. gr. 2.916. Colour dark yellowiſh or greeniſh grey.

91 Glaſſy actinolite.

SPECIES 6. Glaſſy actinolite.

This ſtone is found amorphous, compoſed of fibres adhering longitudinally, or in ſlender four or ſix ſided priſms. Texture fibrous. Fragments long ſplintery, ſo ſharp that they can ſcarcely be handled without injury. External luſtre glaſſy or ſilky, 3 to 4; internal 0. Tranſparency 2. Exceedingly brittle. Sp gr. 2.95 to 3.493. Colour leek green; ſometimes verging towards greeniſh or ſilver white; ſometimes ſtained with yellowiſh or browniſh red. According to Bergman it is compoſed of

72.0	ſilica,
12 7	carbonat of magneſia,
6.0	carbonat of lime,
7.0	oxyd of iron,
2.0	alumina.
99.7 *	

* Opuſc. iv. 171

92 G XXI. SL. Shiſtoſe hornſtone.

GENUS XXI. SL.

SPECIES 1. Shiſtoſe hornſtone †.

† Kirwan, i. 305.

The ſtructure of this ſtone is ſlaty. Luſtre from 0 to 1. Commonly opaque. Hardneſs 9 to 10. Sp. gr. from 2.596 to 2.641. Colour dark bluiſh or blackiſh grey. Infuſible *per ſe*.

Variety 1. Siliceous ſhiſtus.

Commonly interſected by reddiſh veins of iron ſtone. Fracture ſplintery. Luſtre 0. Tranſparency from 0 to 1.

Variety 2. Baſanite or Lydian ſtone.

Commonly interſected by veins of quartz. Fracture even; ſometimes inclining to conchoidal. Luſtre ſcarce 1. Hardneſs 10. Sp. gr. 2.590. Powder black. Colour greyiſh black.

This, or a ſtone ſimilar to it, was uſed by the ancients as a touchſtone. They drew the metal to be examined along the ſtone, and judged of its purity by the

---

(K) *Kirw. Min.* I. 165. Is this the *tremolite* of Werner? It certainly is not the *tremolite* of the French mineralogiſts.

(L) Hence the name *pyroxen* given it by Hauy; from πυρ *fire*, and ξενος, *a ſtranger*. It means, as he himſelf explains it, a *ſtranger in the regions of fire*. By this he means to indicate, that pyroxen, though preſent in lava, is not a volcanic production.

(M) In this and the following ſpecies we have followed Mr Kirwan's new arrangement exactly, without even venturing to give the ſynonimes of other authors. The deſcriptions which have been given are ſo many and incomplete, and the minerals themſelves are ſtill ſo imperfectly known, and have got ſo many names, that no part of mineralogy is in a ſtate of greater confuſion.

the colour of the metallic ſtreak. On this account they called it βασανος, *the trier.* They called it alſo *Lydian ſtone*, becauſe, as Theophraſtus informs us, it was found moſt abundantly in the river Tmolus in Lydia†.

† *Hill's Theopraſtus*, περι λιθων, p. 190.

A ſpecimen of the firſt variety, analyſed by Wiegleb, contained
75.0 ſilica,
10.0 lime,
4.6 magneſia,
3.5 iron,
5.2 carbon.
——
98.3

This ſpecies is rather a mechanical mixture than a chemical combination.

93
G. XXII.
zs.
Zircon.

Genus XXII. zs.

species 1. Zircon*.

Jargon—Hyacinth.

* *Kirwan*, i. 257. and 333.

This ſtone is brought from Ceylon, and found alſo in France, Spain, and other parts of Europe. It is commonly cryſtallized. The primitive form of its cryſtals is an octahedron§, compoſed of two four ſided pyramids applied baſe to baſe, whoſe ſides are iſoſceles triangles (N). The inclination of the ſides of the ſame pyramid to each other is 124° 12′; the inclination of the ſides of one pyramid to thoſe of another 82° 50′. The ſolid angle at the apex is 73° 44′†. The varieties of the cryſtalline forms of zircon amount to ſeven. In ſome caſes there is a four ſided priſm interpoſed between the pyramids of the primitive form; ſometimes all the angles of this priſm are wanting, and two ſmall triangular faces in place of each; ſometimes the cryſtals are dodecahedrons, compoſed of a flat four-ſided priſm with hexagonal faces, terminated by four ſided ſummits with rhomboidal faces ‖; ſometimes the edges of this priſm, ſometimes the edges where the priſm and ſummit join, and ſometimes both together, are wanting, and we find ſmall faces in their place. For an accurate deſcription and figure of theſe varieties, we refer to *Mr Hauy* ‡.

§ Fig. 25.
† *Hauy. Jour. de Min.* N° xxvi. 91.
‖ Fig. 26
‡ *Ibid.*

The texture of the zircon is foliated. Internal luſtre 3. Tranſparency from 4 to 2. Cauſes a very great double refraction. Hardneſs from 10 to 16. Sp. gr. from 4.2 to 4.165 †. Colour commonly reddiſh or yellowiſh; ſometimes it is limpid.

† *Ibid.*

Before the blow pipe it loſes its colour, but not its tranſparency. With borax it melts into a tranſparent glaſs. Infuſible with fixed alkali and microcoſmic ſalt.

1. The variety formerly called *hyacinth* is of a yellowiſh red colour, mixed with brown. Its ſurface is ſmooth. Its luſtre 3. Its tranſparency 3 to 4.

2. The variety formerly called *jargon of Ceylon*, is either grey, greeniſh, yellowiſh brown, reddiſh brown, or violet. It has little external luſtre. Is ſometimes nearly opaque.

The firſt variety, according to the analyſis of Vauquelin, is compoſed of
64.5 zirconia,
32.0 ſilica,
2.0 oxyd of iron.
——
98 5†

† *Ibid.* p. 106.

A ſpecimen analyſed by Klaproth contained
70.0 zirconia,
25.0 ſilica,
0.5 oxyd of iron.
——
95.5‡

‡ *Beiträge*, i. 231.

The ſecond variety, according to Klaproth, who diſcovered the component parts of both theſe ſtones, contains
68.0 zirconia,
31.5 ſilica,
0.5 nickel and iron.
——
100.0§

§ *Ibid.* i. 219.

Order II. SALINE STONES.

94
Genera.

Under this order we comprehend all the minerals which conſiſt of an earthy baſis combined with an acid. They naturally divide themſelves into five genera. We ſhall deſcribe them in the following order.

I. calcareous salts.
  Carbonat of lime,
  Sulphat of lime,
  Phoſphat of lime,
  Fluat of lime,
  Borat of lime.

II. barytic salts.
  Carbonat of barytes,
  Sulphat of barytes.

III. strontitic salts.
  Carbonat of ſtrontites,
  Sulphat of ſtrontites.

IV. magnesian salts.
  Sulphat of magneſia.

V. aluminous salts.
  Alum.

95
G. I. Calcareous ſalts.

Genus I. calcareous salts.

This genus comprehends all the combinations of lime and acids which form a part of the mineral kingdom.

96
Carbonat of lime.

species 1. Carbonat of lime.

No other mineral can be compared with carbonat of lime in the abundance with which it is ſcattered over the earth. Many mountains conſiſt of it entirely, and hardly a country is to be found on the face of the globe where, under the names of limeſtone, chalk, marble, ſpar, it does not conſtitute a greater or ſmaller part of the mineral riches.

It is often amorphous, often ſtalactitical, and often cryſtallized. The primitive form of its cryſtals is a parallelopiped, whoſe ſides are rhombs, with angles of 77° 30′ and 102° 30′ ‡. Its integrant molecules have the ſame form. The varieties of its cryſtals amount to more than 40; for a deſcription and figure of which we refer to *Romé de Liſle* * and *Hauy* (o).

‡ Fig. 28.
* *Cryſtal.* i. 497.

When cryſtallized, its texture is foliated; when amorphous, its ſtructure is ſometimes foliated, ſometimes ſtriated, ſometimes granular, and ſometimes earthy. Its luſtre

---

(N) Let ABC (fig. 27.) be one of the ſides. Draw the perpendicular BD; then AB = 5, BD = 4, AD = 3.

(o) *Eſſai d'une Theorie*, &c p. 75.—*Jour. de Phyſ.* 1793, Auguſt, p. 114.—*Jour. d'Hiſt. Nat.* 1792, February, p. 148.—*Ann. de Chim.* XVII. 249. &c.—*Jour de Min.* N° XXVIII. 304.

luſtre varies from 0 to 3. Tranſparency from 0 to 4. It cauſes double refraction; and it is the only mineral which cauſes double refraction through two parallel faces of the cryſtal. Hardneſs from 3 to 9. Sp. gr. from 2.315 to 2.78. Colour, when pure, white. Effervesces violently with muriatic acid, and diſſolves completely, or leaves but a ſmall reſiduum. The ſolution is colourleſs.

This ſpecies occurs in a great variety of forms; and therefore has been ſubdivided into numerous varieties. All theſe may be conveniently arranged under two general diviſions.

I. Soft carbonat of lime.

Variety 1. Agaric mineral.

Mountain milk, or *mountain meal* of the Germans.

This variety is found in the clefts of rocks, or the bottom of lakes. It is nearly in the ſtate of powder; of a white colour, ſometimes with a ſhade of yellow; and ſo light, that it almoſt floats on water.

Variety 2. Chalk.

The colour of chalk is white, ſometimes with a ſhade of yellow. Luſtre 0. Opaque. Hardneſs 3 to 4. Sp. gr. from 2.315 to 2.657. Texture earthy. Adheres ſlightly to the tongue. Feels dry. Stains the fingers, and marks. Falls to powder in water. It generally contains about $\frac{2}{100}$ of alumina, and $\frac{1}{100}$ of water; the reſt is carbonat of lime.

Variety 3. Arenaceous limeſtone.

Colour yellowiſh white. Luſtre 1. Tranſparency 1. So brittle, that ſmall pieces crumble to powder between the fingers. Sp. gr. 2.742. Phoſphoreſces in the dark when ſcraped with a knife, but not when heated. It conſiſts almoſt entirely of pure carbonat of lime.

Variety 4. Teſtaceous tufa.

The colour of this variety is yellowiſh or greyiſh white. It is exceedingly porous and brittle; and is either compoſed of broken ſhells, or reſembles mortar containing ſhells; or it conſiſts of fiſtulous concretions variouſly ramified, and reſembling moſs.

II. Indurated carbonat of lime.

Variety 1. Compact limeſtone.

The texture of this variety is compact. It has little luſtre; and is moſt commonly opaque. Hardneſs 5 to 8. Sp. gr. 1.3864 to 2.72. Colour grey, with various ſhades of other colours. It moſt commonly contains about $\frac{1}{10}$th of alumina, oxyd of iron, &c.; the reſt is carbonat of lime. This variety is uſually burnt as lime.

Variety 2. Granularly foliated limeſtone.

Structure ſometimes ſlaty. Texture foliated and granular. Luſtre 2 to 1. Tranſparency 2 to 1. Hardneſs 7 to 8. Sp. gr. 2.71 to 2.8376. Colour white, of various ſhades from other colours.

Variety 3. Sparry limeſtone.

Structure ſparry. Texture foliated. Fragments rhomboidal. Luſtre 2 to 3. Tranſparency from 2 to 4; ſometimes 1. Hardneſs 5 to 6. Sp. gr. from 2.693 to 2.718. Colour white: often with various ſhades of other colours. To this variety belong all the cryſtals of carbonat of lime.

Variety 4. Striated limeſtone.

Texture ſtriated or fibrous. Luſtre 1 to 0. Tranſparency 2 to 1. Hardneſs 5 to 7. Sp. gr. commonly from 2.6 to 2.77. Colours various.

Variety 5. Swine ſtone.

Texture often earthy. Fracture often ſplintery. Luſtre 1 to 0. Tranſparency 0 to 1. Hardneſs 6 to 7. Sp. gr. 2.701 to 2.7121. Colour dark grey, of various ſhades. When ſcraped or pounded, it emits an urinous or garlic ſmell.

Variety 6. Oviform.

This variety conſiſts of a number of ſmall round bodies, cloſely compacted together. Luſtre 0. Tranſparency 0 or 1. Hardneſs 6 to 7.

97
Sulphat of lime.

SPECIES 2. Sulphat of lime.

Gypſum—Selenite.

This mineral is found abundantly in Germany, France, England, Italy, &c.

It is found ſometimes in amorphous maſſes, ſometimes in powder, and ſometimes cryſtallized. The primitive form of its cryſtals, according to Romé de Liſle, is a decahedron ‡, which may be conceived as two four-ſided pyramids, applied baſe to baſe, and which, inſtead of terminating in pointed ſummits, are truncated near their baſes; ſo that the ſides of the pyramids are trapeziums, and they terminate each in a rhomb. Theſe rhombs are the largeſt faces of the cryſtal. The angles of the rhombs are 52° and 158°. The inclination of two oppoſite faces of one pyramid to the two ſimilar faces of the other pyramid is 145°, that of the other faces 110° *. Sometimes ſome of the faces are elongated: ſometimes it cryſtallizes in ſix-ſided priſms, terminated by three or four ſided ſummits, or by an indeterminate number of curvilinear faces. For a deſcription and figure of theſe varieties, we refer to *Romé de Liſle* †.

The texture of ſulphat of lime is moſt commonly foliated. Luſtre from 0 to 4. Tranſparency from 0 to 4. It cauſes double refraction. Its hardneſs does not exceed 4. Its ſp. gr. from 1.872 to 2.311. Colour commonly white or grey.

Before the blow-pipe, it melts into a white enamel, provided the blue flame be made to play upon the edges of its laminæ. When the flame is directed againſt its faces, the mineral falls into powder ‡.

It does not effervesce with muriatic acid, except it be impure; and it does not diſſolve in it.

The following varieties of this mineral are deſerving of attention.

Variety 1. Broad foliated ſulphat.

Texture broad foliated. Luſtre glaſſy, from 4 to 2. Tranſparency from 4 to 3. Hardneſs 4. Sp. gr. 2.311. Colour grey, often with a ſhade of yellow.

Variety 2. Grano-foliated ſulphat.

Texture foliated, and at the ſame time granular; ſo that it eaſily crumbles into powder. Luſtre 2 to 3. Tranſparency 2 to 3. Hardneſs 4 to 3. Sp. gr. from 2.274 to 2.310. Feels ſoft. Colour white or grey, often with a tinge of yellow, blue, or green; ſometimes fleſh red, brown, or olive green.

Variety 3. Fibrous ſulphat.

Texture fibrous. Fragments long ſplintery. Luſtre 2 to 3. Tranſparency 2 to 1; ſometimes 3. Hardneſs 4. Brittle. Sp. gr. 2.300. Colour white, often with a ſhade of grey, yellow, or red; ſometimes fleſh red, and ſometimes honey yellow; ſometimes ſeveral of theſe colours meet in ſtripes.

Variety 4. Compact ſulphat.

Texture compact. Luſtre 1 or 0. Tranſparency 2 to

---

‡ Fig. 29.

* *Cryſtal.* i. 144.

† *Ibid.*

‡ *Le Lievre, Jour de Min*, No xxviii. 315.

Earth- and Stones.

1, ſometimes 0. Hardneſs 4. Sp. gr. from 1.872 to 2.288. Feels dry, but not harſh. Colour white, with a ſhade of grey, yellow, blue, or green; ſometimes yellow; ſometimes red; ſometimes ſpotted, ſtriped, or veined.

Variety 5. Farinaceous ſulphat.

Of the conſiſtence of meal. Luſtre 0. Opaque. Scarcely ſinks in water. Is not gritty between the teeth. Feels dry and meagre. Colour white. When heated below redneſs, it becomes of a dazzling white.

98 Phoſphat of lime.

SPECIES 3. Phoſphat of lime.

Apatite—*Phoſphorite*—*Chryſolite*—of the French.

This ſubſtance is found in Spain, where it forms whole mountains, and in different parts of Germany. It is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals is a regular ſix-ſided priſm ‡. Its integrant molecule is a regular triangular priſm, whoſe height is to a ſide of its baſe as 1 to $\surd 2$ §. Sometimes the edges of the primitive hexagonal priſm are wanting, and ſmall faces in their place; ſometimes there are ſmall faces inſtead of the edges which terminate the priſm; ſometimes theſe two varieties are united; ſometimes the terminating edges and the angles of the priſm are replaced by ſmall faces †; and ſometimes the priſm is terminated by four-ſided pyramids *.

‡ Fig. 30.

§ Hauy, *Jour. de Min.* N° xxviii. p. 310.

† Fig. 31.

* Hauy, *ibid.*

Its texture is foliated. Its fracture uneven, tending to conchoidal. External luſtre from 2 to 3, internal 3 to 2. Tranſparency from 4 to 2. Cauſes ſingle refraction. Hardneſs 6 to 7. Brittle. Sp. gr. from 2.8249 to 3.218. Colour commonly green or grey; ſometimes brown, red, blue, and even purple.

It is infuſible by the blow-pipe. When its powder is thrown upon burning coals, it emits a yellowiſh green phoſphoreſcent light. It is ſoluble in muriatic acid without effervеſcence or decompoſition, and the ſolution often becomes gelatinous.

99 Fluat of lime.

SPECIES 4. Fluat of lime.

Fluor.

This mineral is found abundantly in different countries, particularly in Derbyſhire. It is both amorphous and cryſtallized.

The primitive form of its cryſtals is the regular octohedron; that of its integrant molecules the regular tetrahedron *. The varieties of its cryſtals hitherto obſerved amount to 7. Theſe are the primitive octohedron; the cube; the rhomboidal dodecahedron; the cubo-octohedron †, which has both the faces of the cube and of the octohedron; the octohedron wanting the edges; the cube wanting the edges, and either one face ‡, or two faces in place of each. For a deſcription and figure of theſe we refer to *Mr Hauy* †.

* Hauy, *ibid.* p. 325.

† Fig. 32.

‡ Fig. 33.

† *Ibid.*

The texture of fluat of lime is foliated. Luſtre from 2 to 3, ſometimes 0. Tranſparency from 2 to 4, ſometimes 1. Cauſes ſingle refraction. Hardneſs 8. Very brittle. Sp gr. from 3.0943 to 3.1911. Colours numerous, red, violet, green, red yellow, blackiſh purple. Its powder thrown upon hot coals emits a bluiſh or greeniſh light. Two pieces of it rubbed in the dark phoſphoreſce. It decrepitates when heated. Before the blow-pipe it melts into a tranſparent glaſs ‡.

‡ *Ibid.*

It admits of a poliſh, and is often formed into vaſes and other ornaments.

100 Borat of lime.

SPECIES 5. Borat of lime.

Boracite.

This mineral has been found at Kalkberg near Luneburg, ſeated in a bed of ſulphat of lime. It is cryſtallized. The primitive form of its cryſtals is the cube §. In general, all the edges and angles of the cube are truncated; ſometimes, however, only the alternate angles are truncated *. The ſize of the cryſtals does not exceed half an inch.

§ Hauy, *Jour. de Min.* N xxvii. 325

* Hauy Weſtru

The texture of this mineral is compact. Its fracture is flat conchoidal. External luſtre 3; internal, greaſy, 2. Tranſparency from 2 to 3. Hardneſs 9 to 10. Sp. gr. 2.566. Colour greyiſh white, ſometimes paſſing into greeniſh white or purpliſh.

When heated it becomes electric; and the angles of the cube are alternately poſitive and negative †.

† Hauy and An *Chim.* 59.

Before the blow-pipe it froths, emits a greeniſh light, and is converted into a yellowiſh enamel, garniſhed with ſmall points, which, if the heat be continued, dart out in ſparks ‖.

‖ Le L *Jour. d Min.* i

According to Weſtrum, who diſcovered its component parts, it contains

68	boracic acid,
13.5	magneſia,
11	lime,
1	alumina,
2	ſilica,
1	iron.
96 §	

§ *Ann. Chim.* i 116.

10 Nitrat lime.

SPECIES 6. Nitrat of lime.

Found abundantly mixed with native nitre. For a deſcription ſee the article CHEMISTRY in this *Supplement*, n° 672.

10 G. II. rytic ſ

GENUS II. BARYTIC SALTS.

This genus comprehends the combinations of barytes with acids.

10 Carbo baryte

SPECIES 1. Carbonat of barytes.

Witherite.

This mineral was diſcovered by Dr Withering; hence Werner has given it the name of *witherite*. It is found both amorphous and cryſtallized. The cryſtals are octohedrons or dodecahedrons, conſiſting of four or ſix ſided pyramids applied baſe to baſe; ſometimes the ſix-ſided pyramids are ſeparated by a priſm; ſometimes ſeveral of theſe priſms are joined together in the form of a ſtar.

Its texture is fibrous. Its fracture conchoidal. Its fragments long ſplintery. Luſtre 2. Tranſparency 2 to 3. Hardneſs 5 to 6. Brittle. Sp. gr. 4.3 to 4.338. Colour greeniſh white. When heated it becomes opaque. Its powder phoſphoreſces when thrown on burning coals *.

* Ha

It is ſoluble with effervеſcence in muriatic acid. The ſolution is colourleſs.

According to Pelletier it contains

62	barytes,
22	carbonic acid,
16	water.
100 †	

† Jou *Min.* xxi. 1

Sulph baryt

SPECIES 2. Sulphat of barytes.

Boroſelenite.

This mineral is found abundantly in many countries, particularly in Britain. It is ſometimes in powder, often in amorphous maſſes, and often cryſtallized. The primitive form of its cryſtals is a rectangular priſm, whoſe d whoſe baſes are rhombs, with angles of 101° 30′ and 78° 30′ ‡. The varieties of its cryſtals are very numerous. For a deſcription and figure of them we refer to *Romé de Liſle* || and *Hauy* *. The moſt common varieties are the octohedron with cuneiform ſummits, the ſix or four ſided priſm, the hexangular table with bevelled edges. Sometimes theſe cryſtals are needle form.

Its texture is commonly foliated. Luſtre from 0 to 2. Tranſparency from 2 to 0; in ſome caſes 3 or 4. Hardneſs from 5 to 6. Sp. gr. from 4.4 to 4.44. Colour commonly white, with a ſhade of yellow, red, blue, or brown.

When heated it decrepitates. It is fuſible *per ſe* by the blue flame of the blow-pipe, and is converted into ſulphurat of barytes. Soluble in no acid except the ſulphuric; and precipitated from it by water.

Variety 1. Foliated ſulphat.

Luſtre 3 to 3. Tranſparency from 4 to 2, ſometimes 1. Colours white, reddiſh, bluiſh, yellowiſh, blackiſh, greeniſh. Mr Werner ſubdivides this variety into three, according to the nature of the texture. Theſe three ſubdiviſions are *granularly foliated*, *ſtraight foliated*, *curve foliated*.

Variety 2. Fibrous ſulphat.

Texture fibrous; fibres converging to a common centre. Luſtre ſilky or waxy, 2. Tranſparency 2 to 1. Hardneſs 5. Colours yellowiſh, bluiſh, reddiſh.

Variety 3. Compact ſulphat.

Texture compact. Luſtre 0 to 1. Tranſparency 1 to 0. Feels meagre. Almoſt conſtantly impure. Colours light yellow, red, or blue.

Variety 4. Earthy ſulphat.

In the form of coarſe duſty particles, ſlightly cohering. Colour reddiſh or yellowiſh white.

GENUS III. STRONTITIC SALTS.

This genus comprehends all the combinations of ſtrontites and acids which form a part of the mineral kingdom.

SPECIES 1. Carbonat of ſtrontites.

This mineral was firſt diſcovered in the lead mine of Strontion in Argyleſhire; and ſince that time it is ſaid to have been diſcovered, though not in great abundance, in other countries. It is found amorphous, and alſo cryſtallized in needles, which, according to Hauy, are regular ſix ſided priſms.

Its texture is fibrous; the fibres converge. Fracture uneven. Luſtre 2. Tranſparency 2. Hardneſs 5. Sp. gr. from 3.4 to 3.66. Colour light green. Does not decrepitate when heated. Before the blow-pipe becomes opaque and white, but does not melt. With borax it effervеſces, and melts into a tranſparent colourleſs glaſs. Effervеſces with muriatic acid, and is totally diſſolved. The ſolution tinges flame purple.

SPECIES 2. Sulphat of ſtrontites.
Celeſtine.

This mineral has been found in Pennſylvania, in Germany, in France, in Sicily, and Britain. It was firſt diſcovered near Briſtol by Mr Clayfield. There it is found in ſuch abundance, that it has been employed in mending the roads.

It occurs both amorphous and cryſtallized. The cryſtals are moſt commonly bevelled tables, ſometimes rhomboidal cubes. Its texture is foliated. More or leſs tranſparent. Hardneſs 5. Sp. gr. from 3.51 to 3.96. Colour moſt commonly a fine ſky blue; ſometimes reddiſh; ſometimes white, or nearly colourleſs *.

Klaproth found a ſpecimen of this mineral from Pennſylvania compoſed of
58 ſtrontites,
42 ſulphuric acid.

100 †

According to the analyſis of Mr Clayfield, the ſulphat of ſtrontites found near Briſtol is compoſed of
58.25 ſtrontites,
41.75 ſulphuric acid of 2.24, and a little iron ‡.

100.00

According to the analyſis of Vauquelin, the ſulphat of ſtrontites found at Bouvron in France, which was contaminated with .1 of carbonat of lime, is compoſed of
54 ſtrontites,
45 ſulphuric acid.

99 §

GENUS IV. MAGNESIAN SALTS.

108
G IV.
Magneſian Salts.

This genus comprehends the combinations of magneſia and acids which occur in the mineral kingdom. Only two ſpecies have hitherto been found; namely,

109
Sulphat of magneſia.

SPECIES 1. Sulphat of magneſia.

It is found in Spain, Bohemia, Britain, &c.; and enters into the compoſition of many mineral waters.

For a deſcription of it, we refer to CHEMISTRY, n° 633. in this *Suppl.*

110
Nitrat of magneſia.

SPECIES 2. Nitrat of magneſia.

Found ſometimes aſſociated with nitre. For a deſcription ſee CHEMISTRY, n° 674.

GENUS V. ALUMINOUS SALTS.

111
G. V. Aluminous ſalts.

This genus comprehends thoſe combinations of alumina and acids which occur in the mineral kingdom.

112
Alum.

SPECIES 1. Alum.

This ſalt is found in cryſtals, in ſoft maſſes, in flakes, and inviſibly mixed with the ſoil. For a deſcription, we refer to CHEMISTRY, n° 636.

ORDER III. AGGREGATES.

THIS order comprehends all mechanical mixtures of earths and ſtones found in the mineral kingdom. Theſe are exceedingly numerous: the mountains and hills, the mould on which vegetables grow, and indeed the greater part of the globe, may be conſidered as compoſed of them. A complete deſcription of aggregates belongs rather to geology than mineralogy. It would be improper, therefore, to treat of them fully here. But they cannot be altogether omitted; becauſe aggregates are the firſt ſubſtances which preſent themſelves to the view of the practical mineralogiſt, and becauſe, without being acquainted with the names and component parts of many of them, the moſt valuable mineralogical works could not be underſtood.

113
Diviſion of aggregates.

Aggregates may be comprehended under four diviſions: 1. Mixtures of earths; 2. Amorphous fragments of ſtones agglutinated together; 3. Cryſtallized ſtones, either agglutinated together or with amorphous ſtones; 4. Aggregates formed by fire. It will be exceedingly

convenient

---

* Clayfield, Nicholſon's Jour. iii. 36.

† Beiträge, ii. 97.

‡ Ibid. Nicholſon's Journal.

§ Jour. de Min. N° xxxvii. 6.

convenient to treat each of theſe ſeparately. We ſhall therefore divide this order into four ſections.

SECT. I. *Aggregates of Earths.*

The moſt common earthy aggregates may be comprehended under the following genera:

1. Clay,
2. Colorific earths,
3. Marl,
4. Mould.

114 Clay.

GENUS I. CLAY.

Clay is a mixture of alumina and ſilica in various proportions. The alumina is in a ſtate of an impalpable powder; but the ſilica is almoſt always in ſmall ſtones, large enough to be diſtinguiſhed by the eye. Clay, therefore, exhibits the character of alumina, and not of ſilica, even when this laſt ingredient predominates. The particles of ſilica are already combined with each other; and they have ſo ſtrong an affinity for each other, that few bodies can ſeparate them; whereas the alumina, not being combined, readily diſplays the characters which diſtinguiſh it from other bodies. Beſides alumina and ſilica, clay often contains carbonat of lime, of magneſia, barytes, oxyd of iron, &c. And as clay is merely a mechanical mixture, the proportion of its ingredients is exceedingly various.

Clay has been divided into the following ſpecies:

115 Porcelain clay.

SPECIES 1. Porcelain clay.

Its texture is earthy. Its luſtre 0. Opaque. Hardneſs 4. Sp. gr. from 2.23 to 2.4. Colour white, ſometimes with a ſhade of yellow or red. Adheres ſlightly to the tongue. Feels ſoft. Falls to powder in water.

A ſpecimen, analyſed by Haſſenfratz, contained

62	ſilica,
19	alumina,
12	magneſia,
7	ſulphat of barytes.
100 *	

A ſpecimen, analyſed by Mr Wedgewood, contained

60	alumina,
20	ſilica,
12	air of water.
92	

116 Common clay.

SPECIES 2. Common clay.

Its texture is earthy. Luſtre 0. Opaque. Hardneſs 3 to 6. Sp. gr. 1.8 to 2.68. Adheres ſlightly to the tongue. Often feels greaſy. Falls to powder in water. Colour, when pure, white; often tinged blue or yellow.

Variety 1. Potter's clay.

Hardneſs 3 to 4. Sp. gr. 1.8 to 2. Stains the fingers ſlightly. Acquires ſome poliſh by friction. Colour white; often with a tinge of yellow or blue; ſometimes browniſh, greeniſh, reddiſh. Totally diffuſible in water; and, when duly moiſtened, very ductile.

Variety 2. Indurated clay.

Hardneſs 5 to 6. Does not diffuſe itſelf in water, but falls to powder. Diſcovers but little ductility. Colours grey, yellowiſh, bluiſh, greeniſh, reddiſh, browniſh.

Variety 3. Shiſtoſe clay.

Structure ſlaty. Sp. gr. from 2.6 to 2.68. Feels ſmooth. Streak white or grey. Colour commonly bluiſh, or yellowiſh grey; ſometimes blackiſh, reddiſh, greeniſh. Found in ſtrata, uſually in coal mines.

This variety is ſometimes impregnated with bitumen. It is then called bituminous *ſhale*.

117 Lithomarga.

SPECIES 3. Lithomarga.

Texture earthy. Fracture conchoidal. Luſtre from 0 to 2. Opaque. Hardneſs 3 to 7. Sp. gr. when pretty hard, 2.815. Surface ſmooth, and feels ſoapy. Adheres ſtrongly to the tongue. Falls to pieces, and then to powder, in water; but does not diffuſe itſelf through that liquid. Fuſible *per ſe* into a frothy maſs.

Variety 1. Friable lithomarga.

Formed of ſcaly particles ſlightly cohering. Luſtre 1 to 0. Hardneſs 3 to 4. Exceedingly light. Feels very ſmooth, and aſſumes a poliſh from the nail. Colour white; ſometimes tinged yellow or red.

Variety 2. Indurated lithomarga.

Hardneſs 4 to 7. The ſofter ſorts adhere very ſtrongly to the tongue when newly broken; the harder very moderately. Colours grey, yellow, red, brown, blue.

A ſpecimen of lithomarga from Oſmund, analyſed by Bergman, contained

60.0	ſilica,
11.0	alumina,
5.7	carbonat of lime,
4.7	oxyd of iron,
0.5	carbonat of magneſia,
18.0	water and air.
99.9 †	

118 Bole.

SPECIES 4. Bole.

Texture earthy. Fracture conchoidal. Luſtre 0. Tranſparency ſcarce 1. Hardneſs 4. Sp. gr. from 1.4 to 2. Acquires a poliſh by friction. Scarcely adheres to the tongue. Feels greaſy. Colour yellow or brown; ſometimes red; ſometimes ſpotted.

The lemnian earth which belongs to this ſpecies, according to the analyſis of Bergman, contains

47.0	ſilica,
19.0	alumina,
6.0	carbonat of magneſia,
5.4	carbonat of lime,
5.4	oxyd of iron,
17.0	water and air.
99.8 ‡	

119 Ful earth

SPECIES 5. Fullers earth.

Texture earthy. Structure ſometimes ſlaty. Fracture imperfectly conchoidal. Luſtre 0. Opaque. Hardneſs 4. Receives a poliſh from friction. Does not adhere to the tongue. Feels greaſy. Colour uſually light green.

A ſpecimen from Hampſhire, analyſed by Bergman, contained

51.8	ſilica,
25.0	alumina,
3.3	carbonat of lime,
3.7	oxyd of iron,
0.7	carbonat of magneſia,
15.5	moiſture.
100.0 §	

This

---

* *Ann. de Chim.* xiv. 144.

† *Opuſc.*

‡ *Ibid,*
157.

§ *Ibid,*

hs and' ones.

This earth is uſed by fullers to take the greaſe out of their cloth before they apply ſoap. It is eſſential to fullers earth that the particles of ſilica be very fine, otherwiſe they would cut the cloth. Any clay, poſſeſſed of this laſt property, may be conſidered as *fullers earth*; for it is the alumina alone which acts upon the cloth, on account of its ſtrong affinity for greaſy ſubſtances.

o Co- c s.

Genus II. Colorific Earths.

The minerals belonging to this genus conſiſt of clay, mixed with ſo large a quantity of ſome colouring ingredient as to render them uſeful as paints. The colouring matter is commonly oxyd of iron, and ſometimes charcoal.

r chalk.

Species 1. Red chalk.

Reddle.

Texture earthy. Fracture conchoidal. Luſtre 0. Opaque. Hardneſs 4. Sp. gr. inconſiderable. Colour dark red.

Feels rough. Stains the fingers. Adheres to the tongue. Falls to powder in water. Does not become ductile. When heated it becomes black, and at 159° Wedgewood melts into a greeniſh yellow frothy enamel.

Compoſed of clay and oxyd of iron.

2 w .

Species 2. Yellow chalk.

Texture earthy. Fracture conchoidal. Hardneſs 3. Sp. gr inconſiderable. Colour ochre yellow.

Feels ſmooth or greaſy. Stains the fingers. Adheres to the tongue. Falls to pieces in water. When heated becomes red; and at 156° Wedgewood melts into a brown porous porcelain.

According to Sage, it contains
50 alumina,
40 oxyd of iron,
10 water, with ſome ſulphuric acid.
——
100 *

3

Species 3. Black chalk.

Structure ſlaty. Texture earthy. Fragments ſplintery. Luſtre 0. Opaque. Hardneſs 5. Sp. gr. 2.144 to 2.277. Colour black. Streak black.

Feels ſmooth. Adheres ſlightly to the tongue. Does not moulder in water. When heated to redneſs it becomes reddiſh grey.

According to Wiegleb, it is compoſed of
64.50 ſilica,
11.25 alumina,
11.00 charcoal,
2.75 oxyd of iron,
7.50 water.
——
97.00 †

4

Species 4. Green earth.

Texture earthy. Luſtre 0. Opaque. Hardneſs 6 to 7. Sp gr. 2.637. Colour green.

Commonly feels ſmooth. Does not ſtain the fingers. Often falls to powder in water. When heated it becomes reddiſh brown; and at 147° Wedgewood melts into a black compact glaſs.

Compoſed of clay, oxyds of iron and nickel.

5 Marl.

Genus III. Marl.

A mixture of carbonat of lime and clay, in which the carbonat conſiderably exceeds the other ingredient, is called *marl*.

Its texture is earthy. Luſtre 0. Opaque. Hardneſs from 4 to 8; ſometimes in powder. Sp. gr. from 1.6 to 2.877. Colour uſually grey, often tinged with other colours. Effervеſces with acids.

Some marls crumble into powder when expoſed to the air; others retain their hardneſs for many years.

Marls may be divided into two ſpecies: 1. Thoſe which contain more ſilica than alumina; 2. Thoſe which contain more alumina than ſilica. Mr Kirwan has called the firſt of theſe *ſiliceous*, the ſecond *argillaceous*, marls. Attention ſhould be paid to this diſtinction when marls are uſed as a manure.

116 G. IV. Mould.

Genus IV. Mould.

By *mould* is meant the ſoil on which vegetables grow.

It contains the following ingredients: ſilica, alumina, lime, magneſia (ſometimes), iron, carbon derived from decayed vegetable and animal ſubſtances, carbonic acid, and water. And the good or bad qualities of *ſoils* depends upon a proper mixture of theſe ingredients. The ſilica is ſeldom in the ſtate of an impalpable powder, but in grains of a greater or ſmaller ſize: Its chief uſe ſeems to be to keep the ſoil open and pervious to moiſture. If we paſs over the carbon, the iron, and the carbonic acid, the goodneſs of a ſoil depends upon its being able to retain the quantity of moiſture which is proper for the nouriſhment of vegetables, and no more. Now the retentive power of a ſoil increaſes with the proportion of its alumina, lime, or magneſia, and diminiſhes as the proportion of its ſilica increaſes. Hence it follows, that in a dry country, a fertile ſoil ſhould contain leſs ſilica, and more of the other earths, than in a wet country.

Giobert found a fertile ſoil near Turin, where it rains annually 30 inches, to contain
From 77 to 79 ſilica,
9 — 14 alumina,
5 — 12 lime.

Near Paris, where it rains about 20 inches annually, Mr Tillet found a fertile ſoil to contain
Coarſe ſand 25
Fine ſand 21
— 46.0 ſilica,
16.5 alumina,
37.5 lime.
——
100.0 ‡

The varieties of mould are too numerous to admit an accurate deſcription: we ſhall content ourſelves, therefore, with mentioning the moſt remarkable.

127 Sand.

Species 1. Sand.

This conſiſts of ſmall grains of ſiliceous ſtones not cohering together, nor ſoftened by water. When the grains are of a large ſize, the ſoil is called *gravel*.

128 Clay.

Species 2. Clay.

This conſiſts of common clay mixed with decayed vegetable and animal ſubſtances.

129 Loam.

Species 3. Loam.

Any ſoil which does not cohere ſo ſtrongly as clay, but more ſtrongly than chalk, is called *loam*. There are many varieties of it. The following are the moſt common.

---

* m. 1779,

† de xxx. 13.

‡ Kirwan on Manures.

Earths and Stones.

Variety 1. Clayey loam; called alſo *ſtrong*, *ſtiff*, *cold*, and *heavy*, loam.

It conſiſts of a mixture of clay and coarſe ſand.

Variety 2. Chalky loam.

A mixture of clay, chalk, and coarſe ſand; the chalk predominating.

Variety 3. Sandy loam.

A mixture of the ſame ingredients; the ſand amounting to .8 or .9 of the whole.

130 Till.

SPECIES 4. Till.

Till is a mixture of clay and oxyd of iron. It is of a red colour, very hard and heavy.

SECT. II. *Aggregates of amorphous ſtones.*

THE aggregates which belong to this ſection conſiſt of amorphous fragments of ſtones cemented together. They may be reduced to the following genera:

1. Sandſtone,
2. Puddingſtone,
3. Amygdaloid,
4. Breccia.

131 G. I. Sandſtone.

GENUS I. SANDSTONE.

Small grains of ſand, conſiſting of quartz, flint, hornſtone, ſiliceous ſhiſtus, or felſpar, and ſometimes of mica, cemented together, are denominated ſandſtones. They feel rough and ſandy; and when not very hard, eaſily crumble into ſand. The cement or baſis by which the grains of ſand are united to each other is of four kinds; namely, lime, alumina, ſilica, iron. Sandſtones, therefore, may be divided into four ſpecies.

132 Calcareous.

SPECIES 1. Calcareous ſandſtones.

Calcareous ſandſtones are merely carbonat of lime or marl, with a quantity of ſand interpoſed between its particles. Though the quantity of ſand, in many caſes, far exceeds the lime, calcareous ſandſtones are ſometimes found cryſtallized: and, in ſome caſes, the cryſtals, as might be expected, have ſome of the forms which diſtinguiſh carbonat of lime. Thus the calcareous ſandſtone of Fountainbleau is cryſtallized in rhomboidal tables. It contains, according to the analyſis of Laſſone

62.5	ſiliceous ſand,
37.5	carbonat of lime.
100	

Calcareous ſandſtones have commonly an earthy texture. Their ſurface is rough. Their hardneſs from 6 to 7. Their ſpecific gravity about 2.5 or 2.6. Their colour grey; ſometimes yellowiſh or brown. They are ſometimes burned for lime.

133 Aluminous.

SPECIES 2. Aluminous ſandſtones.

The baſis of argillaceous ſandſtones is alumina, or rather clay. Their ſtructure is often ſlaty. Their texture is compact, and either fine or coarſe grained, according to the ſize of the ſand of which they are chiefly compoſed. Their hardneſs is from 6 to 8, or even 9. Their colour is uſually grey, yellow, or brown.

They are often formed into mill-ſtones, filtering-ſtones, and coarſe whet ſtones.

134 Siliceous.

SPECIES 3. Siliceous ſandſtones.

Siliceous ſandſtones conſiſt of grains of ſand cemented together by ſilica, or ſome ſubſtance which conſiſts chiefly of ſilica or flint. They are much harder than any of the other ſpecies.

Sometimes ſtones occur, conſiſting of grains of lime cemented together with ſilica. Theſe ſtones are alſo denominated ſiliceous ſandſtones.

135 Ferruginous.

SPECIES 4. Ferruginous ſandſtones.

The iron which acts as a cement in ferruginous ſandſtones is not far from a metallic ſtate. When iron is completely oxydated, it loſes the property of acting as a cement. This is the reaſon that ferruginous ſandſtones, when expoſed to the air, almoſt always crumble into powder.

The colour of ferruginous ſandſtones is uſually dark red, yellow, or brown. The grains of ſand which compoſe them are often pretty large. Their hardneſs is commonly inconſiderable.

136 G. II. P ding ſto

GENUS II. PUDDING STONE.

Pebbles of quartz, flint, or other ſimilar ſtones of a round or eliptical form, from the ſize of rape ſeed to that of an egg, cemented together by a ſiliceous cement, often mixed with iron, have been denominated *pudding ſtones*.

Pudding ſtones, of courſe, are not inferior in hardneſs to quartz, flint, chalcedony, &c. of which the pebbles may conſiſt. The colour of the cement is uſually yellow, brown, or red. Its fracture is conchoidal.

The finer ſorts of pudding ſtones are capable of a fine poliſh; the coarſe are uſed for mill-ſtones.

137 G. II Amygd loid.

GENUS III. AMYGDALOID.

Rounded or eliptical maſſes of chalcedony, zeolite, limeſtone, lithomarga, ſteatites, green earth, garnets, hornblend, or opal, cemented together by a baſis of indurated clay, trap, mullen, walken or kragg, conſtitute an *amygdaloid*.

Amygdaloids are opaque. They have no luſtre. Their fracture is uneven or conchoidal. Hardneſs 6 to 9. Their colours are as various as the ingredients of which they are compoſed.

138 G. IV Brecc

GENUS IV. BRECCIA.

Angular fragments of the ſame *ſpecies* of ſtone agglutinated together, conſtitute a *breccia*. Thus *calcareous* breccia conſiſts of fragments of marble cemented together by means of lime.

SECT. III. *Aggregates of Cryſtals.*

THE minerals belonging to this ſection conſiſt either of cryſtals of different kinds cemented together, or of cryſtals and amorphous ſtones cemented together.

They may be reduced under the following genera.

1. Granite.
2. Sienite.
3. Granatine.
4. Granitell.
5. Granilite.
6. Trap.
7. Porphyry.

1 G. I. nite.

GENUS I. GRANITE.

An aggregate of felſpath, quartz, and mica, whatever be the ſize or the figure of the ingredients, is denominated *granite*. This aggregate may be divided into two ſpecies, namely, *common* granite, and *ſhiſtoſe* granite or gneiſs.

14 Com

SPECIES 1. Common granite.

Its ſtructure is always granular. The felſpar is often amor-

Earths and Stones. amorphous, and conſtitutes moſt frequently the greateſt part of the aggregate.

Common granites differ much in their appearance, according to the ſize, proportion, colour, and figure of their component parts. They are commonly very hard: Their ſpecific gravity varies from 2.5388 to 2.9564.

141 Gneiſs.

SPECIES 2. Shiſtoſe granite or gneiſs.

The ſtructure of gneiſs is always ſlaty, and this conſtitutes its ſpecific character. In gneiſs, the proportion of quartz and felſpar is nearly equal: the proportion of mica is ſmalleſt. It is evidently ſubject to the ſame varieties with common granite.

142 G. II. Sienite.

GENUS II. Sienite.

Mr Werner has given the name of *ſienite* to aggregates compoſed of felſpar, hornblende, and quartz; or of felſpar, hornblende, quartz, and mica. Theſe aggregates were formerly confounded with quartz.

Sienite is found both of a granular and ſlaty ſtructure: it might, therefore, like granite, be divided into two ſpecies. In ſienite the quartz is commonly in by far the ſmalleſt proportion.

143 G. III. Granatine.

GENUS III. GRANATINE.

Mr Kirwan has applied the name *granatine* to the following aggregates.

Quartz, Felſpar, Shorl.	Quartz, Mica, Garnet.	Quartz, Hornblende, Jade.	Felſpar, Mica, Shorl.
Quartz, Felſpar, Jade.	Quartz, Shorl, Hornblende,	Quartz, Hornblende, Garnet,	Felſpar, Mica, Hornblende.
Quartz, Felſpar, Garnet.	Quartz, Shorl, Jade.	Quartz, Jade, Garnet.	Felſpar, Quartz, Serpentine.
Quartz, Mica, Shorl.	Quartz, Shorl, Garnet.	Quartz, Hornblende, Hornſtone,	Felſpar, Quartz, Steatites.
Quartz, Mica, Jade.			

One of theſe aggregates, namely, *quartz, mica, garnet*, was called by Cronſtedt *norka* or *murkſten*.

144 G. IV. Granitell.

GENUS IV. GRANITELL.

Mr Kirwan gives the name of *granitell* to all aggregates compoſed of any two of the following ingredients: quartz, felſpath, mica, ſhorl, hornblende, jade, garnet, ſteatites. The moſt remarkable of theſe are:

Quartz, Felſpar	Quartz, Hornblende.	Quartz, Steatites.	Felſpar, Hornblende.
Quartz, Mica.	Quartz, Jade.	Felſpar, Mica.	Felſpar, Jade.
Quartz, Shorl.	Quartz, Garnet.	Felſpar, Shorl.	Felſpar, Garnet.
Mica, Shorl.	Mica, Jade.	Hornblende, Jade.	Jade, Garnet.
Mica, Hornblende.	Mica, Garnet.	Hornblende, Garnet.	Steatites, Shorl.

Aggregates

Some of theſe aggregates have received particular names. The aggregate of *quartz* and *mica*, when its ſtructure is ſlaty, is called by Werner *ſhiſtoſe mica*: by the Swedes, it is denominated *ſtellſten*, whatever be its ſtructure.

The aggregate of hornblende and mica is called *grunſtein*, from the dark green colour which it uſually has.

145 G. V. Granilite.

GENUS V. GRANILITE.

Under the name of *granilite*, Mr Kirwan comprehends all aggregates containing more than three ingredients. Of theſe the following are the moſt remarkable.

Quartz, Felſpar, Mica, Shorl.	Quartz, Mica, Shorl, Garnet.	Quartz, Sulph. of barytes, Mica, Shorl.
Quartz, Felſpar, Mica, Steatites.	Quartz, Felſpar, Mica, Garnet.	Quartz, Sulph. of barytes, Mica, Hornblende.

146 G. VI. Trap.

GENUS VI. TRAP (P).

Under this genus we claſs not only what has commonly been called *trap*, but alſo wacken, and mullen, and kragſtone of Kirwan.

147 Common.

SPECIES 1. Common trap.

This ſtone is very common in Scotland, and is known by the name of *whinſtone*. Whole hills are formed of it; and it occurs very frequently in large rounded detached fragments. Sometimes it aſſumes the form of immenſe columns, and is then called *baſalt*. The Giants Cauſeway in Ireland, the iſland of Staffa, and the ſouth ſide of Arthur's Seat in Scotland, are well known inſtances of this figure.

Its texture is earthy or compact. Its fracture uneven. Its luſtre commonly 0. Opaque. Hardneſs 8 to 9. Not brittle. Sp. gr. from 2.78 to 3.021 *. Colour black, with a ſhade of grey, blue, or purple; ſometimes blackiſh or reddiſh brown; in ſome caſes greeniſh grey. By expoſure to the atmoſphere, it often becomes inveſted with a browniſh rind. Before the blow-pipe, it melts *per ſe* into a more or leſs black glaſs.

* *Kirwan.*

Trap conſiſts of ſmall cryſtals of hornblende, felſpar, olivine, &c. uſually ſet in a ground compoſed apparently of clay and oxyd of iron. A ſpecimen, in the form of baſaltes, from Staffa, analyſed by Dr Kennedy of Edinburgh, contained 48 ſilica,
16 alumina,
16 oxyd of iron,
9 lime,
5 moiſture,
4 ſoda,
1 muriatic acid.

99 †

† *Edin. Tranſ.* v. 89.

(P) *Kirw.* I. 231 and 431.—*Faujas de St Fond. Eſſai ſur l'Hiſt. Nat. des Roches de Trap.*—*Phil. Tranſ.* paſſim. See alſo a very ingenious ſet of experiments on the fuſion of trap, by Sir James Hall in *Tranſ. Edin.* V. 43.

A ſpecimen from Saliſbury rock, near Edinburgh, contained, according to the analyſis of the ſame gentleman,

46.0	ſilica,
19.0	alumina,
17.0	oxyd of iron,
8.0	lime,
4.0	moiſture,
3.5	ſoda,
1.0	muriatic acid.
98.5 ‡	

Dr Kennedy conducted theſe analyſes with great ingenuity and judgment; and the diſcovery in which they terminated, that trap contains ſoda, is certainly of importance, and may lead to valuable conſequences both in a geological and mineralogical view.

148 Wacken.

SPECIES 2. Wacken *.

This ſtone often forms conſiderable parts of hills, and, like trap, is amorphous. Its texture is earthy. Its fracture uſually even. Luſtre 0. Opaque. Hardneſs 6 to 9. Sp. gr. from 2.535 to 2.893 †. Colour grey, with a ſhade of green, black, red, brown. When expoſed to the atmoſphere, it withers and becomes more grey.

It melts into a grey porous ſlag.

149 Mullen.

SPECIES 3. Mullen ‡.

This ſtone is alſo found in conſiderable maſſes, and ſometimes has a tendency to a columnar form like baſalt. Texture earthy. Fracture uneven, and fine ſplintery. Luſtre 0, except from ſome ſhining particles of baſaltine. Opaque. Hardneſs from 7 to 9. Sp. gr. from 2.6 to 2.738. Colour aſh or bluiſh grey; ſometimes mixed with ochre yellow, in conſequence of the decompoſition of the ſtone. At 130° Wedgewood it melts into a black compact glaſs.

When mullen is expoſed to the air, its ſurface becomes covered with a greyiſh white rind, ſometimes ſlightly ochry.

150 Kragſtone.

SPECIES 4. Kragſtone *.

This ſtone, which, like the others, forms conſiderable parts of rocks, was formed into a diſtinct ſpecies by Mr Kirwan. Its texture is earthy. It is exceedingly porous, and the pores are often filled with the cryſtals of other minerals. Fracture uneven. Luſtre 0. Opaque. Hardneſs 5 to 7. Sp. gr. 2.314. Feels rough and harſh. Colour reddiſh grey. Streak yellowiſh grey. At 138° Wedgewood it melts into a reddiſh brown porcelain maſs.

151 G. VII. Porphyry.

GENUS VII. PORPHYRY.

Any ſtone which contains ſcattered cryſtals or grains of felſpar, viſible to the naked eye, is denominated a *porphyry*. Beſides felſpar, porphyries generally contain ſmall cryſtals of quartz, hornblende, and mica. Theſe cryſtals are uſually of a different colour from the ſtone in which they are found, and they are ſtuck in it as in a cement. It is evident from this definition, that the number of porphyries muſt be great. Each ſpecies receives its name from the ſtone which forms its baſis. To deſcribe them would be unneceſſary. We ſhall only give a catalogue of the principal ſpecies.

1. Hornſtone porphyry.
2. Pitchſtone porphyry.
3. Hornſlate porphyry.
4. Felſpar or petunſe porphyry.
5. Clay porphyry.
6. Hornblende porphyry.
7. Trap porphyry.
8. Wacken porphyry.
9. Mullen porphyry.
10. Krag porphyry.
11. Argillitic porphyry.
12. Potſtone porphyry.
13. Serpentine porphyry.
14. Sandſtone porphyry,

The aggregates belonging to this ſection compoſe moſt of the mountains of the globe. In giving an account of them, we have adhered implicitly to the arrangement moſt generally received by mineralogiſts. It muſt be acknowledged, that this arrangement is by no means complete, and that ſome of the genera are too vague to be of much uſe. The number of aggregates already diſcovered is too great for giving to each a particular name. Perhaps it would be better henceforth to adopt the method propoſed by Mr Hauy, namely, to conſtitute the genera from that ingredient which enters moſt abundantly into the aggregate, and which forms as it were its baſis, and to diſtinguiſh the ſpecies according to the nature and proportion of the other ingredients. According to this plan, the aggregates hitherto diſcovered have been divided by Hauy into the following genera:

1. Felſpathic rock.
2. Quartzous rock.
3. Micaceous rock.
4. Chloritous rock.
5. Serpentine rock.
6. Trappean rock.
7. Hornblendean rock.
8. Petro-ſiliceous rock.
9. Garnetic rock.
10. Calcareous rock.
11. Argillaceous rock.
12. Corneous rock.

SECT. IV. *Volcanic Aggregates.*

AGGREGATES formed by volcanoes may be reduced to the following genera.

1. Lava.
2. Tufa.
3. Pumice.
4. Aſhes.

152 G. I Lav

GENUS I. LAVA.

All ſubſtances which have iſſued out of a volcano in a ſtate of fuſion are called *lavas*. They have been divided into three ſpecies.

153 Vitreous

SPECIES 1. Vitreous lava.

Found in ſmall pieces.

Texture gloſſy. Fracture conchoidal. Luſtre 3. Tranſparency from 3 to 1. Hardneſs 9 to 10. Sp. gr. from 2 to 3. Colour blackiſh, greeniſh, or whitiſh. Commonly ſomewhat porous.

154 Cellular

SPECIES 2. Cellular lava.

This ſpecies is full of cells. Surface rough and full of cavities. Texture earthy. Luſtre 0. Opaque. Hardneſs 7 to 9. Sp. gr. varies, but does not exceed 2.8. Colour brown or greyiſh black. Commonly ſomewhat magnetic.

155 Compa

SPECIES 3. Compact lava.

This ſpecies is the moſt common of all; it runs into the

---

‡ *Edin. Tranſ.* v. 90.

* *Kirw.* i. 223.

† *Kirwan.*

‡ *Kirw.* i. 225.

* *Kirw.* i. 226.

the ſecond by inſenſible degrees; and indeed is ſeldom found of any conſiderable ſize without ſome pores. It bears in general a very ſtrong reſemblance to trap.

A ſpecimen of the lava of Catania in Sicily, analyſed by Dr Kennedy, contained

51.0 ſilica,
19.0 alumina,
14.5 oxyd of iron,
9.5 lime,
4.0 ſoda,
1.0 muriatic acid.

99.0 †

A ſpecimen of the lava of Sta. Venere in Sicily he found to contain

50.75 ſilica,
17.50 alumina,
14.25 oxyd of iron,
10.00 lime,
4.00 ſoda,
1.00 muriatic acid.

97.5 ‡.

Thus we ſee, that the reſemblance between trap and lava holds not only in their external appearance, but alſo in their component parts.

† T ſ. Edi v. 93.

‡ I 94.

156 G. II. Puzzolana.

Genus II. puzzolana.

Found in ſmall pieces. Surface rough. Texture earthy and porous. Fracture uneven. Luſtre 0. Opaque. Hardneſs 3. Very brittle. Sp. gr. from 2.57 to 2.8. Colour brown or dark grey. Magnetic. Eaſily melts into a black ſlag.

When mixed with lime into a mortar, it poſſeſſes the property of hardening even under water. This property it owes moſt probably, as Mr Kirwan ſuppoſes, to the iron which it contains. The iron decompoſes the water of the mortar, and by this means it becomes too hard to be acted upon by water in a very ſhort time.

157 G. III. Pumice.

Genus III. pumice.

This is a very light ſubſtance ejected from volcanoes. It is porous. Hardneſs 3. Brittle. Sp. gr. below 1. Colour grey or brown.

In ſome varieties the luſtre and tranſparency are 0: in others, the luſtre is glaſſy, 2. Tranſparency from 1 to 2.

158 G. IV. Volcanic aſhes.

Genus IV. volcanic ashes.

Theſe are analogous to the aſhes of common pit coal. Looſe and ſmooth, very light, and fine. Slowly diffuſible in water, and when wet ſomewhat ductile.

Class II. SALTS.

UNDER this claſs we comprehend all the combinations of alkalies with acids which exiſt in the mineral kingdom. As they have been already deſcribed in the article Chemistry, *Suppl.* we ſhall here only give a liſt of their names.

9 Ge ra.

Genus I. potass.

Sp. 1. Sulphat of potaſs.
2. Nitrat of potaſs.

Genus II. soda.

Sp. 1. Carbonat of ſoda.
2. Sulphat of ſoda.
3. Muriat of ſoda.
4. Borax.

Genus III. ammonia.

Sp. 1. Sulphat of ammonia.
2. Muriat of ammonia.

Class III. COMBUSTIBLES.

0 Ge ra.

THE combuſtible ſubſtances belonging to the mineral kingdom, excluding the metals, may be comprehended under the following genera.

1. Sulphur.
2. Carbon.
3. Bitumen.
4. Coal.
5. Amber.

Sr G. Sulph

Genus I. sulphur.

species 1. Native ſulphur.

This ſubſtance is found abundantly in many parts of the world, eſpecially near volcanoes, as Hecla, Ætna, Veſuvius, the Lipari iſlands, &c. It is either in the ſtate of powder, or maſſive, or cryſtallized. The primitive form of its cryſtals is an octohedron, compoſed of two four-ſided pyramids, joined baſe to baſe †. The ſides of theſe pyramids are ſcalene triangles, and ſo inclined that the plane where the baſes of the pyramids join is a rhomb, whoſe long diagonal is to its ſhort as 5 to 4*. Sometimes the apices of the pyramids, to uſe the language of De Liſle, are truncated; ſometimes they are ſeparated from each other by a priſm; ſometimes they are truncated near their baſes, and a low four ſided pyramid riſes from the truncature: this pyramid is alſo ſometimes truncated near its apex ‡. Finally, one of the edges of the pyramids is ſometimes truncated. For figures of theſe varieties, and for the laws of their formation, we refer to *Mr Leſroy* †.

† I. 34.

* né de i. 292. and Jour. de Min. No xxi 337.

‡ Fig. 55.

† *Jour. de Min.* No xxix. 337.

Colour yellow, with a ſhade of green; ſometimes reddiſh (a). Luſtre greaſy, 2. Tranſparency varies from 0 to 4. Cauſes double refraction ‡. Texture compact. Hardneſs 4 to 5. Brittle.—For its other properties, we refer to Chemistry in this *Suppl.*

‡ *Hauy.*

Sometimes ſulphur is mixed with different proportions of earths. Theſe combinations are hardly ſuſceptible of accurate deſcription.

Sulphur combines alſo with metals. Theſe combinations ſhall be deſcribed in the fourth claſs.

161 G. II. Carbon.

Genus II. carbon.

This genus comprehends all minerals compoſed of pure carbon, or of carbon combined with a little earth.

163 Diamond.

species 1. Diamond.

This mineral, which was well known to the ancients, is

(a) It then contains arſenic.

Combuſtibles.

is found in different parts of Aſia, particularly in the kingdoms of Golconda and Viſapour; it is found alſo in Brazil.

It is always cryſtallized; but ſometimes ſo imperfectly, that at the firſt ſight it might paſs for amorphous. Its primitive form is a regular octogon †; but it more commonly aſſumes a ſpheroidal form, and then has uſually 36 curvilinear triangular faces, ſix of which are raiſed upon each of the faces of the primitive octogon ‡. Its integrant molecule, according to Hauy, is a regular tetrahedron.—For a more particular account of the cryſtals of this mineral, we refer the reader to *Mr Romé de Liſle** and *Mr Hauy*†.

† Fig. 36.

‡ Fig. 37.

* Cryſt. ii. 191

Texture foliated. Luſtre 4. Tranſparency from 2 to 4. Cauſes ſingle refraction. Hardneſs 20. Sp. gr. 3.5185 to 3.5310‡. Colour various; ſometimes limpid, ſometimes red, orange, yellow, green, blue, and even blackiſh.

† Jour. de Min. N° xxix. 343.

‡ Hauy, ibid.

When rubbed it becomes poſitively electric, even before it has been cut by the lapidary, which is not the caſe with any other gem ||.

It is compoſed of pure carbon §.

|| Id ibid.

§ Morveau, Ann. de Chim. xxxi. 72.

164 Mineral charcoal.

SPECIES 2. Mineral charcoal.

Kilkenny coal—Wales culm.

This mineral has been found in Hungary, Italy, France, Ireland, and Wales. It occurs in ſtratified maſſes, or in lumps neſted in clay.

Colour black. Luſtre 4, metallic. Opaque. Texture foliated. Hardneſs 5 to 7. Sp. gr. 1.4 to 1.526. Often ſtains the fingers. Inſoluble in acids. Deflagrates with nitre. Does not burn till wholly ignited, and then conſumes ſlowly without emitting flame or ſmoke.

It conſiſts almoſt entirely of *charcoal*, which, as Morveau has proved, is an oxyd of carbon *.

* Ibid.

165 Anthracite.

SPECIES 3. Anthracite (R).

Anthracolite.

This ſubſtance, as Dolomieu informs us, is found excluſively in the primitive mountains. It is always amorphous. Colour black or browniſh black. Luſtre 3 to 4. Structure ſlaty. Fragments rhomboidal. Hardneſs 6 to 7. Sp. gr. greater than that of coal. Often ſtains the fingers.

Burns preciſely like the laſt ſpecies, and leaves .40 of white aſhes. According to Dolomieu, it is compoſed of about

64.0	charcoal,
32.5	ſilica,
3.5	iron,
100.0†	

† Jour. de Min N° xxix. 338.

It is probable that the charcoal in the two laſt ſubſtances is in the ſame ſtate in which it exiſts in plumbago, combined with oxygen, but not containing ſo much as charcoal does ‡.

‡ Morveau, ibid.

166 G. III. Bitumen.

GENUS III. BITUMEN.

By bitumen we underſtand, with mineralogiſts in general, an oil, which is found in different parts of the earth, in various ſtates of conſiſtence. Theſe different ſtates form diſtinct ſpecies; in our arrangement of which we ſhall be guided by the obſervations which Mr Hatchett has made in his valuable paper on bituminous ſubſtances *.

* Nicholſon's Journal, ii. 201, 248.

167 Naphtha.

SPECIES 1. Naphtha.

This ſubſtance is found ſometimes on the ſurface of the water of ſprings, and ſometimes iſſuing from certain ſtrata. It is found in great abundance in Perſia.

It is as fluid and tranſparent as water. Colour white or yellowiſh white. Smell ſtrong, but not diſagreeable. Sp. gr. when white, .708* or .729†; when yellowiſh, .8475‡. Feels greaſy. Catches fire on the approach of flame, burns with a white flame, and leaves ſcarce any reſiduum.

* Muſchroek

† Bould

‡ Briſſo

Inſoluble in alcohol. Does not freeze at 0° Fahrenheit. When pure naphtha is expoſed to the air, it becomes yellow and then brown; its conſiſtence is increaſed, and it paſſes into *petroleum* *.

* Hatc

168 Petrol

SPECIES 2. Petroleum.

This ſubſtance is alſo found in Perſia, and likewiſe in many countries in Europe, particularly Italy, France, Switzerland, Germany, Sweden, England, and Scotland.

Not ſo fluid nor tranſparent as water. Colour yellow, either pale or with a ſhade of red or green; reddiſh brown and reddiſh black. Smell that of naphtha, but leſs pleaſant. Sp. gr. .8783 *. When burned it yields a ſoot, and leaves a ſmall quantity of coally reſiduum.

* Briſſ

By expoſure to the air it becomes like tar, and is then called *mineral tar* †.

† Hatc ibid.

169 Mineral tar.

SPECIES 3. Mineral tar.

This ſubſtance is found in many parts of Aſia, America, and Europe. It is viſcid, and of a black, browniſh black, or reddiſh colour. Smell ſometimes ſtrong, but often faint. Sp. gr. 1.1. When burned, emits a diſagreeable bituminous ſmell. By expoſure to the air it paſſes into *mineral pitch* and *maltha* *.

* Hat ibid.

170 Mineral pitch and maltha

SPECIES 4. Mineral pitch and maltha.

This ſubſtance has a ſtrong reſemblance to common pitch. When the weather is warm it is ſoft, and has ſome tenacity; it is then called *adheſive mineral pitch*: when the weather is cold, it is brittle; its hardneſs is 5; and its fracture has a glaſſy luſtre. In this ſtate it is called *maltha*. Colour black, dark brown, or reddiſh. Luſtre 0. Opaque. Sp gr. from 1.45 to 2.07. Does not ſtain the fingers. On a white hot iron it flames with a ſtrong ſmell, and leaves a quantity of grey aſhes. It is to the preſence of the earths which compoſe theſe aſhes that the great ſpecific gravity of this bitumen is to be aſcribed. By farther induration, it paſſes into *aſphalt*.

171 Aſphal

SPECIES 5. Aſphalt.

This ſubſtance is found abundantly in many parts of Europe, Aſia, and America, eſpecially in the iſland of Trinidad.

Colour black or browniſh black. Luſtre greaſy 2. Opaque. Fracture conchoidal, of a glaſſy luſtre. Hardneſs from 7 to 8. Very brittle. Sp gr 1.07 to 1.165*. Feel ſmooth, but not greaſy. Does not ſtain the fingers. Has little or no ſmell, unleſs when rubbed or heated. When heated melts, ſwells, and inflames; and when pure, burns without leaving any aſhes.

* Kir

172 Elaſtic tumen

SPECIES 6. Elaſtic bitumen.

Mineral caoutchouc.

This ſubſtance was found about the year 178[illegible] in the lead

---

(R) This name was given by Hauy from ανθραξ, *a coal.*

ibuſ- es. lead mine of Odin, near Caſtletown, Derbyſhire. It was firſt mentioned by Mr De Born.

Colour yellowiſh or reddiſh brown, ſometimes blackiſh brown. In its appearance it has a ſtrong reſemblance to caoutchouc or Indian rubber; hence its name. Conſiſtency various: ſometimes ſo ſoft as to adhere to the fingers; ſometimes nearly as hard as aſphalt. When ſoft it is elaſtic; when hard brittle. Sp. gr. 0.9053 to 1.0233‡.

‡ chett, ii.

Inſoluble in alcohol, ether, and oil of turpentine, but ſoluble in oil of olives Not affected by nitric acid. When diſtilled, it yields a bituminous oil inſoluble in alcohol; the reſiduum is carbonaceous*.

* metlie- ri our. de P xxxi. 3

There is a variety of this ſubſtance found in a rivulet near the mine of Odin, which, when freſh cut, exactly reſembles fine cork in colour and texture; but in a few days after being expoſed to the air, becomes of a pale reddiſh brown. This ſubſtance contains within it a nucleus of elaſtic bitumen. It ſeems to be the elaſtic bitumen altered in its texture by the water †.

† tebett, ii.

73 /. Coal.

Genus IV. coal.

The ſubſtances belonging to this genus are compoſed of carbon or rather charcoal, and bitumen.

74 Jet.

species 1. Jet (s).

This ſubſtance is found in France, Spain, Germany, Britain, and other countries. It is found in detached kidneyform maſſes, of various ſizes, from an inch to ſeven or eight feet in length.

Colour full black. Luſtre 3 to 4; internal glaſſy. Opaque. Hardneſs 7 to 8. Not near ſo brittle as aſphalt. Texture ſtriated. Fracture conchoidal. Sp. gr. 1.259*. It has no odour except when heated, and then it reſembles the odour of aſphaltum. Melts in a ſtrong heat, burns with a greeniſh flame, and leaves an earthy reſiduum†.

Becomes ſomewhat electric by friction‡. When diſtilled yields a peculiar acid §.

This mineral is formed into buttons, beads, and other trinkets. The manufacture has been almoſt confined to France ||.

riſſon. atchett. irwan. auquelin. our. de n Nº iv.

175 nnel l.

species 2. Cannel coal.

This mineral is found in Lancaſhire, and in different parts of Scotland, where it is known by the name of *parrot coal*.

Colour black. Luſtre common, 2. Opaque. Structure ſometimes ſlaty. Texture compact. Fracture conchoidal. Hardneſs 5 to 8. Brittle. Sp. gr. 1.232 to 1.426. Does not ſtain the fingers.

Kindles eaſily, and burns with a bright white flame like a candle (T), which laſts but a ſhort time. It does not cake. It leaves a ſtony or ſooty reſiduum.

A ſpecimen of Lancaſhire cannel coal, analyſed by Mr Kirwan, contained 75.20 charcoal,
21.68 maltha,
3.10 alumina and ſilica.

99.98†

Mineral. 523.

A ſpecimen of the ſlaty kind from Airſhire, called *ſplent coal*, was compoſed of
47.62 charcoal,
32.52 maltha,
20.00 earths.

100.14‡

‡ Ibid. 524.

Cannel coal is ſuſceptible of poliſh, and, like jet, is often wrought into trinkets.

176 Common coal.

species 3. Common coal.

This very uſeful combuſtible is never found in the primitive mountains, but only in the ſecondary mountains, or in plains formed of the ſame materials with them. It is always in ſtrata, and generally alternates with clay, ſandſtone, or limeſtone.

Colour black, more or leſs perfect. Luſtre uſually greaſy or metallic, 2 to 4. Opaque. Structure generally ſlaty. Texture often foliated. Fracture various. Hardneſs 4 to 6. Sp. gr. 1.25 to 1.37. Uſually ſtains the fingers. Takes fire more ſlowly, and burns longer, than the laſt ſpecies. Cakes more or leſs during combuſtion.

Of this ſpecies there are many varieties, diſtinguiſhed in Britain by the names of caking coal, rock coal, &c. Theſe are too well known to require any deſcription.

Mr Kirwan analyſed a variety of different kinds of coal: The reſult of his experiments may be ſeen by the following table.

Whitehaven coal.	Wigan.	Swanſey.	Leeirim	
57.0	61.73	73.53	71.43	charcoal.
41.3	36.7	23.14	23.37	maltha & aſph.
1.7	1.57	3.33	5.20	earths ‡.
100.0	100.00	100.00	100.00	

‡ Mineral. ii 525.

177 Spurious coal.

species 4. Spurious coal.

This mineral is generally found amidſt ſtrata of genuine coal. It is alſo called *parrot coal* in Scotland.

Colour greyiſh black. Luſtre 0 to 1. Structure uſually ſlaty. Texture earthy. Hardneſs 7 to 8. Sp. gr. 1.5 to 1.6 Generally explodes, and burſts when heated.

Compoſed of charcoal, maltha, and aſphalt, and above .20 of ſtony matter.

178 G V. Amber.

Genus V. amber.

species 1. Common amber.

This ſubſtance, called *electrum* by the ancients, is found in different countries; but moſt abundantly in Pruſſia, either on the ſea ſhore, or under ground at the depth of about 100 feet, repoſing on *wood coal**. It is in lumps of different ſizes.

* Kirw. Min. ii. 66.

Colour yellow. Luſtre 3 to 2. Tranſparency 2 to 4. Fracture conchoidal. Hardneſs 5 to 6. Sp. gr. 1.078 to 1.085. Becomes electric by friction.

If a piece of amber be fixed upon the point of a knife, and then kindled, it burns to the end without melting †.

† Hauy.

By diſtillation it yields ſuccinic acid.

Class

(s) It was called *gagathes* by the ancients, from the river Gages in Licia, near which it was found; *jayet* in French, *azabache* in Spaniſh, *gagath* in German.

(T) Hence it has been called *cannel coal*. *Candle*, in the Lancaſhire and Scotch dialect, is pronounced *cannel*.

Metallic Ores.

Gold, Silver.

CLASS IV. METALLIC ORES.

THIS claſs comprehends all the mineral bodies, compoſed either entirely of metals, or of which metals conſtitute the moſt conſiderable and important part. It is from the minerals belonging to this claſs that all metals are extracted; for this reaſon they have obtained the name of *ores*.

179 Orders. The metals hitherto diſcovered amount to 21; we ſhall therefore divide this claſs into 21 orders, allotting a diſtinct order for the ores of every particular metal.

Metals exiſt in ores in one or other of the four following ſtates. 1. In a metallic ſtate, and either ſolitary or combined with each other. 2. Combined with ſulphur. 3. In the ſtate of oxyds. 4. Combined with acids. Each order therefore may be divided into the four following genera.

180 Genera,

1. Alloys.
2. Sulphurets.
3. Oxyds.
4. Salts.

It muſt be obſerved, however, that every metal has not hitherto been found in all theſe four ſtates, and that ſome of them are hardly ſuſceptible of them all. Some of the orders therefore want one or more genera, as may be ſeen from the following table.

ORDER I. *Gold ores.*
  1. Alloys.
ORDER II. *Silver ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER III. *Platinum ores.*
  1. Alloys.
ORDER IV. *Ores of mercury.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER V. *Copper ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER VI. *Iron ores.*
  1. Alloys.
  2. Sulphurets.
  3. Carburets.
  4. Silicated iron.
  5. Oxyds.
  6. Salts.
ORDER VII. *Tin ores.*
  1. Sulphurets.
  2. Oxyds.
ORDER VIII. *Lead ores.*
  1. Sulphurets.
  2. Oxyds.
  3. Salts.
ORDER IX. *Zinc ores.*
  1. Sulphurets.
  2. Oxyds.
  3. Salts.
ORDER X. *Antimonial ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER XI. *Biſmuth ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
ORDER XII. *Arſenic ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
ORDER XIII. *Cobalt ores.*
  1. Alloys.
  2. Sulphurets.
  3. Oxyds.
  4. Salts.
ORDER XIV. *Nickel ores.*
  1. Sulphurets.
  2. Oxyds.
  3. Salts.
ORDER XV. *Mangancſe ores.*
  1. Oxyds.
  2. Salts.
ORDER XVI. *Tungsten ores.*
  1. Oxyds.
  2. Salts.
ORDER XVII. *Ores of molybdenum.*
  1. Sulphurets.
ORDER XVIII. *Ores of uranium.*
  1. Oxyds.
  2. Salts.
ORDER XIX. *Ores of titanium.*
  1. Oxyds.
ORDER XX. *Ores of tellurium.*
  1. Alloys.
ORDER XXI. *Ores of chromum.*
  1. Oxyds.

ORDER I. GOLD ORES.

181 Where found. No metal perhaps, if we except iron, is more widely ſcattered through the mineral kingdom than gold *. Hitherto it has been found only in a metallic ſtate; moſt commonly in grains, ramifications, leaves, or rhomboidal, octohedral, or pyramidal cryſtals. It is generally mixed with quartz, though there are inſtances of its having occurred in calcareous rocks. It is not uncommon alſo to find it diſſeminated through the ores of other metals; eſpecially iron, mercury, copper, and zinc. The greateſt quantity of gold is found in the warmer regions of the earth. It abounds in the ſands of many African rivers, and is very common in South America and India. Europe, however, is not deſtitute of this metal. Spain was famous in ancient times for its gold mines, and ſeveral of the rivers in France contain it in their ſands †. But the principal gold mines in Europe are thoſe of Hungary, and next to them thoſe of Salzburg. Gold alſo has been diſcovered in Sweden and Norway, and more lately in the county of Wicklow in Ireland ‡.

GENUS I. Alloys of gold.

SPECIES 1. Native gold.

182 G. I. Nati gold. Native gold is never completely pure; it is alloyed with ſome ſilver or copper, and ſometimes with iron. In the native gold found in Ireland, indeed, the quantity of alloy appears to have been exceedingly ſmall.

Its colour is yellow. Luſtre metallic. Fracture hackly. Hardneſs 5. Sp. gr. from 12 to 19.

ORDER II. SILVER ORES.

183 Where found. SILVER is found moſt commonly in quartz, limeſtone, hornſtone; or combined with the ores of other metals, moſt commonly with copper, antimony, zinc, cobalt, and lead. This laſt metal indeed is ſeldom totally deſtitute of ſilver.

GENUS I. Alloys of ſilver.

SPECIES 1. Native ſilver *.

184 G. I. Nati ſilver. Native ſilver, ſo called becauſe the ſilver is nearly in a ſtate of purity, forms the principal part of ſome of the richeſt ſilver mines in the world. It is ſometimes in ſmall lumps; ſometimes cryſtallized in cubes, hexahedrons, octohedrons, or dodecahedrons; ſometimes in leaves, or threads, often ſo connected with each other as to reſemble branches of trees, and therefore called *dendrites*. The ſilver in the famous mines of Potoſi has this laſt form. When newly extracted, it is not unlike ſmall branches of fir †.

The colour of native ſilver is white; often tarniſhed. Luſtre metallic. Fracture hackly. Hardneſs 6. Malleable. Sp. gr. from 10 to 10.338.

The ſilver in this ſpecies is almoſt conſtantly alloyed with from .03 to .05 of ſome other metal, frequently gold or arſenic.

---

* *Bergma*

† *Reaumu Mem. Pa* 1718, p. 6

‡ *Lloyd, Phil. Tran* 1796, p. 3 *Mills, ibi* p. 38.—N *cholſon's Journ.* ii. 224.

* *Kirw.* i 108.—*Ca ling. Act. Liter. Sve ciæ*, 1738, p. 420.

† *Bergma Phyſ. Geo Jour. de Min.* N° xvi. p. 26

185
loy of
ver and
ld.

SPECIES 2. Alloy of ſilver and gold.
Auriferous native ſilver.

This alloy is not uncommon in ſilver mines. Its colour is yellowiſh white. Its luſtre metallic. Hardneſs 5. Malleable. Sp. gr. above 10.6. Dr Fordyce found a ſpecimen from Norway compoſed of

72 ſilver,
28 gold.

100[*]

186
loy of
ver and
timony.

SPECIES 3. Alloy of ſilver and antimony[†].
Antimoniated ſilver ore.

This alloy, which is found in the ſilver mines of Spain and Germany, is ſometimes in grains or lumps, and ſometimes cryſtallized in ſix-ſided priſms, whoſe ſides are longitudinally channelled[‡].

Its colour is white. Its luſtre metallic. Hardneſs 10. Brittle. Sp. gr. from 9.4406[§] to 10[||]. Texture foliated. Fracture conchoidal. Before the blow-pipe the antimony evaporates in a grey ſmoke, and leaves a browniſh ſlag, which tinges borax green. If borax be uſed at firſt, a ſilver bead may be obtained.

This alloy was long ſuppoſed to contain arſenic. Bergman examined it, and found only ſilver and antimony[¶]. His analyſis has been confirmed by the experiments of Vauquelin and Selb[*]. According to Selb, it is compoſed of 89 ſilver,

11 antimony.

100

A ſpecimen, analyſed by Klaproth, contained

84 ſilver,
16 antimony.

100

Another ſpecimen contained

76 ſilver,
24 antimony.

100[†]

187
. II. Sul-
iurets.
ommon
lphuret of
lver.

GENUS II. SULPHURETS OF SILVER.

SPECIES 1. Common ſulphuret of ſilver[‡].
Vitreous ſilver ore.

This ore occurs in the ſilver mines of Germany and Hungary. It is ſometimes in maſſes, ſometimes in threads, and ſometimes cryſtallized. Its cryſtals are either cubes or regular octohedrons, whoſe angles and edges are often variouſly truncated. For a deſcription of the varieties produced by theſe truncatures, we refer the reader to *Romé de Liſle*[¶].

Its colour is dark bluiſh grey, inclining to black; often tarniſhed. Internal luſtre metallic. Texture foliated. Fracture uneven. Hardneſs 4 to 5. May be cut with a knife like lead. Flexible and malleable. Sp. gr. 6.909[*] to 7.215[†]. In a gentle heat the ſulphur evaporates. Melts when heated to redneſs.

A ſpecimen of this ore, analyſed by Klaproth, contained

85 ſilver,
15 ſulphur.

100[‡]

188
Antimoniated ſilver ore.

SPECIES 2. Antimoniated ſilver ore[*].
Sulphuret of ſilver with antimony and iron.

This ore, which occurs in Saxony and Hungary, ſeems to be ſulphuret of ſilver contaminated with antimony and iron, and ought therefore, in all probability, to be conſidered merely as a variety of the laſt ſpecies. It is ſometimes in maſſes, but more frequently cryſtallized in ſix-ſided priſms, tables, or rhomboids; generally indiſtinct and accumulated together.

Its colour is iron grey; often tarniſhed. Its luſtre metallic. Fracture uneven. Hardneſs 4 to 5. Brittle. Sp. gr. 7.208[†]. Before the blow-pipe the ſulphur and antimony exhale, leaving a bead, which may be freed from iron by fuſion with nitre and borax.

A ſpecimen of this ore, analyſed by Klaproth, contained

66.5 ſilver,
12.0 ſulphur,
10.0 antimony,
5.0 iron,
1.0 ſilica,
0.5 arſenic and copper.

95.0[‡]

189
Sulphuret of ſilver and copper.

SPECIES 3. Sulphuret of ſilver and copper[*].
Cupriferous ſulphurated ſilver ore.

This ore, which is found in the Korbolokinſk mountains in Siberia, was firſt deſcribed by Mr Renovantz. It is in amorphous maſſes, varying in ſize from that of the thumb to that of the fiſt.

Its colour is bluiſh grey like lead. Luſtre metallic. Hardneſs 5 to 6. Brittle. Its powder, when rubbed on the ſkin, gives it a black colour and a leaden gloſs. Before the blow-pipe the ſulphuret of ſilver melts readily; that of copper with difficulty. This ore is compoſed of about

42 ſilver,
21 copper,
35 ſulphur.

98

190
G. III.
Oxyds.
Calciform ſilver ore.

GENUS III. OXYDS OF SILVER.

SPECIES 1. Calciform ſilver ore[†].

This ore was firſt deſcribed by Mr Widenman. It is ſometimes in maſſes, ſometimes diſſeminated through other minerals.

Its colour is greyiſh black. Its ſtreak bright. Its luſtre metallic. Its fracture uneven. Hardneſs 4 to 5. Brittle. Sp. gr. conſiderable. Effervesces with acids. Melts eaſily before the blow-pipe. Froths with borax.

According to Selb, it contains 72.5 ſilver,

15.5 copper,
12.0 carbonic acid.

100.0

191
Red ſilver ore.

SPECIES 2. Red ſilver ore (υ).

This ore is very common in ſeveral German ſilver mines. It occurs in maſſes, diſſeminated and cryſtallized. The primitive form of its cryſtals is a dodecahedron[‡], whoſe ſides are equal rhombs, and which may be con-

[*] *Phil.* *anſ.* 76, p. 2.

[†] *Kirwan,* 110.

[‡] *Romé de* *ſle,* iii. 1.

[§] *Hauy,* *ur. de* *Min.* N° x. p. 473.

[||] *Kirwan,* *d.*

[¶] *Opuſc.* ii. 5.

[*] *Jour. de* *Min. ibid*

[†] *Beiträge,* 301.

[‡] *Kirwan,* 115.

[¶] *Cryſtal.* 441.

[*] *Briſſon.*

[†] *Gellert.*

[‡] *Beiträge,* 162.

[*] *Kirwan,* ii. 118.

[†] *Gellert.*

[‡] *Beiträge,* i. 166.

[*] *Kirwan,* ii. 121.

[†] *Kirwan,* ii. 112.

[‡] Fig. 38.

(υ) *Kirw.* II. 122.—*Scopoli de Minera Argenti Rubra.*—*Sage, Jour. de Phyſ.* XXXIV. 331. and XLI. 370; and *Nouv. Jour. de Phyſ.* II. 284.—*Weſtrum, Jour. de Phyſ.* XLIII. 291.—*Klaproth, Beiträge,* I. 141.

conſidered as a ſix-ſided rhomboidal priſm, terminated by three-ſided ſummits*. Sometimes the priſm is lengthened, and ſometimes its edges, or thoſe of the terminating ſummits, or both, are wanting. For a deſcription and figure of theſe varieties, we refer to *De Liſle*† and *Hauy*‡.

Its colour is commonly red. Streak red. External luſtre metallic, internal common. Tranſparency from 3 to 1; ſometimes opaque Fracture flat conchoidal. Hardneſs 5 to 7. Brittle. Sp. gr. from 5.44§ to 5.592¶. Becomes electric by friction, but only when inſulated‖. Soluble in nitric acid without effervеſcence*. Before the blow pipe melts, blackens, burns with a blue flame, gives out a white ſmoke with a ſlight garlic ſmell, and leaves a ſilver bead†.

* *Romé de Liſle*, iii. 447.
† *Ibid.*
‡ *Jour. d'Hiſt. Naturelle*, N° 18. p. 216.
§ *Kirwan.*
¶ *Vauquelin, Jour de Min*, N° xvii. p. 2.
‖ *Hauy, ibid*, N° xxx. p. 476.
* *Hauy, ibid.* N° xxxi. p. 518.
† *Vauquelin, ibid.*

Variety 1. Light red.

Colour intermediate between blood and cochineal red; ſometimes variegated. Streak orange red. Powder black.

Variety 2. Dark red.

Colour commonly between dark cochineal red and lead grey; ſometimes nearly black and without any ſhade of red. Streak dark crimſon red.

This ore was long ſuppoſed to contain arſenic. Klaproth firſt aſcertained its real compoſition‡; and his analyſis has been confirmed by Vauquelin, who found a ſpecimen compoſed of 56.6748 ſilver,
16.1300 antimony,
15.0666 ſulphur,
12.1286 oxygen.

100.

‡ *Ann. de Chim.* xviii. 81.

Klaproth proved, that the ſilver and antimony are in the ſtate of oxyds; and Vauquelin, that the ſulphur is combined partly with the oxyd of ſilver and partly with the oxyd of antimony. Klaproth obtained a little ſulphuric acid; but this acid, as Vauquelin, with his uſual ingenuity, demonſtrated, was formed during the analyſis.

This ore ſometimes contains a minute portion of arſenic, but never more than .02*.

* *Vauquelin, ibid.* p. 8.

GENUS IV. SALTS OF SILVER.

192 G. IV. Salts. Muriat of ſilver.

SPECIES 1. Muriat of ſilver (x).

Corneous ſilver ore.

This ore occurs at Johanngeorgenſtadt in Saxony, in South America, &c. It is often amorphous, ſometimes nearly in powder, and ſometimes cryſtallized in cubes or parallelopipeds.

Its colours are various: when expoſed to the light it becomes brown. Internal luſtre greaſy, 2; external, 2 to 1. Acquires a gloſs when ſcraped with a knife. Tranſparency 2 to 1. Texture foliated. Hardneſs 4 to 5. Sp. gr. 4.745* to 4.804†. Before the blowpipe it inſtantly melts, and gradually evaporates, but may be reduced by adding an alkali.

* *Briſſon.*
† *Gellert.*

That this ore contains muriatic acid, has been long known. Mr Woulfe firſt ſhewed that it contained alſo ſulphuric acid‡: and this diſcovery has been confirmed by Klaproth, according to whoſe analyſis this ore is compoſed of 67.75 oxyd of ſilyer,
6.00 oxyd of iron,
21.00 mnriatic acid,
.25 ſulphuric acid,
1.75 alumina.

96.75¶

‡ *Phil. Tranſ.* 1776.
¶ *Beiträge* i. 134.

The alumina can only be conſidered as mixed with the ore. Sometimes its quantity amounts to .67 of the whole§.

§ *Ibid.* p. 137.

ORDER III. ORES OF PLATINUM (Y).

193 Mines.

HITHERTO no mine of platinum has been diſcovered. It is found in ſmall ſcales or grains on the ſands of the river Pinto, and near Carthagena in South America. It is always in a metallic ſtate, and always combined with iron.

GENUS I. ALLOYS OF PLATINUM.

194 G. I Alloy Native pl tinum.

SPECIES 1. Native platinum.

Its colour is whitiſh iron grey. Magnetic. Sp. gr. from 12 to 16. Soluble in nitro-muriatic and oxymuriatic acids.

ORDER IV. ORES OF MERCURY.

MERCURY is employed in medicine; it ſerves to ſeparate ſilver and gold from their ores; the ſilvering of looking glaſſes, gilding, &c. are performed by means of it; and its ſulphuret forms a beautiful paint.

195 Mines.

Mercury abounds in Europe, particularly in Spain, Germany, and Hungary: it is found alſo in China(Z), the Philippines*, and in Peru, and perhaps Chili (A) in South America. The moſt productive mines of mercury are thoſe of Idria†; of Almaden, near Cordova in Spain, which were wrought by the Romans (B); of the Palatinate‡; and of Guanca Velica in Peru(C).

Mercury has never been found in Britain, nor has any mine worth working been diſcovered in France It occurs moſt commonly in argillaceous ſhiſtus, limeſtones, and ſandſtones.

* *Carreri Voyage.*
† *Scopoli, Jour. de Min.* N° xxxvi. p. 915.
‡ *Jour. d Min.* No vi. and v

GENUS I. ALLOYS OF MERCURY.

196 G I. All Native mercury

SPECIES 1. Native mercury.

Native mercury is found in moſt mercurial mines: it is in ſmall globules, ſcattered through different kinds of ſtones, clays, and ores.

Fluid. Colour white. Sp. gr. about 13.6.

SPECIES

(X) *Kirw.* II. 113.—*Laxmann. Nov. Comm. Petropol.* XIX. 482.—*Monnet. Mem. Sçav. Etrang.* IX. 717.

(Y) See *Brownrigg, Phil. Tranſ.* XLVI. 584.—*Lewis, ibid.* XLVIII. 638. and L. 148.—*Margraf. Mem. Berlin*, 1757, p. 314.—*Macquer, Mem. Par.* 1758, p. 119.—*Buffon, Jour. de Phyſ.* III. 324.—*Morveau, ibid.* VI. 193.—*Bergman, Opuſc.* II. 166.—*Tillet, Mem. Par.* 1779, p. 373, and 385, and 545.—*Crell, Crell's Annals*, 1784, 1 *Band.* 328.—*Willis, Mancheſter Memoirs*, III. 467.—*Muſſin Puſchkin, Ann. de Chim.* XXIV. 205.—*Morveau, ibid.* XXV. 3.

(Z) See *Entrecolle's Lettres Edificantes.*

(A) See *Molina's Natural Hiſtory of Chili.*

(B) See *Bowle's Natural Hiſtory of Spain*, and *Jour. de Min.* N° xxxi. p. 555.

(C) See *Ulloa's Memoirs concerning America.*

res of ercury.

SPECIES 2. Amalgam of ſilver *.

Native amalgam.

197 alalgam ilver.

This mineral has been found in the ſilver mine of Sahlberg †, in the province of Dalecarlia, in Sweden; in the mines of Deux Ponts ‡, in the Palatinate; and in other places. It is in thin plates, or grains, or cryſtallized in cubes, parallelopipeds, or pyramids.

Kirwan, i25. *onſtedt's n.* † *eyer. ll's An-* ‡ , 1790.

Its colour is ſilvery white or grey. Luſtre metallic. Creaks when cut. Sp. gr. above 10. Tinges gold white. Before the blow-pipe the mercury evaporates and leaves the ſilver.

A ſpecimen of this amalgam, analyſed by Klaproth, contained

64	mercury,
36	ſilver.
100 §	

itrâge, 53.

Sometimes it contains a mixture of alumina, and ſometimes the proportion of mercury is ſo great that the amalgam is nearly as ſoft as paſte.

198 II. Sulirets. mmon hurer.

GENUS II. SULPHURETS OF MERCURY.

SPECIES 1. Common ſulphuret *.

Native cinnabar.

Kirwan, 228.

This ore, which is found in almoſt all mercurial mines, is ſometimes in veins, ſometimes diſſeminated, ſometimes in grains, and ſometimes cryſtallized. The form of its cryſtals is a tetrahedron or three-ſided pyramid, moſt commonly wanting the ſummit; ſometimes two of theſe pyramids are joined baſe to baſe; and ſometimes there is a three-ſided priſm interpoſed between them †.

Romé de e, iii. 4.

Its colour is red. Its ſtreak red and metallic. Luſtre when cryſtallized 2 to 3; when amorphous, often 0. Tranſparency, when cryſtallized, from 1 to 3; when amorphous, often 0. Texture generally foliated. Hardneſs from 3 to 8. Sp. gr. from 5.419 to 10.1285.

Before the blow-pipe evaporates with a blue flame and ſulphureous ſmell. Inſoluble in nitric acid ‡.

Variety 1. Dark red.

Hauy, ir. de in. N° *xi.* p. 8. *Briſſon. Muſchenek.* *Briſſon. Gellert.*

Colour cochineal red. Hardneſs 6 to 7. Sp. gr. when pure, 10.1285 §; ſometimes only 7.2, or even 6.188 ¶.

Variety 2. Bright red.

Colour commonly ſcarlet. Sp. gr. 6.9022 † to 5.419 ‡.

199 . III. yds. patic ercurial .

GENUS III. OXYDS OF MERCURY.

SPECIES 1. Hepatic mercurial ore *.

This ore, which is the moſt common in the mines of Idria, is always amorphous, and is often mixed with native mercury and cinnabar.

Kirwan, 224. *Briſſon.* *Kirwan.*

Its colour is ſomewhat red. Its ſtreak dark red and brighter. Luſtre commonly metallic. Hardneſs from 6 to 8. Sp. gr. from 9.2301 † to 7.186 ‡. When heated the mercury evaporates.

age, ir. de yſ. xxiv. *copoli, ir. de in.* N° *vi.* p. *irwan,* 126.

Though this ore has never been accurately analyſed, chemiſts have concluded that the mercury which it contains is in the ſtate of a red oxyd, becauſe it is inſoluble in nitric and ſoluble in muriatic acid ¶. When pureſt, it contains about .77 of mercury §. It contains alſo ſome ſulphur and iron.

Werner has divided this ſpecies into two varieties, the *compact* and the *ſlaty*. The ſecond is often nothing more than bituminous ſhale impregnated with oxyd of mercury ‡.

200 Mercurial Salts Muriat of mercury.

GENUS IV. MERCURIAL SALTS.

SPECIES 1. Muriat of mercury *.

Corneous mercury.

This ore, which occurs in the Palatinate, is ſometimes in ſcales, ſometimes in grains, and ſometimes cryſtallized. Its cryſtals are either ſmall four or ſix ſided priſms whoſe ſides are rhombs †, or cubes, or four-ſided pyramids wanting their angles. They are always very ſmall and generally confuſed.

* *Kirwan,* ii. 226.
† *Romé de Liſle,* iii. 161.

Its colours are various; but it is moſt frequently white. Its luſtre, when white, is pearly. Sometimes opaque, and ſometimes ſemitranſparent. Evaporates before the blow-pipe.

Mr Woulfe diſcovered, that this ore generally contains ſome ſulphuric acid ‡. Specimens have been found in which the quantity of ſulphuric acid exceeds that of the muriatic §.

‡ *Phil. Tranſ.* lxvi. 618.
§ *Suckow.*

ORDER V. COPPER ORES.

Many of the moſt uſeful utenſils are formed of copper: it enters largely into the compoſition of braſs, bronze, and bell metal; not to mention the dyes and paints of which it is the baſis.

201 Mines.

Copper mines abound in moſt countries. They are wrought in China, Japan, Sumatra; the north of Africa; in Chili and Mexico; and in moſt parts of Europe; eſpecially Britain, Germany, Ruſſia, Hungary.

Copper is found moſt commonly in rocks of hornblende, ſhiſtus, and quartz.

202 G. I. Alloys. Native copper.

GENUS I. ALLOYS OF COPPER.

SPECIES 1. Native copper *.

Native copper occurs now and then in the greater number of copper mines: Sometimes it is in maſſes, ſometimes in plates and threads, which aſſume a variety of forms; and ſometimes, as in Siberia, it is cryſtallized in cubes, or other forms nearly reſembling cubes †.

Colour commonly that of copper, but ſometimes dark brown. Luſtre metallic. Streak brighter. Fracture hackly. Flexible and malleable. Hardneſs 6 to 7. Sp. gr. from 7.6 ‡ to 8.5844 ¶.

* *Kirwan,* ii. 127.—*Cartheuſer.*
† *Hauy, Jour. de Min.* N° xxxi. 509.
‡ *Kirwan's Min.* ii. 128.
¶ *Hauy, ibid.* p. 509.

203 White copper ore

SPECIES 2. White copper ore §.

Alloy of copper, iron, and arſenic.

This ore, which is ſaid to be uncommon, occurs in maſſes. Colour white. Luſtre metallic. Fracture uneven. Hardneſs 8 to 9. Brittle. Sp. gr. conſiderable.

Before the blow-pipe gives out a white arſenical ſmoke, and melts into a greyiſh black ſlag *.

§ *Kir. Min.* ii. 152.
* *Widenman.*

204 G. II. Sulphurets. copper. Common ſulphuret of copper.

GENUS II. SULPHURETS OF COPPER.

SPECIES 1. Common ſulphuret of copper †.

Vitreous copper ore.

This ore, which is found in Cornwal, Hungary, and Siberia, occurs in maſſes, plates, threads, and cryſtallized in ſix-ſided priſms, or four ſided pyramids, joined baſe to baſe.

Colour bluiſh grey. Streak brighter grey, Luſtre metallic. Hardneſs 4 to 7. Sp. gr. 5.452 ‡ to 5.565 §; ſometimes ſo low as 4.129 *. Detonates with nitre.

Before the blow-pipe it melts eaſily; and while in fuſion exhibits a green pearl, which, on cooling, is covered with a brown cruſt. Tinges borax green.

Werner makes two varieties of this ore: the firſt he

† *Kirwan,* ii. 144.
‡ *Kirwan.*
§ *Gellert.*
* *Kirwan.*

calls *compact*, from its fracture; and the ſecond, for the ſame reaſon, he calls *foliated*. This laſt is ſomewhat darker coloured than the firſt, but in other reſpects they agree.

205
Copper pyrites

SPECIES 2. Copper pyrites*.

Yellow copper ore.

This ore, which is probably nothing elſe than ſulphuret of iron combined with copper, and which, therefore, would be more properly placed among iron ores, is found frequently in copper mines, and mixed with common pyrites or ſulphuret of iron. It is ſometimes amorphous, and ſometimes cryſtallized. Its cryſtals are either three or four ſided pyramids applied baſe to baſe, or ſix-ſided plates.

Its colour is yellow; often tarniſhed. Its internal luſtre metallic. Hardneſs 6 to 7; ſometimes 9. Brittle. Sp. gr. 4.314 † to 4.08 ‡. Deflagrates; but does not detonate with nitre ‖.

Before the blow-pipe decrepitates, gives a greeniſh ſulphureous ſmoke, and melts into a black maſs, which tinges borax green. Does not efferveſce with nitric acid.

* *Kirwan*, ii. 140.

† *Briſſon.*

‡ *Kirwan*

‖ *Id. Min.* ii. 141.

206
Purple copper ore.

SPECIES 3. Purple copper ore*.

This ore is found in maſſes, or plates, or diſſeminated; ſometimes, alſo, it is cryſtallized in octohedrons. Colour various, but moſt commonly purple; internally reddiſh. Streak reddiſh and bright. Luſtre metallic. Hardneſs 6 to 7. Brittle. Sp. gr. 4.956 to 4.983†.

Efferveſces with nitric acid, and tinges it green. Deflagrates with nitre. Before the blow-pipe melts readily, without ſmoke, vapour, or ſmell; but is not reduced. Tinges borax a bright green.

A ſpecimen of this ore, analyſed by Klaproth, contained

58 copper,
18 iron,
19 ſulphur,
5 oxygen.

100 ‡

* *Kirwan*, ii. 142.

† *Ibid.* ii. 143.

‡ *Beiträge*, ii. 286.

207
Grey copper ore.

SPECIES 4. Grey copper ore §.

This ore is found in Cornwal, Saxony, Hungary, &c. It is often amorphous, but often alſo cryſtallized. The primitive form of its cryſtals is the regular tetrahedron; but, in general, either the angles or the edges, or both, are truncated or bevelled ‖.

Colour ſteel grey; often tarniſhed, and then dark grey. Streak dark grey; ſometimes reddiſh brown. Powder blackiſh; ſometimes with a tint of red. Luſtre metallic Hardneſs 7 or 8. Very brittle. Sp. gr. 4.8648 *. Deflagrates with nitre. Before the blow-pipe crackles, but at laſt melts, eſpecially if aſſiſted by borax. The bead gives a white ſmoke, without any particular ſmell; tinges borax yellow or browniſh red, but does not unite with it.

A ſpecimen of this ore from Cremnitz, analyſed by Klaproth, contained

31 copper,
14 ſilver,
34 antimony,
3 iron,
11 ſulphur.

93

§ *Kirwan*, ii. 146.

‖ *Romé de Liſle*, iii. 315.

* *Hauy, Jour. de Min.* Nº xxxi. 512.

Napion, in an ore from the valley of Lanzo, found copper, ſilver, and antimony, nearly in the ſame proportions, but more iron, and ſome arſenic †. Savoreſi, as Baron Born informs us, beſides the ingredients of Klaproth's analyſis, found ſome gold and mercury in grey copper ore ‡: and Klaproth himſelf found lead in moſt of the other ſpecimens which he examined.

† *Mem. Turin*, v. 173.

‡ *Catal.* ii. 498.

208
G. III. Oxyds. Red oxyd of copper.

GENUS III. OXYDS OF COPPER.

SPECIES 1. Red oxyd of copper §.

Florid red copper ore—Red copper glaſs.

This ore is found in Cornwal, and many other countries. It occurs in maſſes, diſſeminated, in ſcales, and cryſtallized. The figure of its cryſtals is moſt commonly the regular octohedron *.

Colour commonly cochineal red. Streak brick red. Luſtre ſemimetallic. Tranſparency, when amorphous, generally 0; when cryſtallized, 3 or 4. Hardneſs from 4 to 7. Soluble with efferveſcence in nitric acid. Before the blow-pipe melts eaſily, and is reduced.

This ore was ſuppoſed to be compoſed of carbonic acid and red oxyd of copper; but a ſpecimen, examined by Vauquelin, which conſiſted of pure cryſtals, contained no acid †. It muſt therefore be conſidered as an oxyd of copper.

Werner has made three varieties of this ore, which, from their texture, he has denominated *compact*, *foliated*, and *fibrous*. The firſt is ſeldom or never found cryſtallized, and is opaque; the ſecond occurs amorphous, cryſtallized, and in ſcales; the third is carmine, ruby, or ſcarlet red; and occurs always in ſhort capillary cryſtals, or delicate flakes.

This ore ſometimes contains a mixture of red oxyd of iron; it is then called *brick red, copper ore*, *copper malm, or copper ochre.*

This ore is ſometimes mixed with bitumen. Its colour is then browniſh black, and it is called *pitch ore.*

§ *Kirwan*, ii. 135.

* *Hauy, Jour. de Min.* Nº xxxi. 517.

† *Ibid.*

209
Green oxy of copper.

SPECIES 3. Green oxyd of copper §.

Green ſand of Peru.

This ore, which was brought from Peru by Dombey, is a graſs green powder, mixed with grains of quartz. When thrown on burning coals, it communicates a green colour to the flame. It is ſoluble both in nitric and muriatic acids without efferveſcence. The ſolution is green. It was ſuppoſed to contain muriatic acid *; but Vauquelin has diſcovered, that the appearance of this acid was owing to the preſence of ſome common ſalt, which is accidentally mixed with the ſand ‡.

§ *Kirwan*, ii. 149.

* *Bertbollet Mem. Par.* 1786, 462.

‡ *Jour de Min.* Nº xxxi. 519.

210
G. IV. Salts Blue carbonat of copper.

GENUS IV. SALTS OF COPPER.

SPECIES 1. Blue carbonat of copper (D).

Mountain blue—Azur de cuivre—Blue calx of copper—Kupfer lazur.

This ore, which occurs in the copper mines of Siberia, Sweden, Germany, Hungary, Cornwal, &c. is either amorphous or cryſtallized. The cryſtals are ſmall, and difficult to examine. According to Romé de Liſle, their primitive form is an octohedron, the ſides of which are iſoſceles triangles, and two of them more inclined than the others §. Be that as it may, the cryſtals of blue carbonat of copper are often rhomboidal priſms, either regular, or terminated by dihedral ſummits *.

Its colour is azure or ſmalt blue. Streak blue. Hardneſs

§ *Cryſtal.* iii 343

* *Ibid.* p. 345.

(D) *Kirw.* II. 129.—*Morveau, Mem. Dijon*, 1782. 1 *Semeſtre*, p. 100.

pper
res.

ſon.

neſs 4 to 6. Brittle. Sp. gr. 3.608 ‡. It effervesces with nitric acid, and gives it a blue colour. Before the blow-pipe it blackens, but does not melt. Tinges borax green with effervescences.

The cryſtals, according to Pelletier, are compoſed of

66 to 70 copper,
18 — 20 carbonic acid,
8 — 10 oxygen,
2 — 2 water.

Fontana firſt diſcovered that this ore contained carbonic acid gas.

Variety 1. Earthy blue carbonat.
Mountain blue.

This variety generally contains a mixture of lime. It is never cryſtallized; and ſometimes is almoſt in the ſtate of powder. Luſtre 0. Texture earthy.

Variety 2. Striated blue carbonat of copper.

Luſtre glaſſy. Tranſparency, when cryſtallized, 2; when amorphous, 1. Texture ſtriated; ſometimes approaching to the foliated.

1
car-
of
r.

SPECIES 2. Green carbonat of copper (E).
Oxygenated carbonat of copper—Malachite.

This ore is generally amorphous, but ſometimes it is cryſtallized in four-ſided priſms, terminated by four-ſided pyramids.

ſon.
wan.

Colour green. Luſtre ſilky. Hardneſs 5 to 7. Brittle. Sp. gr. 3.571 * to 3.653 ‡. Effervesces with nitric acid, and gives a blue colour to ammonia. Before the blow pipe it decrepitates and blackens, but does not melt. Tinges borax yellowiſh green. It is compoſed of carbonic acid and green oxyd of iron.

Variety 1. Fibrous malachite.

Texture fibrous. Opaque when amorphous; when cryſtallized its tranſparency is 2. Colour generally graſs green.

Variety 2. Compact malachite.

Texture compact. Opaque. Colour varies from the dark emerald green to blackiſh green.

A ſpecimen of malachite from Siberia, analyſed by Klaproth, contained

58.0 copper,
18.0 carbonic acid,
12 5 oxygen,
11.5 water.

---

100 *

räge,
).

This ſpecies is ſometimes mixed with clay, chalk, and gypſum, in various proportions; it is then known by the name of

Common mountain green.

Its colour is verdigris green. Luſtre 0. Tranſparency 0 to 1. Hardneſs 3 to 4. Brittle. Texture earthy. Effervesces feebly with acids. Before the blow-pipe it exhibits the ſame phenomena with malachite.

2
it of

SPECIES 3. Sulphat of copper.

For a deſcription of this ſalt, ſee CHEMISTRY, n° 648. in this *Supplement*.

3
at of

van,

SPECIES 4. Arſeniat of copper ‡.
Olive copper ore.

This ore is found at Carrarach in Cornwal. It is generally cryſtallized in ſix-ſided compreſſed priſms. Its colour is olive green. Streak ſometimes ſtraw coloured, ſometimes olive green. Luſtre glaſſy. Tranſparency from 4 to 2. Fracture conchoidal. Hardneſs 4 to 7. Before the blow-pipe deflagrates with an arſenical ſmoke, and melts into a grey coloured bead. This bead, fuſed with borax, leaves a button of pure copper ‖.

Metallic
Ores.

Klaproth diſcovered that it was compoſed of oxyd of copper and arſenic acid.

Sometimes this ore is combined with iron. It then cryſtallizes in cubes. Theſe cubes are of a dark green colour; before the blow-pipe they frothe, give out an arſenical ſmoke, and do not ſo quickly form a grey bead as the arſeniat of copper *.

‖ *Klaproth's Obſervations on Cornwal*, p. 29.

* *Ibid.* p. 29.

ORDER VI. IRON ORES.

To deſcribe the uſes of iron, would be to write the hiſtory of every art and manufacture, ſince there is not one which is not more or leſs dependent upon this uſeful metal. Nor is its abundance inferior to its utility. It exiſts almoſt everywhere, and ſeems, as it were, the bond which connects the mineral kingdom together.

214
Mines.

215
G. I. Alloys.
Native
iron.

GENUS I. ALLOYS OF IRON
SPECIES 1. Native iron (F).

Native iron has been found in Siberia and in Peru in immenſe maſſes, which ſeemed as if they had been fuſed. Theſe maſſes evidently did not originate in the place where they were found. See *FIRE-BALLS, Suppl.*

Colour bluiſh white Fracture hackly. Luſtre metallic. Malleable. Magnetic. Hardneſs 8 to 9. Sp. gr. 7.8. Prouſt has diſcovered, that the native iron found in Peru is alloyed with nickel ¶.

¶ *Nicholſon's Jour.* iii. 374.

216
G. III. Sulphurets.
Common
ſulphuret of
iron.

GENUS II. SULPHURETS OF IRON.
SPECIES 1. Common ſulphuret of iron *.
Pyrites.

This mineral occurs very frequently both in ores and mixed with other bodies, for inſtance in ſlates. It is often amorphous, and often alſo cryſtallized. The primitive form of its cryſtals is either a regular cube or an octohedron. The varieties of its form hitherto deſcribed amount to 30; for a deſcription of which we refer the reader to *Romé de Liſle* †.

* *Kirwan*, ii. 76.—*Henkel's Pyritologia.*

† *Cryſtal.* iii. 208.

Its colour is yellow. Its luſtre metallic. Hardneſs 8 to 10. Brittle. Sp. gr. 3.44 to 4.6. Soluble in nitric acid with effervescence. Scarce ſoluble in ſulphuric acid. Before the blow-pipe burns with a blue flame and a ſulphureous ſmell, and leaves a browniſh bead, which tinges borax of a ſmutty green.

Variety 1. Common pyrites.

Fracture uneven. Hardneſs 10. Decrepitates when heated. Emits a ſulphureous ſmell when rubbed. Not magnetic. It occurs often in coal mines and in ſlates.

Variety 2. Striated pyrites.

Texture ſtriated. Hardneſs 10. Not magnetic.

Variety 3. Capillary.

Colour often ſteel grey. Found in needle-form cryſtals. Uncommon. Not magnetic.

Variety 4. Magnetic pyrites.

Found in maſſes. Texture compact. Hardneſs 8, 9. Slightly magnetic. Seems to contain leſs ſulphur than the other varieties.

In pyrites the proportion of the ſulphur to the iron is variable, and this explains the variety of its cryſtalline forms.

GENUS

(E) *Kirw.* II. 131.—*Fontana, Jour. de Phyſ.* XI. 509.—*Klaproth, Beiträge*, II. 287.

(F) *Pallas, Phil. Tranſ.* LXVI. 523.—*Rubin de Celis, ibid.* LXXVIII. 37.—See alſo *Schreiber, Jour. de Phyſ.* XLI. 3.; and *Stelin, Phil. Tranſ.* LXIV. 461.

Iron Ores.

217
G. III.
Plumbago.

GENUS III. CARBURET OF IRON.

SPECIES I. Plumbago *.

Graphite of Werner.

* Kirwan, ii. 58.

This mineral is found in England, Germany, France, Spain, America, &c. It occurs in kidney form lumps of various ſizes. Its colour is dark iron grey or browniſh black; when cut, bluiſh grey. Luſtre metallic, from 3 to 4. Opaque. Structure ſlaty. Texture fine grained. Hardneſs 4 to 5. Brittle. Sp. gr. from 1.987 to 2.089; after being ſoaked in water 2.15; after being heated 2.3, and when heated after that 2.41 †. Feels ſomewhat greaſy. Stains the fingers, and marks ſtrongly. The uſe of this mineral when manufactured into pencils is known to every perſon.

† Briſſon.

Its compoſition was diſcovered by Scheele. When pure it contains
90 carbon,
10 iron.
——
100

But it is often exceedingly impure: A ſpecimen, for inſtance, from the mine of Pluffier, in France, analyſed by Vauquelin, contained
23 carbon,
2 iron,
38 ſilica,
37 alumina.
——
100 ‡

‡ Jour. de Min. Nº xii. p. 16.

218
G. IV.
Emery.

GENUS IV. IRON COMBINED WITH SILICA.

SPECIES I. Emery *.

* Kirwan, ii. 193.

This mineral is commonly diſſeminated through other foſſils, but ſometimes in the Eaſt Indies it occurs in large maſſes.

Its colour is bluiſh grey, greyiſh brown, or bluiſh black, often covered with a yellowiſh rind; internally it diſcovers red or purple ſpots. Luſtre 1 or 0; in ſome parts 2, and metallic. Opaque. Hardneſs 14. Brittle. Sp. gr. 3.92 †. Before the blow pipe it blackens and gives a ſmutty yellow tinge to borax.

† Briſſon.

According to Wieglеb it contains
95.6 ſilica,
4.3 iron.
——
99.9

219
G. V.
Oxyds.

GENUS V. OXYDS OF IRON.

This genus is very extenſive; for iron is much more frequently found in the ſtate of an oxyd than in any other.

220
Black oxyd of iron.

SPECIES I. Black oxyd of iron ‡.

Common magnetic iron ſtone—Blackiſh octohedral iron ore.

‡ Kirwan, ii. 158.

This ſpecies of ore is very common in Sweden; it is found alſo in Switzerland, Norway, Ruſſia, &c. It occurs in maſſes, plates, grains, and cryſtallized. The primitive form of its cryſtals is a regular octohedron †. Sometimes two oppoſite ſides of the pyramids are trapeziums, which renders the apex of the pyramids cuneiform. Sometimes the cryſtals paſs into rhomboidal parallelopipeds, and into dodecahedrons with rhomboidal faces §.

Its ſurface is browniſh black; internally bluiſh grey. Powder black *. Streak blackiſh grey, brighter. Luſtre metallic. Hardneſs 9 to 10. Brittle. Sp. gr. from 4.094 to 4.688 †. Attracted by the magnet, and generally poſſeſſed of more or leſs magnetic virtue ‡. To this ſpecies belongs the magnet. Before the blow-pipe it becomes browner, but does not melt. Tinges borax dark green.

† Romé de Liſle, iii. 178.
§ Ibid.
* Hauy, Jour. de Min, Nº xxxiii. 659.
† Kirwan's Min. ii. 159.
‡ Hauy, Jour. de Min. Nº xxxi. 527.

Metalli Ores.

When pure it conſiſts entirely of oxyd of iron; and this oxyd appears to contain from .15 to .24 oxygen, and from .76 to .85 iron §. Undoubtedly it conſiſts of a mixture of iron in two different ſtates of oxydation. It is often alſo mixed and contaminated with foreign ingredients.

§ Kirwa Min. ii. 159.

There are two varieties of this ore. The firſt is what we have juſt deſcribed; the ſecond is in the form of ſand, and has therefore been called

Magnetic ſand *.

This ſubſtance is found in Italy, Virginia, St Domingo, the Eaſt Indies, and in the ſand of the river Don at Aberdeen in Scotland. It is black, very hard, magnetic. Sp. gr. about 4.6. Not altered by the blow-pipe *per ſe*; melts into a black glaſs with potaſs, and into a green glaſs with microcoſmic ſalt, both opaque †. It probably contains ſome ſilica, as Kirwan has ſuppoſed ‡.

* Kirw ii.—Du get, Jou Min. N xxi. p. 7
† Fourcr Ann. de Chim. ii 127.
‡ Min. 161.

221
Specula iron ore

SPECIES 2. Specular iron ore ¶.

Fer oligiſte.

This ore is found abundantly in the iſle of Elba near Tuſcany. It is either in maſſes or cryſtallized. The primitive form of its cryſtals, and of its integrant molecules, is the cube *. The varieties hitherto obſerved amount to 7. Theſe are the rhomboidal parallelopiped; the cube, with three triangular faces inſtead of two of its angles diagonally oppoſite; two ſix ſided pyramids, applied baſe to baſe, wanting the ſummits ‡, and ſometimes the angles at the baſes, and ſometimes the alternate edges of the pyramid; a polyhedron of 24 ſides, reſembling a cube with three triangular faces for two angles diagonally oppoſite, and two triangles for the reſt of its angles. For a deſcription and figure of theſe varieties, we refer to *Romé de Liſle* † and *Hauy* ‡.

¶ Kirw 162.— drai, J de Phyſ 52.
* Hauy Jour. d Min. N xxxiii.
‡ Fig.
† Cryſt. 189.
‡ Ibid.

Colour ſteel grey; often tarniſhed, and beautifully irideſcent, reflecting yellow, blue, red. Streak red. Powder dark red. Luſtre metallic. Hardneſs 9 to 10. Not brittle. Sp. gr. 5.0116 † to 5.218 ‡. Slightly magnetic. Little altered by the blow-pipe. Tinges borax an obſcure yellow.

† Hauy
‡ Briſ

This ore, according to Mr Muſhet, is compoſed of
66.1 iron,
21.2 oxygen,
10.7 water and carbonic acid,
2.0 lime.
——
100.0 †

† Phil Mag. 354.

The quantity of oxygen here ſtated is probably too ſmall, owing to the unavoidable inaccuracy which reſults from the *dry way* of analyſis which Mr Muſhet followed.

Micaceous iron ore

Is generally conſidered as a variety of this ſpecies. Kirwan, however, ſuppoſes it to contain carbon, and to be a diſtinct ſpecies.

It is found in Saxony, and in the iſle of Elba, &c. generally in amorphous maſſes, compoſed of thin ſix-ſided laminæ. Colour iron grey. Streak bluiſh grey. Luſtre metallic. Opaque. Feel greaſy. Hardneſs 5 to 7. Brittle. Sp. gr. from 4.5 to 5.07. Slightly magnetic.

magnetic. Infuſible by the blow-pipe. Tinges borax greeniſh brown.

SPECIES 3. Laminated ſpecular iron ore.

Fer pyrocete of Hauy.

This ore, which is found at Montd'or in Auvergn, was uſually arranged under the laſt ſpecies; but has been ſeparated from it, we think properly, by Mr Hauy, becauſe the form of its cryſtals is incompatible with the ſuppoſition that their primitive nucleus is a cube, as we have ſeen is the caſe with common ſpecular iron ore. Its cryſtals are thin octagonal plates, bounded by ſix linear trapeziums, alternately inclined different ways†.

Colour ſteel grey. Powder reddiſh black. Luſtre metallic; ſurface poliſhed. Fracture glaſſy. Very brittle ‡. Hauy ſuppoſes that this ore has been produced by fire, and accordingly has given it a name which denotes its origin.

SPECIES 4. Brown iron ore ¶.

This ſpecies of ore is found abundantly in Britain, particularly in Cumberland and Lancaſhire; and it is alſo very common in other counties. It conſiſts of the brown oxyd of iron, more or leſs contaminated with other ingredients.

Its colour is brown. Its ſtreak reddiſh brown. Sp. gr. from 3.4771 to 3.951. Before the blow pipe blackens, but does not melt. Tinges borax greeniſh yellow.

Variety 1. Brown hæmatites.

The name hæmatites (bloodſtone) was probably applied by the ancients only to thoſe ores which are of a red colour, and have ſome reſemblance to clotted blood; but by the moderns it is applied to all the ores of iron which give a reddiſh coloured powder, provided they be of a fibrous texture.

Brown hæmatites occurs in maſſes of various ſhapes, and it is ſaid alſo to have been found cryſtallized in five or ſix ſided acute angled pyramids. Colour of the ſurface brown or black, ſometimes irideſcent; internally nut brown. Powder red. Texture fibrous. Hardneſs 8 to 10. Brittle. Sp. gr. 3.789† to 3.951‡. Not magnetic.

This variety has not been analyſed, but it ſeems to conſiſt of brown oxyd of iron, oxyd of mangancſe, and alumina ¶.

Variety 2. Compact brown iron ſtone.

This variety occurs in maſſes of very various and often fantaſtical ſhapes.

Colour brown. Internal luſtre metallic. Texture compact. Hardneſs 6 to 9. Brittle. Sp. gr. 3.4771† to 3.551‡.

Variety 3. Brown Scaly iron ore.

This variety is generally incumbent on other minerals. Colour brown. Luſtre metallic. Stains the fingers, marks ſtrongly. Feels unctuous. Texture foliated. Hardneſs 3 to 5. Brittle. So light as often to float on water.

Variety 4. Brown iron ochre.

This variety occurs both maſſive and diſſeminated. Colour from nut brown to orange. Luſtre 0. Strongly ſtains the fingers. Texture earthy. Hardneſs 3 to 4. When ſlightly heated reddens.

SPECIES 5. Red iron ore†.

Colour red. Streak blood red. Sp. gr. from 3.423 to 5.005. Before the blow pipe blackens, but does not melt. Tinges borax yellowiſh olive green. When digeſted in ammonia, it becomes black and often magnetic.

Variety 1. Red hæmatites.

Found in maſſes, and all the variety of forms of ſtalactites. Colour between browniſh red and ſteel grey. Powder red. Internal luſtre metallic. Texture fibrous Hardneſs 9 to 10. Brittle. Sp. gr. 4.74† to 5.005‡.

When pure it conſiſts of red oxyd of iron, but it often contains mangancſe and alumina §.

Variety 2. Compact red iron ore.

Found maſſive and ſtalactitic; ſometimes in cryſtals of various forms, but they ſeem to be only ſecondary; ſometimes in columns like baſalt.

Colour between brown red and ſteel grey. Stains the fingers. Luſtre 1 to 0; often ſemimetallic. Texture compact. Hardneſs 7 to 9. Brittle. Sp. gr. 3.423 to 3.76† Sometimes inveſted with a roſy red ochre.

Variety 3. Red ochre.

Found ſometimes in powder, ſometimes indurated. Colour blood red. Stains the fingers. Luſtre 0. Texture earthy. Hardneſs 3 to 5. Brittle.

Variety 4. Red ſcaly iron ore.

This variety is generally found incumbent upon other iron ores. Colour between cherry red and ſteel grey. Stains the fingers. Luſtre ſilky, inclining to metallic. Texture foliated. Feels unctuous. Hardneſs 3 to 4. Brittle. Heavy.

SPECIES 6. Argillaceous iron ore †.

Oxyd of iron combined or mixed with clay.

This ore is exceedingly common; and though it contains leſs iron than the ſpecies already deſcribed, it is, in this country at leaſt, preferred to them, becauſe the method of extracting pure iron from it is eaſier, or rather becauſe it is better underſtood.

Colour moſt commonly dark brown. Streak red or yellowiſh brown. Sp gr. from 2.673 to 3.471‡. Before the blow-pipe blackens, and tinges borax olive green and blackiſh. It is compoſed of oxyd of iron, alumina, lime, ſilica in various proportions It generally yields from 30 to 40 *per cent.* of iron.

Variety 1. Common argillaceous iron ore.

The minerals arranged under this variety differ conſiderably from each other in their external characters. They are found in maſſes of various ſhapes, and often form large ſtrata.

Colour various ſhades of grey, brown, yellow, and red. Streak reddiſh yellow or dark red. Luſtre 0. Hardneſs from 3 to 8. Smell earthy when breathed upon.

Variety 2. Columnar or ſcapiform iron ore.

This variety is found in columns, adhering to each other, but eaſily ſeparable: They are commonly incurvated, and their ſurface is rough. Colour browniſh red. Streak dark red. Slightly ſtains the fingers. Luſtre 0. Adheres ſtrongly to the tongue. Sound hollow. Feel dry. Texture earthy.

Variety 3. Acinoſe iron ore.

This variety is found in maſſes, and is commonly lenticular. Colour generally browniſh red. Luſtre metallic, nearly. Texture granular. Hardneſs 5 to 9. Brittle.

Variety

Metallic Ores.

† Gellert.

‡ Kirwan.

§ Kirwan's Min. ii. 169.

† Kirwan.

215 Argillaceous iron ore.

† Kirw. ii. 173.

‡ Kirwan.

Variety 4. Nodular, or kidney-form iron ore.

Ætites or *Eagleſtone.*

This variety, which was mentioned by the ancients, is generally found under the form of a rounded knob, more or leſs reſembling a kidney, though ſometimes it is quadrangular; and it contains within it a kernel, which is ſometimes looſe, and ſometimes adheres to the outſide rind. Colour of the ſtone yellowiſh brown; of the kernel ochre yellow. Surface generally fouled with earth. Luſtre of the rind metallic; of the kernel 0. Hardneſs from 4 to 7. Brittle.

Variety 5. Piſiform or granular iron ore.

This variety occurs in rounded maſſes, from the ſize of a pea to that of a nut. Surface rough. Colour commonly dark brown. Streak yellowiſh brown. Hardneſs 5 to 6. Brittle.

The oolitic ore found at Creuſot, near mount Cenis, belongs to this variety. It is compoſed of

50 lime,
30 iron,
20 alumina.

100

226 Lowland iron ore. * Kirw. ii. 179.

SPECIES 7. Lowland iron ore *.

This ſpecies of ore is ſuppoſed to conſiſt of oxyd of iron, mixed with clay and phoſphuret or phoſphat of iron. It is called lowland ore, becauſe it is found only in low grounds; whereas the laſt ſpecies is more commonly in high grounds; and is therefore called *highland ore.*

This ore occurs in amorphous maſſes, and alſo in grains or powder. Its colour is brown. Streak yellowiſh brown. Luſtre 0, or common. Texture earthy. Hardneſs 3 to 5.

Variety 1. Meadow lowland ore.

Colour blackiſh or yellowiſh brown: Both colours often meet in the ſame ſpecimen. Found in lumps of various ſizes, often perforated. Fracture compact. Moderately heavy.

Frequently yields from 32 to 38 *per cent.* of iron.

Variety 2. Swampy iron ore.

This variety is generally found under water. It is in lumps, which are commonly perforated or corroded, and mixed with ſand. Colour dark yellowiſh brown, or dark nut brown. Hardneſs 3 to 4. Brittle. Sp. gr. 2.944. It often contains .36 of iron.

Variety 3. Moraſſy iron ore.

This variety is found either in a looſe form or in perforated lumps. Colour light yellowiſh brown. Stains the fingers. Hardneſs 3. Friable.

227 G.VI. Salts. Sparry iron ore.

GENUS VI. SALTS OF IRON.

SPECIES 1. Sparry iron ore (G).

This ore is common in Germany, France, and Spain. It is found ſometimes in amorphous maſſes, and ſometimes cryſtallized.

Its colour is white; but it becomes tarniſhed by expoſure to the air, and then aſſumes various colours. Streak grey or white. External luſtre often metallic; internal common or glaſſy. Tranſparency 1 or 2; ſometimes 0. Texture foliated. Fragments rhomboidal. Hardneſs 5 to 7. Brittle. Sp. gr. 3.6 to 3.810. Not magnetic. Soluble in acids with very little efferveſcence. Before the blow-pipe decrepitates, becomes browniſh black, and magnetic; but is ſcarcely fuſible. Tinges borax ſmutty yellow, with ſome efferveſcence.

This ore, as Bergman aſcertained, conſiſts of iron, manganeſe, lime, and carbonic acid.

One ſpecimen, according to his analyſis, contained

38 iron,
24 manganeſe,
38 carbonat of lime.

100

Another contained 22 iron,
28 manganeſe,
50 carbonat of lime.

100

Whether the iron be combined with the carbonic acid is ſtill a diſputed point. The cryſtals of this ore are rhomboidal parallelopipeds; which is preciſely the form of carbonat of lime. This amounts nearly to a demonſtration, that the carbonic acid is combined with the lime; and that, as Cronſtedt and Hauy have ſuppoſed, this ore is merely carbonat of lime, contaminated with a quantity of the oxyds of iron and manganeſe.

228 Arſenia iron.

SPECIES 2. Arſeniat of iron.

Mr Prouſt has diſcovered this ore in Spain. Its colour is greeniſh white. Its texture granular. Inſoluble in water and nitric acid. When melted on charcoal, the arſenical acid eſcapes with efferveſcence ‡.

‡ Ann. Chim. i. 195.

229 Sulphat iron.

SPECIES 3. Sulphat of iron.

For a deſcription of this ſalt, ſee CHEMISTRY, n° 631. in this *Suppl.*

ORDER VII. TIN ORES (H).

TIN is employed to cover plates of iron and copper, and to ſilver the backs of looking glaſſes: It enters into the compoſition of pewter; and forms a very important article in dyeing.

23 Mine

Tin ores are by no means ſo common as the ores of the metals which we have already deſcribed. They are found only in the *primitive mountains* (1). Hence Werner ſuppoſes them to be the moſt ancient of all metallic ores. They occur moſt frequently in granite, ſometimes in porphyry, but never in limeſtone.

Almoſt

(G) *Kirw.* II. 190.—*Bergman,* II. 184.—*Bayen. Jour. de Phyſ.* VII. 213.—*Razowmowſki, Mem. Lauſanne,* 1783, p. 149.

(H) *Geoffroy, Mem. Par.* 1738, p. 103.—*Morveau, Ann. de Chim.* XXIV. 127.

(1) Geologiſts have divided mountains into three claſſes; *primitive, ſecondary,* and *tertiary.* The *primitive* occupy the centre of all extenſive chains; they are the higheſt, the moſt rugged, and exhibit the moſt pointed tops. They are conſidered as the moſt ancient mountains of the globe.

The *ſecondary* mountains occupy the outſide of extenſive ranges. They are uſually compoſed of ſtrata, more or leſs inclined, and commonly reſt againſt the ſides of the primitive mountains.—The *tertiary* mountains are much ſmaller than the others, and are often ſolitary. We uſe the terms *primitive, ſecondary,* &c. merely as

proer

'in Ores.

Almoſt the only tin mines known to Europeans are thoſe of Cornwal, Devonſhire, Saxony, Bohemia, Sileſia, Hungary, Gallicia; thoſe of the iſland of Banca and the peninſula of Malacca in India; and thoſe of Chili and Mexico in America.

231
. I. Sul-
urets.
lphuret
tin and
pper.
Kirw. ii.
o.

Genus I. sulphurets of tin.

Species 1. Sulphuret of tin and copper *.

Tin pyrites.

Hitherto this ore has only been found in Cornwal. There is a vein of it in that county, in the pariſh of St Agnes, nine feet wide, and twenty yards beneath the ſurface †.

Its colour is yellowiſh grey, paſſing into the ſteel grey. Not unlike grey copper ore. Luſtre metallic. Hardneſs 5 to 6. Very brittle. Sp. gr. 4.35 ‡. Before the blow-pipe it melts eaſily, with a ſulphureous ſmell, into a black bead, and depoſits a bluiſh oxyd on the charcoal.

The compoſition of this ore, as Klaproth informs us, was firſt diſcovered by Mr Raſpe. According to Klaproth's analyſis, it is compoſed of

34 tin,
36 copper,
25 ſulphur,
3 iron,
2 earth.

100 §

232
. II. Ox-
ls. Brown
yd of tin.
Kirw. ii.
7.

Genus II. oxyds of tin.

Species 1. Brown oxyd of tin *.

Tinſtone—Woodtin.

This ore, which may be conſidered as almoſt the only ore of tin, occurs in maſſes, in rounded pieces, and cryſtallized. Theſe cryſtals are very irregular. Hauy ſuppoſes, that their primitive form is a cube †; but Romé de Liſle, with more probability, makes it an octohedron ‡; and in this opinion Mr Day agrees with him ‖. The octohedron is compoſed of two four-ſided pyramids, applied baſe to baſe. The ſides of the pyramids are iſoſceles triangles, the angle at the vertex of which is 70°, and each of the other angles 55°. The ſides of the two pyramids are inclined to each other at an angle of 90° §. This primitive form, however, never occurs, but cryſtals of tinſtone are ſometimes found, in which the two pyramids are ſeparated by a priſm. For a complete deſcription of the varieties of the cryſtals of tinſtone, we refer the reader to *Romé de Liſle* and *Mr Day* *.

Its colour is commonly brown. Streak grey. Hardneſs 9 to 10. Sp. gr. 6.9 to 7.0. Brittle.

Variety 1. Common tinſtone.

Colour dark brown; ſometimes yellowiſh grey, and ſometimes nearly white. Streak light grey. Somewhat tranſparent when cryſtallized. Hardneſs 10. Sp. gr. 6.9 to 6.97. Before the blow-pipe it decrepitates, and on charcoal is partly reduced. Tinges borax white.

According to Klaproth, it is compoſed of

77.50 tin,
21.50 oxygen,
.25 iron,
.75 ſilica.

100.00 †

Variety 2. Woodtin.

This variety has hitherto been found only in Cornwal. It occurs always in fragments, which are generally rounded. Colour brown; ſometimes inclining to yellow. Streak yellowiſh grey. Opaque. Texture fibrous. Hardneſs 9. Sp. gr. 7.0. Before the blow-pipe becomes browniſh red; decrepitates when red hot, but is not reduced.

Klaproth obtained from it .63 of tin; and, in all probability, it is an oxyd of tin nearly pure.

Order VIII. ORES OF LEAD.

The uſeful purpoſes to which lead in its metallic ſtate is applied, are too well known to require deſcription. Its oxyds are employed in painting, in dyeing, and ſometimes alſo in medicine.

Ores of lead occur in great abundance in almoſt every part of the world. They are generally in veins; ſometimes in ſiliceous rocks, ſometimes in calcareous rocks.

233
G. I. Sulphurets.
Galena, or pure ſulphuret of lead.

Genus I. sulphurets of lead.

Species 1. Galena, or pure ſulphuret of lead ‡.

This ore, which is very common, is found both in maſſes and cryſtallized. The primitive form of its cryſtals is a cube. The moſt common varieties are the cube, ſometimes with its angles wanting, and the octohedron, compoſed of two four-ſided pyramids applied baſe to baſe: The ſummits of theſe pyramids are ſometimes cuneiform, and ſometimes their ſolid angles are wanting ‖.

Its colour is commonly bluiſh grey, like lead. Streak bluiſh grey and metallic. Luſtre metallic. Sometimes ſtains

Metallic Ores.

---

* Kirw. ii. 200.

† Klaproth's Cornwall, 21.

‡ Klaproth.

§ Id. 58.

* Kirw. ii. 7.

† Jour. de Min. Nº xii. 576.

‡ Cryſtallog. 413.

‖ Philoſ. Mag. iv. 2.

§ Romé de Liſle, ibid.

* Philoſ. Mag. ibid.

† Beiträge, ii. 256.

‡ Kirw. ii. 216.

‖ Romé de Liſle, iii. 364.

---

proper names, without affirming or denying the truth or falſehood of the theory on which theſe names are founded. That the reader may have a more accurate idea of the compoſition of theſe different claſſes of mountains, we have ſubjoined a liſt of the ſubſtances which, according to Werner, enter into the compoſition of each.

I. Primary Mountains.

1. Granite,
2. Gneiſs,
3. Micaceous ſhiſtus
4. Argillaceous ſhiſtus,
5. Syenite,
6. Porphyry,
7. Shiſtoſe porphyry,
8. Quartz,
9. Primitive limeſtone,
10. Serpentine,
11. Topaz rock.

II. Secondary Mountains.

1. Argillaceous ſhiſtus,
2. Rubble ſtone,
3. Secondary limeſtone,
4. Shiſtoſe hornblende,
5. Grunſtein,
6. Amygdaloid.

III. Tertiary Mountains.

1. Trap,
2. Argillaceous ſhiſtus,
3. Stratified limeſtone,
4. Sandſtone,
5. Breccia,
6. Coal,
7. Chalk,
8. Sulphat of lime,
9. Rock ſalt,
10. Ferruginous clay,
11. Potters earth.

ſtains the fingers. Texture foliated. Fragments cubical. Hardneſs 5 to 7; ſometimes even 9. Brittle. Sp. gr. 6.884 to 7.786 [§]. Effervesces with nitric and muriatic acids. Before the blow-pipe decrepitates, and melts with a ſulphureous ſmell; part ſinks into the charcoal.

§ *Watſon.*

It is compoſed of from .45 to .83 lead, and from .086 to .16 of ſulphur. It generally contains ſome ſilver, and ſometimes alſo antimony aud zinc.

Variety 1. Common galena.

This variety correſponds nearly with the above deſcription. Sp. gr. 7.051 to 7.786. Sometimes ſtains the fingers.

Compact galena.

Found only in amorphous maſſes. Texture compact, inclining to foliated. Hardneſs 6 to 8. Sp. gr. 6.886 to 7.444. Luſtre common. Streak lead grey, brighter and metallic. Often feels greaſy, and ſtains the fingers.

234
Sulphuret of lead, with ſilver and antimony
* *Kirw.* ii. 119.

SPECIES 2. Sulphuret of lead, with ſilver and antimony [*].

Plumliferous antimoniated ſilver ore.

Found in amorphous maſſes. Colour grey. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.2 to 8.

Variety 1. Light grey ſilver ore.

Colour light bluiſh grey. Streak light bluiſh grey, and brighter. Luſtre metallic. Texture compact. Before the blow pipe partly evaporates, and leaves a ſilver bead on the charcoal, ſurrounded by yellow duſt.

According to Klaproth, it contains

48.06 lead,
20.40 ſilver,
7.88 antimony,
12.35 ſulphur,
2.25 iron,
7.00 alumina,
.25 ſilica.

98.09 [†]

† *Beiträge,* i. 172.

Variety 2. Dark grey ſilver ore.

Colour iron grey, verging on black. Powder black, and ſtains the fingers. Luſtre 0. Texture earthy.

According to Klaproth, it contains

41.00 lead,
21.50 antimony,
29.25 ſilver,
22.00 ſulphur,
1 75 iron,
1.00 alumina,
.75 ſilica.

97.25 [‡]

* *Ibid.* 175.

235
Blue lead ore.
* *Kirw.* ii. 220.

SPECIES 3. Blue lead ore [*].

This ore, which is found in Siberia, Germany, and Hungary, and is very rare, occurs ſometimes in maſſes, and ſometimes cryſtallized in ſix-ſided priſms.

Colour between indigo blue and lead grey; ſometimes inclining to black. Internal luſtre metallic. Streak brighter. Texture compact. Hardneſs 6. Sp. gr. 5.461 [†]. Before the blow pipe melts with a low blue flame and a ſulphureous ſmell, and is eaſily reduced.

† *Gellert.*

236
Black lead ore.
‡ *Kirw.* ii. 221.

SPECIES 4. Black lead ore [‡].

This ore, which is found in Germany and Brittanny, and which is ſuppoſed to be common galena decayed, is ſometimes in ſtalactites of various forms, and ſometimes cryſtallized in ſix-ſided priſms, which are generally truncated and confuſed.

Colour black, often with ſome ſtreaks of red. Streak light bluiſh grey. Internal luſtre metallic. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.744 [||] to 5.77 [*]. Before the blow-pipe decrepitates, melts eaſily, and is reduced.

|| *Briſſon.*
* *Gellert.*

According to the experiments of Laumont, this ore is a ſulphuret of lead (or rather ſulphuret of oxyd of lead), mixed with ſome phoſphat of lead.

237
Sulphuret of lead, biſmuth, and ſilver.

SPECIES 5. Sulphuret of lead, biſmuth, and ſilver.

This ore, which occurs in the valley of Schapbach in Saxony, was firſt taken notice of by Selb, and afterwards deſcribed by Weidenmann and Emerling.

Its colour is light bluiſh grey. Its luſtre metallic. Its fracture uneven. Hardneſs 5. Melts eaſily before the blow pipe, emitting ſome ſmoke, and leaves a ſilver bead.

A ſpecimen, analyſed by Mr Klaproth, contained

33.0 lead,
27.0 biſmuth,
15.0 ſilver,
16.3 ſulphur,
4.3 iron,
0.9 copper.

96.5 [†]

† *Beiträge,* ii. 297.

238
G. II. Oxyds. Lead ochre.
‡ *Kirw.* ii. 205.

GENUS II. OXYDS OF LEAD.

SPECIES 1. Lead ochre [‡].

This ore, which is a mixture of the oxyd of lead with various earths, is found maſſive, and of various degrees of hardneſs.

Its colour is either yellow, grey, or red. Luſtre 0. Tranſparency 0 to 1. Hardneſs 6 to 8; ſometimes in powder. Sp. gr. from 4.165 to 5.545 [§]. Texture compact. Effervesces with nitric and muriatic acids. Eaſily reduced by the blow-pipe, leaving a black ſlag, unleſs the lead be mixed with too great a proportion of earth.

§ *Kirwan.*

239
G. III. Salts. Carbonat of lead.
‡ *Kirw.* ii. 203.

GENUS III. SALTS OF LEAD.

SPECIES 1. Carbonat of lead [‡].

White lead ſpar.

This ore of lead, which is very common, is ſometimes in maſſes, and ſometimes cryſtallized. But the cryſtallization is in general ſo confuſed, that the primitive form of the cryſtals has not yet been aſcertained (K).

Its colour is white. External luſtre, waxy or ſilky, from 3 to 1; internal 1 to 2. Generally ſomewhat tranſparent. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.349 [||] to 6.92 [§]. Effervesces with nitric and muriatic acids when they are heated. Soluble in fat oils. Blackened by ſulphuret of ammonia [*]. Decrepitates when heated. Before the blow-pipe, in a ſilver ſpoon, it becomes red by the yellow cone of the flame, while the blue cone renders it yellow [†]. On charcoal it is immediately reduced.

|| *Kirwan.*
§ *Gellert.*
* *Pelletier Ann. de Chim.* ix. 56.
† *Ribbentropp, Ann. de Chim.* xxv. 159.

It contains from .60 to .85 of lead, and from .18 to .24 of carbonic acid. It is generally contaminated with carbonat of lime and oxyd of iron.

(K) See *Hauy, Jour. de Min.* Nº XXXI. 502. and *Romé de Liſle,* III. 380.

240
hoſphat
lead.
Kirw. ii.
07.

SPECIES 2. Phoſphat of lead †.

This ore, which is found in Siberia, Scotland, England, Germany, Carinthia, Brittany. &c. is ſometimes amorphous, and ſometimes cryſtallized. The primitive form of its cryſtals, according to Romé de Liſle, is a dodecahedron, conſiſting of a ſix-ſided rectangular priſm, terminated by ſix ſided pyramids, the ſides of which are iſoſceles triangles (L). Sometimes the pyramids are truncated, and even altogether wanting. The cryſtals of this ore are often acicular.

Its colour is commonly green; ſometimes yellowiſh or browniſh, or greyiſh white. Streak commonly greeniſh white. Powder yellowiſh. External luſtre, waxy, 2 to 3. Somewhat tranſparent, except when its colour is greyiſh white. Hardneſs 5 to 6. Brittle. Sp. gr. from 5.86 * to 6.27 †. Inſoluble in water and ſulphuric acid, and nearly inſoluble in nitric acid; ſoluble in hot muriatic acid, with a ſlight effervefcence ‡. Before the blow-pipe it eaſily melts on charcoal, and cryſtallizes on cooling: with ſoda the lead is in ſome meaſure reduced.

Briſſon.
Klaproth.

Fourcroy,
Inn. de
him. ii.
07.

The compoſition of this ore was firſt diſcovered by Gahn.

According to Fourcroy's analyſis, a ſpecimen from Erlenbach in Alſace, conſiſts of

96	phoſphat of lead,
2	phoſphat of iron,
2	water.
100	

Or it contains	79	oxyd of lead,
	1	oxyd of iron,
	18	phoſphoric acid,
	2	water.
	100 ¶	

Ibid.

241
Arſeniat
f lead.
Kirw. ii.
09.

SPECIES 3. Arſeniat of lead §.

This ore, which has hitherto been found only in Andaluſia in Spain, and always in quartz or feldſpar, is in ſmall maſſes. Colour meadow green, often paſſing into wax yellow. Luſtre waxy, 2. Tranſparency 2. Before the blow-pipe it melts, and retains its colour, and does not cryſtallize on cooling. When heated to whiteneſs, the arſenic acid eſcapes, and the lead is reduced *.

Prouſt,
Jour. de
Phyſ. xxx.
94.

242
Phoſphat
and arſe-
iat of
ead.
Kirw. ii.
10.

SPECIES 4. Phoſphat and arſeniat of lead.

Arſenio phoſphat of lead †.

This ore, which has been found in Auvergne in France, is either in maſſes, or cryſtallized in ſmall ſix-ſided priſms, with curvilineal faces.

Colour yellowiſh green, or ſhews alternate layers of pale and light green. Powder yellowiſh. The cryſtals are ſomewhat tranſparent; but when maſſive, this ore is opaque. Hardneſs 5 to 7. Brittle. Sp. gr. 6.8465‡. Soluble in hot muriatic acid, but not in nitric. When heated it decrepitates. Before the blow-pipe melts eaſily, effervefces, emits a white ſmoke, with an arſenical ſmell. Some particles of lead are reduced, a brown fluid remains, which cryſtallizes on cooling like phoſphat of lead.

Briſſon.

According to Fourcroy, from whom the whole of this deſcription has been taken, it is compoſed of

65	arſeniat of lead,
27	phoſphat of lead,
5	phoſphat of iron,
3	water.
100 *	

* Ann. de Chim. ii. 23.

243
Molybdat
of lead.

SPECIES 5. Molybdat of lead (M).

This ore, which is found in Carinthia and at Leadhills in Scotland, was firſt mentioned in 1781 by Mr Jacquin (N). It occurs either in maſſes, or cryſtallized in cubic, or rhomboidal, or octohedral plates.

Its colour is yellow. Streak white. Luſtre waxy. Generally ſomewhat tranſparent. Texture foliated. Fracture conchoidal. Hardneſs 5 to 6. Sp. gr. 5.486†; when purified from its gangue by nitric acid, 5.706 ‡.

† Macquart.
‡ Hatchett.

Soluble in fixed alkalies and in nitric acid. Communicates a blue colour to hot ſulphuric acid. Soluble in muriatic acid, and decompoſed by it. Before the blowpipe decrepitates, melts into a yellowiſh grey maſs, and globules of lead are reduced ‖.

‖ Macquart.

Klaproth firſt proved that this ore was molybdat of lead.

A very pure ſpecimen, analyſed by him, contained

64.42	oxyd of lead,
34.25	molybdic acid.
98.67 ¶	

¶ Beiträge, ii. 275.

According to the analyſis of Mr Hatchett, it is compoſed of

58.40	oxyd of lead,
38.00	molybdic acid,
2.10	oxyd of iron,
.28	ſilica.
98.78 *	

* Phil. Tranſ. lxxxvi. 323.

Macquart found a ſpecimen to contain

58.74	lead,
4.76	oxygen,
28.00	molybdic acid,
4.50	carbonat of lime,
4.00	ſilica.
100.00 †	

Its gangue is carbonat of lime.

† Jour. de Min. N° xvii. 32.

244
Sulphat of
lead.

SPECIES 6. Sulphat of lead ‡.

This ore, which is found in Angleſey and in Andaluſia, is generally cryſtallized. The cryſtals are regular octohedrons §, and very minute.

Colour white. Luſtre 4. Tranſparency 4. Before the blow-pipe it is immediately reduced.

The compoſition of this ore was firſt aſcertained by Dr Withering.

* Kirw. Min. ii. 211.
§ Hauy, Jour. de Min. N° xxxi. 508.

ORDER IX. ORES OF ZINC.

HITHERTO zinc has not been applied to a great variety of uſes. It enters into the compoſition of braſs; it is uſed in medicine; and Morveau has ſhewn that its oxyd

---

(L) *Cryſtal.* III. 391. See alſo *Hauy's* remarks on the ſame ſubject in the *Jour. de Min.* N° XXXI, 506.

(M) *Kirw.* II. 212.—*Klaproth, Ann. de Chim.* VIII. 103.—*Hatchett, Phil. Tranſ.* 1796, p. 285.

(N) In his *Miſcellanea Auſtriaca*, Vol. II. p. 139.

oxyd might be employed with advantage as a white paint.

Ores of zinc are very abundant; they generally accompany lead ores, particularly galena. Calamine, or oxyd of zinc, has never been diſcovered in the primitive mountains.

245
G. I. Sulphurets. Common ſulphuret of zinc.

Genus I. SULPHURETS OF ZINC.

SPECIES I. Common ſulphuret of zinc*.

Blende.

This ore very commonly accompanies ſulphuret of lead. It occurs both in amorphous maſſes and cryſtallized. The primitive form of its cryſtals is a rhomboidal dodecahedron, conſiſting of a ſix-ſided priſm, terminated by three-ſided pyramids. All the faces of the cryſtals are equal rhombs. This dodecahedron may be mechanically divided into four equal rhomboidal parallelopipeds, and each of theſe into ſix tetrahedrons, whoſe faces are equal iſoſceles triangles. The figure of its integrant particles is the tetrahedron, ſimilar to theſe *.

* Kirw. ii 238.—Berg. ii. 329.

* Hauy, Jour. de Min. N° xxxiii. 669.

The principal varieties of its cryſtals are the tetrahedron; the octohedron; the octohedron with its edges wanting*; a 24-ſided cryſtal, 12 of whoſe faces are trapezoids, and 12 elongated triangles†; and, laſtly, a 28-ſided figure, which is the laſt variety, augmented by four equilateral triangles †.

* Fig. 40.

† Fig. 41.

† See Hauy, ibid and Romé de Liſle, iii. 65.

Colour yellow, brown, or black. Streak reddiſh, browniſh, or grey. Luſtre commonly metallic. Generally ſomewhat tranſparent. Texture foliated. Hardneſs 6 to 8. Sp. gr. 3.93‡ to 4.1665¶. Before the blow-pipe decrepitates, and gives out white flowers of zinc, but does not melt. Borax does not affect it. When breathed upon, loſes its luſtre, and recovers it very ſlowly‖.

‡ Gellert.

¶ Briſſon.

‖ Hauy, Jour de Min. ibid.

Variety 1. Yellow blende.

Colour commonly ſulphur yellow, often paſſing into olive green or browniſh red. Powder pale yellow. Streak yellowiſh or reddiſh grey, not metallic. Luſtre metallic. Tranſparency 2 to 4. Often phoſphoreſces when ſcraped or rubbed*.

* Bergman, ii. 345.

According to Bergman, it is compoſed of
64 zinc,
20 ſulphur,
5 iron,
4 fluor acid,
1 ſilica,
6 water.

100†

† Ibid. 347.

Variety 2. Brown blende.

Colour different ſhades of brown. Surface often tarniſhed. Powder browniſh grey. Streak reddiſh or yellowiſh grey, not metallic. Luſtre commonly metallic. Tranſparency 0 to 2.

A ſpecimen of this variety, analyſed by Bergman, contained
44 zinc,
17 ſulphur,
24 ſilica,
5 iron,
5 alumina,
5 water.

100‡

‡ Ibid. 333.

Variety 3. Black blende.

Colour black, or browniſh black; ſurface often tarniſhed blue; tips of the cryſtals often blood red. Powder browniſh black. Streak reddiſh, browniſh, or grey. Luſtre common or metallic. Tranſparency 0 to 1; the red parts 2. Hardneſs 8.

A ſpecimen of this variety, analyſed by Bergman, contained
52 zinc,
26 ſulphur,
4 copper,
8 iron,
6 ſilica,
4 water.

100‡

‡ Bergman, ii. 335.

246
G. II. Oxyds. White oxyd of zinc.

Genus II. OXYDS OF ZINC.

SPECIES I. White oxyd of zinc†.

Calamine.

This ore is either found looſe, or in maſſes, or cryſtallized. The primitive form of its cryſtals appears, from the mechanical diviſion of one of them by Mr Hauy, to be an octohedron compoſed of two four-ſided pyramids, whoſe ſides are equilateral triangles †. But the cryſtals are minute, and their figure not very diſtinct. They are either four or ſix ſided tables with bevelled edges, ſix-ſided priſms, or three-ſided pyramids.

† Kirw. ii. 233—Berg. ii. 321.

† Jour. de Min. N° xxxii. 596.

Colour commonly white, grey, or yellow. Luſtre often 0, ſometimes 2 or 1. Opaque. The cryſtals are ſomewhat tranſparent. Hardneſs from 4 to 9, ſometimes in powder. Sp. gr. from 2.585 to 3.674‡. When heated, becomes electric, without friction, like the tourmaline†. Not blackened by ſulphuret of ammonia. Soluble in ſulphuric acid. Before the blow-pipe decrepitates, and does not melt.

‡ Kirwan.

† Hauy, Jour. de Min. ibid.

This ore conſiſts of oxyd of zinc more or leſs contaminated with iron, ſilica, lime, and other foreign ingredients. In one ſpecimen Bergman found the following ingredients:
84 oxyd of zinc,
3 oxyd of iron,
12 ſilica,
1 alumina.

100 ¶

¶ Bergman, ii. 323.

In another ſpecimen, which gelatinized with acids, like zeolite, Klaproth found
66 oxyd of zinc,
33 ſilica.

99

In another ſpecimen, analyſed by Pelletier, the contents were
52 ſilica,
36 oxyd of zinc.
12 water.

100 *

* Jour. de Phyſ. xl. 428.

Mr Kirwan has divided this ſpecies into three varieties.

Variety 1. Friable calamine.

In maſſes which eaſily crumble between the fingers. Luſtre 0. Opaque. Texture earthy. When its colour is white, it is pure oxyd of zinc; when yellow, it is mixed with oxyd of iron. The white often becomes yellow when placed in a red heat, but reſumes its colour on cooling. Common in China, where it is called *wohan* or *ore of Tutenago*.

Variety 2. Compact calamine.

Colour different ſhades of grey; ſometimes yellow or browniſh red. Luſtre 0. Opaque. Texture compact.

Variety 3. Striated calamine.

This variety alone is found cryſtallized; but, like the others, it is alſo often amorphous. Colour white, and alſo various ſhades of grey, yellow, and red. Somewhat tranſparent. Texture ſtriated. Luſtre 2 to 1.

GENUS III. SALTS OF ZINC.

SPECIES 1. Sulphat of zinc.

For a deſcription of this ſalt, we refer to CHEMISTRY, n° 643. *Suppl.*

ORDER X. ORES OF ANTIMONY.

ANTIMONY is much uſed to give hardneſs to thoſe metals which otherwiſe would be too ſoft for certain purpoſes: printers types, for inſtance, are compoſed of lead and antimony. It is uſed alſo in medicine.

Ores of antimony are found abundantly in Germany, Hungary, France, Spain, Britain, Sweden, Norway, &c. They often accompany galena and hæmatites. They are found both in the ſecondary and primitive ſtratified mountains. Their gangue (o) is often quartz and ſulphat of barytes.

GENUS I. ALLOYS OF ANTIMONY.

SPECIES 1. Native antimony [*].

This mineral, which was firſt diſcovered by Dr Swab, has been found in Sweden and in France, both in maſſes and kidney-ſhaped lumps. Colour white, between that of tin and ſilver. Luſtre metallic. Texture foliated. Hardneſs 6. Sp. gr. above 6. Deflagrates with nitre. Before the blow-pipe melts and evaporates, depoſiting a white oxyd of antimony.

It conſiſts of antimony, alloyed with 3 or 4 *per cent.* of arſenic.

GENUS II. SULPHURETS OF ANTIMONY.

SPECIES 1. Grey ore of antimony [*].

This ore, which is the moſt common, and indeed almoſt the only ore of antimony, occurs both maſſive, diſſeminated, and cryſtallized. Its cryſtals are four-ſided priſms, ſomewhat flattened, whoſe ſides are nearly rectangles, terminated by ſhort four-ſided pyramids, whoſe ſides are trapeziums [†]. Sometimes two of the edges are wanting, which renders the priſm ſix-ſided [‡].

Colour grey. Luſtre metallic. Streak grey, metallic, and brighter. Powder black or greyiſh black. Hardneſs 6 to 7. Sp. gr. from 4.1327 to 4.516 [¶]. Often ſtains the fingers. Before the blow-pipe melts eaſily, burns with a blue flame, and depoſits a white oxyd on the charcoal. When placed in an open veſſel, over a ſlow fire, the ſulphur evaporates, and leaves a grey oxyd of antimony. This oxyd, if fuſed with tartar, is reduced.

This ore, when taken out of the mine, almoſt always contains a large proportion of quartz or other ſtony matter. When pure, it is compoſed of about

74	antimony,
26	ſulphur.
100	

Werner has divided this ſpecies into three varieties.

Variety 1. Compact ſulphuret.

Colour bluiſh grey, ſurface often tarniſhed, and then it is blue or purpliſh. Luſtre 1 to 2. Texture compact. Fracture fine grained, uneven. Powder black, dull, and earthy. Slightly ſtains the fingers.

Variety 2. Foliated ſulphuret.

Colour light ſteel grey. Luſtre 3 to 4. Texture foliated. Powder as that of the laſt variety.

Variety 3. Striated ſulphuret.

Colour dark ſteel grey, and light bluiſh grey; ſurface often tarniſhed, and then it is dark blue or purpliſh. Luſtre 3 to 2. Texture ſtriated. Powder greyiſh black. This variety alone has been hitherto found cryſtallized.

250
Plumoſe antimonial ore.

SPECIES 2. Plumoſe antimonial ore [†].

Sulphurets of antimony and arſenic.

This ſpecies, which is ſometimes found mixed with the cryſtals of ſulphurated antimony, is in the form of brittle, capillary, or lanuginous cryſtals, often ſo ſmall that they cannot be diſtinctly ſeen without a microſcope.

Colour ſteel or bluiſh grey, often tarniſhed, and then brown or greyiſh black. Luſtre 1, ſemimetallic. Before the blow-pipe emits a ſmoke, which depoſits a whitiſh and yellowiſh powder on the charcoal: it then melts into a black ſlag.

It is ſuppoſed to conſiſt of ſulphur, antimony, arſenic, and ſome ſilver.

[†] *Kirw.* ii. 250.

251
Red antimonial ore.

SPECIES 3. Red antimonial ore [†].

Hydroſulphuret of antimony.

This ſpecies is generally found in cavities of ſulphurated antimonial ore. It is cryſtallized in delicate needles, often diverging from a common centre.

Colour red. Luſtre 2, ſilky. Sp. gr. 4.7. Before the blow-pipe melts eaſily, and evaporates with a ſulphureous ſmell.

This ore has not been analyſed. Mineralogiſts have ſuppoſed it to be a natural kermes. If ſo, we may conclude, from the experiments of Berthollet [*], that it is a hydroſulphuret of antimony, and conſequently compoſed of oxyd of antimony, ſulphur, and ſulphurated hydrogen gas.

[†] *Kirw.* ii. 250.

[*] *Ann. de Chim.* xxv. 259.

252
G. III.
Oxyds of antimony.

GENUS III. OXYDS OF ANTIMONY.

There is a ſubſtance found incumbent on ſulphuret of antimony, of a yellow colour, and an earthy appearance, which has been ſuppoſed an oxyd of antimony, and denominated antimonial ochre. But hitherto it has not been analyſed.

GENUS

(o) The word *gang* is uſed by German mineralogiſts to denote a metallic vein. Now, it is not often that theſe veins conſiſt entirely of *ore*; in general, they contain ſtony matter beſides. For inſtance, in the copper mine at Airthry, near Stirling, the copper ore is merely a narrow ſtripe in the middle of the vein, and the reſt of it is filled up with ſulphat of barytes. We uſe the word *gangue* (as the French do), to denote, not the *metallic* vein, but the *ſtony* matter which accompanies the ore in the vein. The gangue of the copper ore at Airthry is ſulphat of barytes.

Ores of Bifmuth.

253 G. IV. Salts Muriat of antimony.

GENUS IV. SALTS OF ANTIMONY.

SPECIES 1. Muriat of antimony[*].

This ore, which has been found in Bohemia, is fometimes in quadrangular tables; fometimes in acicular cryſtals grouped like zeolites; and fometimes in priſms.

Colour pale yellowiſh or greyiſh white. Luſtre 3 to 1, nearly metallic. Tranſparency 2. Texture foliated. Melts eaſily by the flame of a candle, and emits a white vapour.[†]. Before the blow-pipe decrepitates; when powdered, and juſt ready to melt, it evaporates, and leaves a white powder around. Between two pieces of coal it is reducible to a metallic ſtate.

[*] Kirw. ii. 251.

[†] Hauy, Jour. de Min. No xxxii. 609.

ORDER XI. ORES OF BISMUTH[*].

BISMUTH is employed in the manufacture of pewter, of printers types, in ſoldering; and perhaps alſo its property of rendering other metals more fuſible, might make it uſeful in anatomical injections. The quantity conſumed in commerce is not great.

It has been found only in the primitive mountains, and is by no means common. When unaccompanied by any other metal, it does not form veins, but kidney-form maſſes. It often accompanies cobalt. Its gangue is commonly quartz. Its ores are not very abundant. They have been found chiefly in Sweden, Norway, Tranſylvania, Germany, France, and England

[*] Pott, Obſerv. Chym. 134—Geoffroy, Mem. Par. 1753, p. 296.

254 G. I. Alloys. Native bifmuth.

GENUS I. ALLOYS OF BISMUTH.

SPECIES 1. Native biſmuth[*].

This mineral, which is found at Schneeberg, Johangeorgenſtadt, &c. in Germany, has commonly the form of ſmall plates lying above one another. Sometimes it is cryſtallized in four-ſided tables, or indiſtinct cubes.

Colour white with a ſhade of red; ſurface often tarniſhed red, yellow, or purple. Luſtre metallic, 3 to 2. Opaque. Texture foliated or ſtriated. Hardneſs 6. Sp. gr. 9.022[†] to 9.57[‡]. Exceedingly fuſible. Before the blow-pipe gives a ſilvery white bead, and at laſt evaporates in a yellowiſh white ſmoke, which is depoſited on the charcoal.

It is generally accompanied by cobalt, and ſometimes contains arſenic.

[*] Kirw. ii. 264.

[†] Briſſon.

[‡] Kirwan.

255 G. II. Sulphurets. Common ſulphuret of biſmuth.

GENUS II. SULPHURETS OF BISMUTH.

SPECIES 1. Common ſulphuret of biſmuth[*].

This ore, which is found in Sweden, Saxony, and Bohemia, occurs ſometimes in amorphous maſſes, and ſometimes in needleform cryſtals.

Colour commonly bluiſh grey, ſometimes white; ſurface often tarniſhed yellow, red, and purple. Powder black and ſhining. Luſtre metallic, 2 to 3. Streak obſcurely metallic. Texture foliated. Hardneſs 5. Brittle. Sp gr. 6.131[†] to 6.4672[‡]. When held to the flame of a candle, it melts with a blue flame and ſulphureous ſmell. Before the blow-pipe emits a reddiſh yellow ſmoke, which adheres to the charcoal. This powder becomes white when it cools, and reſumes its former colour when the flame is directed upon it[*].

This ore, according to Sage, contains 60 biſmuth, And, according to La Perouſe, it holds 36 ſulphur.

[*] Kirw. ii. 266.—Sage, Mem. Par. 1782, 307.

[†] Kirwan

[‡] Briſſon.

[*] Gillot, Jour. de Min. No xxxii. 585.

A ſpecimen, analyſed by Klaproth, contained

95 biſmuth,
5 ſulphur.
———
100[†]

It is commonly accompanied by quartz, aſbeſtos, or ſparry iron ore.

[†] Be i. 25

G O Yel oxy biſm

GENUS III. OXYDS OF BISMUTH.

SPECIES 1. Yellow oxyd of biſmuth[‡].

Biſmuth ochre.

This ore generally accompanies the two ſpecies already deſcribed. It is found in two ſtates; either of an earthy conſiſtence, or cryſtallized in cubes or quadrangular plates.

Colour uſually greeniſh yellow, ſometimes grey. Soluble in nitrous acid without effervefcence, and may in a great meaſure be precipitated by the effuſion of water.

[‡] K 265

ORDER XII. ORES OF ARSENIC.

ARSENIC is uſed as an alloy for ſeveral other metals, eſpecially copper. It is ſometimes employed to facilitate the fuſion of glaſs, or to render it opaque, in order to form an enamel. Preparations of arſenic are employed as paints; and, like moſt other violent poiſons, it has been introduced into medicine.

This metal is ſcattered in great abundance over the mineral kingdom, accompanying almoſt every other metal, and forming alſo ſometimes peculiar veins of its own. Of courſe it occurs in almoſt every ſpecies of mountain, and is accompanied by a variety of gangues.

G. I Na ſen

GENUS I. ALLOYS OF ARSENIC.

SPECIES 1. Native arſenic[†].

This mineral is found in different parts of Germany. It occurs generally in maſſes of various ſhapes, kidney-form, botryoidal, &c.

Colour that of ſteel. Its ſurface quickly becomes tarniſhed by expoſure to the air. Luſtre metallic (when freſh), 3 to 2. Streak bluiſh grey, metallic, and bright. Powder dull and black. Texture compact. Hardneſs 7 to 8. Brittle. Sp. gr. 5.67[†] to 5.7249[‡]. Gives an arſenical ſmell when ſtruck. Before the blow-pipe emits a white ſmoke, diffuſes a garlic ſmell, burns with a blue flame, gradually evaporates, depoſiting a white powder.

It is always alloyed with ſome iron[§], and often contains ſilver, and ſometimes gold.

[†] K 255

§ Ga Ra 19

G. ph Or

GENUS II. SULPHURETS OF ARSENIC.

SPECIES 1. Orpiment (P).

Auripigmentum.

This ore, which is found in Hungary, Wallachia, Georgia, and Turkey in Aſia, is either maſſive or cryſtallized. The cryſtals are confuſed, and their figure cannot be eaſily determined; ſome of them appear octohedrous, and others minute four-ſided priſms.

Its colour is yellow. Streak orange yellow. Luſtre waxy, 2 to 3. Tranſparency from 0 to 2. Texture foliated. Hardneſs 4 to 8. Sp. gr. from 3.048[*] to 3.521[‡]. Effervefces with hot nitric acid. Burns with a

---

(P) *Kirw.* II. 260.—*Alberti de Auripigmento.*—*Scopoli in Anno 5to Hiſt. Naturali*, p. 59,—*Berg.* II. 297.

a bluiſh white flame. Before the blow-pipe melts, ſmokes, and evaporates, leaving only a little earth and ſome traces of iron.

Compoſed of 80 ſulphur,
20 arſenic.

100

SPECIES 2. Realgar*.

This mineral is found in Sicily, about Mount Veſuvius, in Hungary, Tranſylvania, and various parts of Germany. It is either maſſive or cryſtallized. The primitive form of the cryſtals is, according to Romé de Liſle, a four-ſided rhomboidal priſm, terminated by four-ſided pyramids, the ſides of which are rhombs †. It commonly appears in 4, 6, 8, 10, or 12 ſided priſms, terminated by four-ſided ſummits ‡.

Colour red. Streak yellowiſh red. Powder ſcarlet. Luſtre 3 to 2. Tranſparency from 2 to 3; ſometimes c. Hardneſs 5 to 6. Sp. gr. 3.3384 §. It is an electric *per ſe*, and becomes negatively electric by friction ||. Nitric acid deprives it of its colour. Before the blow pipe it melts eaſily, burns with a blue flame and garlic ſmell, and ſoon evaporates.

Compoſed of 20 ſulphur,
80 arſenic.

100

GENUS III. OXYDS OF ARSENIC.

SPECIES 1. White oxyd of arſenic *.

Native calx of arſenic.

This ore is found in various parts of Germany, Hungary, &c. either in powder, or maſſive, or cryſtallized in priſmatic needles.

Colour white or grey, often with a tint of red, yellow, green, or black. Luſtre common, 1 to 2. Tranſparency 1 to 0; when cryſtallized, 2. Texture earthy. Hardneſs 6. Brittle. Sp. gr. 3.7 †. Soluble in hot diluted nitric acid without effervescence. Soluble at 60° Fahrenheit in 80 times its weight of water. Before the blow-pipe ſublimes, but does not inflame. Tinges borax yellow.

ORDER XIII. COBALT ORES.

COBALT is employed to tinge glaſs of a blue colour, and is uſeful in painting upon porcelain.

Cobalt ores are found almoſt excluſively in the ſtratified mountains, except one ſpecies, ſulphuret of cobalt, which affects the primitive mountains. They are not very abundant; and for that reaſon cobalt is more valuable than many of the other metals which have been already treated of. They are commonly accompanied by nickel, biſmuth, or iron. They are moſt abundant in Germany, Sweden, Norway, and Hungary; they have been found alſo in Britain and France, but not in any great quantity.

GENUS I. ALLOYS OF COBALT.

SPECIES 1. Cobalt alloyed with arſenic †.

Dull grey cobalt ore.

This ore, which occurs in different parts of Germany, is either amorphous or cryſtallized. The forms of its cryſtals are the cube; ſometimes the cube with its angles, or edges, or both wanting; and the octohedron ‡.

Its colour, when freſh broken, is whitiſh or bluiſh grey, ſometimes with a ſhade of red; when expoſed to the air it ſoon becomes tarniſhed. Streak bluiſh grey and metallic. Luſtre ſcarcely metallic, 0 to 1. Texture compact. Hardneſs 10. Difficultly frangible. Sp. gr. when amorphous, 5.309 to 5.571 §; when cryſtallized 7.7207 † When ſtruck it gives out an arſenical ſmell. Before the blow-pipe it gives out an arſenical vapour, becomes magnetic, and melts eaſily, unleſs it contains a great quantity of iron. Tinges borax dark blue, and a ſmall metallic bead is obtained.

A ſpecimen of this ore from Cornwall, examined by Mr Klaproth, contained 20 cobalt,
24 iron,
33 arſenic,

77

with ſome biſmuth and ſtony matter *.

Another ſpecimen from Tunaberg, according to the analyſis of the ſame chemiſt, contained

55.5 arſenic,
44.0 cobalt,
.5 ſulphur.

100 †

262
G. II. Sulphurets.
White cobalt ore.

GENUS II. SULPHURETS OF COBALT.

SPECIES 1. White cobalt ore ‡.

Sulphuret of cobalt, arſenic, and iron.

The deſcriptions which different mineralogiſts have given of this ore are ſo various, that it is impoſſible not to ſuppoſe that diſtinct ſubſtances have been confounded together.

It occurs either in maſſes, or cryſtallized in cubes, dodecahedrons, octohedrons, and icoſahedrons.

Colour tin white, ſometimes tarniſhed reddiſh or yellowiſh. Powder ſteel grey. Luſtre partly metallic, and from 2 to 4; partly 0 or 1. Texture foliated. Hardneſs 8 to 9. Sp. gr. from 6.284 † to 6.4509 ‡. Before the blow-pipe generally gives out an arſenical vapour, and does not melt.

The analyſes that have been given of this ore are very various. Sometimes it has been found to contain no arſenic nor iron, and ſometimes to contain both. A ſpecimen from Tunaberg in Sweden, which ought to belong to this ſpecies, was analyſed by Taſſaert, and found to conſiſt of 49 arſenic,
36.6 cobalt,
5.6 iron,
6.5 ſulphur.

97.8 †

Klaproth found a ſpecimen of the ſame ore to contain
55.5 arſenic,
44.0 cobalt,
0.5 ſulphur.

100.0 ‡

263
G. III. Oxyds.
Black cobalt ore or ochre.

GENUS III. OXYDS OF COBALT.

SPECIES 1. Black cobalt ore or ochre §.

This ore, which occurs in different parts of Germany, is either in the form of a powder, or indurated.

Colour black, often with a ſhade of blue, grey, brown, or green. Luſtre 0 to 1. Streak brighter. Hardneſs (of the indurated) from 4 to 8. Sp. gr. 3 to 4. Soluble in muriatic acid. Tinges borax blue.

---

§ Kirw. ii. 270.

† Hauy, Jour. de Min. N° xxxii. 588.

* Klaproth's Cornwall, p. 61.

† Beiträge, ii. 307.

‡ Kirw. ii. 273.—Sage, Jour. de Phyſ. xxxix. 53.

† Kirwan.

‡ Hauy.

† Ann. de Chim. xxviii. 100.

‡ Beiträge, ii. 307.

§ Kirw. ii. 275.

Ores of Nickel.

264
Brown cobalt ore.
* *Kirw.* ii. 276.

SPECIES 2. Brown cobalt ore*.

Colour greyiſh or dark leather brown. Streak brighter, unctuous. Communicates a pale blue tinge in fuſion.

265
Yellow cobalt ore.
† *Ibid.*

SPECIES 3. Yellow cobalt ore †.

Colour yellow. Dull and earthy. Hardneſs 4 to 5. Texture earthy. Streak brighter, unctuous. Gives a weak blue tinge.

266
G. IV.
Salts.
Arſeniat of cobalt.
‡ *Id.* 278.

GENUS IV. SALTS OF COBALT.

SPECIES 1. Arſeniat of cobalt ‡.

Red cobalt ore.

This ſpecies, like moſt other ores of cobalt, has neither been accurately deſcribed nor analyſed.

It is found in maſſes of various ſhapes, and cryſtallized in quadrangular tables or acicular priſms.

Colour red. Luſtre from 2 to 3, ſometimes 0. Tranſparency 0 to 2. Hardneſs 5 to 7. Brittle. Before the blow-pipe becomes blackiſh grey. Diffuſes a weak arſenical ſmell. Tinges borax blue.

ORDER XIV. ORES OF NICKEL.

HITHERTO nickel has been found in too ſmall quantities to be applied to any uſe; of courſe there are, properly ſpeaking, no mines of nickel. It occurs only (as far as is yet known) in the ſecondary mountains, and it commonly accompanies cobalt. It has been found in different parts of Germany, in Sweden, Siberia, Spain, France, and Britain.

267
G. I. Sulphurets.
Sulphuret of nickel with arſenic and iron.
* *Ibid.* 286.

GENUS I. SULPHURETS OF NICKEL.

SPECIES 1. Sulphuret of nickel with arſenic and iron.

*Kupfer nickel**.

This, which is the moſt common ore of nickel, occurs either maſſive or diſſeminated, but never cryſtallized.

Colour often that of copper, ſometimes yellowiſh white or grey. Recent fracture often ſilver white. Luſtre metallic, 2 to 3. Texture compact. Hardneſs 8. Sp. gr. 6.6086 to 6.6481 ‡. Soluble in nitric and nitro-muriatic acids. Solution green. Before the blow-pipe exhales an arſenical ſmoke, and melts into a bead which darkens by expoſure to the air.

‡ *Briſſon.*

It is compoſed of various proportions of nickel, arſenic, iron, cobalt, ſulphur; often contains biſmuth, and ſometimes ſilver and copper.

268
G. II. Oxyds.
Nickel ochre.
* *Kirw.* ii. 284.

GENUS II. OXYDS OF NICKEL.

SPECIES 1. Nickel ochre *.

This mineral occurs either in the form of a powder, or indurated, and then is either amorphous, or cryſtallized in acicular form cryſtals. The powder is generally found on the ſurface of other nickel ores.

Colour different ſhades of green. Luſtre 1 to 0. Texture earthy. Sp. gr. conſiderable. Slowly diſſolves in acids: ſolution green. Before the blow-pipe does not melt; but gives a yellowiſh or reddiſh brown tinge to borax.

This ore often contains ſulphat of nickel, which is ſoluble in water. The ſolution, when evaporated, gives oblong rhomboidal cryſtals, from which alkalies precipitate a greyiſh green oxyd. This oxyd is ſoluble by acids and by ammonia. The acid ſolution is green; the alkaline blue.

Metal. Ores

269
G. II
Salts
Arſenia
nickel.
† *Kirw*
285.

GENUS III. SALTS OF NICKEL.

SPECIES 1. Arſeniat of nickel †.

This ore, which was lately diſcovered at Regendorff by Mr Gmelin, is found in ſhapeleſs maſſes, and is often mixed with plates of ſulphat of barytes.

Colour pale grey, here and there mixed with pale green. Streak white. Luſtre 0. Texture compact. Hardneſs 7. Difficultly frangible. Sp. gr. conſiderable. Adheres ſlightly to the tongue, and gives an earthy ſmell when breathed on. Soluble in hot nitric and muriatic acids: ſolution green.

Contains ſome cobalt and alumina.

ORDER XV. ORES OF MANGANESE (q).

HITHERTO manganeſe, in its metallic ſtate, has ſcarcely been put to any uſe; but under the form of an oxyd it has become of great importance. The oxyd of manganeſe has the property of rendering colourleſs a variety of bodies which injure the tranſparency of glaſs; and it has been long uſed in glaſs manufactories for this purpoſe under the name of *glaſs ſoap*. By means of the ſame oxyd, oxy-muriatic acid is prepared, which has rendered manganeſe of great importance in bleaching. Not to mention the utility of manganeſe to the chemiſt, the property which it has of facilitating the oxydation of other metals, and of rendering iron more fuſible—will probably make it, in no very remote period, of very conſiderable importance in numerous manufactories.

Ores of manganeſe occur often in ſtrata, both in the primitive and ſecondary mountains; ſcarcely ever, however, we believe, in thoſe mountains which are conſidered as the moſt ancient of all. They are very common, having been found abundantly in Germany, France, Spain, Britain, Sweden, Norway, Siberia, and other countries.

2
G.I.

GENUS I. OXYDS OF MANGANESE.

Hitherto manganeſe has only been found in the ſtate of oxyd. La Perouſe, indeed, ſuſpected that he had found it in a metallic ſtate: but probably there was ſome miſtake or other in his obſervations.

2
Oxy
man
com
with
rytes

SPECIES 1. Oxyd of manganeſe combined with barytes.

This ſpecies, which exiſts in great abundance in Romaneche near the river Soane in France, is found maſſive, forming a ſtratum in ſome places more than 12 feet thick.

Colour greyiſh black or browniſh black, of great intenſity. Luſtre, external, 0; internal, metallic, 1. Soon tarniſhes by expoſure to the air, and then becomes intenſely black. Texture granular. Fracture uneven; ſometimes conchoidal. Often porous. Hardneſs 11. Difficultly frangible. Sp. gr. from 3.950 to 4.10. Abſorbs water. When taken out of water after a minute's immerſion, it has a ſtrong argillaceous ſmell. Conducts electricity nearly as well as if it were in a metallic ſtate ‡. Infuſible by the blow-pipe. Tinges ſoda red; the colour diſappears before the blue cone of flame, and is reproduced by the action of the yellow flame.

From

(q) *Pott. Miſcelan. Berolens*, VI. 40.—*Margraff*, *Mem. Berlin*, 1773, p. 3.—*La Perouſe*, *Jour. de Phyſ.* XVI. 156. and XV. 67. and XXVIII. 68.—*Sage*, *Mem. Par.* 1785, 235.

s of M anese.

From the analyſis of Vauquelin, it appears that it is compoſed of
50.0 white oxyd of manganeſe,
33.7 oxygen,
14.7 barytes,
1.2 ſilica,
.4 charcoal.
100.0 ¶

¶ omieu, Jo de M N° xii 2.

72 Gi ore of m anese. * rwan, ii. 1.

Spcies 2. Grey ore of manganeſe *.

This ore occurs both maſſive and diſſeminated; it is alſo ſometimes cryſtallized in ſlender four ſided priſms or needles.

Colour uſually duſky ſteel grey; ſometimes whitiſh grey, or reddiſh grey. Streak and powder black. External luſtre 3 to 2; internal metallic, 2 to 1. Texture ſtriated or foliated. Hardneſs 4 to 5. Brittle. Sp. gr. from 4.073 † to 4.8165 ‡. Before the blow-pipe darkens: tinges borax reddiſh brown.

† i quelin ‡ ſon.

A ſpecimen of oxyd of manganeſe from the mountains of Voſges, which probably belonged to this ſpecies, and which was analyſed by Vauquelin, was compoſed of
82 oxyd of manganeſe,
7 carbonat of lime,
6 ſilica,
5 water.
100 §

§ ur. de . N° xi 13.

Sometimes it contains a little barytes and iron.

73 B k or b n ore o anga- n * rwan, ii 92 — Il rewood, . Tranſ. i. 284

Species 3. Black or brown ore of manganeſe *

This ore is found ſometimes in the ſtate of powder, and ſometimes indurated in amorphous maſſes of various figures. Colour either black, ſometimes with a ſhade of blue or brown; or reddiſh brown. Streak of the harder ſorts metallic; of the others, black. Luſtre 0 to 1; internal (when it is indurated), metallic. Texture compact. Hardneſs 5 to 7. Sp. gr. 3.7076 to 3.9039; that of the powdery ſometimes only 2. Before the blow-pipe it exhibits the ſame phenomena as the laſt ſpecies.

A ſpecimen of this ore, analyſed by Weſtrum, contained
45.00 manganeſe,
14.00 oxyd of iron,
11.00 ſilica,
7.25 alumina,
2.00 lime,
1.50 oxyd of copper,
18.00 air and water.
98.75

174 C I. Salts. C bonat o anga- n † irwan, ii 97.

Genus II. Salts of manganese.

Species 1. Carbonat of manganeſe †.

White ore of manganeſe.

This ſpecies occurs in Sweden, Norway, and Tranſylvania. It is either in the form of looſe ſcales, or maſſive, or cryſtallized in needles.

Colour white, or reddiſh white. Texture either radiated or ſcaly. Luſtre of the ſcaly 2. Tranſparency 1 to 2. Hardneſs of the maſſive 6 to 9. Sp. gr. 2.794. Effervesces with mineral acids. Heated to redneſs, blackens. Tinges borax violet.

275 Red ore of manganeſe.

Species 2. Red ore of manganeſe †.

Carbonat of manganeſe and iron.

This ſpecies has been found in Piedmont and in the Pyrenees. It is ſometimes in powder, ſometimes maſſive, ſometimes cryſtallized in rhomboidal priſms or needles.

† Kirwan, ii. 297 — Napion, Mem. Turin, iv. 303.

Colour pale roſy red, mixed with white. Powder nearly white. Luſtre 0. Tranſparency 1. Hardneſs 8. Sp. gr. 3.233. Effervesces with nitric and muriatic acids. When heated to redneſs becomes reddiſh brown. Tinges borax red.

A ſpecimen, analyſed by Ruprecht, contained
55 ſilica,
35 oxyd of manganeſe,
7 oxyd of iron,
1.5 alumina.
98.5 §

§ Jour. de Phyſ. xxxi. 32.

Order XVI. ORES OF TUNGSTEN.

As no eaſy method has hitherto been diſcovered of reducing tungſten to a metallic ſtate, we need not be ſurpriſed that it has been applied to no uſe. Ores of tungſten are by no means common. They have hitherto been found only in the primitive mountains. Their gangue is commonly quartz. They very often accompany tin ores.

276 G I. Oxyds. Wolfram.

Genus I. Oxyds of tungsten.

Species 1. Wolfram (r).

Oxyds of tungſten, iron, and *manganeſe—Tungſtat of iron* and *manganeſe.*

This ſpecies is found in different parts of Germany, in Sweden, Britain, France, and Spain; and is almoſt conſtantly accompanied by ores of tin. It occurs both maſſive and cryſtallized. The primitive form of its cryſtals, according to the obſervations of Mr Hauy, is a rectangular parallelopiped ‡, whoſe length is 8.66, whoſe breadth is 5, and thickneſs 4.33 *. It is not common, however, to find cryſtals of this perfect form; in many caſes, the angles, and ſometimes the edges, of the cryſtal are wanting ‡; owing, as Mr Hauy has ſhewn, to the ſuperpoſition of plates, whoſe edges or angles decreaſe according to a certain law †.

‡ Fig. 42.
* Jour. de Min. N° xix. 8.
‡ Fig. 43.
† Jour. de Min. N° xix. 8.

Colour brown or browniſh black. Streak reddiſh brown. Powder ſtains paper with the ſame colour. Luſtre external, 2; internal, 2 to 3; nearly metallic. Texture foliated. Eaſily ſeparated into plates by percuſſion. Hardneſs 6 to 8. Sp. gr. from 7.006 * to 7.333 †. Moderately electric by communication. Not magnetic. Infuſible by the blow-pipe. Forms with borax a greeniſh globule, and with microcoſmic ſalt a tranſparent globule of a deep red ¶.

* Kirwan.
† Hauy.
¶ Vauquelin, Jour. de Min, N° xix. 11.

The ſpecimen of this ore examined by Meſſrs d'Elhuyarts, was compoſed of 65 oxyd of tungſten,
22 oxyd of manganeſe,
13 oxyd of iron.
100

(r) *Kirw.* II. 316.—*De Luyart, Mem. Thouloufe,* II. 141.—*Gmelin, Crell's Jour.* Engliſh tranſ. III. 127, 205, and 293,—*La Perouſe, Jour. de Min.* N° IV. p. 23.

Another ſpecimen from Pays le Mines in France, analyſed by Vauquelin and Hecht, contained

67.00 oxyd of tungſten,
18.00 black oxyd of iron,
6.25 black oxyd of manganeſe,
1.50 ſilica,
7.25 oxyd of the iron and manganeſe.

100.00 §

§ *Vauquelin, Jour. de Min* Nº xix. 11.

Genus II. salts of tungsten.

species 1. Tungſtat of lime (s).

Tungſten.

277 G. II Salts. Tungſtat of lime. This ore, which is now exceedingly ſcarce, has hitherto been found only in Sweden and Germany. It is either maſſive or cryſtallized; and, according to Hauy, the primitive form of its cryſtals is the octohedron †.

† *Jour. de Min.* Nº xxxiii. 657.

Colour yellowiſh white or grey. Luſtre 3 to 2. Tranſparency 2 to 3. Texture foliated. Hardneſs 6 to 9. Sp. gr, 5.8 to 60665. Becomes yellow when digeſted with nitric or muriatic acids. Infuſible by the blow-pipe. With borax forms a colourleſs glaſs, unleſs the borax exceed, and then it is brown. With microcoſmic ſalt it forms a blue glaſs, which loſes its colour by the yellow flame, but recovers it in the blue flame ‡.

‡ *Scheele* and *Bergman.*

It is compoſed of about 70 oxyd of tungſten,
30 lime,

100

with a little ſilica and iron §.

§ *Scheele.*

species 2. Brown tungſtat.

278 Brown tungſtat. This ore is found in Cornwal, and is either maſſive or compoſed of ſmall cryſtalline grains.

Colour grey, variegated with yellow and brown. Luſtre 2, waxy. Hardneſs 6 to 7. Sp. gr. 5.57. Its powder becomes yellow when digeſted in aqua regia.

According to Klaproth, it is compoſed of

88 oxyd of tungſten,
11.5 lime.

99.5

Order XVII. ORES OF MOLYBDENUM.

If ever molybdenum be found in abundance, it will probably be uſeful in dyeing and painting. At preſent it is very ſcarce, having only been found in Sweden, Germany, Carniola, and among the Alpes. Like tin and tungſten, it affects the primitive mountains.

Genus I. sulphuret of molybdenum.

species 1. Common ſulphuret (t).

Molybdena.

279 G. I. Sulphuret. Common ſulphuret. This ore, which is the only ſpecies of molybdenum ore at preſent known, is found commonly maſſive; ſometimes, however, it is cryſtallized in hexahedral tables.

Colour light lead grey; ſometimes with a ſhade of red. Streak bluiſh grey, metallic. Powder bluiſh. Luſtre metallic, 3 to 2. Texture foliated. Lamellæ ſlightly flexible. Hardneſs 4. Sp. gr. 4.569 * to 4.7385 †. Feels greaſy; ſtains the fingers. Marks bluiſh black. A piece of reſin rubbed with this mineral becomes poſitively electric ‡. Inſoluble in ſulphuric and muriatic acids; but in a boiling heat colours them green. Effervesces with warm nitric acid, leaving a grey oxyd undiſſolved. Before the blow-pipe, on a ſilver ſpoon, emits a white ſmoke, which condenſes into a white powder, which becomes blue in the internal, and loſes its colour in the external, flame. Scarcely affected by borax or microcoſmic ſalt. Effervesces with ſoda, and gives it a reddiſh pearl colour.

* *Karſten.*
† *Briſſon.*
‡ *Hauy, Jour. de Min.* Nº xix. 70.

Compoſed of about 60 molybdenum,
40 ſulphur.

100 *

* *Klaproth*

Order XVIII. ORES OF URANIUM.

Uranium has hitherto been found only in Germany, and has not been applied to any uſe. The only two mines where it has occurred are in the primitive mountains.

Genus I. oxyds of uranium.

species 1. Sulphuret of uranium †.

Pechblende.

280 G I. Oxyd Sulphuret of uranium. This ore, which has been found at Johanngeorgenſtadt in Saxony, and Joachimſthal in Bohemia, is either maſſive or ſtratified with other minerals.

† *Kirwan,* ii. 305.

Colour black or browniſh black; ſometimes with a ſhade of grey or blue. Streak darker. Powder opaque and black. Luſtre ſemimetallic, from 3 to 1. Fracture conchoidal. Hardneſs 7 to 8. Very brittle. Sp. gr. from 6.3785 ‡ to 7.5, and even higher §. Imperfectly ſoluble in ſulphuric and muriatic acids; perfectly in nitric acid and aqua regia. Solution wine yellow. Infuſible with alkalies in a crucible: infuſible by the blow-pipe *per ſe*. With borax and ſoda forms a grey opaque ſlag; with microcoſmic ſalt, a green glaſs.

‡ *Morveau, Jour. de Min* Nº xxxii. 610.
§ *Klaproth, Beiträge,* ii. 197.

Compoſed of oxyd of uranium and ſulphur, and mixed with iron and ſilica, and ſometimes lead.

A ſpecimen of this ore from Joachimſthal, analyſed lately by Klaproth, contained

86.5 uranium,
6.0 ſulphuret of lead,
5.0 ſilica,
2.5 oxyd of iron,

100.0 *

* *Beiträge,* ii. 221.

species 2. Yellow oxyd of uranium ‡.

Uranitic ochre.

281 Yellow oxyd of uranium. This ore is generally found on the ſurface of the laſt ſpecies at Johanngeorgenſtadt, and is either maſſive or in powder.

‡ *Kirwan* ii. 303.

Colour yellow, red, or brown. Streak of the yellow ſorts yellow; of the red, orange yellow. Luſtre 0. Slightly ſtains the fingers. Feels meagre. Texture earthy. Hardneſs 3 to 4. Sp. gr. 3.2438 ‖. Infuſible by the blow-pipe; but in a ſtrong heat becomes browniſh grey.

‖ *Hauy, Jour. de Min, ibid.*

Compoſed of oxyd of uranium and oxyd of iron.

Genus

(s) *Kirw.* II. 314.—*Scheele's Works* (French tranſlation), II. 81.—*Bergman, ibid.* p. 94.—*Crell, Chem. Annalen.* 1784. 2 *Band* 195.

(t) *Kirw.* II. 322.—*Scheele's Works* (French tranſlation), I. 236.—*Pelletier, Jour. de Phyſ.* XXVII. 434.—*Ilſemann, ibid.* XXXIII. 292.—*Sage. ibid.* 389.—*Klaproth* and *Modeer, Ann. de Chim.* III. 120.

Genus II. salts of uranium.

species 1. Carbonat of uranium ¶.

282 l. Salts bot at ranium. This ſubſtance is alſo found at Johanngeorgenſtadt, and near Eibenſtock and Rheinbreidenbach §. It is ſometimes amorphous, but more commonly cryſtallized. Its cryſtals are ſquare plates, octohedrons, and ſix ſided priſms.

¶ irwan, 04.
§ nelin.

Colour green ; ſometimes nearly white ; ſometimes, though rarely, yellow. Streak greeniſh white. Luſtre 3 to 2 ; internal, 2 ; ſometimes pearly ; ſometimes nearly metallic. Tranſparency 2 to 3. Texture foliated. Hardneſs 5 to 6. Brittle. Soluble in nitric acid without efferveſcence. Infuſible by alkalies.

Compoſed of carbonat of uranium, with ſome oxyd of copper. When its colour is yellow it contains no copper.

Order XIX. ORES OF TITANIUM.

Titanium has been known for ſo ſhort a time, and its properties are yet ſo imperfectly aſcertained, that many of its uſes muſt remain to be diſcovered. Its oxyd, as we learn from Mr Darcet, has been employed in painting on porcelain *. Hitherto it has been found only in the primitive mountains, the Crapacks †, the Alpes (u), and the Pyrenees ‡. It has been found alſo in Brittany ‖ and in Cornwal.

* four. de in. N° 27.
† bid, N° 51.
‡ our. de in. N° ii. 614.
‖ bid.

Genus I. oxyds of titanium.

species 1. Red oxyd of Titanium.

Red ſhorl—Sagenite.

283 l. Oxyds. d oxyd i.anium. This ore has been found in Hungary, the Pyrenees, the Alpes, and in Brittany in France. It is generally cryſtallized. The primitive form of its cryſtals, according to the obſervations of Mr Hauy, is a rectangular priſm, whoſe baſe is a ſquare ; and the form of its molecules is a triangular priſm, whoſe baſe is a right angled iſoſceles triangle, and the height is to any of the ſides of the baſe about the right angle as $\surd 12$ to $\surd 5$, or nearly as 3 : 2 ¶. Sometimes the cryſtals of titanium are ſix ſided, and ſometimes four-ſided, priſms, and often they are implicated together ‡.

¶ Jour. de in. N° . 28. and xii. 615.
‡ ig, 44.

Colour red or browniſh red. Powder brick or orange red. Luſtre 3. Tranſparency commonly 0 ; ſometimes 1. Texture foliated. Hardneſs 9. Brittle. Sp. gr. from 4.18 * to 4.2469 †. Not affected by the mineral acids. When fuſed with carbonat of potaſs, and diluted with water, a white powder precipitates, heavier than the titanium employed. Before the blow-pipe it does not melt, but becomes opaque and brown. With microcoſmic ſalt it forms a globule of glaſs, which appears black ; but its fragments are violet. With borax it forms a deep yellow glaſs, with a tint of brown. With ſoda it divides and mixes, but does not form a tranſparent glaſs.

* Klaproth.
† Vauquelin d Hecht.

When pure, it is compoſed entirely of oxyd of titanium.

species 2. Menachanite (x).

Oxyd of titanium combined with iron.

284 enachate. This ſubſtance has been found abundantly in the valley of Menachan in Cornwal ; and hence was called menachanite by Mr Gregor, the diſcoverer of it. It is in ſmall grains, like gunpowder, of no determinate ſhape, and mixed with a fine grey ſand. Colour black. Eaſily pulverized. Powder attracted by the magnet. Sp. gr. 4.427. Does not detonate with nitre. With two parts of fixed alkali it melts into an olive coloured maſs, from which nitric acid precipitates a white powder. The mineral acids only extract from it a little iron. Diluted ſulphuric acid, mixed with the powder, in ſuch a proportion that the maſs is not too liquid, and then evaporated to dryneſs, produces a blue coloured maſs. Before the blow pipe does not decrepitate nor melt. It tinges microcoſmic ſalt green ; but the colour becomes brown on cooling : yet microcoſmic ſalt does not diſſolve it. Soluble in borax, and alters its colour in the ſame manner.

According to the analyſis of Mr Gregor, it is compoſed of
46 oxyd of iron,
45 oxyd of titanium.
—
91 with ſome ſilica and manganeſe †.

According to Mr Klaproth's analyſis, it is compoſed of
51.00 oxyd of iron,
45.25 oxyd of titanium,
3.50 ſilica,
.25 oxyd of manganeſe.
—
100.00 ‡

† Mr Gregor, Jour. de Phyſ. xxxix. 72. 152.
‡ Beiträge, ii. 231.

A mineral, nearly of the ſame nature with the one juſt deſcribed, has been found in Bavaria. Its ſpecific gravity, however, is only 3.7. According to the analyſis of Vauquelin and Hecht, it is compoſed of
49 oxyd of titanium,
35 iron,
2 manganeſe,
14 oxygen combined with the iron and manganeſe.
—
100 §

§ Jour. de Min. No xix. 57.

species 3. Calcarco ſiliceous ore of titanium.

Oxyd of titanium combined with lime and ſilica—Titanite †.

285 Calcareo-ſiliceous ore of titanium. This ore has hitherto been found only near Paſſau. It was diſcovered by Profeſſor Hunger. It is ſometimes maſſive, but more commonly cryſtallized in four ſided priſms, not longer than one fourth of an inch.

† Kirwan, ii. 331.

Colour reddiſh, yellowiſh, or blackiſh brown ; ſometimes whitiſh grey. Powder whitiſh grey. Luſtre waxy or nearly metallic, 2 to 3. Tranſparency from 0 to 2. Texture foliated. Hardneſs 9 or more. Brittle. Sp. gr. 3.510. Muriatic acid, by repeated digeſtion, diſſolves one-third of it. Ammonia precipitates from this ſolution a clammy yellowiſh ſubſtance. Infuſible by the blow-pipe, and alſo in a clay crucible ; but in charcoal is converted into a black opaque porous ſlag.

According to the analyſis of Klaproth, it is compoſed of
33 oxyd of titanium,
35 ſilica,
33 lime.
—
101

(u) *Dolomieu, Jour. de Min.* N° XLII. 431. and *Sauſſure, Voyages*, N° 1894.

(x) *Kirw.* II. 326.—*Gregor, Jour. de Phyſ.* XXXIX. 72. and 152.—*Schmeiſſer, Crell's Annals* (Engliſh tranſlation), III. 252.

ORDER XX. ORES OF TELLURIUM.

HITHERTO tellurium has only been found in Tranſylvania. It occurs in three different mines; that of Fatzbay, Offenbanya, and Nagyag, which are conſidered as gold mines, becauſe they contain leſs or more of that metal. Its gangue is commonly quartz.

GENUS I. ALLOYS OF TELLURIUM.

286 G. I. Alloys. White gold ore of Fatzbay.

SPECIES 1. White gold ore of Fatzbay.

Alloy of tellurium and iron, with ſome gold.

This ſpecies is generally maſſive. Its colour is between tin white and lead grey. Luſtre conſiderable, metallic. Texture granular *.

According to Klaproth's analyſis, it is compoſed of

72.0 iron,
25.5 tellurium,
2.5 gold.

100.0 †

287 Graphic golden ore of Offenbanya.

SPECIES 2. Graphic golden ore of Offenbanya.

Tellurium alloyed with gold and ſilver.

This ore is compoſed of flat priſmatic cryſtals; the arrangement of which has ſome reſemblance to Turkiſh letters. Hence the name of the ore.

Colour tin white, with a tinge of braſs yellow ‡. Luſtre metallic, 3. Hardneſs 4 to 5. Brittle. Sp. gr. 5.723. Before the blow-pipe decrepitates, and melts like lead. Burns with a lively brown flame and diſagreeable ſmell, and at laſt vaniſhes in a white ſmoke, leaving only a whitiſh earth ‖.

According to Klaproth's analyſis, it is compoſed of

60 tellurium,
30 gold,
10 ſilver,

100 §

The yellow gold ore of Nagyag would belong to this ſpecies were it not that it contains lead. Its compoſition, according to Klaproth's analyſis, is as follows:

45.0 tellurium,
27.0 gold,
19.5 lead,
8.5 ſilver,

100.0 and an atom of ſulphur *

288 Grey foliated gold ore of Nagyag.

SPECIES 3. Grey foliated gold ore of Nagyag.

This ore is found in plates, of different degrees of thickneſs, adhering to one another, but eaſily ſeparable: theſe are ſometimes hexahedral, and often accumulated ſo as to leave cells between them.

Colour deep lead grey, paſſing to iron black, ſpotted. Luſtre metallic, moderate. Texture foliated; leaves ſlightly flexible †. Hardneſs 6. Sp. gr. 8.919. Stains the fingers. Soluble in acids with efferveſcence ‡.

According to Klaproth, it is compoſed of

50.0 lead,
33.0 tellurium,
8.5 gold,
7.5 ſulphur,
1.0 ſilver and copper.

100.0 §

ORDER XXI. ORES OF CHROMUM.

CHROMUM has hitherto been found in too ſmall quantities for its extenſive application to the arts. Whenever it becomes plentiful, its properties will render it of great importance both to the dyer and painter. Nature has uſed it to colour ſome of her moſt beautiful mineral productions: And can art copy after a better model? Hitherto it has been found only in two places, near Ekaterinbourg in Siberia, and in the department of the Var in France. In the firſt of theſe places, and probably alſo in the ſecond, its gangue is quartz.

GENUS I. SALTS OF CHROMUM.

289 G. I. Salts. Chromat of lead.

SPECIES 1. Chromat of lead.

Red lead ore of Siberia.

This ſingular mineral, which has now become ſcarce, is found in the gold mines of Bereſof near Ekaterimbourg in Siberia, cryſtallized in four-ſided priſms, ſometimes terminated by four-ſided pyramids, ſometimes not.

Colour red, with a ſhade of yellow. Streak and powder a beautiful orange yellow. Luſtre from 2 to 3. Tranſparency 2 to 3. Structure foliated. Texture compact. Fracture uneven. Hardneſs 5 to 4. Sp. gr. 6.0269 † to 5.75 ‡. Does not effervеſce with acids. Before the blow-pipe decrepitates; ſome lead is reduced, and the mineral is converted to a black ſlag, which tinges borax green.

According to the analyſis of Vauquelin, it is compoſed of

65.12 oxyd of lead,
34.88 chromic acid.

100.00 ‖.

290 Chromat of iron.

SPECIES 2. Chromat of iron.

This mineral, which has been found only near Gaſſin in the department of Var in France, is in irregular maſſes.

Colour brown, not unlike that of brown blende. Luſtre metallic. Hardneſs moderate. Sp. gr. 4.0326. Melts with difficulty before the blow pipe; to borax it communicates a dirty green. Inſoluble in nitric acid. Melted with potaſs, and diſſolved in water, the ſolution aſſumes a beautiful orange yellow colour.

It is compoſed of 63.6 chromic acid,
36.0 oxyd of iron.

99.6 †

CHAP. IV. OF THE CHEMICAL ANALYSIS OF MINERALS.

291 Analyſis of minerals.

THE progreſs which the art of analyſing minerals has made within theſe laſt twenty years is truly aſtoniſhing. To ſeparate five or ſix ſubſtances intimately combined together, to exhibit each of them ſeparately, to aſcertain the preciſe quantity of each, and even to detect the preſence and the weight of ſubſtances which do not approach $\frac{1}{100}$th part of the compound, would, at no very remote period, have been conſidered as a hopeleſs, if not an impoſſible, taſk; yet this can now be done with the moſt rigid accuracy.

292 Begun by Margraff.

The firſt perſon who undertook the analyſis of minerals was Margraff of Berlin. His attempts were indeed rude; but their importance was ſoon perceived by other chemiſts, particularly by Bergman and Scheele, whoſe

---

* Ann. de Chim. xxv. 327.

† Ibid. 280.

‡ Ann. de Chim. xxv. 328.

‖ De Born, Kirwan's Min. ii. 101.

§ Ann. de Chim. xxv. 280.

* Ibid.

† Klaproth, Ann. de Chim. xxv. 329.

‡ De Born, Kirwan's Min. ii. 99.

§ Ann. de Chim. ibid. 280.

† Briſſon.

‡ Bindheim.

‖ Jour. de Min. N° xxxiv. 760.

† Taſſaert, Ann. de Chim. xxxi. 220.

Ana is of Mi als.

whoſe induſtry and addreſs brought the art of analyſing minerals to a conſiderable degree of perfection.

Imp ed by K . prot

But their methods, though they had very conſiderable merit, and, conſidering the ſtate of the ſcience, are wonderful proofs of the genius of the inventors, were often tedious and uncertain, and could not in all caſes be applied with confidence. Theſe defects were perceived by Mr Klaproth of Berlin, who applied himſelf to the analyſis of minerals with a perſevering induſtry which nothing could fatigue, and an ingenuity and accuracy which nothing could perplex. He corrected what was wrong, and ſupplied what was wanting, in the analytical method; invented new proceſſes, diſcovered new inſtruments; and it is to his labours, more than to thoſe of any other chemiſt, that the degree of perfection, to which the analyſis of minerals has attained, is to be aſcribed. Many improvements, however, were introduced by other chemiſts, eſpecially by Mr Vauquelin, whoſe analyſes in point of accuracy and ingenuity rival thoſe of Klaproth himſelf.

And her cher ts.

We ſhall, in this chapter, give a ſhort deſcription of the moſt perfect method of analyſing minerals, as far as we are acquainted with it. We ſhall divide the chapter into four ſections. In the firſt, we ſhall give an account of the inſtruments uſed in analyſes; in the ſecond, we ſhall treat of the method of analyſing ſtones; in the third, of analyſing combuſtibles; and in the fourth, of the analyſes of ores.

SECT. I. *Of the Inſtruments of Analyſes.*

Me d of obta ng cher al a- gent ure.

I. The chemical agents, by means of which the analyſis of minerals is accompliſhed, ought to be prepared with the greateſt care, becauſe upon their purity the exactneſs of the operation entirely depends. Theſe agents are the three alkalies, both pure and combined with carbonic acid; the ſulphuric, nitric, and muriatic acids; hydroſulphuret of potaſs and ſulphurated hydrogen gas diſſolved in water; pruſſic alkali, and a few neutral ſalts.

1. Potaſs and ſoda may be obtained pure, either by means of alcohol, or by the method deſcribed in the article CHEMISTRY, nº 372. *Suppl.* Theſe alkalies are known to be pure when their ſolution in pure water occaſions no precipitate in lime and barytic water; when the precipitate which it produces in a ſolution of ſilver is completely diſſolved by nitric acid; and, laſtly, when ſaturated with carbonic acid it depoſits no ſilica.

2. Ammonia is procured by diſtilling one part of muriat of ammonia with two parts of quicklime, and receiving the gas in a diſh containing a quantity of pure water, equal in weight to the muriat employed. Its purity is known by the ſame teſts which aſcertain the purity of fixed alkalies.

3. The carbonats of potaſs and ſoda may be formed by diſſolving the potaſs and ſoda of commerce in pure water, ſaturating the ſolution with carbonic acid, and cryſtallizing them repeatedly. When pure, theſe cryſtals effloreſce in the air; and the precipitate which they occaſion in ſolutions of barytes and of ſilver is completely ſoluble in nitric acid. Carbonat of ammonia is obtained by diſtilling together one part of muriat of ammonia and two parts of carbonat of lime.

4. The ſulphuric acid of commerce often contains nitric acid, potaſs, lead, &c. It may be purified by diſtillation in a low cucurbite. The firſt portion, when it comes over, muſt be ſet aſide; it contains the nitric acid. The other impurities remain behind in the cucurbite. Sulphuric acid, when pure, diſſolves indigo without altering its colour, does not attack mercury while cold, and cauſes no precipitate in pure alkaline ſolutions.

Analyſis of Minerals.

5. Nitric acid often contains both ſulphuric and muriatic acids. It is eaſily purified by throwing into it about three parts of litharge in fine powder for every 100 parts of the acid, allowing the mixture to remain for 24 hours, ſhaking it occaſionally, and then diſtilling it. The ſulphuric and muriatic acids combine with the lead, and remain behind in the retort. Pure nitric acid occaſions no precipitate in the ſolutions of barytes and ſilver.

6. The muriatic acid of commerce uſually contains ſulphuric acid, oxymuriatic acid, and oxyd of iron. It may be purified by diſtillation with a little muriat of ſoda; taking care to ſet aſide the firſt portion which comes over. When pure it cauſes no precipitate in the ſolution of barytes, nor of pure alkalies, and does not attack mercury while cold.

7. Hydroſulphuret of potaſs is made by ſaturating a ſolution of pure potaſs with ſulphurated hydrogen gas; and water may be ſaturated with ſulphurated hydrogen gas in the ſame manner. See CHEMISTRY, nº 857. *Suppl.*

8. The method of preparing pruſſic alkali, oxalic acid, and the other ſubſtances uſed in analyſes, has been already deſcribed in the article CHEMISTRY, *Suppl.* it is unneceſſary therefore to repeat it here.

296
How to reduce the mineral to powder.

II. Before a mineral is ſubmitted to analyſis, it ought to be reduced to an impalpable powder. This is by no means an eaſy taſk when the ſtone is extremely hard It ought to be raiſed to a bright red or white heat in a crucible, and then inſtantly thrown into cold water. This ſudden tranſition makes it crack and break into pieces. If theſe pieces are not ſmall enough, the operation may be repeated on each till they are reduced to the proper ſize. Theſe fragments are then to be beaten to ſmall pieces in a poliſhed ſteel mortar; the cavity of which ſhould be cylindrical, and the ſteel peſtle ſhould fit it exactly, in order to prevent any of the ſtone from eſcaping during the act of pounding. As ſoon as the ſtone is reduced to pretty ſmall pieces, it ought to be put into a mortar of rock cryſtal or flint, and reduced to a coarſe powder. This mortar ſhould be about four inches in diameter, and rather more than an inch in depth. The peſtle ſhould be formed of the ſame ſtone with the mortar, and care ſhould be taken to know exactly the ingredients of which this mortar is compoſed. Klaproth's mortar is of flint. We have given its analyſis in nº 32. of this article.

When the ſtone has been reduced to a coarſe powder, a certain quantity, whoſe weight is known exactly, 100 grains for inſtance, ought to be taken and reduced to as fine a powder as poſſible. This is beſt done by pounding ſmall quantities of it at once, not exceeding 10 grains. The powder is as fine as poſſible when it feels ſoft, adheres together, and as it were forms a cake under the peſtle. It ought then to be weighed exactly. It will almoſt always be found heavier after being pounded than it was before; owing to a certain quantity of the ſubſtance of the mortar which has been rubbed off during the grinding and mixed with the powder.

der. This additional weight muſt be carefully noted ; and after the analyſis, a portion of the ingredients of the mortar, correſponding to it, muſt be ſubtracted.

297 Chemical diſhes. III. It is neceſſary to have a crucible of pure ſilver, or, what is far preferable, of platinum, capable of holding rather more than ſeven cubic inches of water, and provided with a cover of the ſame metal. There ſhould alſo be ready a ſpatula of the ſame metal about four inches long.

The diſhes in which the ſolutions, evaporations, &c. are performed, ought to be of glaſs or porcelain. Thoſe of porcelain are cheaper, becauſe they are not ſo apt to break. Thoſe which Mr Vauquelin uſes are of porcelain ; they are ſections of ſpheres, and are glazed both within and without, except that part of the bottom which is immediately expoſed to the fire.

Sect. II. *Analyſis of Stones* (y).

298 Ingredients of ſtones. The only ſubſtances which enter into the compoſition of the ſimple ſtones, as far at leaſt as analyſis has diſcovered, are the ſix earths, ſilica, alumina, zirconia, glucina, lime, and magneſia ; and the oxyds of iron, mangaeſe, nickel, chromum, and copper (z). Seldom more than four or five of theſe ſubſtances are found combined together in the ſame ſtone : we ſhall ſuppoſe, however, in order to prevent unneceſſary repetitions, that they are all contained in the mineral which we are going to analyſe.

259 Method of decompoſing ſtones. Let 100 or 200 grains of the ſtone to be analyſed, previouſly reduced to a fine powder, be mixed with three times its weight of pure potaſs and a little water, and expoſed in the ſilver or platinum crucible to a ſtrong heat. The heat ſhould at firſt be applied ſlowly, and the matter ſhould be conſtantly ſtirred, to prevent the potaſs from ſwelling and throwing any part out of the crucible. When the whole water is evaporated, the mixture ſhould be kept for half an hour or three quarters in a ſtrong red heat.

If the matter in the crucible melts completely, and appears as liquid as water, we may be certain that the ſtone which we are analyſing conſiſts chiefly of ſilica ; if it remains opaque, and of the conſiſtence of paſte, the other earths are moſt abundant ; if it remains in the form of a powder, alumina is the prevalent earth. If the matter in the crucible be of a dark or browniſh red colour, it contains oxyd of iron ; if it is graſs green, mangaeſe is preſent ; if it is yellowiſh green, it contains chromum.

When the crucible has been taken from the fire and wiped on the outſide, it is to be placed in a capſule of porcelain, and filled with water. This water is to be renewed from time to time till all the matter is detached from the crucible. The water diſſolves a part of the combination of the alkali with the ſilica and alumina of the ſtone, and if a ſufficient quantity were uſed, it would diſſolve the whole of that combination.

Muriatic acid is now to be poured in till the whole of the matter is diſſolved. At firſt a flaky precipitate appears, becauſe the acid combines with the alkali which kept it in ſolution. Then an efferveſcence takes place, owing to the decompoſition of ſome carbonat of potaſs formed during the fuſion. At the ſame time the flaky precipitate is rediſſolved ; as is alſo that part of the matter which, not having been diſſolved in the water, had remained at the bottom of the diſh in the form of a powder. This powder, if it conſiſts only of ſilica and alumina, diſſolves without efferveſcence ; but if it contains lime, an efferveſcence takes place.

If this ſolution in muriatic acid be colourleſs, we may conclude that it contains no metallic oxyd, or only a very ſmall portion ; if its colour be purpliſh red, it contains mangaeſe ; orange red indicates the preſence of iron ; and golden yellow the preſence of chromum.

This ſolution is to be poured into a capſule of porcelain, covered with paper, and evaporated to dryneſs in a ſand bath. When the evaporation is drawing towards its completion, the liquor aſſumes the form of jelly. It muſt then be ſtirred conſtantly with a glaſs or porcelain rod, in order to facilitate the diſengagement of the acid and water, and to prevent one part of the matter from being too much, and another not ſufficiently dried. Without this precaution, the ſilica and alumina would not be completely ſeparated from each other.

300 How the ſilica is ſeparated. When the matter is reduced almoſt to a dry powder, a large quantity of pure water is to be poured on it ; and, after expoſure to a ſlight heat, the whole is to be poured on a filter. The powder which remains upon the filter is to be waſhed repeatedly, till the water with which it has been waſhed ceaſes to precipitate ſilver from its ſolutions. This powder is the whole of the *ſilica* which the ſtone that we are analyſing contained. It muſt firſt be dried between folds of blotting paper, then heated red hot in a platinum or ſilver crucible, and weighed while it is yet warm. It ought to be a fine powder, of a white colour, not adhering to the fingers, and entirely ſoluble in acids. If it be coloured, it is contaminated with ſome metallic oxyd ; and ſhews, that the evaporation to dryneſs has been performed at too high a temperature. To ſeparate this oxyd, the ſilica muſt be boiled with an acid, and then waſhed and dried as before. The acid ſolution muſt be added to the water which paſſed through the filter, and which we ſhall denominate A.

The watery ſolution A is to be evaporated till its quantity does not exceed 30 cubic inches, or nearly an Engliſh pint. A ſolution of carbonat of potaſs is then to be poured into it till no more matter precipitates. It ought to be boiled a few moments to enable all the precipitate to fall to the bottom. When the whole of the precipitate has collected at the bottom, the ſupernatant liquid is to be decanted off ; and water being ſubſtituted in its place, the precipitate and water are to be thrown upon a filter. When the water has run off, the filter with the precipitate upon it is to be placed between folds of blotting paper. When the precipitate has acquired ſome conſiſtence, it is to be carefully collected by an ivory knife, mixed with a ſolution of pure potaſs, and boiled in a porcelain capſule. If any alumina

---

(y) Part of this ſection is to be conſidered as an abſtract of a treatiſe of Vauquelin on the analyſis of ſtones, publiſhed in the *Annales de Chimie*, Vol. XXX. p. 66.

(z) Barytes has alſo been diſcovered in one ſingle ſtone, the *ſtaurolite* ; but its preſence in ſtones is ſo uncommon, that it can ſcarcely be looked for. The method of detecting it ſhall be noticed afterwards.

alumina or glucina be preſent, they will be diſſolved in the potaſs; while the other ſubſtances remain untouched in the form of a powder, which we ſhall call B.

3 And e alun 3,

Into the ſolution of potaſs as much acid muſt be poured as will not only ſaturate the potaſs, but alſo completely rediſſolve any precipitate which may have at firſt appeared. Carbonat of ammonia is now to be added in ſuch quantity that the liquid ſhall taſte of it. By this addition the whole of the alumina will be precipitated in white fleaks, and the glucina will remain diſſolved, provided the quantity of carbonat of ammonia uſed be not too ſmall. The liquid is now to be filtered, and the alumina which will remain on the filter is to be waſhed, dried, heated red hot, and then weighed. To ſee if it be really alumina, diſſolve it in ſulphuric acid, and add a ſufficient quantity of ſulphat or acetite of potaſs; if it be alumina, the whole of it will be converted into cryſtals of alum.

Glu a,

Let the liquid which has paſſed through the filter be boiled for ſome time, and the glucina, if it contains any, will be precipitated in a light powder, which may be dried and weighed. When pure, it is a fine, ſoft, very light, taſteleſs powder, which does not concrete when heated, as alumina does.

Li e,

The reſiduum B may contain lime, magneſia, and one or more metallic oxyds. Let it be diſſolved in weak ſulphuric acid, and the ſolution evaporated to dryneſs. Pour a ſmall quantity of water on it. The water will diſſolve the ſulphat of magneſia, and the metallic ſulphats; but the ſulphat of lime will remain undiſſolved. Let it be heated red hot in a crucible, and weighed. The lime amounts to 0.41 of the weight.

Let the ſolution containing the remaining ſulphats be diluted with a large quantity of water, let a ſmall exceſs of acid be added, and then let a ſaturated carbonat of potaſs be poured in. The oxyds of chromum, iron, and nickel, will be precipitated, and the magneſia and oxyd of mangneſe will remain diſſolved. The precipitate we ſhall call C.

M a- nef

Into the ſolution let a ſolution of hydroſulphuret of potaſs be poured, and the manganeſe will be precipitated in the ſtate of a hydroſulphuret. Let it be calcined in contact with air, and weighed.

Ma ſia,

The magneſia may then be precipitated by pure potaſs, waſhed, expoſed to a red heat, and then weighed.

Chr um,

Let the reſiduum C be boiled repeatedly with nitric acid, then mixed with pure potaſs; and after being heated, let the liquid be decanted off. Let the precipitate, which conſiſts of the oxyds of iron and nickel, be waſhed with pure water; and let this water be added to the ſolution of the nitric acid and potaſs. That ſolution contains the chromum converted into an acid. Add to this ſolution an exceſs of muriatic acid, and evaporate till the liquid aſſumes a green colour; then add a pure alkali: The chromum precipitates in the ſtate of an oxyd, and may be dried, and weighed.

Ir ,

Let the precipitate, conſiſting of the oxyds of iron and nickel, be diſſolved in muriatic acid; add an exceſs of ammonia: the oxyd of iron precipitates. Let it be waſhed, dried, and weighed.

3 And kel.

Evaporate the ſolution, and the oxyd of nickel will alſo precipitate; and its weight may be aſcertained in the ſame manner with the other ingredients.

The weights of all the ingredients obtained are now to be added together, and their ſum total compared with the weight of the matter ſubmitted to analyſis. If the two are equal, or if they differ only by .03 or .04 parts, we may conclude that the analyſis has been properly performed: but if the loſs of weight be conſiderable, ſomething or other has been loſt. The analyſis muſt therefore be repeated with all poſſible care. If there is ſtill the ſame loſs of weight, we may conclude that the ſtone contains ſome ſubſtance, which has either evaporated by the heat, or is ſoluble in water.

309 Method of detecting volatile bodies.

A freſh portion of the ſtone muſt therefore be broken into ſmall pieces, and expoſed in a porcelain crucible to a ſtrong heat. If it contains water, or any other volatile ſubſtance, they will come over into the receiver; and their nature and weight may be aſcertained.

If nothing comes over into the receiver, or if what comes over is not equal to the weight wanting, we may conclude that the ſtone contains ſome ingredient which is ſoluble in water.

310 Method of aſcertaining whether ſtones contain potaſs

To diſcover whether it contains *potaſs*, let the ſtone, reduced to an impalpable powder, be boiled five or ſix times in ſucceſſion, with very ſtrong ſulphuric acid, applying a pretty ſtrong heat towards the end of the operation, in order to expel the exceſs of acid; but taking care that it be not ſtrong enough to decompoſe the ſalts which have been formed.

Water is now to be poured on, and the reſiduum, which does not diſſolve, is to be waſhed with water till it becomes taſteleſs. The watery ſolution is to be filtered, and evaporated to dryneſs, in order to drive off any exceſs of acid which may be preſent. The ſalts are to be again diſſolved in water: and the ſolution, after being boiled for a few moments, is to be filtered and evaporated to a conſiſtence proper for cryſtallizing. If the ſtone contains a ſufficient quantity of alumina, and if potaſs be preſent, cryſtals of alum will be formed; and the quantity of potaſs may be diſcovered by weighing them, it being nearly $\frac{1}{10}$th of their weight. If the ſtone does not contain alumina, or not in ſufficient quantity, a ſolution of pure alumina in ſulphuric acid muſt be added. Sometimes the alum, even when potaſs is preſent, does not appear for ſeveral days, or even weeks; and ſometimes, when a great quantity of alumina is preſent, if the ſolution has been too much concentrated by evaporation, the ſulphat of alumina prevents the alum from cryſtallizing at all. Care, therefore, muſt be taken to prevent this laſt ſource of error. The alum obtained may be diſſolved in water, and barytic water poured into it as long as any precipitate forms. The liquor is to be filtered, and evaporated to dryneſs. The reſiduum will conſiſt of potaſs and a little carbonat of potaſs. The potaſs may be diſſolved in a little water. This ſolution, evaporated to dryneſs, gives us the potaſs pure; which may be examined and weighed.

311 Or ſoda.

If no cryſtals of alum can be obtained, we muſt look for ſome other ſubſtance than potaſs. The ſtone, for inſtance, may contain ſoda. The preſence of this alkali may be diſcovered by decompoſing the ſolution in ſulphuric acid, already deſcribed, by means of ammonia. The liquid which remains is to be evaporated to dryneſs, and the reſiduum is to be calcined in a crucible. By this method, the ſulphat of ammonia will be volatilized, and the ſoda will remain. It may be rediſſolved in water, cryſtallized, and examined.

If ſulphuric acid does not attack the ſtone, as is often the caſe, it muſt be decompoſed by fuſion with ſoda, da, in the ſame manner as formerly directed with potaſs. The matter, after fuſion, is to be diluted with water, and then ſaturated with ſulphuric acid. The ſolution is to be evaporated to dryneſs, the reſiduum again diſſolved in water, and evaporated. Sulphat of ſoda will cryſtallize firſt; and by a ſecond evaporation, if the ſtone contains potaſs and alumina, cryſtals of alum will be depoſited.

The preſence of potaſs may be diſcovered, by mixing with a ſomewhat concentrated ſolution of muriat of platinum, the ſalt obtained, either by decompoſing the ſtone immediately by an acid, or by ſaturating with an acid the matter obtained by fuſing the ſtone with ſoda. If any potaſs be preſent, a very red precipitate will be formed. This precipitate is a triple ſalt, compoſed of potaſs, muriatic acid, and oxyd of platinum. Ammonia, indeed, produces the ſame precipitate; but ammonia has not hitherto been diſcovered in ſtones.

312 Analyſis of ſaline ſtones,

In this manner may ſimple ſtones and aggregates be analyſed. As to ſaline ſtones, their analyſis muſt vary according to the acid which they contain. But almoſt all of them may be decompoſed by one or other of two methods; of each of which we ſhall give an example.

I. Analyſis of Carbonat of Strontites.

313 Of Carbonats,

Klaproth analyſed this mineral by diſſolving 100 parts of it in diluted muriatic acid: during the ſolution, 30 parts of carbonic acid eſcaped. The ſolution cryſtallized in needles, and when diſſolved in alcohol, burnt with a purple flame. Therefore it contained ſtrontites. He diſſolved a grain of ſulphat of potaſs in ſix ounces of water, and let fall into it three drops of the muriatic ſolution. No precipitate appeared till next day. Therefore the ſolution contained no barytes; for if it had, a precipitate would have appeared immediately.

He then decompoſed the muriatic acid ſolution, by mixing it with carbonat of potaſs. Carbonat of ſtrontites precipitated. By the application of a ſtrong heat, the carbonic acid was driven off. The whole of the earth which remained was diſſolved in water. It cryſtallized; and when dried, weighed 69½ *.

II. Analyſis ol Sulphat of Strontites.

Mr Vauquelin analyſed an impure ſpecimen of this mineral as follows:

314 Sulphats,

On 200 parts of the mineral, diluted nitric acid was poured. A violent effervescence took place, and part of the mineral was diſſolved. The undiſſolved portion, after being heated red hot, weighed 167. Therefore 33 parts were diſſolved.

The nitric ſolution was evaporated to dryneſs: A reddiſh ſubſtance remained, which indicated the preſence of oxyd of iron. This ſubſtance was rediſſolved in water, and ſome ammonia mixed with it; a reddiſh precipitate appeared, which, when dried, weighed 1, and was oxyd of iron. The remainder of the ſolution was precipitated by carbonat of potaſs. The precipitate weighed, when dried, 20, and poſſeſſed the properties of carbonat of lime. Therefore 200 parts of this mineral contain 20 of carbonat of lime, 1 of oxyd of iron, and the remainder of the 33 parts he concluded to be water.

The 167 parts, which were inſoluble in nitric acid, were mixed with 500 parts of carbonat of potaſs, and 7000 parts of water, and boiled for a conſiderable time. The ſolution was then filtered, and the reſiduum waſhed and dried. The liquid ſcarcely effervesced with acids; but with barytes it produced a copious precipitate, totally indiſſoluble in muriatic acid. Therefore it contained ſulphuric acid.

The undiſſolved reſiduum, when dried, weighed 129 parts. It diſſolved completely in muriatic acid. The ſolution cryſtallized in needles; when diſſolved in alcohol, it burnt with a purple flame; and, in ſhort, had all the properties of muriat of ſtrontites. Therefore theſe 129 parts were carbonat of ſtrontites. Now, 100 parts of this carbonat contain 30 of carbonic acid; therefore 129 contain 38.7. Therefore the mineral muſt contain in 200 parts 90.3 of ſtrontites.

Now, the inſoluble reſiduum of 167 parts was pure ſulphat of ſtrontites; and we have ſeen that it contained 90.3 of ſtrontites. Therefore the ſulphuric acid muſt amount to 76.7 parts †.

Nearly in the ſame manner as in the firſt of theſe examples, may the analyſis of carbonat of lime and barytes be performed; and nearly in the ſame manner with the ſecond, we may analyſe the ſulphats of lime and barytes.

315 Phoſphat

Phoſphat of lime may be diſſolved in muriatic acid, and the lime precipitated by ſulphuric acid, and its quantity aſcertained by decompoſing the ſulphat of lime obtained. The liquid ſolution may be evaporated to the conſiſtence of honey, mixed with charcoal powder, and diſtilled in a ſtrong heat. By this means phoſphorus will be obtained. The impurities with which the phoſphat may be contaminated will partly remain undiſſolved, and be partly diſſolved, in muriatic acid. They may be detected and aſcertained by the rules laid down in the ſecond ſection of this chapter.

316 Fluat.

The fluat of lime may be mixed with ſulphuric acid and diſtilled. The fluoric acid will come over in the form of gas, and its weight may be aſcertained. What remains in the retort, which will conſiſt chiefly of ſulphat of lime, may be analyſed by the rules already laid down.

317 And borats.

The borat of lime may be diſſolved in nitric or ſulphuric acid: The ſolution may be evaporated to dryneſs, and the boracic acid ſeparated from the reſiduum by means of alcohol, which will diſſolve it without acting on any of the other ingredients. The remainder of the dry maſs may be analyſed by the rules laid down in Sect. II. of this Chapter.

SECT. III. *Of the Analyſis of Combuſtibles.*

THE only combuſtibles of whoſe analyſis it will be neceſſary to ſpeak are coals and ſulphur; for the method of analyſing the diamond and oil has already been given in the article CHEMISTRY, *Suppl.*

318 Earths coal ho examin

Coal is compoſed of carbon, bitumen, and ſome portion of earth. The earths may be detected by burning completely a portion of the coal to be analyſed. The aſhes which remain after incineration conſiſt of the earthy part. Their nature may be aſcertained by the rules laid down in Sect. II. of this Chapter.

For the method of aſcertaining the proportion of carbon and bitumen in coal, we are indebted to Mr Kirwan.

31 Metho detect the re propo of cha and bi men.

When nitre is heated red hot, and charcoal is thrown on it, a violent detonation takes place; and if the quantity of charcoal be ſufficient, the nitre is completely decompoſed. Now, it requires a certain quantity of pure carbon

---

* *Klaproth's Beiträge*, i. 260.

† *Jour. de Min* N° xxxvii. p.

carbon to decompoſe a given weight of nitre. From the experiments of Lavoiſier, it follows, that when the detonation is performed in cloſe veſſels under water, 13.31 parts of charcoal are capable of decompoſing 100 parts of nitre*. But when the detonation is performed in an open crucible, a ſmaller proportion of charcoal is neceſſary, becauſe part of the nitre is decompoſed by the action of the ſurrounding air. Scheele found, that under theſe circumſtances 10 parts of plumbago were ſufficient to decompoſe 96 parts of nitre, and Mr Kirwan found, that nearly the ſame quantity of charcoal was ſufficient for producing the ſame effect.

Macquer long ago obſerved, that no volatile oily matter will detonate with nitre, unleſs it be previouſly reduced to a charcoal; and that then its effect upon nitre is preciſely proportional to the charcoal which it contains†. Mr Kirwan, upon trying the experiment with *vegetable pitch* and *maltha*, found, that theſe ſubſtances did not detonate with nitre, but merely burn upon its ſurface with a white or yellow flame; and that after they were conſumed, nearly the ſame quantity of charcoal was neceſſary to decompoſe the nitre which would have been required if no bitumen had been uſed at all‡. Now coals are chiefly compoſed of charcoal and bitumen. It occurred therefore to Mr Kirwan, that the quantity of charcoal which any coal contains may be aſcertained by detonating it with nitre: For ſince the bitumen of the coal has no effect in decompoſing nitre, it is evident that the detonation and decompoſition muſt be owing to the charcoal of the coal; and that therefore the quantity of coal neceſſary to decompoſe a given portion of nitre will indicate the quantity of carbon which it contains: and the proportion of charcoal and earth which any coal contains being aſcertained, its bituminous part may be eaſily had from calculation.

The crucible which he uſed in his experiments was large; it was placed in a wind furnace at a diſtance from the flue, and the heat in every experiment was as equal as poſſible. The moment the nitre was red hot, the coal, previouſly reduced to ſmall pieces of the ſize of a pin head, was projected in portions of one or two grains at a time, till the nitre would no longer detonate; and every experiment was repeated ſeveral times to enſure accuracy.

He found, that 480 grains of nitre required 50 grains of Kilkenny coal to decompoſe it by this method. Therefore 10 grains would have decompoſed 96 of nitre; preciſely the quantity of charcoal which would have produced the ſame effect. Therefore Kilkenny coal is compoſed almoſt entirely of charcoal.

Cannel coal, when incinerated, left a reſiduum of 3.12 in the 100 parts of earthy aſhes. 66.5 grains of it were required to decompoſe 480 grains of nitre; but 50 parts of charcoal would have been ſufficient: therefore 66.5 grains of cannel coal contain 50 grains of charcoal, and 2.08 of earth; the remaining 14.42 grains muſt be bitumen. In this manner may the compoſition of any other coal be aſcertained.

20 M hod of ar ſing fu ur.

As for ſulphur, in order to aſcertain any accidental impurities with which it may be contaminated, it ought to be boiled in thirty times its weight of water, afterwards in diluted muriatic acid, and laſtly in diluted nitro-muriatic acid. Theſe ſubſtances will deprive it of all its impurities without acting on the ſulphur itſelf, at leaſt if the proper cautions be attended to. The ſulphur may then be dried and weighed. The deficiency in weight will mark the quantity of the ſubſtances which contaminate the ſulphur. The ſolutions may be evaporated and examined, according to the rules laid down in the ſecond and fourth ſections of this chapter.

SECT. IV. *Of the Analyſis of Ores.*

321 No general method of analyſing ores.

THE method of analyſing ores muſt vary conſiderably, according to the metals which they are ſuſpected to contain. A general method, therefore, of analyſing would be of no uſe, even if it could be given, becauſe it would be too complicated ever to be practiſed. We ſhall content ourſelves with exhibiting a ſufficient number of the analyſes of ores, to take in moſt of the caſes which can occur. He who wiſhes for more information on the ſubject, may conſult the treatiſe of Bergman on the *Analyſes of Ores*; Mr Kirwan's treatiſe on the ſame ſubject; and, above all, he ought to ſtudy the numerous analyſes of ores which have been publiſhed by Mr Klaproth.

I. Analyſis of Red Silver Ore.

322 Method of analyſing red ſilver ore.

Mr Vauquelin analyſed this ore as follows:

He reduced 100 parts of it to fine powder, poured over it 500 parts of nitric acid previouſly diluted with water, and applied a gentle heat to the mixture. The colour of the powder, which before the mixture with nitric acid was a deep purple, became gradually lighter, till at laſt it was pure white. During this change no nitrous gas was extricated; hence he concluded, that the metals in the ore were in the ſtate of oxyds.

When the nitric acid, even though boiled gently, did not appear to be capable of diſſolving any more of the powder, it was decanted off, and the reſiduum, after being carefully waſhed, weighed 42.06.

Upon theſe 42.06 parts concentrated muriatic acid was poured; and by the application of heat, a conſiderable portion was diſſolved. The reſiduum was repeatedly waſhed with muriatic acid, and then dried. Its weight was 14.6666. One portion of theſe 14.6666 parts, when thrown upon burning coals, burnt with a blue flame and ſulphureous ſmell. Another portion ſublimed in a cloſe veſſel without leaving any reſiduum. In ſhort, they had all the properties of ſulphur. Therefore 100 parts of red ſilver ore contain 14.6666 of ſulphur.

The muriatic acid ſolution was now diluted with a great quantity of water; it became milky, and depoſited a white flaky powder, which when waſhed and dried weighed 21.25. This powder, when heated with tartar in a crucible, was converted into a bluiſh white brittle metal, of a foliated texture, and poſſeſſing all the other properties of antimony. Red ſilver ore therefore contains 21.25 of oxyd of antimony.

The ſolution in nitric acid remained now to be examined. When muriatic acid was poured into it, a copious white precipitate appeared, which, when waſhed and dried, weighed 72.66. It had all the properties of muriat of ſilver. According to Mr Kirwan's tables, 72.66 of muriat of ſilver contain 60.57 of oxyd of ſilver. Therefore red ſilver ore, according to this analyſis, is compoſed of

60.57 oxyd of ſilver,
21.25 oxyd of antimony,
14.66 ſulphur.
96.48

---

* em. Sç E- trc xi. 62

† acquer's D onary, 2 dit. p. 1.

‡ inera- lo ii. 5

The loſs, which amounts to 3.52 parts, is to be aſcribed to unavoidable errors which attend ſuch experiments.

II. Antimoniated Silver Ore.

323 Analyſis of antimoniated ſilver ore. Klaproth analyſed this ore as follows:

On 100 parts of the ore, reduced to a fine powder, he poured diluted nitric acid, raiſed the mixture to a boiling heat, and after pouring off the acid, added new quantities repeatedly, till it would diſſolve nothing more. The reſiduum was of a greyiſh yellow colour, and weighed, when dry, 26.

Theſe 26 parts he digeſted in a mixture of nitric and muriatic acid; part was diſſolved, and part ſtill remained in the form of a powder. This reſiduum, when waſhed and dried, weighed 13 parts. It had the properties of ſulphur; and when burnt, left a reſiduum of one part, which had the properties of ſilica. Antimoniated ſilver ore, therefore, contains, in the 100 parts, 12 parts of ſulphur and 1 of ſilica.

When the nitro-muriatic ſolution was diluted with about 20 times its weight of water, a white precipitate appeared; which, when heated to redneſs, became yellow. Its weight was 13. No part evaporated at a red heat: therefore it contained no arſenic. On burning coals, eſpecially when ſoda was added, part was reduced to a metal, having the properties of antimony; and in a pretty high heat, the whole evaporated in a grey ſmoke. Theſe 13 parts were therefore oxyd of antimony: They contain about 10 parts of metallic antimony; and as the ſtate of oxyd was produced by the action of the nitric acid, we may conclude, that antimoniated ſilver ore contains 10 parts of antimony.

The nitric acid ſolution remained ſtill to be examined. It was of a green colour. When a ſolution of common ſalt was poured in, a white precipitate was obtained, which poſſeſſed the properties of muriat of ſilver. When dried, it weighed 87.75 parts; and when reduced, 65.81 parts of pure ſilver were obtained from it. Antimoniated ſilver ore, therefore, contains 65.81 of ſilver.

Into the nitric acid ſolution, thus deprived of the ſilver, he dropped a little of the ſolution of ſulphat of ſoda; but no precipitate appeared. Therefore it contained no lead.

He ſuperſaturated it with pure ammonia, on which a grey precipitate appeared. When dried, it weighed 5 parts. This, on burning coals, gave out an arſenical ſmell. It was rediſſolved in nitric acid; ſulphurated alkali occaſioned a ſmutty brown precipitate; and pruſſic alkali a pruſſian blue, which, after torrefaction, was magnetic. Hence he concluded, that theſe 5 parts were a combination of iron and arſenic acid.

The nitric ſolution, which had been ſuperſaturated with ammonia, was blue; he therefore ſuſpected that it contained copper. To diſcover this, he ſaturated it with ſulphuric acid, and put into it a poliſhed plate of iron. The quantity of copper was ſo ſmall, that none could be collected on the iron.

III. Grey Copper Ore.

324 Analyſis of grey copper ore. Klaproth analyſed this ore as follows:

Three hundred grains of it, not completely freed from its matrix, were reduced to a fine powder; four times their weight of nitric acid was poured on them, and the whole was digeſted. The acid was then poured off, and an equal quantity again digeſted on the reſiduum. The two acid ſolutions were mixed together. The reſiduum was of a yellowiſh grey colour, and weighed 188 grains.

On this reſiduum ſix times its weight of muriatic acid was boiled. The reſiduum was waſhed, firſt with muriatic acid, and afterwards with alcohol, and the waſhings added to the muriatic acid ſolution. The reſiduum, when dried, weighed 105.5 grains. Part of it burned with a blue flame; and was therefore ſulphur. The reſiduum amounted to 80.25 grains, and had the properties of ſilica. When melted with black flux, about $\frac{3}{4}$ths of a grain of ſilver were obtained from it. Thus 300 parts of grey copper ore contain 25.25 gr. of ſulphur, and 79.5 of ſilica.

The muriatic acid ſolution, which was of a light yellow colour, was concentrated by diſtillation, a few cryſtals of muriat of ſilver appeared in it, which contained about $\frac{1}{4}$th grain of ſilver. The ſolution, thus concentrated, was diluted with a great quantity of water; a white precipitate was depoſited, which, when dried, weighed 97.25 grains. It poſſeſſed the properties of oxyd of antimony, and contained 75 grains of antimony. Therefore 300 grains of grey copper ore contain 70 of antimony.

The nitric acid ſolution was of a clear green colour. A ſolution of common ſalt occaſioned a white precipitate, which was muriat of ſilver, and from which 31.5 grains of ſilver were obtained.

A little ſulphat of potaſs, and afterwards ſulphuric acid, were added, to ſee whether the ſolution contained lead; but no precipitate appeared.

The ſolution was then ſuperſaturated with ammonia; a looſe fleaky browniſh red precipitate appeared, which, when heated to redneſs, became browniſh black, and weighed $9\frac{1}{4}$th grains. This precipitate was diſſolved in muriatic acid; half a grain of matter remained undiſſolved, which was ſilica. The muriatic acid ſolution, when pruſſic alkali was added, afforded a blue precipitate; and ſoda afterwards precipitated 1.5 grains of alumina. Therefore 300 grains of grey copper ore contain 7.25 grains of iron, and 1.5 of alumina.

Into the nitric ſolution ſuperſaturated with ammonia, and which was of an azure blue colour, a poliſhed plate of iron was put: By this method 69 grains of copper were obtained.

IV. Sulphuret of Tin.

325 Analyſis of ſulphuret of tin. Klaproth analyſed this ore as follows*:

On 120 grains of the ore reduced to powder, ſix times their weight of nitro muriatic acid, compoſed of 2 parts of muriatic, and 1 of nitric acid, were poured. There remained undiſſolved 43 grains, which had the appearance of ſulphur; but containing green ſpots, was ſuſpected not to be pure. After a gentle combuſtion, 13 grains remained; 8 of which were diſſolved in nitro-muriatic acid, and added to the firſt ſolution. The remaining 5 were ſeparated by the filtre, and heated along with wax. By this method about a grain of matter was obtained, which was attracted by the magnet; and which therefore was iron. The reſiduum weighed 3 grains, and was a mixture of alumina and ſilica. Thus 120 grains of ſulphuret of tin contain 30 grains of ſulphur, 1 of iron, and 3 of alumina and ſilica.

---

* *Obſervations on the Foſſils of Cornwall*, p. 48.

The nitro-muriatic ſolution was completely precipitated by potaſs. The precipitate was of a greyiſh green colour. It was waſhed and dried, and again diſſolved in diluted muriatic acid. Into the ſolution a cylinder of pure tin was put, which weighed exactly 217 grains. The ſolution became gradually colourleſs, and a quantity of copper precipitated on the cylinder of tin, which weighed 44 grains. To ſee whether it was pure, a quantity of nitric acid was digeſted on it; the whole was diſſolved, except one grain of tin. Therefore 120 grains of ſulphuret of tin contains 43 grains of copper.

The cylinder of tin now weighed only 128 grains; ſo that 89 grains had been diſſolved. Into the ſolution a cylinder of zinc was put; upon which a quantity of tin precipitated. When waſhed and dried, it weighed 130 grains. The tin he melted with tallow and powdered charcoal; and when cold, he waſhed off the charcoal. Among the tin globules were found ſome black flocculi of iron, which weighed one grain. Deducting this grain, and the 89 grains of the tin cylinder which had been diſſolved, we ſee that the 120 grains of ſulphuret of tin contained 40 grains of tin beſides the grain which had been detected in the copper.

V. Plumbiferous Antimoniated Silver Ore.

6
A ſis of pl bife- ro nti- m ated ſil ore.

Klaproth analyſed this ore as follows:

He digeſted 400 grains of it, reduced to a fine powder, firſt in five times its weight of nitric acid, and then in twice its weight of the ſame acid. He then diluted this laſt portion of acid with eight times its weight of water, and continued the digeſtion. The undiſſolved reſiduum, when waſhed and dried, weighed 326 grains.

On this reſiduum he boiled muriatic acid repeatedly. The ſolution, on cooling, depoſited acicular cryſtals. Theſe he carefully ſeparated, and put by. The undiſſolved reſiduum weighed 51 grains. It had the properties of ſulphur. When burned, it left one grain of ſilica.

The muriatic acid ſolution was concentrated to half its former bulk by diſtillation: this made it depoſite more acicular cryſtals. He continued the diſtillation as long as any cryſtals continued to appear. He then collected the whole of theſe cryſtals together. They had the properties of muriat of lead. When mixed with twice their weight of black flux, and heated in a crucible lined with charcoal, they yielded 160$\frac{1}{8}$ grains of lead.

Sulphuret of ammonia was now added to the muriatic acid ſolution; an orange-coloured precipitate appeared, which ſhewed that the ſolution contained antimony. It was precipitated by a copious effuſion of water, and by ſoda. The oxyd of antimony being reduced to a maſs with Spaniſh ſoap, mixed with black flux, and heated in a lined crucible, yielded 28.5 grains of antimony.

Into the nitric acid ſolution, obtained by the firſt part of the proceſs, a ſolution of muriat of ſoda was dropped; a white precipitate was depoſited, and over it acicular cryſtals. Theſe cryſtals he diſſolved, by pouring boiling water on the precipitate. The water was added to the nitric acid ſolution. The white precipitate was muriat of ſilver: when heated with twice its weight of ſoda, it yielded 81.5 grains of ſilver.

He now concentrated the nitric acid ſolution by evaporation; and then adding a ſolution of ſulphat of ſoda, a white precipitate was obtained, which had the properties of ſulphat of lead, and weighed 43 grains. It contained 32 grains of pure lead.

He now poured ammonia into the ſolution; a pale brown precipitate was obtained, which weighed 40 grains, and which appeared to conſiſt of oxyd of iron and alumina. He rediſſolved it in nitric acid, precipitated the iron by pruſſic alkali, and the alumina by ſoda. The alumina, after being heated to redneſs, weighed 28 grains; conſequently the oxyd of iron was 12 grains, which is equivalent to 9 grains of iron.

VI. Molybdat of Lead.

327
Analyſis of molybdat of lead.

Mr Hatchett analyſed this ore as follows †:

On 250 grains of the ore, reduced to a fine powder, he poured an ounce of ſtrong ſulphuric acid, and digeſted the mixture in a ſtrong heat for an hour. When the ſolution was cool, and had ſettled, he decanted it off, and waſhed the undiſſolved powder with pure water, till it came away taſteleſs. This operation was repeated twice more; ſo that three ounces of ſulphuric acid were uſed All theſe ſolutions were mixed together, and filtered.

Four ounces of a ſolution of carbonat of ſoda were poured upon the powder which remained undiſſolved, and which conſiſted of ſulphat of lead. The mixture was boiled for an hour, and then poured off. The powder was then waſhed, and diluted nitric acid poured on it: The whole was diſſolved, except a little white powder, which, when waſhed, and dried on a filter by the heat of boiling water, weighed ſeven-tenths of a grain. It poſſeſſed the properties of ſilica.

The nitric acid ſolution was ſaturated with pure ſoda; a white precipitate was obtained, which, when waſhed, and dried for an hour in a heat rather below redneſs, weighed 146 grains. It poſſeſſed the properties of oxyd of lead.

To ſee whether this oxyd of lead contained any iron, it was diſſolved in diluted nitric acid, and the lead precipitated by ſulphuric acid. The ſolution was then ſaturated with ammonia; a brown powder precipitated, which, when dried, weighed one grain, and had the properties of oxyd of iron.

The ſulphuric acid ſolution was of a pale blue colour: It was diluted with 16 times its weight of pure water, and then ſaturated with ammonia. It became of a deep blue colour, and appeared turbid. In 24 hours a pale yellow precipitate ſubſided, which, when collected on a filter, and dried by a boiling water heat, weighed 4.2 grains. Its colour was yellowiſh brown. Muriatic acid diſſolved it, and pruſſiat of potaſs precipitated it from its ſolution in the ſtate of pruſſian blue. It was therefore oxyd of iron.

The ſulphuric acid ſolution, ſaturated with ammonia, was gradually evaporated to a dry ſalt. This ſalt was a mixture of molybdat of ammonia and ſulphat of ammonia. A ſtrong heat was applied, and the diſtillation continued till the whole of the ſulphat of ammonia was driven off; and to be certain that this was the caſe, the fire was raiſed till the retort became red hot. The reſiduum in the retort was a black bliſtered maſs; three ounces of nitric acid, diluted with water, were poured upon it, and diſtilled off. The operation was again repeated.

---

† *Phil. Tranſ* lxxxvi. 320.

peated. By this method the oxyd of molybdenum was converted into a yellow powder, which was yellow acid of molybdenum. It weighed 95 grains.

VII. Grey Ore of Manganeſe.

328 Analyſis of grey ore of manganeſe.

Mr Vauquelin analyſed this ore as follows ‡ :

When 200 grains of it were expoſed to a ſtrong heat in a retort, there came over 10 grains of water, and 18 cubic inches of oxygen gas, mixed with a little carbonic acid gas. The mineral now weighed only 176 grains. Therefore the weight of the gas was 14 grains.

On 200 grains of the ſame mineral muriatic acid was poured, and heat applied. 75 cubic inches of oxy muriatic acid gas came over, which, though mixed with ſome carbonic acid gas, enflamed metals when reduced to powder. When no more gas came over, the reſiduum was boiled. The whole was diſſolved, except a white powder, which weighed 12 grains, and which poſſeſſed the properties of ſilica.

Carbonat of potaſs was poured into the ſolution ; a white precipitate was obtained, which became black by expoſure to the air, and weighed 288 grains. Strong nitric acid was boiled on it repeatedly to dryneſs. It became of a deep black colour, and, when well waſhed with water and dried, weighed 164 grains. This powder was black oxyd of manganeſe.

To ſee whether it contained iron, nitric acid, with a little ſugar, was poured upon it, and digeſted on it. The acid diſſolved it completely. Therefore no oxyd of iron was preſent.

Into the water with which the black oxyd of manganeſe had been waſhed, carbonat of potaſs was poured ; a white powder precipitated, which, when dried, weighed 149 grains, and which poſſeſſed the poperties of carbonat of lime.

VIII. Wolfram.

329 Analyſis of wolfram.

Meſſrs Vauquelin and Hecht analyſed this mineral as follows :

On 200 parts of Wolfram in powder, three times its weight of muriatic acid were poured, and the mixture boiled for a quarter of an hour : a yellow powder appeared, and the ſolution was of a brown colour. The acid was allowed to cool, and then carefully decanted off, and the reſiduum waſhed. The reſiduum was then digeſted for ſome hours with ammonia, which diſſolved a part of it. The reſiduum was waſhed, and new muriatic acid again poured over it ; then the reſiduum was digeſted with ammonia, as before : and the operation was continued till the whole wolfram was diſſolved.

All the ammoniacal ſolutions being joined together, were evaporated to dryneſs, and the ſalt which remained was calcined : a yellow powder was obtained ; it weighed 134 grains, and was yellow acid of tungſten.

Into the muriatic acid ſolutions, which were all mixed together, a ſufficient quantity of ſulphuric acid was poured to decompoſe all the ſalts. The ſolution was then evaporated to dryneſs ; and the ſalts which were obtained by this evaporation were rediſſolved in water. A white powder remained, which weighed three grains, and which poſſeſſed the properties of ſilica.

The exceſs of acid of the ſolution was ſaturated with carbonat of potaſs ; the liquor became brown, but nothing precipitated. When boiled, a red powder precipitated, and the brown colour diſappeared. The addition of more carbonat of potaſs cauſed a farther precipitation of a yellowiſh powder. This precipitate conſiſted of the oxyds of iron and manganeſe combined. Nitric acid was diſtilled off it repeatedly ; it was then boiled in acetous acid. The acetous ſolution was precipitated by potaſs. Nitric acid was again diſtilled off it, and it was again boiled in acetous acid. This proceſs was repeated till nitric acid produced no further change. The different powders which could not be diſſolved in the acetous acid were collected, mixed with a little oil, and heated red hot. The powder became black, and was attracted by the magnet. It was therefore oxyd of iron. It weighed 36 grains.

The acetous ſolution contained the oxyd of manganeſe : It was precipitated by an alkali, and, when dried, weighed 12.5 grains.

IX. Oxyd of Titanium and Iron.

330 Analyſis oxyd of t tanium a iron.

Vauquelin analyſed this ore as follows :

A hundred parts of the ore, reduced to a fine powder, and mixed with 400 parts of potaſs, were melted in a ſilver crucible for an hour and a half. When cool, the mixture was diluted with water ; a powder remained of a brick red colour, which, when waſhed and dried, weighed 124 parts.

The watery ſolution had a fine green colour ; when an exceſs of muriatic acid was added, it became red. By evaporation the liquor loſt its colour. When evaporated to dryneſs, a ſalt remained, which was totally diſſolved by water. From this ſolution carbonat of potaſs precipitated two parts, which had the properties of oxyd of manganeſe.

The 124 parts of reſiduum were boiled in a ſolution of pure potaſs for an hour. The ſolution was ſaturated with an acid, filtered, and carbonat of potaſs added, which precipitated three parts. Theſe had the properties of oxyd of titanium.

The remainder of the 124 parts of reſiduum, which ſtill was undiſſolved, was boiled with diluted muriatic acid. The liquor became yellow, and depoſited 46 parts of a white powder, with a tint of red. This powder was ſoluble in ſulphuric and muriatic acids : from theſe ſolutions, it was precipitated of a brick red colour by the infuſion of nut galls ; of a green colour by ſulphuret of ammonia and pruſſiat of potaſs ; and of a white colour by carbonat of potaſs and pure ammonia. A rod of tin made theſe ſolutions red ; a rod of zinc made them violet. Theſe 46 parts, therefore, are oxyd of titanium.

The muriatic ſolution, from which theſe 46 parts were depoſited, formed, with pruſſiat of potaſs, a pruſſian blue ; and ammonia precipitated from it 50 parts, which had the properties of yellow oxyd of iron.

---

‡ Jour. de Min N° xvii. p. 12.

INDEX.

Mirabeau.

MIRABEAU (Honnoré Gabriel, Comte de), well known both by his writings, and the active part which he took in bringing about the French revolution, was born in 1749 of a noble family. Throughout life, he diſplayed a ſpirit averſe from every reſtraint, and was one of thoſe unhappy geniuſes in whom the moſt brilliant talents ſerve only as a ſcourge to themſelves and all around them. It is told by his democratical panegyriſts, as a wonderful proof of family tyranny under the old government, that not leſs than 67 *lettres de cachet* had been obtained by Mirabeau the father againſt this ſon and others of his relatives. This ſtory, if true, proves, with at leaſt equal force, what many anecdotes confirm, that, for his ſhare of them, the ſon was not leſs indebted to his own ungovernable diſpoſition than to the ſeverity of his parent. He was indeed a monſter of wickedneſs. Debauchery, gaming, impiety, and every kind of ſenſuality, were not enough for him. He was deſtitute of decency in his vices; and to ſupply his expences, ſcrupled not to perform tricks which would diſgrace a thief-catcher. His father and mother diſagreeing, commenced a proceſs of ſeparation; when Mirabeau, juſt liberated from priſon for a groſs miſdemeanor, was in want of money. He went to his father, ſided with him againſt his mother, on whom he poured a torrent of invectives; and, for 100 guineas, wrote his father's memorial for the court. He then went to his mother; and by a ſimilar conduct got the ſame ſum from her; and both memorials were preſented. That the father of ſuch a man ſhould frequently get him ſhut up in priſon, can excite no ſurpriſe; for confinement only could withhold him from the perpetration of crimes.

The talents of Mirabeau led him frequently to employ his pen; and his publications form the chief epochas of his life. His firſt publication was, 1. *Eſſai ſur le Deſpotiſme*, "An Eſſay on Deſpotiſm," in 8vo. Next, in one of his confinements, he wrote, 2. a work in 2 vols 8vo, *On Lettres de Cachet*. 3. *Conſiderations ſur l'Ordre de Cincinnatus*, 8vo. A remonſtrance againſt the order of Cincinnatus, propoſed at one time to be eſtabliſhed in America. The public opinion in America favoured this remonſtrance, and it proved effectual. 4. His next work was in favour of the Dutch, when Joſeph II. demanded the opening of the Scheldt, in behalf of the Brabançons. It is entitled, *Doutes ſur la Liberté de l'Eſcaut*, 8vo. 5. *Lettre à l'Empereur Joſeph II. ſur ſon Réglement concernant l'Emigration*; a pamphlet of forty pages, in 8vo. 6. *De la Caiſſe d'Eſcompte*; a volume in 8vo, written againſt that eſtabliſhment. 7. *De la Banque d'Eſpagne*, 8vo; a remonſtrance againſt eſtabliſhing a French bank in Spain. A controverſy

Fig. 35.

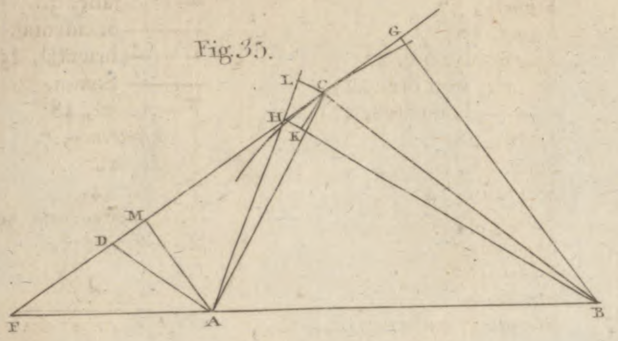


Fig. 36.

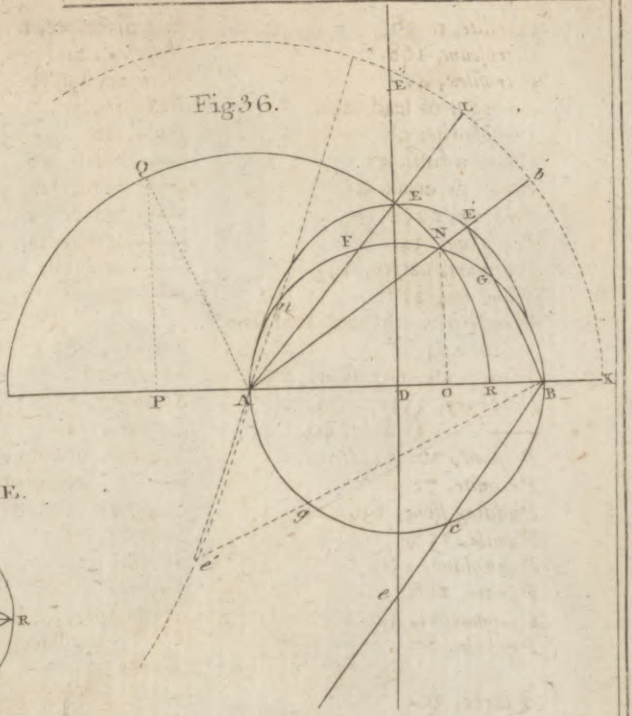
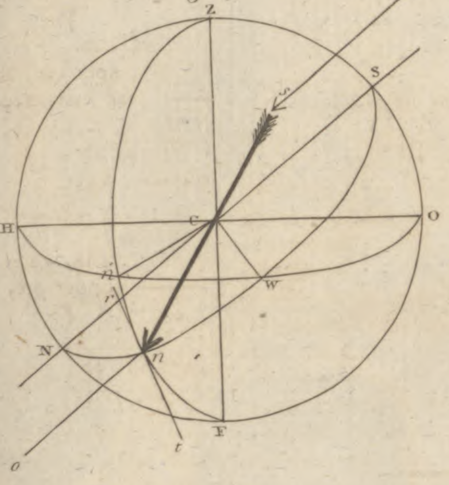


Fig. 37.



MERIDIAN LINE.

MINERALOGY.

Fig. 1.

Fig. 2.

Fig. 3.

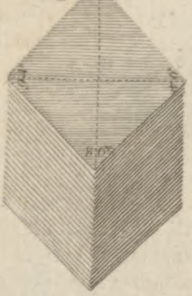


Fig. 4.

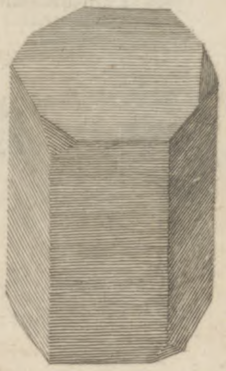


Fig. 5.

Fig. 6.

Fig. 7.

Fig. 10.

Fig. 8.

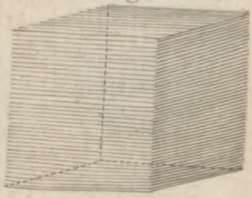


Fig. 9.

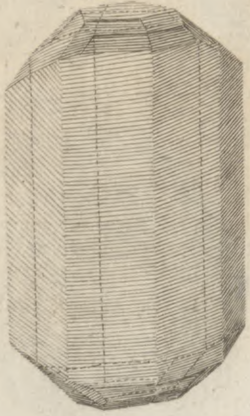


Fig. 12.

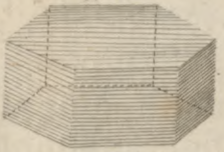


Fig. 11.

Fig. 13.

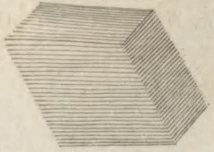
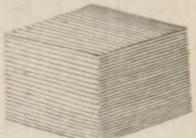
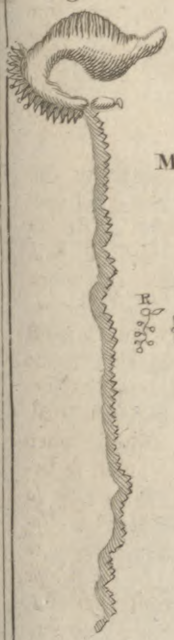


Fig. 14.



MEDUSA

Fig. 1.



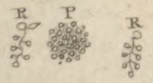


Fig. 2.

D.Lizars Sculp.

Fig: 20.

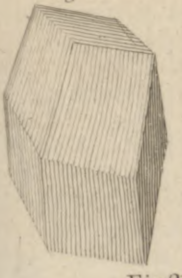


Fig. 16.

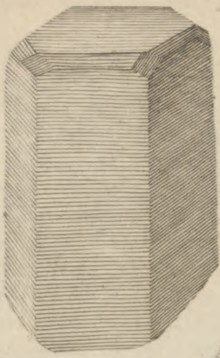


Fig: 18.

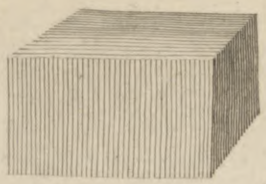


Fig: 17.

Fig: 15.

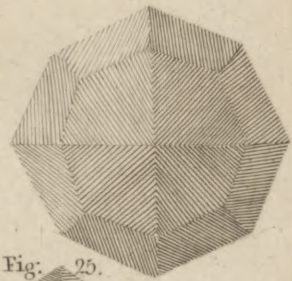


Fig: 21.

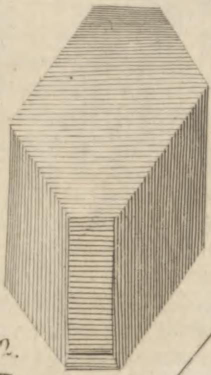


Fig. 23.

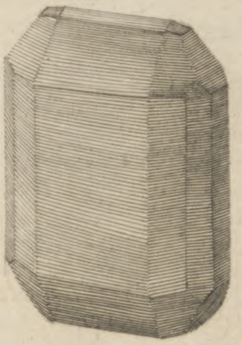


Fig: 19.

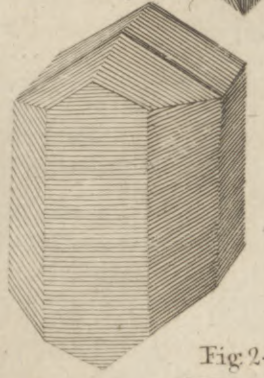


Fig. 25.

Fig: 26.

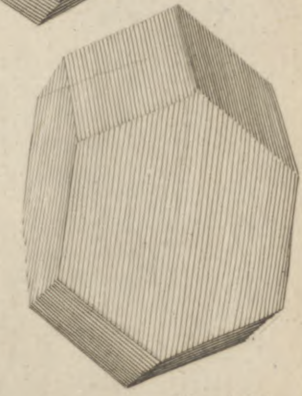


Fig: 27.

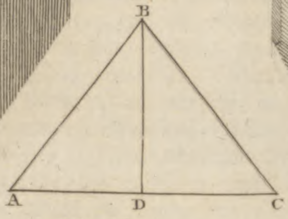


Fig: 24.

Fig. 22.

Fig: 28.

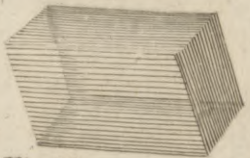


Fig: 31.

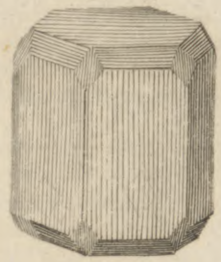


Fig: 29.

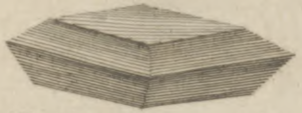


Fig. 34.

Fig: 32.

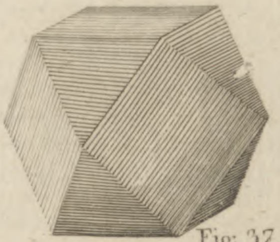


Fig: 30.

Fig: 33.

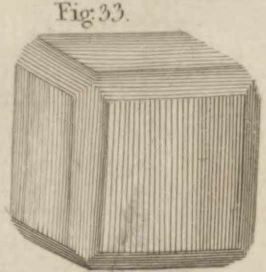


Fig. 36.

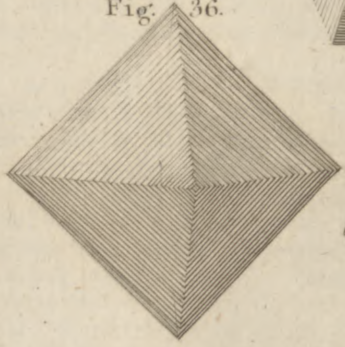


Fig. 35.

Fig: 37.

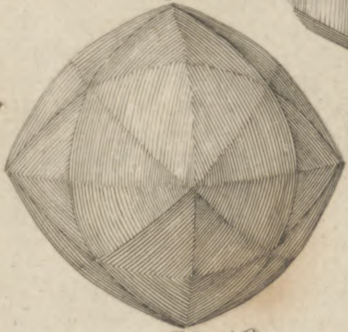


Fig: 39.

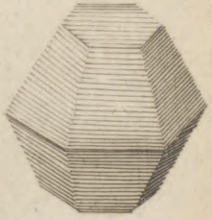


Fig. 38.

Fig: 44.

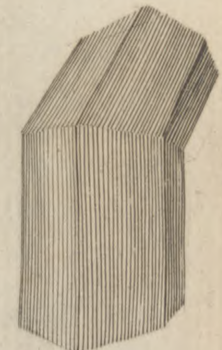


Fig 41.

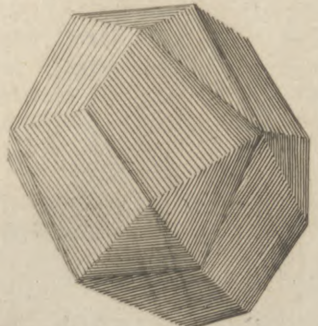


Fig. 40.

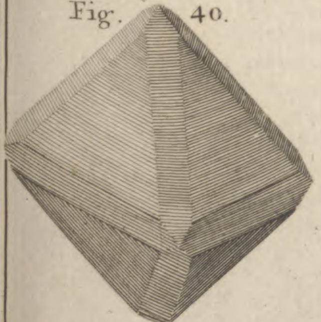


Fig: 43.

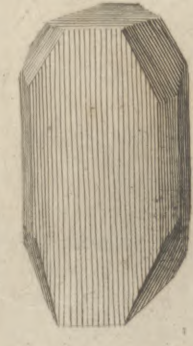
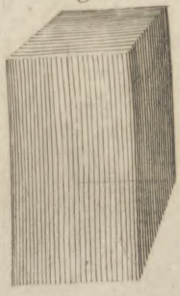


Fig: 42.



D. Lizars sculp!

controverſy ariſing upon this ſubject, he wrote again upon it. 8. Two pamphlets on the monopoly of the water company in Paris.

Soon after the publication of theſe works, he was ſent in a public character to the court of Berlin; where he conducted the king's affairs juſt as he had formerly done thoſe of his father and mother, fully ready to ſacrifice all parties, and to ſell himſelf to the higheſt bidder. With ſuch a diſpoſition, he could not long avoid the notice of the Pruſſian illuminees; and Nicolai Bieſter, Gedicke, and Leuchſenring, ſoon became his conſtant companions. At Brunſwick he met with Mauvillon, the worthy diſciple of Philo Knigge, and at that time a profeſſor in the Caroline college. This was the man who initiated the profligate Marquis in the laſt myſteries of illuminiſm.

Mirabeau was ſtill at Berlin when Frederick II. died. That monarch, as is well known, was a naturaliſt, who, holding this life for his all, encouraged the propagation of infidelity in his dominions, from which reſulted the very worſt conſequences to the peace of ſociety. Of this truth his ſucceſſor Frederick William was duly ſenſible; and determined to ſupport the church eſtabliſhment in the moſt peremptory manner, conſiſtent with the principles of religious toleration. He publiſhed, therefore, ſoon after his acceſſion, an edict on religion, which is a model worthy of imitation in every country; but it was attacked with the greateſt virulence in numberleſs publications. It was called an unjuſtifiable tyranny over the conſciences of men; the dogmas ſupported by it were termed abſurd ſuperſtitions; the king's private character and his religious opinions were ridiculed and ſcandalouſly abuſed. The moſt daring of theſe attacks was a collection of anonymous letters on the conſtitution of the Pruſſian ſtates, univerſally believed to be the compoſition of Mirabeau, who certainly wrote a French tranſlation, with a preface and notes more impudent than the work itſelf. The monarch is declared to be a tyrant; the people of the Pruſſian dominions are addreſſed as a parcel of tame wretches, crouching under oppreſſion; and the inhabitants of Sileſia, repreſented as ſtill in a worſe condition, are repeatedly called upon to rouſe themſelves, and aſſert their rights.

About this time he publiſhed, 9 An *Eſſai ſur le Secte des Illuminés;* one of the ſtrangeſt and moſt impudent books that ever appeared. In it he deſcribes a ſect exiſting in Germany, called the *Illuminated;* and ſays, that they are the moſt abſurd and groſs fanatics imaginable, waging war with every appearance of reaſon, and maintaining the moſt *ridiculous ſuperſtitions.* He gives ſome account of theſe, and of their rituals and ceremonies, as if he had ſeen them all; yet no ſuch ſociety as he deſcribes ever exiſted: and Mirabeau employed his powers of deception, merely to ſcreen from obſervation the real *illuminati*, by holding out to the rulers of ſtates this *ignis fatuus* of his own brain. For a while the eſſay certainly contributed to blind the eyes of the German princes; and Nicolai. with others of the junto, adopting the whim, called Mirabeau's fanatics *Obſcuranten*, and joined with him in placing on the liſt of *Obſcuranten* ſeveral perſons whom they wiſhed to make ridiculous.

Long before his initiation in the myſteries of illuminiſm, Mirabeau had been acquainted with all the revolutionary powers of the maſonic lodges; nor did he, when initiated, undervalue thoſe which flowed, or might flow, from Weiſhaupt's inventive genius. On his return to France, he began to introduce the new myſteries among ſome of his maſonic brethren. His firſt aſſociate was the Abbé Talleyrand de Perigord, who had already begun to act the part of Judas in the firſt order of the church. But to have only introduced the myſteries was not ſufficient for the Marquis; he would have teachers come from Germany, who were better verſed than he was in the illuminizing arts. Well acquainted with the reaſons that had induced the chiefs of the order to defer the converſion of France, he found means to convince them, that the time was now come for the accompliſhment of their views; and at his requeſt a deputation was ſent by Spartacus to illuminize that great kingdom. See Illuminati, n° 40, 41, *Suppl.*

When the aſſembly of Notables was convened at Paris, Mirabeau foretold that it would ſoon be followed by a meeting of the States; and at that period he publiſhed a volume againſt the ſtockjobbing, then carried to a great height, intitled, 10. *Denonciation de l'agiotage au Roi, et a l'Aſſemblée de Notables*, 8vo. A *lettre de cachet* was iſſued againſt him in conſequence of this publication; but he eluded purſuit, and publiſhed a pamphlet as a ſequel to the book. His next work was againſt M. Necker, 11. *Lettre á M. de Cretelle, ſur l'Adminiſtration de M. Necker*, a pamphlet in 8vo. 12. A volume, in 8vo. againſt the Stadtholderſhip: *Aux Bataves, ſur le Stadthouderat.* 13. *Obſervations ſur la maiſon de force appellé Bicetre*, an 8vo pamphlet. 14. Another tract, intitled, *Conſeils à un jeune Prince qui ſent la néceſſité de refaire ſon education.* 15. He now proceeded to a larger and more arduous work than any he had yet publiſhed, on the Pruſſian monarchy under Frederick the Great: *De la Monarchie Pruſſienne ſous Fréderic le Grand*, 4 vols, 4to, or eight in 8vo. In this work, he undertakes to define preciſely how a monarchy ſhould be conſtituted. When the orders were iſſued for convening the States-general, Mirabeau returned into Provence; and at the ſame time publiſhed, 16. *Hiſtoire Secrette de la Cour de Berlin*, two volumes of letters on the Secret Hiſtory of the Court of Berlin. This work was condemned by the parliament of Paris, for the unreſerved manner in which it delivered the characters of many foreign princes. As the elections proceeded, he offered himſelf a candidate in his own order at Aix; but he was ſo abhorred by the nobleſſe, that they not only rejected him, but even drove him from their preſence. This affront ſettled his meaſures, and he determined on their ruin. He went to the commons, diſclaimed his being a gentleman, ſet up a little ſhop in the market-place of Aix, where he ſold trifles; and now, fully reſolved what line he ſhould purſue, he courted the commons, by joining in all their exceſſes againſt the nobleſſe, and was at laſt returned a member of the aſſembly.

In conſequence of this, he went to Paris; where the part he took was active, and ſuch as tended, in general, to accelerate all the violences of the revolution. He now publiſhed, periodically, 17. his *Lettres à ſes Commettans*, Letters to his Conſtituents, which form, when collected, 5 vols, 8vo. It is ſuppoſed, that the fatal meaſure of the junction of the three orders into one national

tional aſſembly, was greatly promoted by theſe letters. The public events of theſe times, and the part taken in them by Mirabeau, are the ſubject of general hiſtory. He lived to ſee the conſtitution of 1789 eſtabliſhed, but not to ſee its conſequences—the deſtruction of the monarchy, the death of the king, and the ruin of all property! He was accuſed, as well as the duke of Orleans, of hiring the mob which attacked Verſailles on the 5th and 6th of October 1789; but with him was alſo acquitted by the tribunal of the Châtelet. The dominion of his eloquence in the National Aſſembly had long been abſolute, and, on the 29th of January 1791, he was elected preſident. At the latter end of March, in the ſame year, he was ſeized by a fever, and died on the 2d of April.

The talents of Mirabeau will not be doubted, though they were certainly rather brilliant than profound. To be noticed, and to lead, were the ſole objects of his ambition; and for the attainment of them, he took the ſide of the diſcontented, as the beſt field for his matchleſs eloquence. Yet there was no man more devoted to the principles of a court than this Marquis, provided he could have a ſhare in the adminiſtration; and a ſhare he would have obtained, if any thing moderate would have ſatisfied him: But he thought nothing worthy of him but a place of active truſt, and a high department; ſtations which all knew him not qualified to fill. Wanting knowledge of great things, he was learned only in the buſtling detail of intrigue, and would, at any time, have ſacrificed his deareſt friend, and the intereſts of his country, for an opportunity of exerciſing his brilliant eloquence, and indulging his propenſity to ſatire and lampoon. But the greateſt obſtacle to his advancement under the old government was the abject worthleſſneſs of his character. Drinking was the only vice in which he did not indulge; and from this he was reſtrained by his exhauſted conſtitution. To his brother, the Viſcount, who was frequently intoxicated, the Marquis one day ſaid, "How can you, brother, ſo expoſe yourſelf?" "What (replied the Viſcount)! how inſatiable are you? Nature has given you every vice; and having left me only this one, you grudge it me!"

MISTRAL, the name of a wind, which is mentioned in almoſt every account that we have of Provence, and which is remarkable for blowing almoſt the whole year from north weſt or weſt-north-weſt, in a climate where the wind ſhould be variable. It is ſaid to contribute to the ſalubrity of the air, by diſperſing the exhalations of the marſhes and ſtagnant waters, ſo common in the ſouth of Languedoc and Provence; but at times it is alſo very injurious, or at leaſt very troubleſome. It is not, however, on either of theſe accounts that it is introduced into this Work, but for the ſake of the cauſes aſſigned by Sauſſure for its conſtancy, which may be applied to other winds that nearly reſemble it; and which he found might be reduced to three.

"The firſt and moſt effectual cauſe (he ſays) is the ſituation of the Gulf of Lyons, the banks of which are the principal theatre of its ravages. This Gulf, in fact, is ſituated at the bottom of a funnel, formed by the Alps and Pyrenees. All the winds blowing from any point between weſt and north, are forced by theſe mountains to unite in the Gulf. Thus, winds which would not have prevailed but at one extremity of the Gulf, or even much beyond it, are obliged to take this route, after having undergone the repercuſſion of theſe mountains; and the middle of the Gulf, inſtead of the calm which it might have enjoyed, is expoſed to the united efforts of two ſtreams of wind, deſcending in different directions. Hence ariſe thoſe whirlwinds which ſeem to characteriſe the miſtral, and appear to have induced the ancients to call it *Circius, à turbine ejus ac vertigine*. See *Aul. Gellius*, l. ii. cap. 22.

"The ſecond cauſe is, the general ſlope of the grounds, deſcending from all ſides towards the Gulf; which becoming all at once lower and more ſoutherly than the lands extending behind it, is, from theſe joint circumſtances, rendered the hotteſt point of all the adjacent country: and, as the air on the ſurface of the earth always tends from the colder to the warmer regions, the Gulf of Lyons is actually the centre towards which the air from all colder points between eaſt and weſt muſt preſs. This cauſe, then, alone would be productive of winds directed to the Gulf, even if the repercuſſion of the mountains did not exert its influence.

"Finally, it is well known, that in all gulfs the land-winds blow more forcibly than oppoſite to plains and promontories, whatever be the ſituation of thoſe gulfs. I apprehend, indeed, on ſtrict examination (ſays our author), that this cauſe is blended with the preceding; but as the fact is generally admitted, and in ſome caſes can be explained only by reaſons drawn from the effects of heat, it may not improperly, perhaps, be diſtinctly mentioned. It is, at leaſt, neceſſary to ſuppoſe, that ſeveral cauſes produce the miſtral, in order to underſtand why, notwithſtanding the variableneſs of the ſeaſons and temperatures, that wind is ſo ſingularly conſtant in Lower Languedoc and Lower Provence. A very remarkable inſtance of this conſtancy is recorded by the Abbé Papon, in his *Voyage de Provence*, tom. ii. p. 81. He aſſerts, that during the years 1769 and 1770, the miſtral continued for fourteen months ſucceſſively. But the three cauſes which I have ſtated, taken ſeparately, will explain its frequency, and, united, will account for its force."

MIXT ANGLE, or *Figure*, is one contained by both right and curved lines

Mixt Number, is one that is partly an integer and partly a fraction; as $3\frac{1}{2}$.

Mixt Ratio, or *Proportion*, is when the ſum of the antecedent and conſequent is compared with the difference of the antecedent and conſequent;

$$\text{as if} \left\{ \begin{array}{l} 4 : 3 :: 12 : 9 \\ a : b :: c : d \end{array} \right.$$

$$\text{then} \left\{ \begin{array}{l} 7 : 1 :: 21 : 3 \\ a + b : a - b :: c + d : c - d. \end{array} \right.$$

MOCASSIMAH, in Bengal, revenue ſettled by a diviſion of the produce.

MOCHULKAH, bond or obligation.

MŒRIS, a lake in EGYPT, occaſionally mentioned in that article (*Encycl.*), and generally ſuppoſed the production of human art. Of this, however, Mr Brown ſays it bears no mark. "The ſhape, as far as was diſtinguiſhable, ſeems not inaccurately laid down in D'Anville's map, unleſs it be, that the end neareſt the Nile ſhould run more in a north-weſt and ſouth-eaſt direction. The length may probably be between 30 and 40 miles; the breadth, at the wideſt part he could gain, was 5000 toiſes, as taken with a ſextant; that is, nearly ſix miles. The utmoſt poſſible extent of circuit muſt of courſe be 30 leagues. On the north-eaſt and ſouth is a rocky ridge, in every appearance primeval. In ſhort, nothing can preſent an appearance more unlike the works of men. Several fiſhermen, in miſerable boats, are conſtantly employed on the lake. The water is brackiſh, like moſt bodies of water under the ſame circumſtances. It is, in the language of the country, *Birket-el-kerun*, probably from its extremities bearing ſome reſemblance to horns.

MOFUSSEL, a relative term, ſignifying the ſubordinate lands or diſtricts, oppoſed to Sudder, which is the head.

MOHACZ, Mohatz, or *Mohoz*, a town in the Lower Hungary, upon the Danube, between the river Sarwiza to the north, and the Drave to the ſouth; four German miles from either, ſix from Eſſeck to the north, and nine from Colocoa to the ſouth. This otherwiſe ſmall place is memorable for two great battles here fought; the firſt between Lewis king of Hungary and Solyman the Magnificent, in 1526: in which that unfortunate Prince Lewis (being about 20 years old), with 25,000 men, fought 300,000 Turks; when, being overpowered by numbers, 22,000 of the Chriſtian army were ſlain upon the place; 5000 waggons, eighty great cannon, 600 ſmall ones, with all their tents and baggage, were taken by the victors; and the King, in his flight over the brook Curaſs, fell into a quagmire, and was ſwallowed up. After which, Solyman took and ſlew 200,000 Hungarians, and got ſuch a footing in that kingdom, that he could never be expelled. This fatal battle was fought October 29. The ſecond, in ſome part, retrieves the loſs and infamy of the former. The Duke of Loraine being ſent by the Emperor, with expreſs orders to paſs the Drave and take Eſſeck, his highneſs, July 10, 1687, with great difficulty paſſed that river, then extremely ſwelled with rains; but finding the Prime Viſier encamped at Eſſeck, with an army of 100,000 men, ſo ſtrongly, that it was not poſſible to attack him in that poſt without the ruin of the Chriſtian army, he retreated, and repaſſed it the 23d of the ſame month; where, upon the 29th, the Prime Viſier paſſed that river at Eſſeck; and upon Auguſt 12th, there followed a bloody fight, in which the Turks loſt 100 pieces of cannon, 12 mortars, all their ammunition, proviſions, tents, baggage, and treaſure, and about 8000 men upon the place of battle, beſides what were drowned in paſſing the river, which could never be known. After which victory, General Dunewalt, September 30th, found Eſſeck totally deſerted by the Turks, and took poſſeſſion of it.

MOHER, in Bengal, a gold coin, worth about 33 ſhillings.

MOHERIR, a writer of accounts.

MOINEAU, a flat baſtion raiſed before a curtin when it is too long, and the baſtions of the angles too remote to be able to defend one another. Sometimes the moineau is joined to the curtin, and ſometimes it is divided from it by a moat. Here muſquetry are placed to fire each way.

MOLE (See Talpa, *Encycl.*), is an animal exceedingly troubleſome, both to gardeners and farmers; and there are perſons who contrive to make a livelihood by the trade of *mole-catching*. Theſe men, it is well known, are generally quacks and cheats; and the ſecrets which they ſell for extirpating thoſe deſtructive animals are of very little avail. Even poiſon ſeldom produces any conſiderable effect; becauſe the mole, while it does not drink, lives only on roots and worms. Under the word Mole (*Encycl.*), ſome directions will be found for clearing fields of this deſtructive animal; but the following are perhaps preferable, as they ſeem to have been the reſult of much experience:

Mole.

Immediately at day-break, it will be neceſſary to make a tour round the garden or meadow, from which it is wiſhed to extirpate the moles; for at that time they will be all found at work, as may be ſeen by the hills newly thrown up. If the perſon is then cloſe to the hill, he muſt proceed as the gardeners do, and turn up with a ſtroke of the ſpade the hill together with the digger. The paſſage is then cut through before the animal is aware of the attack; and therefore it has not power to eſcape. If the mole-hill be freſh, even though the animal may not be throwing up earth, the perſon ought not to loſe his time in waiting, but ſhould immediately proceed to the operation above-mentioned.

If you find a freſh hill ſtanding by itſelf, which ſeems to ſhew by its ſituation that it has no communication with any other, which is always the caſe when the mole has worked from the ſurface downwards in endeavouring to procure a more convenient habitation, after the hill has been turned up with the ſpade, a bucket of water ſhould be poured over the mouth of the paſſage. By theſe means the animal, which is at no great diſtance, will be obliged to come forth, and may be eaſily caught with the hand.

You may diſcover alſo whether a hill has any communication with another, if you apply your ear to it, and then cough or make a loud noiſe. If it has no communication with the neighbouring hills, you will hear the terrified animal make a noiſe by its motion. It will then be impoſſible for it to eſcape; and you may either pour water into the hole, or turn up the hill with a ſpade, until the mole is found; for, in general, it never goes deeper into the earth than from fifteen to eighteen inches.

When any of the beds in a garden have been newly watered, the mole, attracted by the coolneſs and moiſture, readily repairs thither, and takes up its reſidence in them, making a paſſage at the depth of ſcarcely an inch below the ſurface. In that caſe it may eaſily be caught. When you ſee it at work, you need only tread behind the animal with your feet on the paſſage to prevent its retreat, and then turn up the hill with a ſpade; by which means you will be ſure to catch it.

When you dig after it with a ſpade, the animal forces its way downwards into the earth in a perpendicular direction, in order that it may the better eſcape the threatened danger. In that caſe it will not be neceſſary to dig long, but to pour water over the place, which will ſoon make the animal return upwards.

People, in general, are not aware of the great miſchief occaſioned in fields and gardens by theſe animals. We are, however, informed by Buffon, that in the year 1740 he planted fifteen or ſixteen acres of land with acorns, and that the greater part of them were in a little time carried away by the moles to their ſubterranean retreats. In many of theſe there were found half a buſhel, and in others a buſhel. Buffon, after this circumſtance, cauſed a great number of iron traps to be conſtructed; by which, in leſs than three weeks, he caught 1300. To this inſtance of the devaſtation occaſioned by theſe animals, we may add the following: In the year 1742 they were ſo numerous in ſome parts of Holland, that one farmer alone caught between five and ſix thouſand of them. The deſtruction occaſioned by theſe animals is, however, no new phenomenon. We are informed by hiſtory, that the inhabitants of the iſland of Tenedos, the Trojans, and the Æolians, were infeſted by them in the earlieſt ages. For this reaſon a temple was erected to Apollo Smynthius, the deſtroyer of moles. See *Economiſche Hefte*. Vol. VII. Part 5. and Vol IX. Part 4.; or *Phil. Magazine*, N° 5.

MOMENTS, in the new doctrine of infinites, denote the indefinitely ſmall parts of quantity; or they are the ſame with what are otherwiſe called infiniteſimals and differences, or increments and decrements; being the momentary increments or decrements of quantity conſidered as in a continual flux.

Moments are the generative principles of magnitude; they have no determined magnitude of their own, but are only inceptive of magnitude.

Hence, as it is the ſame thing if, inſtead of theſe moments, the velocities of their increaſes and decreaſes be made uſe of, or the finite quantities that are proportional to ſuch velocities; the method of proceeding which conſiders the motions, changes, or fluxions of quantities, is denominated by Sir Iſaac Newton, the *method of fluxions*.

Leibnitz, and moſt foreigners, conſidering theſe infinitely ſmall parts, or infiniteſimals, as the differences of two quantities, and thence endeavouring to find the differences of quantities, *i. e.* ſome moments, or quantities indefinitely ſmall, which taken an infinite number of times ſhall equal given quantities, call theſe moments differences; and the method of procedure, the differential calculus.

MONGEARTS, one of the tribes of wandering Arabs which inhabit the SAHARA, or Great Deſert of Africa. Their time is wholly occupied by tending their cattle; and becauſe they are little ſkilled in the uſe of arms, *Mongeart* is a term of contempt among the people by whom they are ſurrounded. Their country, with its produce, will be deſcribed under the title SAHARA in this *Supplement;* it is the buſineſs of this article merely to exhibit the manners of the people.

They are all Mahometans, and offer up prayers three times a-day, ſometimes oftener; but having no moſques, theſe prayers are never pronounced in public, except when the horde is viſited by a prieſt, who ſeldom comes but upon account of the childrens education. Then all the Arabs aſſemble at the hour of prayer, place themſelves in a line, turn to the eaſt, and, wanting water in the deſert, rub their face and arms with ſand; while the prieſt recites aloud the general prayer. It is the ſame as that which is rehearſed by the public crier in the moſques in civilized countries.

The prieſts are employed in travelling about the country to inſtruct the children. There is nothing like force in their education. The little boys meet in the morning of their own accord, at the place of inſtruction, which is to them a place of recreation. They go there with a ſmall board inſcribed with the Arabic characters, and a few maxims of the Koran. The oldeſt, and the beſt informed, receive their leſſons directly from the prieſts, and afterwards communicate them to their fellows. They are never corrected; becauſe it would be a crime to beat a child, who, according to the received notions, has not ſufficient reaſon to diſtinguiſh good from evil. This lenity extends even to the children of Chriſtians, though in a ſtate of ſlavery. They are treated in all reſpects like the children of Arabs; and the man who ſhould be raſh enough to ſtrike one of them, would endanger his life. Very different is their treatment of Negro children; who may indeed join in all the amuſements of the young Arabs, and even attend the public ſchools; but if they be guilty of a fault, they are ſeverely puniſhed.

When the child of a Mongeart becomes tired of the places of public inſtruction, he quits them at pleaſure, and, without feeling conſtraint, or hearing reproach, goes and employs himſelf in tending his father's flocks: and accordingly there are very few among them who can read. Thoſe who perſevere in the ſtudy of the Koran are made prieſts, after having paſt an examination before the learned elders, and enjoy the greateſt public conſideration. They have no need of cattle; for thoſe of the nation being theirs, they find their ſubſiſtence everywhere.

It is generally at ſeven or eight years of age that children undergo the painful operation of circumciſion. Their head is alſo ſhaved, nothing being left but four locks of hair; one of which is cut off in a meeting of the family, at each remarkable action performed by the child. If, at the age of 12 or 13, he kill a wild boar, or other beaſt of prey, that ſhould fall upon his flock, he loſes one of his locks. If, in the paſſage of a river, a camel be carried away by the ſtream, and he ſave it by ſwimming to its aſſiſtance, another is cut off. If he kill a lion, a tiger, or a warrior of an hoſtile nation, in a ſurpriſe or an attack, he is conſidered as a man, and his head is entirely ſhaved.

Different from the other Arabs their neighbours, and indeed from the Mahometans in general, the Mongearts trouble no man on account of his religion. The only one which they do not tolerate is the Jewiſh; and were a Jew to enter their territory, and have the miſfortune to be taken, he would certainly be burnt alive.

According to M. Saugnier, the women are much more reſpected among the Mongearts than among the neighbouring nations; but the evidences which he gives of that reſpect are very extraordinary.

When a Mongeart is deſirous of undertaking the care of a family, he pitches upon the girl that pleaſes him the moſt, and aſks her of her father without further formality; nor can the latter refuſe her, unleſs the man who pretends to her hand have done ſomething contrary to the laws of the nation. The girl is conducted by her parents to the tent of her future huſband, where there is always an abundant repaſt prepared for the ceremony. Preſents are made to the father; but if the ſon-in law be poor, his wife's family aſſiſt him, and furniſh him with the means of increaſing his flocks; if, on the contrary, he be rich, and the father poor, he ſupports the whole family in his own tent. The employment of the wife, thus married, is to prepare the food; to ſpin the goats and camels hair, of which the tents are made; to milk the cattle; to pick up the neceſſary ſupply of wood for the night; and when the hour of repaſt is come, to wait upon her huſband. She then eats by herſelf what has been left by him and his male ſlaves. She is, indeed, in no great danger of having a rival brought into the family; for though polygamy be allowed by his religion, the poverty of the Mongeart generally prevents him from taking a plurality of wives. She is, however, liable to be divorced at will when ſhe does not bear boys; but if ſhe have the good fortune to have one or more male children, her huſband's regard for her is inconceivable. She has no longer a divorce to fear, has an abſolute authority in the tent, and paſſes her whole time in converſation, ſleep, or dancing, as ſhe thinks fit. The captive negreſſes do all her work, and are no longer aſſiſted in their labour by the Arab's wife, who treats them, on the contrary, with the greateſt harſhneſs and arrogance.

When a woman is not agreeable to her huſband, or when he is diſagreeable to her, they have it in their power to part. The formality in this caſe conſiſts in the wife's retiring to her parents. If the huſband be attached to her, he goes thither in queſt of her; but if ſhe perſiſt in refuſing to return, ſhe is free, and at liberty to marry another. If, however, ſhe have had a child, eſpecially a boy, ſhe has not the ſame privilege; in that caſe, if her retreat ſhould laſt more than eight days, it might be puniſhed with death.

When a man beats his wife, it is a ſure ſign that he is ſincerely attached to her, and that he does not mean to part with her; if he content himſelf with reproaches, the wife thinks herſelf deſpiſed, and infallibly retires to her parents. Hence it is, that in the moſt trifling diſputes the women are cruelly beaten: they prefer it to the complaints that the huſband might make to their parents; this proof being the moſt certain one of a man's fondneſs for his wife. When a girl marries, ſhe makes up her mind to ſuch treatment, deeming it much more ſupportable than the humiliations ſhe would otherwiſe experience from her family, in conſequence of her huſband's complaints.

The conjugal fidelity of the Mongeart women is incorruptible. Differing in their opinions from many other Mahometans, they believe themſelves immortal like the men; but they do not flatter themſelves with the poſſibility of happineſs in the other world, unleſs they ſhall have been faithful to their huſbands in this. Women, who have been falſe to their huſband's bed, will be doomed, they think, to eternal ſlavery to the more virtuous part of their ſex, without ever partaking, in the ſmalleſt degree, of their bliſs.

Mongeart women often viſit one another; and on theſe occaſions, the honour conſiſts in letting the female who comes to ſee her friend or relation do all the work of the tent. The viſitor aſſumes the management of every thing, dreſſes the victuals, churns the butter, and keeps herſelf continually employed; while her friend entertains her with an account of the different affairs of the family or nation. The heartineſs of the welcome is meaſured by the extent of the work ſubmitted to the gueſt, who generally prepares double the uſual quantity of food; ſo that the Arab is obliged to invite his neighbours to partake of the repaſt. The ſlaves are always pleaſed with theſe entertainments, a larger portion then coming to their lot. It is the buſineſs of the viſitor to do the honours; nor will ſhe ſuffer any body about her to remain diſſatisfied.

The laws of hoſpitality are obſerved among the Mongearts as among all the wandering Arabs. Indeed they are carried to ſuch a length, that were a man to enter the tent of him whom he had wounded, or even killed, he would there meet with a ſacred and inviolable aſylum, although ſurrounded by thoſe who muſt naturally deſire his ruin. The tent of the chief is always that to which ſtrangers, upon their arrival in the horde, are directed. But the chief could not entertain, at his own expence, all the ſtrangers that happen to paſs; and therefore every tent in the horde is obliged to furniſh him with two pounds of ground barley *per* week, to enable him to maintain the ancient hoſpitality.

The chiefs of hordes are always the eldeſt of their families. The difference of wealth is not conſidered; the chief often having ſeveral individuals at his houſe richer than himſelf, who nevertheleſs obey him in every particular. He is, properly ſpeaking, their king: examines their difference with the old men, and judges without appeal. As to himſelf, he cannot be tried but by the chiefs of ſeveral hordes aſſembled. It is his buſineſs to determine the ſpots where the tents are to be pitched, the moment of departure, and the place where the caravan is to ſtop. If the paſturage do not ſuffice for the herds of all the horde, it divides, and the chief aſſigns the ground for the different encampments. They are very often compoſed of no more than ſeven or eight tents, according to the quality of the ground they meet with. The tent of the chief is always the largeſt and moſt lofty, and is placed in the centre of the diviſions. When it is determined upon to quit an encampment, which never happens till the paſture is exhauſted, the chief ſets off to chooſe another ſpot. In theſe removals the women alone do all the work. Early in the morning they fold up the tent, and load every thing upon the camels backs; they then move ſlowly on, that the cattle may have time to feed upon the way.

Great reſpect is paid by the Mongearts to all old men, who enjoy the ſame prerogatives as the prieſts, and ſuch Arabs as have viſited the tomb of Mahomet at Mecca. Together with the chief they are the judges of the horde, and take cognizance of all offences. the pain of death being the only puniſhment which they cannot decree. An aſſembly of ſeveral chiefs is the only tribunal which can inflict capital puniſhment; but as the accuſed has generally a number of friends, it ſeldom happens that he is capitally convicted.

A war between two Mongeart tribes ſeldom happens, and is never bloody; but the different families deſtroy one another faſt enough in their inteſtine broils. They are all thieves; and indeed theft is a crime only in the day time, being authoriſed by law during the night, in order to compel them to take care of their cattle. Could they find redreſs when robbed by night, they would be leſs vigilant; and their herds and flocks would be more expoſed to the wild beaſts that over-run their country; but being obliged to be on their guard even againſt their neareſt neighbours, they are always ready to repel both the lion and the tiger. Theft, even in the day-time, is ſo far from being puniſhed, unleſs detected at the inſtant of commiſſion, that when any thing is ſtolen unperceived, it becomes the lawful property of the thief. In vain would the rightful owner recognize it in his neighbour's tent; he cannot reclaim it; it ceaſes to be his from the moment he has been negligent in its care. Hence ariſes this peoples inclination for rapine:

they do not think they commit a crime, and only follow, in this regard, a cuſtom allowed by their laws.

When an Arab is going to market, or on his return from thence, if he do not take the greateſt care to keep his journey a ſecret, he is often attacked. Neighbouring Arabs are deſirous of profiting by his induſtry; and as there are no perſons in the country appointed to apprehend robbers, the hope of booty ſpurs them on to the attack. That they may have nothing to fear, they lie in wait, when the night is coming on, for him whom they mean to pillage. Their intention is never to kill; they only endeavour to ſurprize, to diſarm, and to make themſelves maſters of every thing that comes in their way. But it ſometimes happens, that the man they intend to plunder, being acquainted with the cuſtoms of his country, keeps an attentive ear, ſtands on his guard, fires upon his aſſailants at the firſt motion he obſerves, and then fights deſperately with his dagger. The report of the muſket almoſt always brings out the neighbouring Arabs, who, in virtue of the laws of hoſpitality, take the defence of the weaker ſide. They run up well armed; and then woe to the aggreſſors, if they do not ſave themſelves by a ſpeedy flight.

The flocks and herds of the Mongearts are compoſed of nothing but ſheep, goats, and camels; all animals patient of thirſt. Horſes are very ſcarce in theſe cantons, none but the poſſeſſors of numerous herds being able to keep them; becauſe, for want of water, it is neceſſary to have milk in ſufficient abundance to give it them to drink. Great care is taken to preſerve the camel's urine, both to mix with milk, and to waſh the different veſſels in which they put their food. Deteſtable as is this mixture of milk and urine, they are often reduced to the uſe of it; hunger and thirſt give a reliſh to every thing.

The only workmen uſeful to this nation are blackſmiths or goldſmiths, as they may be called indifferently. The Mongearts not being ſufficiently laborious to apply themſelves to ſuch occupations, theſe workmen come from Bilidulgerid, and diſperſe themſelves all over the different parts of the deſert. Wherever there are tents they are ſure to find work. They are fed for nothing, and receive beſides the hire for their labour. They make trinkets for the women, ſuch as ear-rings and bracelets, &c. mend the broken veſſels, by rivetting them, and clean the arms. They are generally paid in ſkins, goats and camels hair, or oſtrich feathers, according to their agreement. Thoſe who have ſilver pay them a tenth part of its weight for any thing wrought out of that metal. On their return they ſell what they have earned; four or five excurſions at moſt enabling them to live afterwards at their eaſe in their own country.

The Mongearts always carry a leathern bag, ſuſpended from their neck, in which they put their tinder, their pipe, and their tobacco. Their daggers are elegant; the hilt is always black, and inlaid with ivory; the blade is crooked, and ſharp on either ſide; the ſheath is of braſs on one ſide, and of ſilver on the other, and of very tolerable workmanſhip. They wear ſabres when they can get them, and prefer thoſe of Spaniſh make. Their muſkets are always highly ornamented; the ſtock is very ſmall, and inlaid on every ſide with ivory, and the barrel emboſſed with braſs or ſilver, according to the opulence of the owner. There is a ſpring to the lock, covering the priming, to prevent the piece from going off, contrary to the intention of him who carries it. The poor, who do not poſſeſs muſkets, wear daggers, made like the Flemiſh knives, with leathern ſheaths. They arm themſelves alſo with a thick ſtick, to the end of which they fix a kind of iron wedge. This weapon is exceedingly dangerous at cloſe quarters. Others carry *zagays*, or ſlender javelins. In a word, the principal riches of an Arab, and his higheſt gratifications, are a handſome muſket and a good dagger. He prefers them to neatneſs of apparel; for as to dreſs, it is indifferent to him whether he be clothed in Guinea blues, woollen ſtuffs, or goats ſkins. Their arms being their principal ornament, they take particular care to put the muſkets in leathern bags, by way of keeping them in good order, and preſerving them from the ruſt.

All the riches of the Mongearts conſiſt in their herds; and accordingly they take the greateſt care to preſerve them. If a beaſt be ſick, every thing is done to cure it; no care is ſpared; it is even treated with more attention than a man: but when it evidently appears that there is no hope of ſaving its life, they kill and eat it. If it be a camel, the neighbours are called in to partake of the repaſt; if a goat, the inhabitants of the tent ſuffice for its conſumption. An animal that dies without ſhedding blood is unclean. Its throat muſt be cut; the perſon who kills it turning to the eaſt, and pronouncing beforehand the firſt words of the general prayer. An animal killed by a wild boar is unclean; nor is it eaten although its blood has been ſhed, becauſe the wild boar is itſelf an unclean beaſt. That ſpecies is ſo numerous in the deſart, that they do more miſchief than all the other wild beaſts together. The Arabs kill as many as they can; but never taſte their fleſh.

Whatever loſſes an Arab may meet with, he is never heard to complain; he riſes ſuperior to poverty, ſupports hunger, thirſt, and fatigue, with patience, and his courage is proof againſt every event. God will have it ſo, ſays he: he employs, however, every means in his power to avert misfortune; and often expoſes himſelf to the greateſt dangers to procure matters of no real utility.

When a father of a family dies, all the effects in his tent are ſeized upon by the eldeſt ſon preſent at his deceaſe. Gold, ſilver, trinkets, every thing diſappears; and the abſent children have only an equal ſhare in the diviſion of the cattle and the ſlaves. The girls are entirely excluded from all participation, and take up their reſidence with their eldeſt brother. If the deceaſed leave children in helpleſs infancy, the mother takes them with her to her ſiſter's, if ſhe have a ſiſter married; if not, to her own maternal roof. The dead man's poſſeſſions, however, are not loſt; the chief of the horde takes care of them, and delivers them in equal portions to the heirs, as ſoon as they are old enough to manage their own property. If an Arab die without male children, his wife returns to her relations, and his brother inherits his effects.

The Mongearts have a rooted abhorrence of the Spaniards, and never fail to maſſacre every man of that nation who is ſo unfortunate as to be ſhipwrecked on their coaſts, while they reſerve the women for ſale at Morocco. The reaſon of this hatred is, that the inhabitants of the Canaries make frequent deſcents on the Mongeart coaſts, and carry off men, women, cattle, and every

every thing that they meet with ; and theſe people, being ignorant of the fate of their countrymen, retaliate by death on all Spaniards that fall into their hands, whilſt they treat the Britiſh and French as well as they can.

MONNIER (Peter Charles Le), was born at Paris on the 20th of November 1715 The profeſſion of his father, or the rank which he held in ſociety, we have not learned ; and we are equally ignorant of the mode in which he educated his ſon. All that we know is, that young Monnier, from his earlieſt years, devoted himſelf to the ſtudy of aſtronomy ; and that, when only ſixteen years of age, he made his firſt obſervation, viz. of the oppoſition of Saturn. At the age of twenty he was nominated a member of the Royal Academy of Sciences at Paris. In the year 1735 he accompanied Maupertuis in the celebrated expedition to Lapland, to meaſure a degree of latitude. In 1748 he went to Scotland with Lord Macclesfield, to obſerve the annular eclipſe of the ſun, which was moſt viſible in that country ; and he was the firſt aſtronomer who had the pleaſure to meaſure the diameter of the moon on the diſk of the ſun.

Louis XV. it is well known, was extremely fond of aſtronomy, and greatly honoured its profeſſors : he loved and eſteemed Le Monnier. I have ſeen the king himſelf (ſays Lalande) come out of his cabinet, and look around for Le Monnier ; and when his younger brother was preſented to him on his appointment to the office of firſt phyſician, his Majeſty was pleaſed to wiſh him the merit and reputation of his brother the aſtronomer. All the remarkable celeſtial phenomena were always obſerved by the king, in company with Le Monnier. Thus he obſerved with him, at his chateau of St Hubert, the two celebrated tranſits of Venus thro' the diſk of the ſun in the years 1761 and 1769; as appears from the Memoirs of the Royal Pariſian Academy of Sciences. It well deſerves to be here recorded in what manner the king behaved during theſe important obſervations, and how little he diſturbed his aſtronomers (the celebrated La Condamine being likewiſe permitted to obſerve the tranſit in his preſence) in this occupation ; the proper time for which, if permitted to paſs by, could not be recalled. Le Monnier relates in his Diſſertation, that "his Majeſty perceiving that we judged the laſt contacts to be of the greateſt importance, a profound ſilence at that moment reigned around us." At the tranſit of Venus in 1769, the king allowed the Marquis de Chabert, an intelligent and expert naval officer, who was juſt returned from a literary voyage to the Levant, to aſſiſt at the obſervation. In a court like that of Louis XV. ſo ſcrupulouſly obſervant of etiquette, theſe will be allowed to have been moſt diſtinguiſhed marks of honour, and of royal favour and condeſcenſion.

In the year 1750, Le Monnier was ordered to draw a meridian at the royal Chateau of Bellevue, where the king frequently made obſervations. The monarch on this occaſion rewarded him with a preſent of 15,000 livres; but Le Monnier applied this ſum of money likewiſe in a manner that redounded to the honour of his munificent ſovereign and of his country, by procuring new and accurate inſtruments, with which he afterwards made his beſt and moſt remarkable obſervations. In 1742, the king gave him in Paris *Reu de la Poſte*, a beautiful free dwelling, where, till the breaking out of the revolution, he reſided, and purſued his aſtronomical labours, and where his inſtruments in part yet remain. Some of them the preſent French government has, at the inſtance of Lalande, purchaſed for the National Obſervatory. In 1751, the king preſented him with a block of marble, eight feet in height, ſix feet in breadth, and fifteen inches in thickneſs, to be uſed for fixing his mural quadrant of five feet. This marble wall, together with the inſtruments appended to it, turns on a large braſs ball and ſocket, by which the quadrant may be directed from ſouth to north ; thus ſerving to rectify the large mural quadrant of eight feet, which is immoveably made faſt to a wall towards the ſouth.

With theſe quadrants Le Monnier obſerved, for the long period of forty years, the moon with unwearied perſeverance at all hours of the night. It is requiſite, to be a diligent aſtronomer, to be able to conceive to what numberleſs inconveniences the philoſopher is expoſed during an uninterrupted ſeries of lunar obſervations. As the moon during a revolution may paſs through the meridian at all hours of the day or night ; the aſtronomer who, day after day, proſecutes ſuch obſervations, muſt be prepared at all, even the moſt inconvenient, hours, and ſacrifice to them his ſleep and all his enjoyments. How ſecluded from all the pleaſures of ſocial intercourſe, and how fatiguing ſuch a mode of life is, thoſe aſtronomers, indeed, know not who then only ſet their pendulum clocks in motion, when ſome of the eclipſes of the ſun, moon, or of the ſatellites of Jupiter, are to be viewed. At this time, and in the preſent ſtate of the ſcience, theſe are juſt the moſt inſignificant obſervations; and an able aſtronomer, well ſupplied with accurate inſtruments, may *every day*, if he take into his view the whole of his profeſſion, make more important and more neceſſary obſervations.

Le Monnier was Lalande's preceptor, and worthy of ſuch a ſcholar ; and he promoted his ſtudies by his advice, and by every other means in his power. Le Monnier's penetrating mind, indeed, preſaged in young Lalande, then only ſixteen years old, what in the ſequel has been ſo ſplendidly confirmed. In his twentieth year, he became, on the recommendation of his preceptor, a member of the Royal Academy: and in 1752 he was propoſed by him as the fitteſt perſon to be ſent to Berlin, to make with La Caille's, who had been ſent to the Cape of Good Hope, correſpondent obſervations, for the purpoſe of determining the parallaxes of the moon, then but imperfectly known. Le Monnier lent his pupil for this expedition his mural quadrant of five feet. His zeal for aſtronomy knew no bounds. For this reaſon Lalande, in his *Notice des Travaux du C. Le Monnier*, ſays of himſelf : "*Je ſuis moi-meme le principal reſultat de ſon zele pour l'aſtronomie.*"

Le Monnier was naturally of a very irritable temper: as ardently as he loved his friends, as eaſily could he be offended ; and his hatred was then implacable. Lalande, as he himſelf expreſſes it, had the misfortune to incur the diſpleaſure of his beloved preceptor ; and he never after could regain his favour. But Lalande's gratitude and reſpect for him always continued undiminiſhed, and were on every occaſion with unremitting conſtancy publicly declared : patiently he endured from him undeſerved ill treatment ; ſo much did he love and

eſteem

eſteem his inſtructor and maſter to the day of his death. "I have not ceaſed to exclaim (writes Lalande), as Diogenes exclaimed to his maſter Antiſthenes, You cannot find a ſtick ſtrong enough to drive me away from you!"

What a noble trait in the character of Lalande, who in 1797 wrote likewiſe an eulogium on Le Monnier in the ſtyle of a grateful pupil, penetrated with ſentiments of profound veneration and eſteem for his beloved maſter; but Le Monnier would not read it. This is not the place to give a circumſtantial account of this intricate quarrel; we ſhall only further remark, that Lalande was the warm friend and admirer of the no leſs eminent aſtronomer La Caille, whom Le Monnier mortally hated. An intimate friendſhip likewiſe ſubſiſted between Le Monnier and D'Alembert; but Lalande had no friendly intercourſe with the latter.

Among the ſcholars of Le Monnier may likewiſe be reckoned Henwart, the celebrated geometrician and profeſſor of mathematics at Utrecht; who, in a letter to Von Zach, aſtronomer to the Duke of Saxe Gotha, dated the 26th of May 1797, ſays, "Le Monnier is a penetrating and philoſophical aſtronomer: I learned much from him in Paris; though I lodged with the late De l'Iſle, where I frequently made obſervations in company with Meſſier. Le Monnier was the friend of D'Alembert; and conſequently an oppoſer of Lalande."

This great man, who had, for ſome years, ceaſed to exiſt either for the ſcience of aſtronomy, or for the comfort of his friends, died at Lizeaux, in the province of Normandy, in 1799, aged 84 years. He left behind him ſome valuable manuſcripts, and a number of good obſervations; with reſpect to which he had always been very whimſical, and of which in his latter years he never would publiſh any thing. He had by him a ſeries of lunar obſervations, and a multitude of obſervations of the ſtars, for a catalogue of the ſtars, which he had announced ſo early as the year 1741; among which was twice to be found the new planet Uranus: (See *Lalande's Aſtronomie, Tables*, p. 188, (A). The more he was requeſted to communicate his obſervations, the more obſtinate he became; he even threatened to deſtroy them. At the breaking out of the revolution, Lalande was greatly alarmed for the ſafety of theſe papers; he wiſhed to preſerve them from deſtruction, and made an attempt to get them into his poſſeſſion; but all his endeavours were in vain. He was only able to learn, that Le Monnier had hidden them under the roof of his houſe. Le Monnier having been firſt ſeized with a fit of the apoplexy ſo early as the 10th of November 1791, Lalande apprehended, leſt, if no one except himſelf ſhould know where he had hidden his papers, the infirm old man might perhaps have himſelf forgot it. He hopes, however, that La Grange, who married his ſecond daughter, may have ſome information concerning them. Le Monnier left behind him no ſon.

MONOMIAL, in algebra, is a ſimple or ſingle nomial, conſiſting of only one term; as a or $a x$, or $a^2 b x^3$, &c.

MONOTRIGLYPH, a term in architecture, denoting the ſpace of one triglyph between two pilaſters, or two columns.

MONSELEMINES, are a people which inhabit that part of BILEDULGERID (ſee *Encycl.*) that borders on the territories of the Emperor of Morocco. They are a mixed race, being deſcended from the ancient Arabs and fugitive Moors; and they occupy a ſpace of land, of which the limits are indicated by lofty columns placed at intervals towards the deſart. Their territory extends from about 30 leagues beyond Cape Non, to the diſtance of 20 leagues from St Croix or Agader. Though of different qualities, it is, for the moſt part, very fertile, and produces the neceſſaries of life with little cultivation. The plains are watered by an infinite number of ſtreams, and abound with palm, date, fig, and almond trees. The gardens produce excellent grapes, which are dried by the Arabs, and converted into brandy by the Jews. Great quantities of oil, wax, and tobacco, appear in the public markets.

More induſtrious and more laborious than their neighbours, the Monſelemine nation cultivates the earth. The chiefs of families chooſe the ground moſt fit for cultivation. Its ſurface is turned ſlightly over with a kind of hoe, and then the ſeed is ſown upon it: the field is ſurrounded with buſhes, to mark the ſpot, and to preſerve it from the cattle of the wandering Arabs. When the crop is ripe, which is generally at the end of Auguſt, three months after the ſowing of the ſeed, it is cut about ſix inches from the ear, and formed into little bundles; during which time every one labours without intermiſſion from morning to night. The corn is brought before the tent, thraſhed, winnowed, and placed in the magazines. When the harveſt is over, they ſet fire to the long ſtubble, and abandon the field for two or three years. Their magazines are large holes in the earth, formed like the fruſtum of a cone, the inſides of which are hardened by burning wood in them, before the half winnowed corn be depoſited. When filled with corn, they are covered with planks placed cloſe to each other; over which a layer of earth is laid level with the ſoil, to prevent it from being diſcovered by enemies. In theſe magazines every one ſhares in proportion to the number of men he employed in the common labour.

The inhabitants of the plains remain by the cultivated fields in ſeed time, and return at the time of harveſt. During the intervals they wander in all directions with their cattle, taking only neceſſaries along with them, and having recourſe to the magazines when they require

---

(A) Such is the French and German account of his diſcovery of this planet; but our readers have been very inattentive, if they have not perceived, in various articles of this Work, complete proofs of the plagiariſm of our neighbours on the Continent, from the celebrated philoſophers and divines of England. As it is extremely probable that, half a century hence, a claim may be put in for Le Monnier's diſcovery of the Georgium Sidus (*Uranus*), ſimilar to that which in 1757 the editor of Abbé St Real's works put in for that Abbé being the author of Leſlie's *Short Method with the Deiſts* (ſee LESLIE in this *Suppl.*), we think it our duty to declare, that in 1800 there was no evidence whatever on which to found that claim, and that the diſcovery was then univerſally allowed to have been made by Herſchel.

M ſele-
r es.

quire a ſupply. The more opulent people, and the artizans who are engaged in ſedentary occupations, dwell in towns, which are all ſituated upon the declivity of hills. Their houſes are built of ſtone and earth, according to the Mooriſh conſtruction, low and covered with ſloping terraces; yet they are ſo much injured by the heavy rains which prevail for three months of the year, as to be rendered uninhabitable in 15 or 20 years. Thoſe who reſide in towns are generally weavers, ſhoemakers, goldſmiths, potters, &c. and have no cattle; but the more opulent perſons have flocks and herds of cows, horſes, camels, ſheep, goats, beſides poultry, which are kept by their ſlaves at a diſtance from the towns. In the towns they take two meals a day; one at ten o'clock, and the other at the ſetting of the ſun, though the inhabitants of the country only eat in the evening. In the towns they ſleep in mats upon the floors of their apartments, and make uſe of linen; but the inhabitants of the country ſleep upon terraces in the open air. The paſtoral families of the country practiſe hoſpitality like thoſe of the deſart, and make the traveller pay nothing for his entertainment. In the towns this practice is impoſſible, as the concourſe of ſtrangers, eſpecially on market-days, would ſoon impoveriſh the inhabitants. In this manner hoſpitality is always extinguiſhed among a trading and commercial people. It is only where the ſuperfluity of commodities runs neceſſarily to waſte, that it is ever practiſed in a great extent; but where every commodity can find a market, every kind of property acquires a definite value, and will be preſerved with the ſame care as money.

By M. Saugnier the government of the Monſelemines is ſaid to be republican; but he writes inconſiſtently about it In one place, he ſays that they chooſe their chiefs annually; in another, that in the time of war they chooſe from the natives or fugitive Moors indiſcriminately, chiefs, whoſe authority laſts no longer than the campaign, during which it is abſolute; and he afterwards repreſents their government as a kind of theocracy, during war as well as peace. But we muſt follow him in his detail, as it has been well arranged in a late anonymous publication, entitled, *An Hiſtorical Sketch of Diſcoveries in Africa*.

At the end of each campaign, he ſays the chief gives an account of his actions to the aſſembled aged men, and is rewarded or puniſhed according to his conduct; after which his ſucceſſor is appointed, and he ſerves in the army he commanded as an undiſtinguiſhed individual. The country is populous, and would be ſtill more ſo, were it not for the continual wars which its inhabitants are obliged to ſupport againſt the Emperor of Morocco. The liberty they enjoy imparts energy and courage to their character, and renders their arms invincible to the Moors. They conſider it as the moſt invaluable poſſeſſion, and defend it to the laſt extremity. The nature of the country, ſurrounded on every ſide by ſteep and arid mountains, contributes to fruſtrate the efforts of their enemies. The Monſelemine, richer than the ſubject of Morocco, is always well clothed and armed. He pays no tribute, enjoys the fruit of his labour and commerce, and, as no contributions are requiſite for the charges of the ſtate, whatever he acquires is his own. The fugitive Moors are never armed, except when they go to battle; but the natives go continually armed, whether they reſide in the country, reſort to the markets, attend the aſſemblies of the nation, or pay viſits.

Monſelemines.

As the Monſelemine territory is the retreat of the rich Moors, who wiſh to fly from the tyranny of the Emperor of Morocco, they are too well acquainted with the Mooriſh cuſtoms to be ſurpriſed by that prince. No ſooner does a Mooriſh army take the field, than the inhabitants of the country cantons mount their horſes, and occupy the paſſes of the mountains; while the women and ſlaves, eſcorted by a ſufficient number of warriors, retire to the interior parts of the country, or, if they be hard preſſed, to the deſart. Among the paſtoral tribes there are many that addict themſelves entirely to arms, and ſerve as cavalry in the time of war. During peace they eſcort caravans, or exerciſe themſelves in military evolutions, and the management of their horſes. Being almoſt always on horſeback, and wearing no boots, they have a callous lump on that part of the leg that comes in contact with the iron of the ſtirrup. Their horſes, which they break in an admirable manner, are the beſt in the world: as they are treated with great care by their maſters, they know them, and are obedient to their voice, and will admit no ſtranger to mount them.

The Monſelemines derive their origin and name from Moſeílama, a contemporary of Mahomet; and, in their love of liberty, as well as in many of their cuſtoms, reſemble the Arabs of remoter times. They reſpect the prophet like other Mahometans; but neither believe that he was infallible, nor that his deſcendants are all inſpired by God, nor that their will ſhould be a law, nor that ſuch faith is neceſſary in order to be a good Mahometan. Their prieſts are reſpected, and in old age generally become the civil judges of the nation; but the influence of the high prieſt is almoſt deſpotic. Though he has no troops, he may command the nation; and war and peace depend upon his will. Though he has no property, every thing is at his diſpoſal: he requires nothing from any one, and yet all are inclined to give. He adminiſters juſtice according to the opinion of his counſel, without pretending to be inſpired by the prophet.

On Friday the Monſelemines aſſemble in their moſques to pray: this is likewiſe the day of their principal market, when their merchandize is expoſed to ſale in the public ſquares, where the old men judge without appeal, when diſputes ariſe. Different from their neighbours of Morocco and Sahara, the Monſelemines never attempt to make proſelytes. Their Chriſtian ſlaves are treated with humanity; but they owe this to the avarice of their maſters. Theſe deteſt Chriſtians, but they love money, and are afraid leſt ſickneſs or death ſhould deprive them of the ranſom of the ſlave, or of the advantage of his labour. Among the inhabitants of the deſart, a Chriſtian, that adopts the religion of Mahomet, is admitted as a citizen and member of the family, and is preſented with cattle to form an eſtabliſhment. The Monſelemines pay more attention to the value of their property than the ſituation of the infidel. A Chriſtian who enters a moſque at Morocco is put to death, or forced to aſſume the turban. The Monſelemines would turn him civilly out, and content themſeles with impoſing the higheſt poſſible fine. Among the Moors, a Chriſtian diſcovered in an intrigue with a woman of that nation ſuffers death, or ſubmits to

con-

Monſelemines, Monterey.

converſion; but the Monſelemines prefer money to religion. From them the Chriſtian has nothing to fear: the woman alone is puniſhed, being put into a ſack, and thrown into the ſea. If a Chriſtian ſlave among the neighbouring nations defends himſelf againſt his maſter, he is puniſhed with death; but money ſaves him among the Monſelemines; he would at moſt receive a ſlight correction.

The Jews are allowed the free exerciſe of their religion among the Monſelemines, but are treated with the ſame indignity as among other Mahometan tribes. A Jew is not permitted to carry arms; and if he ſhould make uſe of them againſt an Arab, he would be puniſhed with death, and probably involve his family in his fate. The Jews inhabit the towns only, where they follow trade and various arts, but are not allowed to cultivate the earth.

Polygamy is permitted, as in other Mahometan countries; but the ſituation of the women is more reſpectable, and they are not ſo much ſecluded as among the Moors. They mingle more in ſociety, walk at large, and viſit their friends; neither are their apartments ſo inviolable. Among the Monſelemines, that degrading picture of humanity is never ſeen which ſometimes occurs in Morocco, a woman drawing the plough with an aſs, a mule, or ſome other beaſt of burden. More happy than the women of the Sahara, and treated with greater attention by their huſbands, they are more humane in their diſpoſitions. Like other Arab women, they ſtain the edges of their eyelids black with henna, and paint their faces red and yellow. Their children are brought up with great care, and are not obliged to exhibit proofs of their courage before they can be conſidered as men, as is the cuſtom in the deſart. Avarice is the principal defect in the character of the Monſelemines. They hoard their money with the utmoſt care, bury it in the earth, and in many caſes die without diſcovering their ſecret even to their children. Miſers, ſays M. Saugnier, ſhould go to that country, where they would learn means of economy; which would ſhew them, that, in compariſon with the Monſelemines, they are themſelves perfect prodigals.

The medicinal applications of the Monſelemines, which differ not from thoſe of the MONGEARTS and other inhabitants of the deſart, are extremely ſimple, but appear ſufficiently complex from the mummery of the prieſts, who are the depoſitories of their medical ſcience. Fleſh wounds are cauteriſed with a hot iron, and then covered with herbs dipped in turtles oil and tar. In headachs, a compreſs is applied with ſuch violence that the blood ſtarts from the forehead. In internal diſeaſes, the general remedies are regimen, reſt, and a few maxims of the Koran myſteriouſly applied to the affected parts.

MONTEREY BAY, in North California, was viſited in 1786 by La Perouſe, who places it in 36° 58′ 43″ N. Lat. and 124° 40′ W. Long. from Paris. It is formed by New-year Point to the north, and by that of Cyprus to the ſouth; has an opening of eight leagues in this direction, and nearly ſix of depth to the eaſtward, where the land is ſandy and low. The ſea breaks there as far as the foot of the ſandy downs with which the coaſt is ſurrounded, with a roaring which may be heard more than a league off. The lands north and ſouth of this bay are high, and covered with trees. Thoſe ſhips which are deſirous of touching there ought to follow the ſouth coaſt, and after having doubled the Point of Pines, which ſtretches to the northward, they get ſight of the preſidency, and may come to an anchor in ten fathoms within it, and a little within the land of this point, which ſhelters from the winds from the offing. The Spaniſh ſhips, which propoſe to make a long ſtay at Monterey, are accuſtomed to bring up within one or two cable's lengths of the land, in ſix fathoms, and make faſt to an anchor, which they bury in the ſand of the beach; they have then nothing to fear from the ſoutherly winds, which are ſometimes very ſtrong; but, as they blow from the coaſt, do not expoſe them to any danger. The two French frigates, which our author commanded, found bottom over the whole bay, and anchored four leagues from the land, in 60 fathoms, ſoft muddy ground; but there is a very heavy ſea, and it is only an anchorage fit for a few hours, in waiting for day, or the clearing up of the fog. At full and change of the moon it is high water at half paſt one o'clock: the tide riſes ſeven feet; and as this bay is very open, the current in it is nearly imperceptible. It abounds with whales; a genus of fiſhes, of which our *ſcientific* voyagers knew ſo little, that they were ſurpriſed at their ſpouting water!

The coaſts of Monterey Bey are almoſt continually enveloped in fogs, which cauſe great difficulty in the approach to them. But, for this circumſtance, there would be few more eaſy to land upon; there is not any rock concealed under water that extends a cable's length from the ſhore; and if the fog be too thick, there is the reſource of coming to an anchor, and there waiting for a clear, which will enable you to get a good ſight of the Spaniſh ſettlement, ſituated in the angle formed by the ſouth and eaſt coaſt. The ſea was covered with pelicans. Theſe birds, it ſeems, never go farther than five or ſix leagues from the land; and navigators, who ſhall hereafter meet with them during a fog, may reſt aſſured that they are within that diſtance of it.

A lieutenant-colonel, whoſe reſidence is at Monterey, is governor of the Californias: the extent of his government is more than 800 leagues in circumference, but his real ſubjects conſiſt only of 282 cavalry, whoſe duty it is to garriſon five ſmall forts, and to furniſh detachments of four or five men to each of the 25 miſſions, or pariſhes, eſtabliſhed in old and new California. So ſmall are the means which are adequate to the reſtraining about 50,000 wandering Indians in this vaſt part of America, among whom, nearly 10,000 have embraced Chriſtianity. Theſe Indians are, in general, ſmall and weak (A), and diſcover none of that love of liberty and independence which characteriſes the northern nations, of whoſe arts and induſtry they are alſo deſtitute. Their colour very nearly approaches that of the negroes whoſe hair is not woolly; the hair of theſe people is ſtrong, and of great length; they cut it four or five inches from the roots. Several among them have a beard; others, according to the miſſionary fathers, have never had any; and this is a queſtion which is even undecided

---

(A) The chief ſurgeon of the expedition ſays they are *ſtrong*, but ſtupid.

decided in the country. The governor, who had travelled a great way into the interior of theſe lands, and who had paſſed 15 years of his life among the ſavages, aſſured our author, that thoſe who had no beards had plucked them up with bivalve ſhells, that ſerved them as pincers: the preſident of the miſſions, who had reſided an equal length of time in California, maintained the contrary;—it was difficult, therefore, for travellers to decide between them." The difficulty, ſurely, was not great. By their own account, the governor had travelled much farther into the country than the miſſionary; and his report being confirmed by the evidence of their own ſenſes, was intitled to unlimited credit.

Theſe Indians are extremely ſkilful in drawing the bow; they killed, in the preſence of the French, the ſmalleſt birds: it is true, they diſplay an inexpreſſible patience in approaching them; they conceal themſelves, and, as it were, glide along near to the game, ſeldom ſhooting till within 15 paces. Their induſtry in hunting the larger animals is ſtill more admirable. Perouſe ſaw an Indian, with a ſtag's head fixed upon his own, walk on all-fours, as if he were browſing the graſs; and he played this pantomime to ſuch perfection, that all the French hunters would have fired at him at 30 paces, had they not been prevented. In this manner they approach herds of ſtags within a very ſmall diſtance, and kill them with a flight of arrows.

Before the Spaniſh ſettlements, the Indians of California cultivated nothing but maize, and almoſt entirely lived by fiſhing and hunting. There is not any country in the world which more abounds in fiſh and game of every deſcription: hares, rabbits, and ſtags are very common there; ſeals and otters are alſo found there in prodigious numbers; but to the northward, and during the winter, they kill a very great number of bears, foxes, wolves, and wild cats. The thickets and plains abound with ſmall grey tufted partridges, which, like thoſe in Europe, live in ſociety, but in large companies of three or four hundred; they are fat, and extremely well flavoured. The trees ſerve as habitations to the moſt delightful birds; and the ornithologiſts of the voyage ſtuffed a great variety of ſparrows, titmice, ſpeckled wood-peckers, and tropic birds. Among the birds of prey are found the white-headed eagle, the great and ſmall falcon, the goſs hawk, the ſparrow hawk, the black vulture, the large owl, and the raven. On the ponds and ſea-ſhore are ſeen the wild duck, the grey and white pelican with yellow tufts, different ſpecies of gulls, cormorants, curlews, ring-plovers, ſmall ſea water hens, and herons; together with the bee-eater, which, according to moſt ornithologiſts, is peculiar to the old continent.

The country about Monterey Bay is inexpreſſibly fertile. The crops of maize, barley, corn, and peaſe, cannot be equalled but by thoſe of Chili; our European cultivators can have no conception of a ſimilar fertility; the medium produce of corn is from ſeventy to eighty for one; the extremes ſixty and a hundred. Fruit trees are ſtill very rare there, but the climate is extremely ſuitable to them: it differs a little from that of the ſouthern French provinces. The foreſt trees are, the ſtone-pine, cyprus, evergreen oak, and occidental plane tree. There is no underwood; and a verdant carpet, over which it is very agreeable to walk, covers the ground. There are alſo vaſt ſavannahs, abounding with all ſorts of game.

Perouſe writes with great reſpect of the wiſe and pious conduct of the Spaniſh miſſionaries at Monterey, who ſo faithfully fulfil the purpoſe of their inſtitution. Totally unlike the monks at Conception in Chili (ſee that article in this *Suppl.*), they have left the lazy life of a cloiſter, to give themſelves up to cares, fatigues, and ſolicitudes of every kind. They invited the officers of the frigates to dine with them at their monaſtery, contiguous to which ſtands the Indian village, conſiſting of about 50 cabins, which ſerve as dwelling-places to 740 perſons of both ſexes, compriſing their children, which compoſe the miſſion of Saint Charles, or of Monterey. Theſe cabins are the moſt miſerable that are to be met with among any people; they are round, ſix feet in diameter, by four in height; ſome ſtakes, of the ſize of an arm, fixed in the earth, and which approach each other in an arch at the top, compoſe the timber work of it; eight or ten bundles of ſtraw, very ill arranged over theſe ſtakes, defend the inhabitants, well or ill, from the rain and wind; and more than half of this cabin remains open when the weather is fine; their only precaution is to have each of them two or three bundles of ſtraw at hand by way of reſerve.

All the exhortations of the miſſionaries have never been able to procure a change of this general architecture of the two Californias. The Indians ſay, that they like plenty of air; that it is convenient to ſet fire to their houſes when they are devoured in them by too great a quantity of fleas; and that they can build another in leſs than two hours. The independent Indians, who as hunters ſo frequently change their places of abode, have a ſtronger motive.

The monks gave the moſt complete information reſpecting the government of this ſpecies of religious community; for no other name can be given to the legiſlation they have eſtabliſhed. They are ſuperiors both in ſpiritual and temporal affairs: the products of the land are entirely entruſted to their adminiſtration. There are ſeven hours allotted to labour in the day, two hours to prayers, and four or five on Sundays and feſtivals, which are altogether dedicated to reſt and divine worſhip. Corporal puniſhments are inflicted on the Indians of both ſexes who neglect pious exerciſes; and ſeveral ſins, the puniſhment of which in Europe is reſerved only to Divine Juſtice, are puniſhed with chains or the ſtocks.

The Indians, as well as the miſſionaries, riſe with the ſun, and go to prayers and maſs, which laſt an hour; and during this time there is cooked in the middle of the ſquare, in three large kettles, barley meal, the grain of which has been roaſted previous to being ground; this ſpecies of boiled food, which the Indians call *atole*, and of which they are very fond, is ſeaſoned neither with ſalt nor butter, and to us would prove a very inſipid meſs. Every cabin ſends to take the portion for all its inhabitants in a veſſel made of bark: there is not the leaſt confuſion or diſorder; and when the coppers are empty, they diſtribute that which ſticks to the bottom to the children who have beſt retained their leſſons of catechiſm. This meal continues three quarters of an hour, after which they all return to their labours; ſome go to plough the earth with oxen, others to dig the garden; in a word, every one is employed in different

Mongearts. rent domeſtic occupations, and always under the ſuperintendance of one or two of the religious.

The women are charged with little elſe but the care of their houſewifery, their children, and roaſting and grinding the ſeveral grains: this laſt operation is very long and laborious, becauſe they have no other means of doing it but by cruſhing the grain in pieces with a cylinder upon a ſtone. M. de Langle, being a witneſs of this operation, made the miſſionaries a preſent of his mill; and a greater ſervice could not have been rendered them, as by theſe means four women would in a day perform the work of a hundred, and time enough will remain to ſpin the wool of their ſheep, and to manufacture coarſe ſtuffs.

At noon the dinner was announced by the bell; the Indians quitted their work, and ſent to fetch their rations in the ſame veſſels as at breakfaſt: but this ſecond meſs was thicker than the firſt; there was mixed in it corn and maize, and peaſe and beans; the Indians name it *pouſſole*. They return again to their labour from two o'clock till four or five; afterwards they attend evening prayers, which continue near an hour, and are followed by a new ration of *atole* like that at breakfaſt. Theſe three diſtributions are ſufficient for the ſubſiſtence of the far greater number of Indians; and this very economical ſoup might perhaps be very profitably adopted in our years of ſcarcity; ſome ſeaſoning would certainly be neceſſary to be added to it, their whole knowledge of cookery conſiſting in being able to roaſt the grain before it is reduced into meal. As the Indian women have no veſſels of earth or metal for this operation, they perform it in large baſkets made of bark, over a little lighted charcoal; they turn theſe veſſels with ſo much rapidity and addreſs, that they effect the ſwelling and burſting of the grain without burning the baſket, though it is made of very combuſtible materials.

The corn is diſtributed to them every morning; and the ſmalleſt diſhoneſty, when they give it out, is puniſhed by whipping: but it is very ſeldom, indeed, they are expoſed to it. Theſe puniſhments are adjudged by Indian magiſtrates, called *caciques;* there are in every miſſion three of them, choſen by the people from amongſt thoſe whom the miſſionaries have not excluded: but theſe caciques are like the governors of a plantation, paſſive beings, blind executors of the will of their ſuperiors; and their principal functions conſiſt in ſerving as beadles in the church, and their maintaining order and an air of contemplation. The women are never whipped in public, but in an incloſed and ſomewhat diſtant place, leſt perhaps their cries might inſpire too lively a compaſſion, which might ſtimulate the men to revolt; theſe laſt, on the contrary, are expoſed to the view of all their fellow-citizens, that their puniſhment may ſerve as an example. In general they aſk pardon; in which caſe the executioner leſſens the force of his laſhes, but the number of them is never receded from.

The rewards are particular ſmall diſtributions of grain, of which they make little thin cakes, baked on burning coals: and on the great feſtivals the ration is in beef; many of them eat it raw, eſpecially the fat, which they eſteem equal to the beſt butter or cheeſe. They ſkin all animals with the greateſt addreſs; and when they are fat, they make, like the ravens, a croaking of pleaſure, devouring, at the ſame time, the moſt delicate parts with their eyes.

They are frequently permitted to hunt and fiſh on their own account; and on their return they generally make the miſſionaries ſome preſent in game and fiſh; but they always proportion the quantity to what is abſolutely neceſſary for them, always taking care to increaſe it if they hear of any new gueſts who are on a viſit to their ſuperiors. The women rear fowls about their cabins, the eggs of which they give their children. Theſe fowls are the property of the Indians, as well as their clothes, and other little articles of houſehold furniture, and thoſe neceſſary for the chace. There is no inſtance of their having robbed each other, though their faſtenings to the doors conſiſt only of a ſimple bundle of ſtraw, which they place acroſs the entrance when all the inhabitants are abſent.

The men in the miſſions have ſacrificed much more to Chriſtianity than the women; becauſe they were accuſtomed to polygamy, and were even in the cuſtom of eſpouſing all the ſiſters of a family. The women, on the other hand, have acquired the advantage of excluſively receiving the careſſes of one man only. With this, however, it would appear that they are not ſatisfied; for the religious have found it neceſſary to conſtitute themſelves the guardians of female virtue. At an hour after ſupper, they have the care of ſhutting up, under lock and key, all thoſe whoſe huſbands are abſent, as well as the young girls above nine years of age; and during the day they are entruſted to the ſuperintendance of the matrons. So many precautions are ſtill inſufficient; for our voyagers ſaw men in the ſtocks, and women in irons, for having deceived the vigilance of theſe female arguſſes, who had not been ſufficiently ſharp-ſighted.

The converted Indians have preſerved all the ancient uſages which their new religion does not prohibit; the ſame cabins, the ſame games, the ſame dreſſes: that of the richeſt conſiſts of an otter's ſkin cloak, which covers their loins, and deſcends below their groin; the moſt lazy have only a ſimple piece of linen cloth, with which they are furniſhed by the miſſion, for the purpoſe of hiding their nakedneſs; and a ſmall cloak of rabbit's ſkin covers their ſhoulders, which is faſtened with a pack-thread under the chin; the head and the reſt of the body is abſolutely naked; ſome of them, however, have hats of ſtraw, very neatly matted. The womens dreſs is a cloak of deer ſkin, ill tanned; thoſe of the miſſions have a cuſtom of making a ſmall boddice, with ſleeves, of them: it is their only apparel, with a ſmall apron of ruſhes, and a petticoat of ſtag's ſkin, which covers their loins, and deſcends to the middle of the leg. The young girls, under nine years of age, have merely a ſimple girdle; and the children of the other ſex are quite naked.

The independent ſavages are very frequently at war; but the fear of the Spaniards makes them reſpect their miſſions; and this, perhaps, is not one of the leaſt cauſes of the augmentation of the Chriſtian villages. Their arms are the bow, and arrow pointed with a flint very ſkilfully worked: theſe bows are made of wood, and ſtrung with the ſinews of an ox. Our author was aſſured, that they neither eat their priſoners, nor their enemies killed in battle; that, nevertheleſs, when they

had

had vanquiſhed, and put to death on the field of battle, chiefs, or very courageous men, they have eaten ſome pieces of them, leſs as a ſign of hatred or revenge, than as a homage which they paid to their valour, and in the full perſuaſion that this food would be likely to increaſe their own courage. They ſcalp the vanquiſhed as in Canada, and pluck out their eyes; which they have the art of preſerving free from corruption, and which they carefully keep as precious ſigns of their victory. Their cuſtom is to burn their dead, and to depoſit their aſhes in morais.

MOORS, in common language, are the natives of Morocco, of whom an account is given under that title in the *Encyclopædia;* but there is another people, a mixed race, called alſo Moors, who lead a wandering and paſtoral life in the habitable parts of the Great Deſert, and in the countries adjacent to it. Of the origin of theſe Mooriſh tribes, as diſtinguiſhed from the inhabitants of Barbary, nothing farther ſeems to be known than what is related by John Leo the African; whoſe account may be abridged as follows:

Before the Arabian conqueſt, about the middle of the ſeventh century, all the inhabitants of Africa, whether they were deſcended from Numidians, Phœnicians, Carthaginians, Romans, Vandals, or Goths, were comprehended under the general name of *Mauri* or Moors. All theſe nations were converted to the religion of Mahomet, during the Arabian empire under the Kaliphs. About this time many of the Numidian tribes, who led a wandering life in the deſert, and ſupported themſelves upon the produce of their cattle, retired ſouthward acroſs the Great Deſert, to avoid the fury of the Arabians; and by one of thoſe tribes, ſays Leo (that of Zanhaga), were diſcovered, and conquered, the Negro nations on the Niger. By the Niger, is here undoubtedly meant the river of Senegal, which in the Mandingo language is called *Baſing*, or the Black River.

To what extent theſe people are now ſpread over the African continent, it is difficult to aſcertain. There is reaſon to believe, that their dominion ſtretches from weſt to eaſt, in a narrow line or belt, from the mouth of the Senegal (on the northern ſide of that river) to the confines of Abyſſinia. Mr Park deſcribes them as reſembling, in complexion, the Mulattoes of the Weſt Indies, and as having cruelty and low cunning pictured in their countenances. "From the ſtaring wildneſs in their eyes (ſays he), a ſtranger would immediately ſet them down as a nation of lunatics. The treachery and malevolence of their character are manifeſted in their plundering excurſions againſt the Negro villages. Oftentimes, without the ſmalleſt provocation, and ſometimes under the faireſt profeſſions of friendſhip, they will ſuddenly ſeize upon the Negroes cattle, and even on the inhabitants themſelves. The Negroes very ſeldom retaliate. The enterpriſing boldneſs of the Moors, their knowledge of the country, and, above all, the ſuperior fleetneſs of their horſes, make them ſuch formidable enemies, that the petty Negro ſtates, which border upon the deſert, are in continual alarm while the Mooriſh tribes are in the vicinity, and are too much awed to think of reſiſtance.

"Like the roving Arabs, the Moors frequently remove from one place to another, according to the ſeaſon of the year, or the convenience of paſturage. In the month of February, when the heat of the ſun ſcorches up every ſort of vegetation in the deſert, they ſtrike their tents, and approach the Negro country to the ſouth; where they reſide until the rains commence, in the month of July. At this time, having purchaſed corn, and other neceſſaries from the Negroes, in exchange for ſalt, they again depart to the northward, and continue in the deſert until the rains are over, and that part of the country becomes burnt up and barren.

"This wandering and reſtleſs way of life, while it inures them to hardſhips, ſtrengthens, at the ſame time, the bonds of their little ſociety, and creates in them an averſion towards ſtrangers, which is almoſt inſurmountable. Cut off from all intercourſe with civilized nations, and boaſting an advantage over the Negroes, by poſſeſſing, though in a very limited degree, the knowledge of letters, they are at once the vaineſt and proudeſt, and perhaps the moſt bigotted, ferocious, and intolerant, of all the nations on the earth; combining in their character the blind ſuperſtition of the Negro, with the ſavage cruelty and treachery of the Arab." But for them Mr Park would have accompliſhed the utmoſt object of his miſſion, and have reached Tombuctoo, and even Houſſa, with no other danger than what ariſes neceſſarily from the climate, from wild beaſts, and from the poor accommodation afforded in the huts of the hoſpitable Negroes. The wandering Moors, however, have all been taught to regard the Chriſtian name with inconceivable abhorrence; and to conſider it nearly as lawful to murder a European as it would be to kill a dog. It is, therefore, much leſs ſurpriſing that our traveller did not proceed farther along the banks of the Niger, than that he eſcaped the ſnares of ſo relentleſs a people.

MORINDA, is a plant, of which a very meagre deſcription has been given in the *Encyclopædia*, though it is of much importance in oriental commerce. It is cultivated to a great extent in the province of *Malwa* in the Eaſt Indies, where it furniſhes a valuable dye-ſtuff; and is thus deſcribed by William Hunter, Eſq; in the fourth volume of the Aſiatic Reſearches:

"It is a tree of a middling ſize; the *root* branchy; the *trunk* columnar, erect, covered with a ſcabrous bark. *Branches*, from the upper part of the trunk, ſcattered; of the ſtructure of the trunk. *Leaves* (ſeminal) oval, obtuſe, entire (mature), oppoſite, decuſſated, ovate, pointed at both ends, ſmooth, with very ſhort petioles. *Stipules*, lanced, very ſmall, withering. *Peduncles*, from the axils of the leaves, ſolitary, bearing an aggregate flower. *Calyx*, common receptacle roundiſh, collecting the ſeſſile flowers into an irregular head. *Perianth*, moſt entire, ſcarce obſervable above. *Coral*, one-petalled, funnel-form. *Tube*, cylindric: *Border*, five cleft; the *diviſions* lanced. *Stamen: Filaments*, five, thread-form, ariſing from the tube, and adhering to it through two thirds of their length, a little ſhorter than the tube. *Anthers*, linear, erect. *Piſtil. Germ*, beneath, four celled, containing the rudiments of four ſeeds. *Style*, thread-form, longer than the ſtamens. *Stigma*, two-cleft, thickiſh. *Pericarp*, common, irregular, divided on the ſurface into irregular angular ſpaces; compoſed of berries, pyramidal, compreſſed on all ſides by the adjacent ones, and concreted with them; lopped; containing towards the baſe a fleſhy pulp. *Seeds*, in each berry four; towards the point oblong, externally convex, internally angular."

The ſpecies here deſcribed is the *morinda arborea pedunculis ſolitariis* of Linnæus. It grows beſt in a black rich ſoil, free from ſtones, in ſituations moderately moiſt, not too high, yet ſufficiently elevated to prevent the rain water from ſtagnating, and where a ſupply of water can be had for the dry months. As the colouring matter, for which alone it is valuable, reſides chiefly in the bark of the root, the ſmall twigs, which contain little wood, bear a higher price than the larger pieces. The natives employ it in dyeing a pale red, or clay colour; which Mr Hunter ſays is more valuable for its durability than for its beauty. They likewiſe uſe it in dyeing a dark purple or chocolate colour: but for the proceſs, in both caſes, we muſt refer to the original memoir.

MORION, in botany, a name given by the ancients to a kind of nightſhade. See SOLANUM, *Encycl.*

MORION, in ancient mineralogy, a name given to one of the ſemipellucid gems, more commonly called *pramnion*. It is a ſtone appearing externally of a fine deep black; but when held up againſt a candle, or againſt the ſun-beams, it gives a very beautiful red in different degrees.

MOSHAIRA, or MOSHAHEREH, penſion or allowance in Bengal.

MOSS, the name given in Scotland, and we believe alſo in ſome parts of England, to what is more properly called a *moraſs*, a *fen*, or a *bog*. On the formation of theſe moſſes ſome conjectures have been hazarded in the *Encyclopædia*, where the reader will likewiſe find a copious account of the method which has for many years been ſucceſsfully employed to convert the MOSS OF KINCARDINE into an arable ſoil, or rather to remove the ſubſtance called *moſs* or *peat* from the rich ſoil which is found below it. A method, however, has been invented by Mr John Smith of Swindrig-muir, in the ſhire of Ayr, for *actually* converting the ſubſtance called moſs into a vegetable mould, which has been found by experience to carry rich crops of corn, hay, potatoes, &c. Of this gentleman's practice we have the following account in a ſmall pamphlet publiſhed in Edinburgh, 1798, by Fairbairn and Dickſon.

"The firſt thing to be done is to mark off, and cut out, proper main or maſter drains, in order to carry off the ſuperfluous water, taking care to preſerve the greateſt poſſible level; which drains are ſo conſtructed as to divide the field into incloſures from ſix to ten Scotch acres. If the moſs hangs or declines, the incloſures may be of any dimenſion whatever. The dimenſions of theſe drains when firſt made are eight feet wide, by four and a half feet deep, declining to two and a half feet at bottom, and coſt at the rate of one ſhilling per fall of eighteen and a half feet, running meaſure. The ridges are then to be marked off regularly, ſix or ſeven yards broad, formed with the ſpade in the manner following.

"In the centre of each ridge, a ſpace of about 20 inches is allowed to remain untouched, on each ſide of which a furrow is opened, and turned upon the untouched ſpace, ſo as completely to cover it (like what is called the feering of a gathered ridge). Thus begun, the work is continued, by cutting with the ſpade, in width about 12 inches, and turning it over to appearance as if done with a plough, until you come to the diviſion furrow, which ſhould be two feet wide, cut out and thrown upon the ſides of the ridges. The depth of the diviſion furrow is to be regulated by circumſtances, according as the moſs is wet or dry, but ſo as to anſwer the purpoſe of as it were bleeding the moſs, and conducting the water to the main drains.

"It may be here obſerved, that the ſucceſs of the aftercrops depends very much upon a proper formation of the ridges. They muſt not be made too high in the middle, for there they will be too dry like a peat, upon which the lime cannot act, and near the furrows they will be too wet, which is equally prejudicial; they ſhould therefore be conſtructed with a gentle declivity to the furrows, ſo as the rain which falls may rather filtrate through the ridge to the furrows than run quickly off the ſurface.

"The next operation is to top-dreſs the ridges with lime, at the rate of from four to eight chalders per acre. Five Wincheſter buſhels make a boll, and eight bolls a chalder of ſhell lime, producing ſixteen bolls powdered lime. The quicker the lime is put on after being ſlacked the better.

"The proper ſeaſon to prepare the moſs for a firſt crop is early the preceding ſummer; in that caſe the lime, aided by the heat, the after rains, and the winter froſts, makes conſiderable progreſs in the proceſs of putrefaction, conſequently forms a mould to receive the ſeed.

"Though oats have ſometimes ſucceeded as a firſt crop, potatoes have been found greatly preferable. The method of planting them is ſimple, and attended with little expence. The moſs, prepared by ridges, and limed as before deſcribed, beds for the potatoes are, in the ſpring, marked off, acroſs the ridges, five or ſix feet broad, with intermediate ſpaces of about two feet, as furrows or trenches. The beds are covered over with a thin ſtratum of dung, about eighteeen ſingle-horſe carts to an acre, the cuttings of the potatoes are laid or placed upon the beds, about ten or twelve inches aſunder, and the whole covered over with a thin ſtratum of moſs from the intermediate trenches, which is followed by another covering from the trenches when the potatoe plants make their firſt appearance; the covering in whole four or five inches. In this ſtate they remain without any hoeing till the crop is taken up. The produce on Mr Smith's moſs has never been leſs than from forty to fifty bolls of excellent potatoes, eight Wincheſter buſhels to the boll, and the buſhel a little heaped.

"When the potatoe crop is removed, the ridges are again formed as before deſcribed, and the diviſion-furrow cleared out. In performing this part of the work, it will naturally occur, that a great part of the manured ſurface will be buried in filling up the trenches between the potatoe beds: but that is not the caſe; the workman makes two cuts with the ſpade, at eighteen inches diſtance, upon the ſide of the trench; another, one foot from the edge of it, as deep as the trench; which, inſtead of turning over, he preſſes a foot forward into the trench, which is continued the length of it; and when he comes to the other ſide he does the ſame, making both meet, and ſo proceeds; ſo that no part of the manured ſurface is thrown down, and the ridge is left in the ſame form as before the lazy-beds* were made.

"When the potatoe crop is taken off, and the ridges formed as before deſcribed, they remain in that ſtate till ſpring, when oats are ſown (a wet or dry ſeaſon has

---

* Thi a
vulgar te-
tiſh p e
for be of
a part lar
kind o-
tatoe.

from experience been found a matter of indifference), and harrowed in with a ſmall harrow drawn by two men. Four men with eaſe harrow at leaſt one acre one rood per day, two and two by turns with the harrow, and the other two in the interim with ſpades, ſmoothing the inequalities, breaking and dividing the mould, and clearing out the diviſion furrows; which laſt in all operations upon moſs are eſſentially neceſſary. The early or hot ſeed oats are always preferred for ſeed. The late or cold ſeed runs too much to ſtraw, falls down, and becomes ſloomy, conſequently the grain is of mean quality, and unproductive in meal.

"The produce of the firſt crop of oats after potatoes is ſeldom leſs than ten bolls per acre, the Linlithgow boll of ſix Wincheſter buſhels, and conſiderably more has been known; as good grain in quality, and meals as well as any in the country. It has been ſold when growing, what is called upon the foot, including the ſtraw, from eight to ten pounds per acre. To prepare for a ſecond crop of oats, the ridges muſt be dug acroſs, and turned over in the manner before deſcribed, and the diviſion furrows cleared out as ſoon as convenient after the firſt crop is removed.

"Such is the effect of lime in conſolidating moſs, aided by the draining, that often after the ſecond, and always after the third year, it can be ploughed by horſes within two bouts or ſtitches of the diviſion furrow; and alſo harrowed by horſes, and the crops taken off by carts.

"Five and often ſix conſecutive crops of oats are taken, without any other manure than what it received the firſt year for potatoes, without any apparent ſigns of it being exhauſted. The produce of the firſt two crops of oats has been mentioned to be ten bolls, and the third, fourth, fifth, and ſixth, produce from ſix to ten bolls per acre. The moſs is now turned into a ſeeming rich dark brown mould; and what renders it leſs productive of corn crops the fourth, fifth, and ſixth years is, its naturally running into ſweet and luxuriant graſſes. The ſoft meadow graſs, the daiſy, ſome plaintain, but principally the white clover, are the moſt prevalent graſſes; or more probably it may be aſcribed to theſe crops being ploughed, in place of being dug with the ſpade, as the former years were. Along with the fifth or ſixth crop of oats, rye graſs is ſown, which, with the natural graſſes in general, produce an abundant crop of hay.

"If the moſs in the original ſtate has been wet and ſpongy, it will be found to have ſubſided ſome feet after the third or fourth year's operation has been performed; but care muſt always be taken to deepen, clear out, and keep clear the main drains and the diviſion furrows, to prevent a ſuperabundance of moiſture, which would infallibly be the caſe were they neglected in conſequence of the ſubſidence of the moſs. Indeed moſs of all ſorts will ſubſide leſs or more, in proportion as it has been dry or wet in its original ſtate; at the ſame time, as ſtated before, care muſt be taken not to lay it too dry, but to keep in a proper degree of temperature between theſe two extremes."

By having recourſe to the pamphlet from which this extract has been made, the reader may ſatiſfy himſelf of the real advantages of this ſpecies of agriculture. The author calculates, with much apparent fairneſs, the expence of improvement, and the value of each crop, and concludes that no waſte can be improved with equal advantage as moſs. It muſt not, however, be concealed, that we have heard practical farmers, who ſeemed to be acquainted with the ſubject, give it as their opinion that this mode of cultivation anſwers only in moſſes of no great depth; though our author affirms that it has with great ſucceſs been practiſed by Mr Smith in moſſes of the depth of 14 feet.

MOTION in fluids. When in the publication of this *Supplement* we had arrived at the title FLUIDS, we were ſtruck with the importance given, in ſome of the journals, to *The Experimental Reſearches of* Venturi *concerning the Principle of the lateral communication of Motion in Fluids, applied to the Explanation of various Hydraulic Phenomena.* Of theſe reſearches we intended to lay an abridged account before our readers under the preſent title; but having examined the work with ſome attention, we find in it hardly any thing of conſequence which the mechanical philoſopher may not learn from our articles RESISTANCE *of Fluids* and RIVER in the *Encyclopædia*. That our readers, however, may find ſomething under a title to which we raſhly referred them, we ſhall, in the words of Nicholſon's Journal of Natural Philoſophy, &c. inform them what Venturi's work contains.

"This author, who is profeſſor of experimental philoſophy at Modena, has introduced an horizontal current of water into a veſſel filled with the ſame fluid at reſt. This ſtream entering the veſſel with a certain velocity, paſſes through a portion of the fluid, and is then received in an inclined channel, the bottom of which gradually riſes until it paſſes over the border or rim of the veſſel itſelf. The effect is found to be, not only that the ſtream itſelf paſſes out of the veſſel through the channel, but carries along with it the fluid contained in the veſſel; ſo that after a ſhort time no more of the fluid remains than was originally below the aperture at which the ſtream enters. This fact is adopted as a principle or primitive phenomenon by the author, under the denomination of the lateral communication of motion in fluids, and to this he refers many important hydraulic facts. He does not undertake to give an explanation of this principle, but ſhews that the mutual attraction of the particles of water is far from being a ſufficient cauſe to account for it.

The firſt phenomenon which the author propoſes to explain by this eſtabliſhed principle, is the emiſſion of a fluid through different adjutages applied to the reſervoir which contains it. It is known that the vein of fluid which iſſues from an orifice or perforation through a thin plate, becomes contracted, ſo as to exhibit a ſection equal to about 0,64 of the orifice itſelf, ſuppoſed to be circular; and that the place of the greateſt contraction is uſually at the diſtance of one ſemi-diameter of the orifice itſelf. If a ſmall adjutage be adapted to the orifice, having its internal cavity of the ſame conoidal form as the fluid itſelf affects in that interval, the expenditure is the ſame as by the ſimple orifice. But if at the extremity of this adjutage a cylindric tube be affixed, of a greater diameter than that of the contracted vein, or a divergent conical tube, the expence of fluid increaſes, and may exceed the double of that which paſſes through the aperture in the thin plate, though the adjutage poſſeſs an horizontal or even aſcending direction.

By the interpoſition of a ſmall adjutage, adapted to the form of the contracted vein, Venturi aſcertained, in the firſt place, that there is an increaſe of velocity in the tubes he employed, though the velocity of emiſſion itſelf be leſs than that of the ſtream which iſſues from a hole in a thin plate. He afterwards proves, by the fact, that the interior velocity and expenditure of fluid, which is increaſed through tubes, even in the horizontal or aſcending direction, is owing to the preſſure of the atmoſphere. If the ſmalleſt hole be made in the ſide of the tube near the place of contraction of the vein, the increaſed expenditure does not take place; and when a vertical tube is inſerted in ſuch a hole, the lower end of which tube is immerſed in water or mercury, it is found that aſpiration takes place, and the water or mercury riſes; and this aſpiration in conical tubes is leſs in proportion, as the place of inſertion of the upright tube is more remote from the ſection where the greateſt contraction would have taken place. And, laſtly, the difference between the expenditure of fluid, through an orifice made in a thin plate, and that which is obſerved through an additional tube, does not take place in vacuo.

The influence of the weight of the atmoſphere on the horizontal or aſcending flux being thus eſtabliſhed, the author conſiders it as a ſecondary cauſe, referable to, and explicable by, his principle of the lateral communication of motion in fluids. In conical divergent tubes, for example, the effect of this lateral communication is, that the central cylindrical jet, having for its baſis the ſection of the contracted vein, carries with it the lateral fluid which would have remained ſtagnant in the enlarged part of the cone. Hence a vacuum tends to be produced in this enlarged part which ſurrounds the central cylindric ſtream; the preſſure of the atmoſphere becomes active to ſupply the void, and is exerted on the ſurface of the reſervoir, ſo as to increaſe the velocity of the fluid at the interior extremity of the tube.

The author proves, that the velocity or total expenditure of fluid through an aperture of given dimenſions, may be increaſed by a proper adjutage in the proportion of 24 to 10: he applies this reſult to the conſtruction of the funnels of chimneys. He determines the loſs of emitted fluid, which may be ſuſtained by ſinuoſity in pipes. He ſhews by experiment, that a pipe which is enlarged in any part affords a much leſs quantity of fluid than if it were throughout of a diameter equal to that of its ſmalleſt ſection. This, as he remarks, is a circumſtance to which ſufficient attention has not been paid in the conſtruction of hydraulic machines. It is not enough to avoid elbows and contractions; for it ſometimes happens that, by an intermediate enlargement, the whole of the advantage ariſing from other judicious diſpoſitions of the parts of the machine is loſt.

There are two cauſes of the increaſe of expenditure through deſcending pipes. The firſt is owing to the lateral communication of motion which takes place in deſcending pipes, in the ſame manner as in thoſe which poſſeſs an horizontal ſituation; the ſecond ariſes from the acceleration by gravity which takes place in the fluid while it falls through the deſcending tube. This ſecond kind of augmentation was known to the ancients, though they poſſeſſed no good theory nor deciſive experiments reſpecting it. The author endeavours to eſtabliſh a theory on the principle of virtual aſcenſion combined with the preſſure of the atmoſphere. His deductions are confirmed by experiment, in which he has ſucceeded ſo far as to ſeparate the two cauſes of augmentation, and aſſigned to each their reſpective degree of influence.

Profeſſor Venturi then proceeds to different objects of enquiry, to which his principle ſeemed applicable. He gives the theory of the water blowing machine (ſee *Water Blowing Machine* in this *Suppl.*), and he determines by calculation the quantity of air which one of theſe machines can afford in a given time. He obſerves, that the natural falls of water in the mountains always produce a local wind; and he even thinks, that the falling ſtreams in the internal parts of mountains are in ſome inſtances the cauſe of the winds which iſſue from caves. He proves, by the facts, that it is poſſible, in certain inſtances, to carry off, without any machinery, the waters from a ſpot of ground, though it may be ſituated on a lower level than that of the channel which is to receive the water.

The whirlpools, or circular eddies of water ſo frequent in rivers, are, according to the theory of our author, the effect of motion communicated from the parts of the current which are moſt rapid, to thoſe lateral parts which are leaſt ſo. In the application of this principle, he points out the circumſtances adapted to produce ſuch eddies at the ſurface or at the bottom of rivers. He concludes, that every movement of this kind deſtroys a part of the force of the current, and that in a channel through which water conſtantly flows, the height of this fluid will be greater than it would have been if the dimenſions of the channel had been uniformly reduced to the meaſure of its ſmalleſt ſection.

There is another kind of whirling motion ſomewhat different in its nature from theſe laſt. It is produced in the water of a reſervoir, when it is ſuffered to flow through an horizontal orifice. The author deduces the theory of theſe vortices from the doctrine of central forces. The form of the hollow funnel, which in this caſe opens through the fluid of the reſervoir, is a curve of the 64th ſpecies of the lines of the third order, enumerated by Newton. Theory and experiment both unite here in proving, that it is not only poſſible, but that there really exiſts in nature a vortex, the concavity of which is convex towards the axis, and of which the revolutions of its different parts follow the ratio of the ſquare of the diſtance from the centre. Daniel Bernoulli was in the wrong, in his Hydrodynamics, to reproach Newton for having ſuppoſed a vortex to be moved according to this law.

In the laſt place, the author conſiders that lateral communication of motion which takes place in the air as well as in the water. This is the cauſe of ſuch local and partial winds as ſometimes blow contrary to the direction of the general wind. It is by virtue of the ſame principle, that the reſonant vibration, excited laterally in the extremity of an organ pipe, is communicated to the whole column of air contained in the pipe itſelf.

From the ſame principle, the author deduces the augmentation of force which ſound receives in conical divergent tubes, compared with thoſe of a cylindrical form. On this occaſion, he points out the remarkable diffe-

differences which appear to take place between the reſonant vibrations of air contained in a tube, and the ſonorous pulſations propagated through the open atmoſphere. See *Speaking Trumpet*, Encycl.

In an appendix, Venturi relates different experiments which he has made to determine the convergence and velocity of the fluid filaments which preſs forward to iſſue out of a reſervoir by an orifice through a thin plate. He proves, by a very clear experiment, that the contraction of the vein is made at a greater diſtance from the orifice under ſtrong than under weak preſſures. He explains why, in a right-lined orifice, the ſides of the contracted vein correſpond with the angles of the orifice and the angles with the ſides. He examines the expenditure through a tube, the extremity of which is thruſt into the reſervoir itſelf, according to the method of Borda in the Memoirs of the Academy of Sciences for the year 1766."

For a full account of the author's experiments, and his deductions from them, we refer the reader either to the original work, intitled, *Recherches expérimentales ſur le Principe de la Communication latérale du Mouvement dans les Fluides, appliqué à l'Explication de différens Phénomènes hydrauliques. Par le Citoyen J. B. Venturi, Profeſſeur de Phyſique expérimentale à Modène, Membre de la Societé Italienne, &c. &c. A Paris chez Houel et Ducros, Rue du Bacq,* N° 940—*Théophile Barrois, Rue Haute-feuille,* N° 22. *Ann.* VI. 1797—or to the 2d and 3d vols of the valuable Journal from which this abſtract is taken.

MOURZOUK, the capital of Fezzan in Africa, is ſituated on a ſmall river, and ſupplied with water from a multitude of ſprings and wells. Being formerly built of ſtone, it ſtill retains the appellation of a Chriſtian town; and the medley which it preſents to the eye, of the vaſt ruins of ancient buildings, and the humble cottages of earth and ſand that form the dwellings of its preſent Arab inhabitants, is ſingularly groteſque and ſtrange. It is ſurrounded by a high wall, which not only affords the means of defence, but enables the government to collect, at its three gates, a tax on all goods (proviſions excepted) that are brought for the ſupply of its people A caravan ſets out annually from Meſurata to this place; and hence the Fezzaners themſelves diſpatch every year a caravan to Caſhna and another to Bornou. For the latitude of Mourzouk, ſee Fezzan in this *Suppl.* Dr Brookes, in his Gazetteer, places it in 15° 5′ E. Long.

MOWAZZEF, in Bengal, fixed revenue.

MOZART, the celebrated German muſician, was born at Salzburg in the year 1756. His father was alſo a muſician of ſome eminence, but not to be compared with the ſon; of whom we have the following account in one of the monthly miſcellanies, taken by Mr Buſhby from ſome biographical ſketches by two eminent German profeſſors.

At the age of three years, young Mozart, attending to the leſſons which his ſiſter, then ſeven years old, was receiving at the harpſichord, he became captivated with harmony; and when ſhe had left the inſtrument, he would inſtantly place himſelf at it, find the thirds, ſound them with the livelieſt joy, and employ whole hours at the exerciſe. His father, urged by ſuch early and ſtriking indications of genius, immediately began to teach him ſome little airs; and ſoon perceived that his pupil improved even beyond the hopes he had formed of him. Half an hour was generally ſufficient for his acquiring a minuet or a little ſong, which, when once learned, he would of himſelf perform with taſte and expreſſion.

Mozart.

At the age of ſix years he had made ſuch a progreſs as to be able to compoſe ſhort pieces for the harpſichord, which his father was obliged to commit to paper for him. From that time nothing made any impreſſion upon him but harmony; and infantine amuſements loſt all their attractions unleſs muſic had a ſhare in them. He advanced from day to day, not by ordinary and inſenſible degrees, but with a rapidity which hourly excited new ſurpriſe in his parents—the happy witneſſes of his progreſs.

His father returning home one day with a ſtranger, found little Mozart with a pen in his hand. "What are you writing," ſaid he? "A concerto for the harpſichord," replied the child. "Let us ſee it (rejoined the father); it is a marvellous concerto without doubt." He then took the paper, and ſaw nothing at firſt but a maſs of notes mingled with blots of ink by the mal-addreſs of the young compoſer, who, unſkilled in the management of the pen, had dipped it too freely in the ink; and having blotted and ſmeared his paper, had endeavoured to make out his ideas with his fingers; but on a cloſer examination, his father was loſt in wonder; and his eyes delighted and flowing with tears, became rivetted to the notes. "See (exclaimed he to the ſtranger) how juſt and regular it all is! but it is impoſſible to play it; it is too difficult." "It is a concerto (ſaid the child), and muſt be practiſed till one can play it. Hear how this part goes." He then ſat down to perform it; but was not able to execute the paſſages with ſufficient fluency to do juſtice to his own ideas. Extraordinary as his manual facility was univerſally allowed to be for his age, it did not keep pace with the progreſs of his knowledge and invention. Such an inſtance of intellectual advancement, in a child only ſix years of age, is ſo far out of the common road of nature, that we can only contemplate the fact with aſtoniſhment, and acknowledge, that the poſſible rapidity of mental maturation is not to be calculated.

In the year 1762, his father took him and his ſiſter to Munich, where he performed a concerto before the elector, which excited the admiration of the whole court; nor was he leſs applauded at Vienna, where the emperor called him the *little ſorcerer*.

His father gave him leſſons only on the harpſichord; but he privately taught himſelf the violin; and his command of the inſtrument afforded the elder Mozart the utmoſt ſurpriſe, when he one day at a concert took a ſecond violin, and acquitted himſelf with more than paſſable addreſs. True genius ſees no obſtacles. It will not therefore excite our wonder, if his conſtant ſucceſs in whatever he attempted begot an unbounded confidence in his own powers; he had even the *laudable* hardihood to undertake to qualify himſelf for the *firſt* violin, and did not long remain ſhort of the neceſſary proficiency.

He had an ear ſo correct, that he felt the moſt minute diſcordancy; and ſuch a fondneſs for ſtudy, that it was frequently neceſſary to take him by force from the inſtrument. This love of application never diminiſhed. He every day paſſed a conſiderable time at his harpſichord, and generally practiſed till a late hour at night.

Mozart.

night. Another characteriſtical trait of real genius; always full of its object, and loſt as it were in itſelf.

In the year 1763 he made, with his father and ſiſter, his firſt grand muſical journey. He viſited Paris; and was heard by the French court in the chapel-royal at Verſailles, where his talent on the organ was admired even more than on the harpſichord. At Paris the muſical travellers gave two concerts, which procured them the higheſt reputation, and the diſtinction of public portraits. It was here that a ſet of ſonatas for the harpſichord, ſome of his earlieſt compoſitions, were engraved and publiſhed.

From Paris they went to London, where they alſo gave two concerts, conſiſting of ſymphonies compoſed by young Mozart, who even at that early age ſang alſo with much expreſſion, and practiſed publicly with his ſiſter. Mozart played already at ſight, and in a concert, at which the king was one of his auditors, a baſs being placed before him as a *ground*, immediately applied to it a moſt beautiful melody. Thoſe who are beſt acquainted with the extent of ſuch a taſk, will be the moſt aſtoniſhed at ſuch mature familiarity with the intricacies of the ſcience, and ſuch prompt and ready invention in ſo juvenile a mind.

From London, where Mozart alſo publiſhed ſix ſonatas for the harpſichord, the muſical family went to Holland, thence again to France, and in 1766 returned to Salzburg. There this extraordinary youth remained more than a year in perfect repoſe; devoting the whole of his time to the ſtudy of compoſition, the principles of which he ſcrutinized with the depth and penetration of confirmed manhood. Emmanuel Bach, Haſſe, and Handel, were his chief guides and models; though he by no means neglected the old Italian maſters.

In 1768 he again viſited Vienna, where Joſeph II. engaged him to ſet to muſic a comic opera, entitled, *La Finta Semplice*, which obtained the approbation of Haſſe and Metataſio. At the houſe of the prince of Kaunitz, it often happened that the firſt Italian air which came to hand would be given him, that in the preſence of the company he might add to it accompaniments for numerous inſtruments; which he would write in the firſt ſtyle of excellence, and without the leaſt premeditation. This is at once a proof with what acuteneſs of obſervation he had liſtened to the muſic of the beſt maſters; how intimate he had already rendered himſelf with the characters, capacities, and effects of the different inſtruments; and what ſkill he had acquired in that abſtruſe art of mixed combination which, while it calculates the conjoint effect of ſounds, as they regard the eſtabliſhed laws of harmony, accommodates the different parts to the ſcales, tones, and powers of the reſpective inſtruments by which they are to be executed. It was at this time alſo that, although but twelve years of age, he compoſed the muſic for the conſecration of the church of orphans, at the performance of which he himſelf preſided.

In 1769 Mozart again returned to Salzburg, where he became *maitre de concert*. Not having yet ſeen Italy, in December of the ſame year he ſet out for that ſeat of the fine arts. Thoſe talents which had already excited the admiration of Germany, France, and England, now awakened in that land of muſical taſte the moſt lively enthuſiaſm.

In 1771 he had no ſooner given perſonal proofs of his genius, than *la ſcrittura* for the following carnival was conferred upon him. He viſited Bologna, then as famous for harmonic excellence as Naples, where the celebrated theoriſt Martini was amazed to ſee a German boy work and execute the theme of a fugue which he preſented to him, in the extraordinary ſtyle in which Mozart acquitted himſelf. He next went to Florence. Florence even enhanced the eulogiums which Bologna had laviſhed upon him.

During the holy week he arrived at Rome, and aſſiſted at the *Miſerere* in the Sixtine chapel; which performance is juſtly conſidered as the *ne plus ultra* of vocal muſic. This circumſtance claims particular notice, as inducing a proof of another faculty of his mind, only to be equalled by thoſe wonderful powers which he had already demonſtrated. He was prohibited from taking a copy of this *Miſerere*, and therefore piqued himſelf on retaining it in his memory. Having heard it with attention, he went home, made out a manuſcript from recollection, returned the next day to the chapel, heard the piece a ſecond time, corrected the rough draught, and produced a tranſcript which ſurpriſed all Rome. This *Miſerere* formed a *ſcorer* numerous in its parts, and extremely difficult of execution. His mind had embraced and retained the whole!

He ſoon after received from the Pope the order of the gilt ſpur; and at Bologna was complimented, by an unanimous deciſion, with the title of *Member and Maſter of the Phil-harmonic Academy*. As a proof, *pro forma*, of his qualifications for this academical honour, a fugue, for four voices, in the church ſtyle, was required of him, and he was ſhut up alone in his chamber. He completed it in half an hour, and received his diploma. This evinced that he poſſeſſed an imagination conſtantly at his command, and that his mind was ſtored with all the riches of his beloved ſcience.

The opera which he compoſed for Milan was called *Mithridates*. This piece procured him *la ſcrittura* for the grand opera of the carnival of 1773, which was his *Lucio Sulla*. At length, after a tour of fifteen months, he returned to Salzburg.

In 1771 Mozart viſited Paris; but not reliſhing the muſic of that capital, he ſoon quitted it, and returned to his domeſtic comforts. In 1781, at the requeſt of the elector of Bavaria, he compoſed the opera of *Idomeneo* for the carnival of that year. The general merit of this opera is ſo great, that it might ſerve alone for the baſis of a diſtinguiſhed reputation. At his twenty-fifth year he was invited to Vienna, where he continued ſpreading, as from a centre, the taſte of his compoſitions through all Germany, and the luſtre of his name over the whole of Europe.

Of all the virtuoſi of the piano forte who then crowded Vienna, Mozart was much the moſt ſkilful. His finger was extraordinarily rapid and taſteful, and the execution of his left hand exceeded every thing that had before been heard. His touch was replete with delicacy and expreſſion; and the profound ſtudy he had beſtowed on his art, gave his performance a ſtyle the moſt brilliant and finiſhed. His compoſitions had a rapid circulation; and in every new piece the connoiſſeurs were ſtruck with the originality of its caſt, the novelty of the paſſages, and the energy of the effect.

Joſeph II. ſolicitous for the perfection of the German opera, engaged Mozart to compoſe a piece. He aczart.

cordingly produced *L'enlevement du Serail;* performed for the firſt time in 1782. It excited the jealouſy of the Italian company, who therefore ventured to cabal againſt it. The emperor, addreſſing himſelf to the compoſer, ſaid, "It is *too fine* for our ears, my dear Mozart, and moſt *charmingly crowded* with notes." "Preciſely what it ought to be," replied the ſpirited muſician, who juſtly ſuſpected that this remark had been ſuggeſted to Joſeph by the envious Italians. "Though I cannot deſcribe, as an auricular evidence, (ſays the faithful author of the biography), the applauſes and the admiration which this opera produced at Vienna, yet I have witneſſed the enthuſiaſm it excited at Prague among all the connoiſſeurs, as well as among thoſe whoſe ears were leſs cultivated. It was ſaid, that all which had been heard before was not muſic: it drew the moſt overflowing audiences: every body was amazed at its new traits of harmony, and at paſſages ſo original, and till then ſo unheard from wind inſtruments."

The cautious reader will perhaps heſitate to admit, in its fulleſt extent, this account by the author of the biography; but even after an allowance for ſome exaggeration, the moſt phlegmatic will grant that much muſt have been atchieved by this great maſter, to afford a baſis for ſo glowing a picture of the merit and ſucceſs of *L'enlevement du Serail.* During the compoſition of this opera, he married Mademoiſelle Weber, a diſtinguiſhed virtuoſa; and the piece was ſuppoſed to owe to this felicitous circumſtance much of that endearing character, that tone of tenderneſs, and that expreſſion of the ſofter paſſions, which form its principal attractions.

"The Marriage of Figaro," which was in the higheſt repute at all the theatres, was in the year 1787 transformed into an Italian opera; and Mozart, at the inſtance of the emperor, ſet it to muſic. This piece was highly received everywhere, and kept poſſeſſion of the theatre at Prague during almoſt the whole of the winter in which it firſt appeared: numerous extracts were made from it, and the ſongs and dances of Figaro were vociferated in the ſtreets, the gardens, and the taverns. Mozart came that very winter to Prague, and performed in public on the piano forte. His auditors at all times liſtened to him with admiration; but whenever he played extempore, and indulged the ſpontaneous and uninterrupted ſallies of his fancy, which he ſometimes would for more than half an hour, every one was ſeized with the moſt enthuſiaſtic raptures, and acknowledged the unrivalled reſources of his imagination. About this time the manager of the theatre contracted with him for the compoſition of a new opera, which, when produced, was called *Il diſſoluto Punito*, or *Don Giovanni.* His reputation was now ſo exalted, that the Bohemians piqued themſelves on the circumſtance that this opera was compoſed for their entertainment.

But this fame, this great and univerſal applauſe, had not yet produced to the admired artiſt any ſolid advantages; he had obtained no place, no ſettled income; but ſubſiſted by his operas, and the inſtructions and occaſional concerts which he gave. The profits of theſe proved inſufficient for the ſtyle which he was obliged to ſupport; and his finances became much deranged. The critical ſituation in which he now found himſelf, made him reſolve to quit Vienna, and ſeek an aſylum in London; to which metropolis he had often been invited; but Joſeph nominating him *compoſiteur de la chambre*, though, with a very inadequate ſalary, he was induced to accept it; and Germany had the advantage of retaining him.

Mozart.

It is lamentable that premature genius too rarely enjoys a long career: The acceleration of nature in the mental powers ſeems to hurry the progreſs of the animal œconomy, and to anticipate the regular cloſe of temporal exiſtence.

In the year 1791, Mozart, juſt after he had received the appointment of *Maitre de chapelle* of the church of St Peter, and when he was only thirty-five years of age, paid the laſt tribute; and left the world at once to admire the brilliancy, and lament the ſhortneſs of his earthly ſojournment.

Indefatigable, even to his death, he produced, during the laſt few months of his life, his three great maſter pieces *La Flutte Enchantée*, *La Clemence de Titus*, and a *Requiem*, his laſt production. *La Flutte Enchantée* was compoſed for one of the theatres at Vienna; and no dramatic *Olio* could ever boaſt a greater ſucceſs. Every air ſtruck the audience with a new and ſweet ſurpriſe; and the *tout enſemble* was calculated to afford the deepeſt and moſt varied impreſſions. This piece had, in fact, ſo great a number of ſucceſſive repreſentations, that for a long time it was unneceſſary to conſult the opera-bill; which only announced a permanent novelty. And the airs ſelected from it, and repeated throughout the empire, as well in the cottage as in the palace, and which the echoes have reſounded in the moſt diſtant provinces, favoured the idea that Mozart had actually the deſign to enchant all Germany with his *Flutte Enchantée.*

La Clemence de Titus was requeſted by the ſtates of Bohemia for the coronation of Leopold. The compoſer began it in his carriage during his route to Prague, and finiſhed it in eighteen days.

Some circumſtances attending the compoſition of the piece which we have already mentioned as the laſt effort of his genius, are too intereſting to be omitted. A ſhort time before his death, a ſtranger came to him with the requeſt that he would compoſe, as ſpeedily as poſſible, a *requiem* for a catholic prince, who, perceiving himſelf on the verge of the grave, wiſhed, by the execution of ſuch a piece, to ſoothe his mind, and familiariſe it to the idea of his approaching diſſolution. Mozart undertook the work; and the ſtranger depoſited with him as a ſecurity 400 ducats, though the ſum demanded was only 200. The compoſer immediately began the work, and during its progreſs felt his mind unuſually raiſed and agitated. He became at length ſo infatuated with his *requiem*, that he employed not only the day, but ſome hours of the night in its compoſition. One day, while he was converſing with Madame Mozart on the ſubject, he declared to her that he could not but be perſuaded that it was for himſelf he was writing this piece. His wife, diſtreſſed at her inability to diſſipate ſo melancholy an impreſſion, prevailed on him to give her the *ſcore.* He afterwards appearing ſomewhat tranquillized, and more maſter of himſelf, ſhe returned the *ſcore* to him, and he ſoon relapſed into his former deſpondency. On the day of his death he aſked for the *requiem*, which was accordingly brought to his bed: "Was I not right (ſaid he), when I declared that it was for myſelf I was compoſing this funeral piece?" And the tears trickled from his eyes. This production of a man, impreſſed during its compoſition with a preſentiment of his approaching death, is *unique* in its kind, and contains paſſages which have frequently drawn tears from the performers.

Only one complaint eſcaped him during his malady: "I muſt quit life (ſaid he), preciſely at the moment when I could enjoy it, free from care and inquietude; at the very time when, independent of ſordid ſpeculations, and at liberty to follow my own principles and inclinations, I ſhould only have to write from the impulſes of my own heart: and I am torn from my family juſt when in a ſituation to ſerve it." Mozart, at the time of his death, was conſiderably involved in debt; but Vienna and Prague diſputed the honour of providing for his widow and children.

The countenance of this great maſter did not indicate any thing uncommon. He was ſmall of ſtature; and, except his eyes, which were full of fire, there was nothing to announce ſuperiority of talent. His air, unleſs when he was at the harpſichord, was that of an abſent man. But when he was performing, his whole phyſiognomy became changed: a profound ſeriouſneſs recalled and fixed his eyes; and his ſentiments were expreſſed in every movement of his muſcles. Never has a muſician more ſucceſsfully embraced the whole extent of his art, and ſhone with greater luſtre in all its departments. His great operas, no leſs than his moſt ſimple ſongs; his learned ſymphonies as well as his airy dances—all carry the ſtamp of the richeſt imagination, the deepeſt ſenſibility, and the pureſt taſte. All his works develope the originality of his genius; and imply a mind great and exalted; an imagination which ſtrikes out for itſelf a new courſe. He therefore merits to be ranked with that ſmall number of original geniuſes, thoſe *phænomena ſplendida*, who form an epoch in their art, by carrying it to perfection, or giving it an unknown career.

It is in the employment of wind inſtruments that Mozart diſplays his greateſt powers. His melody is always ſimple, natural, and full of force; and expreſſes with preciſion the ſentiments and individual ſituations of his perſonages. He wrote with extraordinary facility. "*La Clemence de Titus*," the reader will recollect, coſt him the ſtudy of but eighteen days; and his *requiem*, which is equal in length to an opera, was produced in four weeks. It is alſo worthy of remark, that the overture to his *Don Giovanni* was not begun till the night before the piece was to be performed. At midnight, after having devoted the evening to amuſement, he locked himſelf up in his ſtudy, and compoſed it in a few hours. His memory was wonderfully retentive, as we may judge from his copying by recollection the *miſerere* at Rome. But a fact equally aſtoniſhing is, that, ſoon diſcovering the eagerneſs of people to procure his works, and fearful that they might be pirated, it was his conſtant cuſtom to tranſcribe from the *ſcores* of his ſonatas only a part for one hand, and at the public performance to ſupply the other by memory.

He very early began to diſplay that true dignity of an artiſt which renders him indifferent to the praiſes of thoſe who are unqualified to judge. The commendations of the ignorant great he never conſidered as fame. His hearers, whether the wealthy or the titled, muſt have acquired ſome credit for their judgment before he could be ambitious of their applauſe. Indeed he entertained ſo juſt a ſenſe of ſcientific elevation and importance, that he would inſiſt upon reſpect. And the leaſt noiſe or idle babble, while he was at the inſtrument, excited a diſpleaſure which he was too indignant to conceal. Once, to the honour of his feelings, he ſuddenly roſe from his ſeat, and left his inattentive auditory to experience the keen though ſilent reproach of inſulted genius.

His mind was by no means unlettered; nor was it embelliſhed with one ſcience alone. He was maſter of ſeveral languages, and had made conſiderable progreſs in the mathematics. He was honeſt, mild, generous, full of frankneſs; and with his friends had an air at once amiable, gay, and free from the leaſt tincture of pedantry.

Far from viewing with envy the ſucceſs of others, a weakneſs too cloſely interwoven in the general nature of man, he was always juſt to the talents of his fellow profeſſors; and valued and reſpected merit wherever he found it; a clearer proof of which cannot be adduced than the following circumſtance: At a concert, where a new piece compoſed by the celebrated Joſeph Haydn was performed, a certain muſician, who never diſcovered any thing worthy of praiſe except in his own productions, did not fail to criticiſe the muſic; exclaiming to Mozart, "There now! there again! why, that is not what *I* ſhould have done:" "No; neither ſhould I (replied Mozart); but do you know why? Becauſe neither you nor I ſhould have been able to conceive it."

MUMBO-JUMBO, a ſtrange bugbear employed by the Pagan Mandingoes (ſee MANDING, *Suppl.*) for the purpoſe of keeping their women in ſubjection. Polygamy being allowed among theſe people, every man marries as many wives as he can conveniently maintain; and the conſequence is, that family quarrels ſometimes riſe to ſuch a height, that the huſband's authority is not ſufficient to reſtore peace among the ladies. On theſe occaſions, the interpoſition of *Mumbo-Jumbo* is called in; and it is always deciſive. This ſtrange miniſter of juſtice, who is either the huſband himſelf, or ſome perſon inſtructed by him, diſguiſed in a ſort of maſquerade habit, made of the bark of trees, and armed with the rod of public authority, announces his coming by loud and diſmal ſcreams in the woods near the town. He begins the pantomime at the approach of night; and as ſoon as it is dark, he enters the town, and proceeds to the *Bentang* or market-place, at which all the inhabitants immediately aſſemble.

It may eaſily be ſuppoſed that this exhibition is not much reliſhed by the women; for as the perſon in diſguiſe is entirely unknown to them, every married female ſuſpects that the viſit may poſſibly be intended for herſelf; but they dare not refuſe to appear when they are ſummoned; and the ceremony commences with ſongs and dances, which continue till midnight, about which time Mumbo fixes on the offender. This unfortunate victim being thereupon immediately ſeized, is ſtripped naked, tied to a poſt, and ſeverely ſcourged with Mumbo's rod, amidſt the ſhouts and deriſion of the whole aſſembly; and it is remarkable, that the reſt of the women are the loudeſt in their exclamations on this occaſion againſt their unhappy ſiſter. Daylight puts an end to this

ſhy
ll
rray.

indecent and unmanly revel. It is truly aſtoniſhing that the women ſhould be deluded by ſo clumſy an impoſture, and that the men ſhould ſo faithfully keep their own ſecret. That the women are deluded ſeems evident; for Mr Park aſſures us, that the dreſs of Mumbo is ſuffered to hang on a tree at the entrance of each town; which could hardly be the caſe, if the women were not perſuaded that it is the dreſs of ſome ſupernatural being.

MUNSHY, a Perſian ſecretary or writer.

MUNSUB, in the language of Bengal, a dignity or command conferred by the emperor.

MUNSUBDAR, a dignitary or commander.

Murray.

MURRAY (William), afterwards Earl of Manſfield and Lord Chief Juſtice of England, was the fourth ſon of David Viſcount Stormont. He was born on the 2d day of March 1705 at Perth, in the kingdom of Scotland, of which kingdom his father was a peer. His reſidence in Scotland, however, was of ſhort duration; for he was carried up to London at the early age of three years. Hence his total exemption from the peculiarities of the dialect of his native country.

At the age of fourteen he was admitted as a king's ſcholar of Weſtminſter ſchool; and during his reſidence in that ſeminary, ſays his contemporary Biſhop Newton, he gave early proofs of his uncommon abilities, not ſo much in his poetry, as in his other exerciſes; and particularly in his declamations, which were ſure tokens and prognoſtics of that eloquence which grew up to ſuch maturity and perfection at the bar, and in both houſes of parliament. At the election in May 1723, he ſtood firſt on the liſt of thoſe gentlemen who were ſent to Oxford, and was entered of Chriſt Church, June the 18th, in that year. In the year 1727 he had taken the degree of B. A. and on the death of King George the Firſt, was amongſt thoſe of the univerſity who compoſed verſes on that event.

In April 1724 he was admitted a ſtudent of Lincoln's Inn, though he ſtill continued to reſide much in the univerſity; where, on the 26th of June 1730, he took the degree of M. A. and ſoon afterwards left Oxford, determined to make the tour of Europe before he ſhould devote himſelf ſeriouſly to buſineſs. About this period he wrote two letters to a young nobleman on the ſtudy of ancient and modern hiſtory, which are publiſhed by his biographer Mr Holliday, and ſhew how amply his own mind was then ſtored with general literature.

On his return to England he commenced his legal ſtudies; but proceeded not in the way then uſually adopted, of labouring in the chambers of a ſpecial pleader, or copying (to uſe the words of Blackſtone) the traſh of an attorney's office. Being bleſſed with the powers of oratory in their higheſt perfection, and having ſoon an opportunity of diſplaying them, he very early acquired the notice of the chancellor and the judges, as well as the confidence of the inferior practiſers. How much he was regarded in the houſe of lords, Pope's well-known couplet will prove:

Grac'd as thou art with all the power of words,
So known, ſo honour'd at the houſe of lords.

The graces of his elocution, however, produced their uſual effect with a certain claſs of people, who would not believe that ſuch bright talents could aſſociate with the more ſolid attainments of the law, or that a man of genius and vivacity could be a profound lawyer. As Pope obſerved at that time,

The Temple late two brother ſerjeants ſaw,
Who deem'd each other oracles of law;
With equal talents theſe congenial ſouls,
One lull'd the exchequer, and one ſtunn'd the rolls;
Each had a gravity would make you ſplit,
And ſhook his head at Murray as a wit.

It is remarkable that this ridiculous prejudice accompanied Lord Manſfield to the end of his judicial life, in ſpite of daily proofs exhibited in the court of King's Bench and in the Houſe of Lords, of very profound knowledge of the abſtruſeſt points of juriſprudence. Lord Cheſterfield has given his ſanction to this unfounded opinion. In a letter to his ſon, dated Feb. 12. 1754, he ſays, "The preſent Solicitor General Murray has leſs law than many lawyers, but he has more practice than any, merely upon account of his eloquence, of which he has a never-failing ſtream."

In the outſet of Lord Manſfield's life, it will be the leſs ſurpriſing, that a notion ſhould have been entertained of his addicting himſelf to the purſuits of Belles Lettres too much, when the regard ſhewn to him by Mr Pope, who deſpotically ruled the regions of literature at that period, is conſidered. That great Poet ſeemed to entertain a particular affection for our young lawyer, and was eager to ſhew him marks of his regard. He addreſſed to him his imitation of the 6th Epiſtle of the Firſt Book of Horace; and even condeſcended to become his maſter in the art of elocution. "Mr Murray (ſays his biographer) was one day ſurpriſed by a gentleman of Lincoln's Inn, who could take the liberty of entering his rooms without the ceremonious introduction of a ſervant, in the ſingular act of practiſing the graces of a ſpeaker at a glaſs, while Pope ſat by in the character of a friendly preceptor. Mr Murray, on this occaſion, paid that poet the handſome compliment of, *Tu es mihi Mæcenas* (A)."

Whatever propenſities this ſprightly lawyer might have towards polite literature, he did not permit them to divert his attention from his profeſſion. He ſoon diſtinguiſhed himſelf in an extraordinary manner, as may be ſeen by thoſe who are converſant with, or chuſe to refer to the Books of Reports. In the year 1736, the murder of Captain Porteous by a mob in Edinburgh, after he had been reprieved, occaſioned a cenſure to fall on that city, and a bill of pains and penalties was brought into Parliament againſt the Lord Provoſt and the corporation; which, after various modifications, and a firm and unabated oppoſition in every ſtage of its progreſs, paſſed into a law. In both Houſes Mr Murray was employed as an advocate, and ſo much to the ſatisfaction of his clients, that afterwards, in September 1743, he was preſented with the freedom of Edinburgh in a gold box, profeſſedly, as it was decla-

---

(A) It is thus that eminence is attained even by genius, and Mr Murray was properly employed; though we do not clearly perceive the uſe of the glaſs, when his maſter was watching all his geſtures.

red, for his ſignal ſervices by his ſpeeches to both Houſes of Parliament in the conduct of that buſineſs.

On the 24th of November 1738, he had married Lady Elizabeth Finch, daughter of the Earl of Winchelſea, and in the month of November 1742, was appointed Solicitor General in the place of Sir John Strange, who reſigned (B). He likewiſe was choſen to repreſent the town of Boroughbridge in Parliament, for which place he was alſo returned in 1747 and 1754.

In the month of March 1746-7 he was appointed one of the managers for the impeachment of Lord Lovat by the Houſe of Commons, and it fell to his lot to obſerve on the evidence previous to the Lords giving their judgment. This taſk he executed with ſo much candour, moderation, and gentleman-like propriety, that Lord Talbot, at the concluſion of his ſpeech, paid him the following compliment: “The abilities of the learned manager who juſt now ſpoke, never appeared with greater ſplendour than at this very hour, when his candour and humanity has been joined to thoſe great abilities which have already made him ſo conſpicuous, that I hope one day to ſee him add luſtre to the dignity of the firſt civil employment in this nation.” Lord Lovat himſelf alſo bore teſtimony to the abilities of his adverſary: “I thought myſelf (ſays his lordſhip) very much loaded by one Murray (C), who your Lordſhips know was the bittereſt evidence there was againſt me. I have ſince ſuffered by another Mr Murray, who, I muſt ſay with pleaſure, is an honour to his country, and whoſe eloquence and learning is much beyond what is to be expreſt by an ignorant man like me. I heard him with pleaſure, though it was againſt me. I have the honour to be his relation, though perhaps he neither knows it nor values it. I wiſh that his being born in the North may not hinder him from the preferment that his merit and learning deſerve.”

During the time that Mr Murray continued in office, he ſupported, with great ability, the adminiſtration with which he was connected; and, of courſe, rendered himſelf obnoxious to thoſe who were in oppoſition. Nothing, however, could be urged either againſt his public conduct or his private life; but he was involved in ſome trouble by an ill-deviſed tale, concurring with the known principles of the family of Stormont, to make him ſuſpected of Jacobitiſm. Of this affair, a full and particular account is given by the late Lord Melcombe in the following words:

“Meſſrs Murray, Fawcett, and Stone, were much acquainted, if not ſchool-fellows, in earlier life. Their fortune led them different ways; Fawcett's was to be a country lawyer and recorder of Newcaſtle. Johnſon, now Biſhop of Glouceſter, was one of their aſſociates. On the day the King's birth-day was kept, they dined at the Dean of Durham's at Durham; this Fawcett, Lord Ravenſworth, Major Daviſon, and one or two more, who retired after dinner into another room. The converſation turning upon the late Biſhop of Glouceſter's preferments, it was aſked who was to have his prebend of Durham? The Dean ſaid, that the laſt news from London was, that Dr Johnſon was to have it: Fawcett ſaid, he was glad that Johnſon got off ſo well, for he remembered him a Jacobite ſeveral years ago, and that he uſed to be with a relation of his who was very diſaffected, one Vermon, a mercer, where the Pretender's health was frequently drunk. This paſſing among a few familiar acquaintance, was thought no more of at the time: it ſpread, however, ſo much in the North (how I never heard accounted for), and reached town in ſuch a manner, that Mr Pelham thought it neceſſary to deſire Mr Vane, who was a friend to Fawcett, and who employed him in his buſineſs, to write to Fawcett, to know if he had ſaid this of Johnſon, and if he had, if it was true.

“This letter was written on the 9th of January; it came to Newcaſtle the Friday following. Fawcett was much ſurpriſed; but the poſt going out in a few hours after its arrival, he immediately acknowledged the letter by a long, but not very explicit, anſwer. This Friday happened to be the club day of the neighbouring gentlemen at Newcaſtle. As ſoon as Lord Ravenſworth, who was a patron and employer of Fawcett, came into the town, Fawcett acquainted him with the extraordinary letter he had received; he told him that he had already anſwered it; and being aſked to ſhew the copy, ſaid he kept none; but deſired Lord Ravenſworth to recollect if he held ſuch a converſation at the Deanry of Durham the day appointed for the birth-day. Ravenſworth recollected nothing at all of it: they went to the club together, and Ravenſworth went the next morning to ſee his mother in the neighbourhood, with whom he ſtaid till Monday; but this thing of ſuch conſequence lying upon his thoughts, he returned by Newcaſtle. He and Fawcett had another converſation; and in endeavouring to refreſh each other's memory about this dreadful delinquency of Johnſon, Fawcett ſaid he could not recollect poſitively at ſuch a diſtance of time, whether Johnſon drank theſe healths, or had been preſent at the drinking of them, but that Murray and Stone had done both ſeveral times. Ravenſworth was exceſſively alarmed at this with relation to Stone, on account of his office about the prince; and thus the affair of Johnſon was quite forgotten, and the epiſode became the principal part. There were many more conferences between Ravenſworth and Fawcett

---

(B) On this occaſion a doggrel poem was publiſhed by one Morgan, a perſon then at the bar, entitled, “The Cauſidicade,” in which all the principal lawyers were ſuppoſed to urge their reſpective claims to the poſt. At the concluſion it is ſaid,

Then Murray, prepar'd with a fine panegyric
In praiſe of himſelf, would have ſpoke it like Garrick;
But the Preſident ſtopping him ſaid, “As in truth
“Your worth and your praiſe is in every one's mouth,
“'Tis needleſs to urge what's notoriouſly known,
“The office, by merit, is your's all muſt own;
“The voice of the public approves of the thing,
“Concurring with that of the Court and the King.”

(C) One of the evidences againſt him.

cett upon this ſubject, in which the latter always perſiſted that Stone and Murray were preſent at the drinking, and did drink thoſe healths. It may be obſerved here, that when he was examined upon oath, he ſwore to the year 1731 or 1732, at lateſt. Fawcett comes up as uſual about his law buſineſs, and is examined by Meſſrs Pelham and Vane, who never had heard of Murray or Stone being named: he is aſked, and anſwers only with relation to Johnſon, never mentioning either of the others; but the love of his country, his king, and poſterity, burned ſo ſtrongly in Ravenſworth's boſom, that he could have no reſt till he had diſcovered this enormity. Accordingly, when he came to town, he acquainted the miniſtry and almoſt all his great friends with it, and inſiſted upon the removal of Stone. The miniſtry would have ſlighted it as it deſerved; but as he perſiſted, and had told ſo many of it, they could not help laying it before the king, who, though he himſelf ſlighted it, was adviſed to examine it; which examination produced this moſt injudicious proceeding in parliament *."

This is Lord Melcombe's account; and the ſame author informs us, that Mr Murray, when he heard of the committee being appointed to examine this idle affair, ſent a meſſage to the king, humbly to acquaint him, that if he ſhould be called before ſuch a tribunal on ſo ſcandalous and injurious an account, he would reſign his office, and would refuſe to anſwer. It came, however, before the Houſe of Lords, 22d January 1753, on the motion of the Duke of Bedford.

The debate was long and heavy, ſays Lord Melcombe; the Duke of Bedford's performance moderate enough; he divided the Houſe, but it was not told, for there went below the bar with him the Earl Harcourt, Lord Townſhend, the Biſhop of Worceſter, and Lord Talbot only. The Biſhop of Norwich and Lord Harcourt both ſpoke, not to much purpoſe; but neither of them in the leaſt ſupported the Duke's queſtion.

Upon the whole, Lord Melcombe concludes, "It was the worſt judged, the worſt executed, and the worſt ſupported point that I ever ſaw of ſo much expectation."

The King, his late Majeſty, viewed it in its true light; and is reported to have ſaid, "Whatever they were when Weſtminſter boys, they are now my very good friends." He was likewiſe, as we have been informed by a gentleman connected with the family of Stormont, ſo delighted with Mr Murray's ſpeech in his own vindication, that he deſired to have a copy of it, as a model of dignified and candid eloquence. Fawcett, the original author of the ſtory, ſeems indeed to have been a very ſneaking knave, totally unworthy of credit. Biſhop Johnſon, who was overlooked in the turmoil, excited by the ſuppoſed guilt of Murray and Stone (ſee STONE, in this *Suppl.*), went to Fawcett's chambers in the Temple, and deſired an interview. Being told by the ſervant that his maſter was not at home, he renewed his viſit very early next morning, and declared his reſolution to wait till Mr Fawcett ſhould riſe, the laundreſs having inadvertently confeſſed that he was ſtill in bed. Fawcett, upon this, left his thorny pillow with reluctance; for ſomething ſharper than thorns (ſays Mr Holliday) awaited him, which he could not now poſſibly avoid. The reſult of the interview produced expreſſions of deep contrition, together with a letter, addreſſed to the Lord Biſhop of Glouceſter, acknowledging, in the moſt explicit terms, that his Lordſhip was innocent of the charge which he had been the inſtrument of bringing againſt him.

On the advancement of Sir Dudley Rider to the chief juſticeſhip of the King's Bench in 1754, Mr Murray ſucceeded him as attorney general; and on his death, November 1756, again became his ſucceſſor as chief juſtice, when he was created Baron of Mansfield, in the county of Nottingham, with remainder to the heirs male of his body lawfully begotten.

As ſoon as Lord Mansfield was eſtabliſhed in the King's Bench, he began to make improvements in the practice of that court. On the 12th of November, four days after he had taken his ſeat, he made a very neceſſary regulation, obſerving, "Where we have no doubt, we ought not to put the parties to the delay and expence of a farther argument; nor leave other perſons, who may be intereſted in the determination of a point ſo general, unneceſſarily under the anxiety of ſuſpence."

The anxiety of ſuſpence, from this period, was no longer to be complained of in the court of King's Bench. The regularity, punctuality, and diſpatch of the new chief juſtice, afforded ſuch general ſatisfaction, that they, in proceſs of time, drew into that court moſt of the cauſes which could be brought there for determination.

Sir James Burrows ſays, "I am informed, that at the ſittings for London and Middleſex only, there are not ſo few as 800 cauſes ſet down in a year, and all diſpoſed of. And though many of them, eſpecially in London, are of conſiderable value, there are not more, upon an average, than between 20 and 30 ever heard of afterwards in the ſhape of ſpecial verdicts, ſpecial caſes, motions for new trials, or in arreſt of judgment. Of a bill of exceptions there has been no inſtance (I do not include judgments upon criminal proſecutions; they are neceſſary conſequences of the convictions). My reports give but a very faint idea of the extent of the whole buſineſs which comes before the court: I only report what I think may be of uſe as a determination or illuſtration of ſome matter of law. I take no notice of the numerous queſtions of fact which are heard upon affidavits (the moſt tedious and irkſome part of the whole buſineſs). I take no notice of a variety of conteſtations, which, after having been fully diſcuſſed, are decided without difficulty or doubt. I take no notice of many caſes which turn upon a conſtruction ſo peculiar and particular, as not to be likely to form a precedent for any other caſe. And yet, notwithſtanding this immenſity of buſineſs, it is notorious, that, in conſequence of method, and a few rules which have been laid down to prevent delay (even where the parties themſelves would willingly conſent to it), nothing now hangs in court. Upon the laſt day of the very laſt term, if we exclude ſuch motions of the term as by deſire of the parties went over of courſe as peremptories, there was not a ſingle matter of any kind that remained undetermined, excepting one caſe relating to the proprietary Lordſhip of Maryland, which was profeſſedly poſtponed on account of the preſent ſituation of America. One might ſpeak to the ſame effect concerning the laſt day of any former term for ſome years backward."

The ſame author alſo informs us, that, excepting two

---

* Lor Mel-
mbe Dia-
y, p 10.

Murray.

caſes, there had not been, from the 6th of November 1756 to the time of his then preſent publication, 26th May 1776, a final difference of opinion in the court in any caſe, or upon any point whatſoever. "It is remarkable, too (he adds), that, excepting theſe two caſes, no judgment given during the ſame period has been reverſed, either in the exchequer chamber or in parliament: and even theſe reverſals were with great diverſity of opinion among the judges." Of the two caſes here mentioned, one was the famous queſtion concerning literary property, which the majority of the judges of the court of King's Bench held to be permanent; and in ſupport of which opinion, ſuch arguments were urged by the chief juſtice, as have not yet perhaps been completely anſwered.

The ill ſucceſs of the war, which had lately been begun, occaſioned a change in the adminiſtration; and the conflicts of contending parties rendered it impracticable for the crown, at that juncture, to ſettle a new miniſtry. In order, therefore, to give pauſe to the violence of both ſides, Lord Mansfield was induced to accept the poſt of chancellor of the exchequer on the 9th of April 1757; which he held until the 2d of July in the ſame year. During this interval, he employed himſelf, with great ſucceſs, to bring about a coalition; which being effected, produced a ſeries of events, which raiſed the glory of Great Britain to the higheſt point at which it has ever been ſeen. In the ſame year he was offered, but refuſed, the office of Lord High Chancellor; and in November 1758, he was elected a governor of the charter houſe, in the room of the Duke of Marlborough, then lately deceaſed.

For ſeveral years after this period, the tenor of Lord Mansfield's life was marked only with a moſt ſedulous diſcharge of the duties of his office. In 1760 Geo. II. died, and the new reign commenced with alterations in the adminiſtration; which gave riſe to a virulent ſpirit of oppoſition, conducted with a degree of violence and aſperity never known at any former time. As a friend to the then adminiſtration, Lord Mansfield was marked out for a more than ordinary ſhare of malicious invective. It is in alluſion to this, that Warburton, after tracing the riſe and progreſs of the irreligion and licentiouſneſs which then prevailed, and obſerving that, amid ſuch general corruption, the pure adminiſtration of public juſtice ſtill afforded a cheerful conſolation to thinking men, proceeds thus:

"But the evil genius of England would not ſuffer us to enjoy it long; for, as if envious of this laſt ſupport of government, he hath now inſtigated his blackeſt agents to every extent of their malignity; who, after the moſt villainous inſults on all other orders and ranks in ſociety, have at length proceeded to calumniate even the king's ſupreme court of juſtice, under its ableſt and moſt unblemiſhed adminiſtration. After this, who will not be tempted to deſpair of his country, and ſay with the good old man in the ſcene,

——"*Ipſa ſi cupiat ſalus*
"*Servare, prorſus non poteſt, hanc Familiam* (D)?"

A change of adminiſtration again took place in 1765, which introduced the Marquis of Rockingham and his friends to govern the country; and the meaſures then adopted not agreeing with Lord Mansfield's ſentiments, he, for the firſt time, became an opponent of government. On the bill for repealing the ſtamp act, he ſpoke, and divided againſt it; and is ſuppoſed to have had ſome ſhare in the compoſition of the proteſts on that occaſion, though he did not ſign them. In the ſame year, he is ſaid to have animadverted, with no ſmall degree of ſeverity, on the incautious expreſſions of Lord Camden, on the affair of prohibiting the exportation of corn, that it was but a 40 days tyranny at the outſide (E).

In 1767, the Diſſenters cauſe was determined, in which Lord Mansfield delivered a ſpeech, which has ſince been printed, and ſhews his Lordſhip to have been a ſteady friend to religious toleration, as well as to the rights of the eſtabliſhed church. The conſcientious Diſſenters themſelves laviſhed upon that ſpeech the higheſt praiſe; whilſt others of them, in the ſucceeding year, deluged the public prints with torrents of abuſe on the Chief Juſtice. In that year was the general election. Mr Wilkes returned from abroad, became a candidate for the city of London, and afterwards was choſen repreſentative for the county of Middleſex. Having been outlawed ſome years before, he now applied for a reverſal of that proceeding. On the 8th of June, the conſideration of it came before the court of King's Bench; when the judges delivered their opinions very fully, and were unanimous that the outlawry was illegal, and muſt be reverſed. On this occaſion Lord Mansfield took the opportunity of entering into a full ſtatement of the caſe, and a juſtification of his own conduct. The reader will find the caſe reported by Sir James Burrow; from whom we ſhall extract the following, which appears to have been the moſt important part of his Lordſhip's ſpeech:

"It is fit to take ſome notice of the various terrors hung out; the numerous crowds which have attended, and now attend, in and about the hall, out of all reach of hearing what paſſes in court; and the tumults which in other places have ſhamefully inſulted all order and government. Audacious addreſſes in print dictate to us, from thoſe they call the people, the judgment to be given now, and afterwards upon the conviction. Reaſons of policy are urged, from danger to the kingdom, by commotions and general confuſion.

"Give me leave to take the opportunity of this great and reſpectable audience, to let the whole world know all ſuch attempts are vain. Unleſs we have been able to find an error which will bear us out to reverſe the outlawry, it muſt be affirmed. The conſtitution does not allow reaſons of ſtate to influence our judgment: God

---

(D) See the dedication of the 5th edition of the Divine Legation of Moſes, which deſerves to be read at preſent with peculiar attention, as the work of a man of gigantic talents, deeply read in law as well as in theology.

(E) The ſpeeches in the debate were never printed; but the ſubſtance of them all was conſolidated in a pamphlet publiſhed at the time, intitled, "A Speech againſt the ſuſpending and diſpenſing prerogative," 8vo. Since reprinted in Debrett's Debates, Vol. IV. p. 384.

God forbid it ſhould! We muſt not regard political conſequences, how formidable ſoever they may be; we are bound to ſay, *Fiat Juſtitia, ruat Cœlum.* The conſtitution truſts the king with reaſons of ſtate and policy: He may pardon offences; it is his to judge whether the law or the criminal ſhould yield. We have no election. None of us encouraged or approved the commiſſion of either of the crimes of which the defender is convicted: none of us had any hand in his being proſecuted. As to myſelf, I took no part (in another place) in the addreſſes for that proſecution. We did not adviſe or aſſiſt the defender to fly from juſtice; it was his own act, and he muſt take the conſequences. None of us have been conſulted, or had any thing to do with the preſent proſecution. It is not in our power to ſtop it; it was not in our power to bring it on. We cannot pardon. We are to ſay what we take the law to be. If we do not ſpeak our real opinions, we prevaricate with God and our own conſciences.

"I paſs over many anonymous letters I have received: thoſe in print are public; and ſome of them have been brought judicially before the court. Whoever the writers are, they take the wrong way. I will do my duty unawed. What am I to fear? That *mendax infamia* from the preſs, which daily coins falſe facts and falſe motives? The lies of calumny carry no terror to me. I truſt, that my temper of mind, and the colour and conduct of my life, have given me a ſuit of armour againſt theſe arrows. If, during this king's reign, I have ever ſupported his government, and aſſiſted his meaſures, I have done it without any other reward than the conſciouſneſs of doing what I thought right. If I have ever oppoſed, I have done it upon the points themſelves, without any collateral views. I honour the king, and reſpect the people. But many things acquired by the favour of either are, in my account, objects not worth ambition. I wiſh popularity; but it is that popularity which follows, not that which is run after.—It is that popularity which, ſooner or later, never fails to do juſtice to the purſuit of noble ends by noble means. I will not do that which my conſcience tells me is wrong upon this occaſion, to gain the huzzas of thouſands, or the daily praiſe of all the papers which come from the preſs. I will not avoid doing what I think is right, though it ſhould draw on me the whole artillery of libels, all that falſehood and malice can invent, or the credulity of a deluded populace can ſwallow. I can ſay with a great magiſtrate, upon an occaſion, and under circumſtances not unlike, '*Ego hoc animo ſemper fui, ut invidiam virtute partam, gloriam, non invidiam putarem.*'

"The threats go further than abuſe: Perſonal violence is denounced. I do not believe it: it is not the genius of the worſt men of this country in the worſt of times. But I have ſet my mind at reſt. The laſt end that can happen to any man never comes too ſoon, if he falls in ſupport of the law and liberty of his country (for liberty is ſynonymous to law and government). Such a ſhock, too, muſt be productive of public good: It might awake the better part of the kingdom out of that lethargy which ſeems to have benumbed them; and bring the mad part back to their ſenſes, as men intoxicated are ſometimes ſtunned into ſobriety

"Once for all, let it be underſtood, that no endeavours of this kind will influence any man who at preſent ſits here. If they had any effect, it would be contrary to their intent: Leaning againſt their impreſſion might give a bias the other way. But I hope, and I know, that I have fortitude enough to reſiſt even that weakneſs. No libels, no threats, nothing that has happened, nothing that can happen, will weigh a feather againſt allowing the defendant, upon this and every other queſtion, not only the whole advantage he is intitled to from ſubſtantial law and juſtice, but every benefit from the moſt critical nicety of form, which any other defender could claim under the like objection. The only effect I feel is an anxiety to be able to explain the grounds upon which we proceed; ſo as to ſatisfy all mankind, that a flaw of form given way to in this caſe, could not have been got over in any other."

In January 1770, Lord Mansfield again was offered the Great Seal, which was given to Mr Charles York: and in Hilary Term 1771, he a third time declined the ſame offer, and the Seal was entruſted to Lord Bathurſt.

The year 1770 was alſo memorable for various attacks made on his Lordſhip's judicial character, in both the Houſes of Lords and Commons. In one of theſe, the propriety of a direction given to the jury in the caſe of the king and Woodfal was called in queſtion; which occaſioned his Lordſhip to produce to the Houſe a copy of the unanimous opinion of the court of King's Bench in that cauſe; which, after being much canvaſſed and oppoſed, was ſuffered to ſtand its ground without being over-ruled.

On the 19th of October 1776, his Lordſhip was advanced to the dignity of an Earl of Great Britain, by the title of the Earl of Mansfield, and to his male iſſue; and for want of ſuch iſſue, to Louiſa Viſcounteſs Stormont, and to her heirs male by David Viſcount Stormont her huſband. The ſame title, in 1792, was limited to Lord Stormont himſelf; who afterwards ſucceeded to it.

We come now to a period of his Lordſhip's life, which furniſhes an event diſgraceful to the age and country in which the fact was committed. An union of folly, enthuſiaſm, and knavery, had excited alarms in the minds of ſome weak people, that encouragements were given to the favourers and profeſſors of the Roman Catholic faith inconſiſtent with religion and true policy. The act of Parliament, which excited the clamour, had paſſed with little oppoſition, and had not received any extraordinary ſupport from Lord Mansfield. The minds of the public were inflamed by artful miſrepreſentations; the rage of a popular mob was ſoon directed towards the moſt eminent perſons. Accordingly, in the night between Tueſday the 6th and Wedneſday the 7th of June 1780, his Lordſhip's houſe in Bloomſbury Square was attacked by a party of rioters, who, on the Friday and Tueſday preceding, had, to the amount of many thouſands, ſurrounded the avenues of both Houſes of Parliament, under pretence of attending Lord George Gordon when he preſented the petition from the Proteſtant Aſſociation. On Tueſday evening the priſon of Newgate had been thrown open, all the combuſtible part reduced to aſhes, and the felons let looſe upon the public. It was after this attempt to deſtroy the means of ſecuring the victims of criminal juſtice that the rioters aſſaulted the reſidence of the chief magiſtrate of the firſt criminal court in the kingdom; nor were they diſperſed till they had burnt all the furniture, pictures, books, manuſcripts, deeds, and, in ſhort, every thing which fire could conſume in his Lord-

Murray.

ſhip's houſe ; ſo that nothing remained but the walls, which were ſeen next morning almoſt red-hot from the violence of the flames, preſenting a melancholy and awful ruin to the eyes of the paſſengers. For a fuller account of thoſe dreadful riots, ſee Britain, n° 644. *Encyclopædia*.

So unexpected was this daring outrage on order and government, that it burſt on Lord Mansfield without his being prepared in the ſlighteſt manner to reſiſt it. He eſcaped with his life only, and retired to a place of ſafety, where he remained until the 14th of June, the laſt day of term, when he again took his ſeat in the court of King's Bench. "The reverential ſilence (ſays Mr Douglas) which was obſerved when his Lordſhip reſumed his place on the Bench, was expreſſive of ſentiments of condolence and reſpect, more affecting than the moſt eloquent addreſs the occaſion could have ſuggeſted.

"The amount of that part of Lord Mansfield's loſs which might have been eſtimated, and was capable of a compenſation in money, is known to have been very great. This he had a right to recover againſt the *hundred*. Many others had taken that courſe ; but his Lordſhip thought it more conſiſtent with the dignity of his character not to reſort to the indemnification provided by the legiſlature. His ſentiments, on the ſubject of a reparation from the ſtate, were communicated to the Board of Works in a letter, dated 18th July 1780, written in conſequence of an application which they had made to him (as one of the principal ſufferers), purſuant to directions from the treaſury, founded on a vote of the Houſe of Commons, requeſting him to ſtate the nature and amount of his loſs. In that letter, after ſome introductory expreſſions of civility to the ſurveyor general, to whom it was addreſſed, his Lordſhip ſays, 'Beſides what is irreparable, my pecuniary loſs is great. I apprehended no danger, and therefore took no precaution. But how great ſoever that loſs may be, I think it does not become me to claim or expect reparation from the ſtate. I have made up my mind to my misfortune, as I ought, with this conſolation, that it came from thoſe whoſe object manifeſtly was general confuſion and deſtruction at home, in addition to a dangerous and complicated war abroad. If I ſhould lay before you any account or computation of the pecuniary damage I have ſuſtained, it might ſeem a claim or expectation of being indemnified. Therefore you will have no further trouble upon this from, &c.—*Mansfield*."

From this time the luſtre of Lord Mansfield continued to ſhine with unclouded brightneſs until the end of his political life, unleſs his oppoſition to the meaſures of the preſent adminiſtration, at the early period of their appointment, ſhall be thought to detract, in ſome ſmall degree, from his merit. It is certain many of his admirers ſaw, with concern, a connection with the opponents of government at that juncture, ſcarce compatible with the dignity of the chief juſtice of Great Britain. At length infirmities preſſed upon him, and he became unable to attend his duty with the ſame punctuality and aſſiduity with which he had been accuſtomed. It has been ſuppoſed, that he held his office after he was diſabled from executing the duties of it, from a wiſh to ſecure the ſucceſſion of it to a very particular friend. Be this as it may, the chief juſtice continued in his office until the month of June 1788, when he ſent in his reſignation.

Murra

From this period the bodily powers of his Lordſhip continued to decline ; his mental faculties, however, remained without decay almoſt to the laſt. During this time he was particularly inquiſitive and anxious about the proceedings in France, and felt his ſenſibility, in common with every good man, wounded by the horrible inſtance of democratic infatuation in the murder of the innocent Louis XVI. He lived juſt long enough to expreſs his ſatisfaction at the check given to the French by the Prince of Cobourg in March 1793; on the 20th of which month, after continuing ſome days in a ſtate of inſenſibility, he departed this life, at the age of 88 years.

"In his political oratory (ſays a writer of the preſent times), he was not without a rival; no one had the honour of *ſurpaſſing* him ; and let it be remembered, that his competitor was Pitt.

"The rhetorician that addreſſed himſelf to Tully in theſe memorable words—*Demoſthenes tibi præripuit ne primus eſſes Orator, tu illi ne ſolus*—anticipated their application to Mansfield and Pitt. If the one poſſeſſed Demoſthenean fire and energy, the other was at leaſt a Cicero. Their oratory differed in ſpecies, but was equal in merit. There was, at leaſt, no ſuperiority on the ſide of Pitt. Mansfield's eloquence was not, indeed, of that daring, bold, declamatory kind, ſo irreſiſtibly powerful in the momentary buſtle of popular aſſemblies ; but it was poſſeſſed of that pure and Attic ſpirit, and ſeductive power of perſuaſion, that delights, inſtructs, and eventually triumphs. It has been very beautifully and juſtly compared to a river, that meanders through verdant meads and flowery gardens, reflecting in its cryſtal boſom the varied objects that adorn its banks, and refreſhing the country through which it flows.

"To illuſtrate his oratory by example, would require voluminous tranſcripts from the records of Parliament ; and it is unneceſſary, as we can appeal to living recollection.

"Having added weight and dignity to the offices of attorney and ſolicitor general, his reputation as a ſpeaker, a lawyer, and a politician, elevated him to the peerage, and the exalted poſt of chief juſtice of England. He aſcended to the dignities of ſtate by rapid ſtrides : they were not beſtowed by the caprice of party favour or affection. They were (as was ſaid of Pliny) liberal diſpenſations of power upon an object that knew how to add new luſtre to that power, by the rational exertion of his own.

"Here we can ſpeak of this great man within our own recollection ; and however party prejudices may adopt their different favourites, and each contend in detracting from the merit of the other, it is, we believe, generally underſtood, that precedence is allowed the Earl of Mansfield, as the firſt magiſtrate that ever ſo pre-eminently graced that important ſtation. The wiſdom of his deciſions, and unbiaſſed tenor of his public conduct, will be held in veneration by the ſages of the law, as long as the ſpirit of the conſtitution, and juſt notions of equity, continue to have exiſtence. No man has ever, in an equal degree, poſſeſſed that wonderful ſagacity in diſcovering chicanery and artifice, and ſeparating fallacy from truth, and ſophiſtry from argument, ſo as to hit the exact equity of the caſe. He ſuffered not juſtice to be ſtrangled in the nets of form.

"His memory was aſtoniſhing—he never took notes, or, or, if he did, ſeldom or ever conſulted them." His references to expreſſions which fell from him in the courſe of the debate, or his quotations from books, were ſo faithful, that they might have been ſaid to have been repeated *verbatim*. The purpoſes to which he employed theſe amazing talents were ſtill more extraordinary: if it was the weak part of his opponent's arguments that he referred to, he was ſure to expoſe its fallacy, weakneſs, or abſurdity, in the moſt poignant ſatire, or hold it up in the moſt ridiculous point of view. If, on the contrary, it were a point on which his adverſaries laid their chief ſtreſs, he ſtated the words correctly; collected their obvious meaning, conſidered the force of the ſeveral arguments that had or might have been raiſed upon them, with a preciſion that would induce an auditor almoſt to ſuppoſe that he had previouſly conſidered the whole, and that his ſpeech was the reſult of much previous ſtudy.

"It may be ſaid of Mansfield as of Virgil, that if he had any faults, they might be conſidered in the ſame manner with thoſe of ſome eminent fixed ſtar, which, if they exiſt at all, are above the reach of human obſervation. The luminous æther of his life was not obſcured by any ſhade dark enough to be denominated a defect. On account of his deſcent, local prejudices and propenſities were imputed to him, and his conduct, on that account, examined with a microſcopic eye; but the optic through which it was viewed poſſeſſed a party tinge, equally odious and deceptive.

"His political principles were ever conſiſtent; and to preſerve conſiſtency in ſuch ſtations and in ſuch times as occupied the life of Mansfield, conſtitutes an ordeal ſtrongly impreſſive of virtue. It has been ſaid that he wanted ſpirit. Is the uniform oppoſition of popular opinion, and apparently the contempt of it, any proof of the aſſertion? His ſpeech and conduct in the affair of Wilkes's outlawry, when popular prejudice ran in torrents, illuſtrate each other. He deſpiſed (to borrow an expreſſion of his own) that muſhroom popularity that is raiſed without merit, and loſt without a crime. He diſdained being the ſlave of popular impulſe, or to acknowledge the ſhouts of a mob for the trumpet of fame."

He had a mind too great to be aſhamed of revering the ordinances of religion; and as, after the moſt impartial inquiry, he was a firm believer of the truth and importance of Chriſtianity, he frequented the church regularly, and received the holy ſacrament on the higher feſtivals. Mr Holliday has publiſhed a ſermon, which he ſays was dictated by Lord Mansfield to his friend biſhop Johnſon, and preached by that prelate before the Houſe of Lords. It is a very ſerious and appropriate diſcourſe; but judging upon internal evidence, we ſhould not have ſuppoſed it the compoſition of the eloquent and argumentative chief juſtice of England. His Lordſhip's will, which was written with his own hand, upon little more than half a ſheet of paper, begins with the following elegant and pious paragraph, with which we ſhall conclude this ſketch of his character:

"When it ſhall pleaſe Almighty God to call me to that ſtate, to which, of all I now enjoy I can carry only the ſatisfaction of my own conſcience, and a full reliance upon his mercy through Jeſus Chriſt, I deſire that my body may be interred as privately as may be: and out of reſpect for the place of my early education, I ſhould wiſh it to be in Weſtminſter Abbey." It was interred in Weſtminſter Abbey, in the ſame vault with the Counteſs (who had died April 10. 1784), between the late Earl of Chatham and Lord Robert Manners.

MUSEUM, in the language of the preſent day, is a building in which are depoſited ſpecimens of every object that is in any degree curious, whether ſuch objects be natural or artificial. What the word *muſeum* expreſſed originally, has been told under that title in the *Encyclopædia*.

A complete muſeum contains collections of preſerved beaſts, birds, fiſhes, reptiles, &c.; models of machines; rare manuſcripts; and indeed ſpecimens of every thing neceſſary to illuſtrate phyſical ſcience, to improve art, to aid the antiquarian in his reſearches, and to exhibit the manners and cuſtoms of men in diſtant ages and nations. As natural objects of uncommon ſize or beauty, and other rare productions, were, in the earlieſt periods, conſecrated to the gods, the temples were, of courſe, the firſt repoſitories of ſuch collections, or, in other words, the firſt *Muſeums*. This, we think, has been completely proved by Profeſſor Beckmann *.

"When Hanno (ſays he) returned from his diſtant voyages, he brought with him to Carthage two ſkins of the hairy women whom he found on the Gorgades iſlands, and depoſited them as a memorial in the temple of Juno, where they continued till the deſtruction of the city. The horns of a Scythian animal, in which the Stygian water that deſtroyed every other veſſel could be contained, were ſent by Alexander as a curioſity to the temple of Delphi, where they were ſuſpended, with an inſcription, which has been preſerved by Ælian. The monſtrous horns of the wild bulls which had occaſioned ſo much devaſtation in Macedonia, were, by order of King Philip, hung up in the temple of Hercules. The unnaturally formed ſhoulder bones of Pelops were depoſited in the temple of Elis. The horns of the ſo called Indian ants were ſhewn in the temple of Hercules at Erythræ; and the crocodile found in attempting to diſcover the ſources of the Nile was preſerved in the temple of Iſis at Cæſarea. A large piece of the root of the cinnamon tree was kept in a golden veſſel in one of the temples at Rome, where it was examined by Pliny. The ſkin of that monſter which the Roman army in Africa attacked and deſtroyed, and which probably was a crocodile, an animal common in that country, but never ſeen by the Romans before the Punic war, was, by Regulus, ſent to Rome, and hung up in one of the temples, where it remained till the time of the Numantine war (A). In the temple of Juno, in the iſland of Melita, there were a pair of elephants teeth of extraordinary ſize, which were carried away by Maſiniſſa's admiral, and tranſmitted to that prince, who, though he ſet a high value upon them, ſent them again back, becauſe he heard they had been taken from a temple. The head of a baſiliſc was exhibited in one of the temples of Diana; and the bones of that ſea monſter, probably a whale, to which Andromeda was expoſed, were preſerved at Joppa, and afterwards brought to Rome.

* Inventions, vol. ii. p. 44.

(A) We think, with the tranſlator of Beckmann's Hiſtory, that this animal was not the crocodile, but the *Boa conſtrictor*. See Boa and Serpent, *Encycl.*

Rome. In the time of Pauſanias, the head of the celebrated Calydonian boar was ſhewn in one of the temples of Greece; but it was then deſtitute of briſtles, and had ſuffered conſiderably by the hand of time. The monſtrous tuſks of this animal were brought to Rome, after the defeat of Anthony, by the Emperor Auguſtus, who cauſed them to be ſuſpended in the temple of Bacchus. Apollonius tells us, that he ſaw in India ſome of thoſe nuts which in Greece were preſerved in the temples as curioſities."

Though theſe curioſities were preſerved in the temples for purpoſes very different from thoſe for which our collections are made, there can be no doubt but that they contributed to promote the knowledge of natural hiſtory. If it be true, as Pliny and Strabo inform us, that Hippocrates availed himſelf of the accounts which were hung up in the temple of Æſculapius of different diſeaſes, and of the medicines and mode of treatment by which they were cured; it will eaſily be believed, that the natural hiſtorians availed themſelves, in a ſimilar manner, of the various rare objects which were preſerved in the temples of the other gods. This, we ſee, Pliny actually did.

Suetonius informs us, that Auguſtus had, in his palace, a collection of natural curioſities; and it is well known that Alexander gave orders to all huntſmen, bird-catchers, fiſhermen, and others, to ſend to Ariſtotle whatever rare animals they could procure. M. Beckmann ſeems to be of opinion, that the firſt private muſeum was formed by Apuleius, who, next to Ariſtotle and his ſcholar Theophraſtus, certainly examined natural objects with the greateſt ardour and judgment; who cauſed animals of every kind, and particularly fiſh, to be brought to him either dead or alive, in order to deſcribe their external and internal parts, their number and ſituation, and to determine their characteriſing marks, and eſtabliſh their real names; who undertook diſtant journeys to become acquainted with the ſecrets of nature; and who, on the Getulian mountains, collected petrefactions, which he conſidered as the effects of Deucalion's flood.

The principal cauſe why collections of natural curioſities were ſcarce in ancient times, muſt have been the ignorance of naturaliſts in regard to the proper means of preſerving ſuch bodies as ſoon ſpoil or corrupt. Some methods were indeed known and practiſed, but they were all defective and inferior to that by ſpirit of wine, which prevents putrefaction, and which, by its perfect tranſparency, permits the objects which are covered by it to be at all times viewed and examined. Theſe methods were the ſame as thoſe employed to preſerve proviſions, or the bodies of great men deceaſed. They were put into ſalt brine or honey, or were covered over with wax. Thus the hippopotamus, deſcribed by Columna, was ſent to him from Egypt preſerved in ſalt. The body of Ageſipolis King of Sparta, who died in Macedonia, was ſent home in honey; the celebrated purple dye of the ancients was preſerved freſh for many years by the ſame means; and at this day, when the Orientals are deſirous of tranſporting fiſh to any diſtance, they cover them over with wax.

In thoſe centuries which are uſually called the middle ages, the Profeſſor finds no traces of what can be called a muſeum, except in the treaſuries of emperors, kings, and princes, where, beſides articles of great value, curioſities of art, antiquities, and relics, one ſometimes found ſcarce and ſingular foreign animals, which were dried and preſerved. Such objects were to be ſeen in the old treaſury at Vienna; and in that of St Denis was exhibited the claw of a griffin, ſent by a king of Perſia to Charlemagne; the teeth of the hippopotamus, and other things of the like kind. In theſe collections, the number of the rarities always increaſed in proportion as a taſte for natural hiſtory became more prevalent, and as the extenſion of commerce afforded better opportunities for procuring the productions of remote countries. Menageries were eſtabliſhed to add to the magnificence of courts; and the ſtuffed ſkins of rare animals were hung up as memorials of their having exiſted. Public libraries alſo were made receptacles for ſuch natural curioſities as were from time to time preſented to them; and as in univerſities the faculty of medicine had a hall appropriated for the diſſection of human bodies, curioſities from the animal kingdom were collected there alſo by degrees; and it is probable that the profeſſors of anatomy firſt made attempts to preſerve different parts of animals in ſpirit of wine, as they were obliged to keep them by them for the uſe of their ſcholars; and becauſe in old times dead bodies were not given up to them as at preſent, and were more difficult to be obtained. Private collections appear for the firſt time in the 16th century; and there is no doubt (ſays our author) that they were formed by every learned man who at that period applied to the ſtudy of natural hiſtory.

MUSHROOM, a fungus, of which ſome of the principal ſpecies have been deſcribed in the *Encyclopædia* under the generic name AGERICUS. There is, however, one ſpecies not mentioned there—the *Boletus hirſutus* of Bulliard, which is certainly worthy of notice, ſince one of the French chemiſts has lately extracted from it a bright, ſhining, and very durable yellow dye. This pretty large muſhroom grows commonly on walnut and apple-trees. Its colouring-matter is contained in abundance, not only in the tubular part, but alſo in the parenchyma of the body of the muſhroom. In order to extract it, the muſhroom is pounded in a mortar, and the liquor thence obtained is boiled for a quarter of an hour in water. An ounce of liquor is ſufficient to communicate colouring-matter to ſix pounds of water. When the liquor has been ſtrained, the ſtuff to be dyed is put into it, and boiled for a quarter of an hour. All kinds of ſtuff receive this colour and retain it; but on linen and cotton it is leſs bright. This colour may be modified, in a very agreeable manner, by the effect of mordants.

The proceſs ſucceeded beſt on ſilk. When this ſubſtance, after being dyed, is made to paſs through a bath of ſoft ſoap, it acquires a ſhining golden yellow colour, which has a perfect reſemblance to the yellow of that ſilk employed to imitate embroidery in gold, and which has hitherto been brought from China and ſold at a dear rate, as the method of dyeing it is unknown in Europe. The yellow colour extracted from this muſhroom may be employed alſo with advantage for painting in water-colours as well as in oil.

MUTSUDDIES, in Bengal, writers, accountants, officers of government.

MUZCOORET, allowances to zemindars in land or money. See ZEMINDAR, *Suppl.*

N.

abob ‖ cowry.

Nancowry.

NABOB, or Nowab, a title of courteſy given in India to Mahomedans high in ſtation, particularly provincial governors.

The Sun's NADIR, is the axis of the cone projected by the ſhadow of the earth: ſo called, becauſe that axis being prolonged, gives a point in the ecliptic diametrically oppoſite to the ſun.

NAIB, a deputy.

NAKED, in architecture, as the naked of a wall, &c. is the ſurface, or plane, from whence the projectures ariſe; or which ſerves as a ground to the projectures.

NANCOWRY, or Soury, as it is ſometimes called, is one of the Nicobar iſles, and ſituated nearly in the centre of the cluſter (See Nicobar, *Encycl.*). Its length may be about eight miles, and its breadth nearly equal. The iſland of Comerty, which is near it, is more extenſive, but does not perhaps contain more ſolid land, being excavated by a very large bay from the ſea. The ſpace between theſe two iſlands forms a capacious and excellent harbour, the eaſtern entrance of which is ſheltered by another iſland, called Trikut, lying at the diſtance of about a league. The inlet from the weſt is narrow, but ſufficiently deep to admit the largeſt ſhips when the wind is fair.

The Danes have long maintained a ſmall ſettlement at this place, which ſtands on the northern-moſt point of Nancowry, within the harbour. A ſerjeant and three or four ſoldiers, a few black ſlaves, and two ruſty old pieces of ordnance, compoſe the whole of their eſtabliſhment. They have here two houſes; one of which, built entirely of wood, is their habitation; the other, formerly inhabited by their miſſionaries, ſerves now for a ſtorehouſe.

Theſe iſlands are in general woody, but contain likewiſe ſome portions of clear land. From the ſummits of their hills the proſpects are often beautiful and romantic. The ſoil is rich, and probably capable of producing all the various fruits and vegetables common to hot climates. The natural productions of this kind, which moſtly abound, are cocoa nuts, *papias*, plantains, limes, tamarinds, beetle nuts, and the *melóri*, a ſpecies of breadfruit; yams, and other roots are cultivated and thrive; but rice is here unknown. The *mangoſtain*-tree, whoſe fruit is ſo juſtly extolled, grows wild; and pineapples of a delicious flavour are found in the woods.

Of all the Nicobar iſles Nancowry and Comerty are ſaid to be the beſt peopled; the population of both being ſuppoſed to amount to eight hundred. The natives of Nancowry and of the Nicobar iſlands in general, live in villages on the ſea-ſhore, and never erect their habitations inland (a). Their houſes are of a circular form, and are covered with elliptical domes, thatched with graſs and the leaves of cocoa nut. They are raiſed upon piles to the height of ſix or eight feet above the ground; the floor and ſides are laid with planks, and the aſcent is by a ladder. In thoſe bays or inlets which are ſheltered from the ſurf, they erect them ſometimes ſo near the margin of the water as to admit the tide to flow under, and waſh away the ordure from below.

In front of their villages, and a little advanced in the water, they plant beacons of a great height, which they adorn with tufts made of graſs, or the bark of ſome tree. Theſe objects are diſcernible at a great diſtance, and are intended probably for landmarks; their houſes, which are overſhadowed by thick groves of cocoa-nut trees, ſeldom being viſible from afar.

The Nicobareans, though indolent, are in general robuſt and well-limbed. Their features are ſomewhat like the Malays, and their colour is nearly ſimilar. The women are much inferior in ſtature to the men, but more active in all domeſtic affairs. Contrary to the cuſtom of other nations, the women ſhave the hair of their heads, or keep it cloſe cropt, which gives them an uncouth appearance, in the eyes of ſtrangers at leaſt.

The inhabitants of Nancowry perform, every year, a very extraordinary ceremony in honour of the dead. It is thus deſcribed by Lieutenant Colebrooke:

"On the anniverſary of this feſtival, if it can be ſo called, their houſes are decorated with garlands of flowers, fruits, and branches of trees. The people of each village aſſemble, dreſt in their beſt attire, at the principal houſe in the place, where they ſpend the day in a convivial manner; the men, ſitting apart from the women, ſmoke tobacco, and intoxicate themſelves; while the latter are nurſing their children, and employed in preparations for the mournful buſineſs of the night. At a certain hour of the afternoon, announced by ſtriking the *Goung*, the women ſet up the moſt diſmal howls and lamentations, which they continue without intermiſſion till about ſun-ſet; when the whole party get up, and walk in proceſſion to the burying-ground. Arrived at the place, they form a circle around one of the graves, when a ſtake, planted exactly over the head of the corpſe, is pulled up. The woman who is neareſt of kin to the deceaſed, ſteps out from the crowd, digs up the ſkull, and draws it up with her hands. At ſight of the bones, her ſtrength ſeems to fail her; ſhe ſhrieks, ſhe ſobs; and tears of anguiſh abundantly fall on the mouldering object of her pious care. She clears it from the earth, ſcrapes off the feſtering fleſh, and laves it plentifully with the milk of freſh cocoa-nuts, ſupplied by the byſtanders; after which ſhe rubs it over with an infuſion of ſaffron, and wraps it carefully in a piece of new cloth. It is then depoſited again in the earth, and covered up; the ſtake is replanted, and hung with the various trappings and imple-

---

(a) The great Nicobar iſland is perhaps an exception, where, it is ſaid, a race of men exiſts, who are totally different in their colour and manners. They are conſidered as the *Aborigines* of the country. They live in the interior parts among the mountains, and commit frequent depredations on the peaceable inhabitants of the coaſts.

implements belonging to the deceaſed. They proceed then to the other graves; and the whole night is ſpent in repetitions of theſe diſmal and diſguſtful rites.

"On the morning following, the ceremony is concluded by an offering of many fat ſwine; when the ſacrifice made to the dead affords an ample feaſt to the living: they beſmear themſelves with the blood of the ſlaughtered hogs, and ſome, more voracious than others, eat the fleſh raw. They have various ways, however, of dreſſing their meat, but always eat it without ſalt. A kind of paſte made of the *melóri*, ſerves them for bread; and they finiſh their repaſt with copious potations of *taury*, an inebriating liquor."

The Nicobareans are hoſpitable and honeſt, and are remarkable for a ſtrict obſervance of truth, and for punctuality in adhering to their engagements. Such crimes as theft, robbery, and murder, are unknown in theſe iſlands; but they do not want ſpirit to revenge their injuries, and will fight reſolutely, and ſlay their enemies, if attacked or unjuſtly dealt with. Their only vice, if this failing can be ſo called, is inebriation; but in their cups they are generally jovial and good-humoured. It ſometimes, however, happens at their feaſts, that the men of different villages fall out; and the quarrel immediately becomes general. In theſe caſes they terminate their differences in a pitched battle; where the only weapons uſed are long ſticks, of a hard and knotty wood. With theſe they drub one another moſt heartily, till, no longer able to endure the conflict, they mutually put a ſtop to the combat, and all get drunk again.

NANKAR, ancient allowance to zemindars in land or money.

NANKEEN, or NAN-KING, is a well-known cotton ſtuff, which derives its name from the ancient capital of China (See NAN-KING, *Encycl.*). It is, however, according to Van Braam, manufactured at a great diſtance from that city, in the diſtrict of *Fong-kiang-fou*, ſituated in the ſouth-eaſt of the province of *Kiang-nam* upon the ſea-ſhore. The colour of nankeen is natural, the down of which it is made being of the ſame yellow tinge with the cloth. The colour, as well as ſuperior quality of this cotton, ſeems to be derived from the ſoil; for it is ſaid that the ſeeds of the nankeen cotton degenerate in both particulars when tranſplanted to another province, however little different in its climate. The common opinion, that the colour of the ſtuff is given by a dye, occaſioned an order from Europe, ſome years ago, to dye the pieces of nankeen of a deeper colour than they had at that period; and the reaſon of their being then paler than formerly is as follows:

Shortly after the Americans began to trade with China, the demand increaſed to nearly double the quantity it was poſſible to furniſh. To ſupply this deficiency, the manufacturers mixed common white cotton with the brown; this gave it a pale caſt, which was immediately remarked; and for this lighter kind no purchaſer could be found, till the other was exhauſted. As the conſumption is grown leſs during the laſt three years, the mixture of cotton is no longer neceſſary, and nankeen is become what it was before. By keeping them two or three years, it even appears that they have the property of growing darker. This kind of ſtuff muſt be acknowledged to be the ſtrongeſt yet known. Many perſons have found that clothes made of it will laſt three or four years, although for ever in the waſh. This it is that makes them the favourite wear for breeches and waiſtcoats both in Europe and America. The white nankeen is of the ſame quality, and is made of white cotton as good as the brown, and which alſo grows in Kiang-nam.

NAPLES-YELLOW, called alſo *Neapolitan earth*, in Italian *Giallolino*, and in French *Jaune de Naples*, is a beautiful pigment, concerning which we have much information from the indefatigable Beckmann. "It has (ſays he) the appearance of an earth, is of a pale orange-yellow colour, ponderous, granulated, exceedingly friable, does not effloreſce, nor become moiſt when expoſed to the air, but when applied to the tongue ſeems to adhere to it. When reduced to a fine powder, it remains for ſome time ſuſpended in water, but ſoon depoſits itſelf at the bottom in the form of a ſlime. When boiled with water, the water, at leaſt ſometimes, is obſerved to have a ſomewhat ſaline taſte. It does not efferveſce with acids, but is in part diſſolved by aqua regia (nitro-muriatic acid). In the fire it emits no ſulphureous vapour, is difficult to be fuſed, and by that operation undergoes no material change, only that its colour becomes ſomewhat redder. When fuſed with colourleſs glaſs, it gives it a milk-white colour, a ſure proof that it contains no iron; and, with inflammable ſubſtances, there is obtained from it a regulus which has the appearance of a mixture of lead and antimony.

"This article is brought from Naples for the moſt part in the form of an earthy cruſt about three or four lines in thickneſs, and it ſometimes retains the form of the veſſel in which it has hardened. It can be procured alſo as a fine powder, as the colourmen keep it ſometimes ready pounded for uſe."

About the nature of the ſubſtance called Naples yellow there has been much diverſity of opinion. Moſt of thoſe who have written about it, conſider it as originating from fire, and as a volcanic production of Mount Veſuvius or Mount-Ætna; others have pronounced it to be a natural ochre. Guettard thought it rather a kind of bole; but Pott approached neareſt the truth, by aſſerting it to be an artificial preparation *. Fougeroux is entitled to the merit of having proved this, and of having ſhewn the poſſibility of preparing it. According to his experiments, Naples yellow will be obtained, if you boil for ſeven or eight hours, firſt over a ſlow and then over a ſtrong fire, a mixture finely pulveriſed of twelve parts of pure white lead, one part of alum, one part of ſal ammoniac, and three parts of diaphoretic antimony † (white oxyd of antimony by nitre). But before Fougeroux, who may have obtained an account of the proceſs during his travels through Italy, a more certain proceſs was publiſhed in the year 1758, by Giambattiſta Paſſeri, in his intereſting work on the painting of earthen-ware ‡. The articles to be employed, according to this author, are, "one pound of antimony, a pound and a half of lead, one ounce of *alume di feccia*, and the ſame quantity of common ſalt." I am inclined (ſays M. Beckmann) to think that this receipt was not unknown to Fougeroux, and that he conſidered *alume di feccia* to be alum. Profeſſor Leonhardi, a man of very ſound learning, has tranſlated this expreſſion by the word alum. I will, however, freely confeſs, that I conſider *alume di feccia* not to mean alum, but ſalt of tartar, or potaſh. Paſſeri

---

* *Lithognoſie*, v. ii p. 15.

† *Mem. of the Acad. of Sciences*, 1766.

‡ *In Nuo raccolta d'opuſculi ſcientifici*, t iv.

ſeri ſays, that the proportions may be varied different ways; and he gives ſix other receipts, in which he does not mention *alume di feccia*, but only *feccia ;* and this word certainly means *weinheſen* or wineſtone (tartar). Profeſſor Leonhardi himſelf ſeems to confirm this opinion, by ſaying, that Vairo, profeſſor of chemiſtry at Naples, has tranſlated "the aſhes of wine lees" (*cineres inſectorii*) by the words *alume di feccia.*

After Fougeroux's paper was printed, De la Lande publiſhed a receipt which he had received from the well-known prince San Severo, and in which lead and antimony only are employed ; but no mention is made either of alum, tartar, or any other ſalt. This receipt is as follows :

Take lead well calcined and ſifted, with a third part of its weight of antimony pounded and ſifted alſo. Mix theſe ſubſtances well together, and ſift them again through a piece of ſilk. Then take large flat earthen diſhes, not varniſhed, cover them with white paper, and ſpread out the powder upon them to the depth of about two inches. Place theſe diſhes in a potter's furnace, but only at the top, that they may not be expoſed to too violent a heat. The reverberation of the flame will be ſufficient. The diſhes may be taken out at the ſame time as the earthen-ware, and the ſubſtance will then be found hard, and of a yellow colour. It is then pounded on a piece of marble with water, and afterwards dried for uſe.

The enamel-painters in Germany prepare a yellow glazing, not very different from the real Naples yellow, by a preſcription, according to which, "one pound of antimony, ſix ounces of red lead, and two ounces of white ſand, are to be fuſed together. The produce, which appears quite black, is to be pounded, and then fuſed again ; and this proceſs is to be repeated till the whole maſs becomes thoroughly yellow. Half a pound of this maſs is to be mixed with two ounces of red lead, and afterwards fuſed ; and by this tedious proceſs an orange-yellow pigment will be obtained."

All artiſts who ſpeak of the uſe of Naples yellow, give cautions againſt applying iron to it, as the colour by theſe means becomes greeniſh, or at leaſt dirty. For this reaſon, it muſt be pounded on a ſtone, and ſcraped together with an ivory ſpatula. It is employed chiefly in oil painting, becauſe the colour is ſofter, brighter, and richer than that of ochre, yellow lead, or orpiment, and becauſe it far exceeds theſe pigments in durability. It is employed in particular when the yellow ought to have the appearance of gold, and in this reſpect it may be prepared with gum water, and uſed as a water colour. A ſtill greater advantage of it is, that it is proper for enamel painting, and on that account may be employed on porcelain or earthen ware (A). Profeſſor Beckmann, however, recommends to artiſts to examine whether the oxyd prepared from wolfram, by boiling in the muriatic acid, which has a beautiful yellow colour, might not be uſed in the ſame manner as Naples yellow.

NARDUS. Under this generic term we have, in the *Encyclopædia*, given, from the *Philoſophical Tranſactions*, a deſcription of the plant or graſs which Dr Blane conſiders as the ſpikenard of the ancients. It is our duty, in this place, to inform our readers, that Sir William Jones, in the 2d and 4th volumes of the *Aſiatic Reſearches*, ſeems to have completely proved that the ſpikenard of Dioſcorides and Galen, or *Nardus Indica*, was a very different plant from the Andropogon of Dr Blane, and that it grows in a country far diſtant from *Mackran.* The proofs brought by the illuſtrious preſident of the Aſiatic Society, in ſupport of his own opinion, are too numerous and circumſtantial to be introduced into ſuch a work as this. We ſhall therefore only give one of them ; which though, when ſeparated from the reſt, it loſes much of its force, muſt be allowed, even ſingly, to have great weight.

The true Indian ſpikenard is confeſſedly called by the Arabs *Sumbulu'l Hind;* for ſo they tranſlate the name of it in Dioſcorídes. Now (ſays Sir William) I put a fair and plain queſtion ſeverally to three or four Muſſulman phyſicians : "What is the Indian name of the plant which the Arabs call *Sumbulu'l Hind?*" They all anſwered, but ſome with more readineſs than others, *Játámansí.* After a pretty long interval, I ſhewed them the ſpikes (as they are called) of *Játámansí*, and aſked, what was the Arabic name of that Indian drug? They all anſwered readily, *Sumbulu'l Hind.* The ſame evidence may be obtained in this country by any other European who ſeeks it ; and if among twelve native phyſicians, verſed in Arabian and Indian philology, a ſingle man ſhould, after due conſideration, give different anſwers, I will cheerfully ſubmit to the Roman judgment of *non liquet.* But the *Játámansí* * evidently belongs to the natural order which Linnæus calls *aggregate ;* with the following *characters :*

* Plate XXX.

Calyx, ſcarce any ; *margin*, hardly diſcernible. *Corolla*, one petal ; *tube* ſomewhat gibbous ; *border* five cleft. *Stamina*, three *Anthers*. *Piſtula*, *Germ* beneath ; one *Style* erect. *Seed*, ſolitary, crowned with a pappus. *Root*, fibrous. *Leaves*, hearted, fourfold ; *radical* leaves petioled.

It appears therefore (continues the learned author) to be the Protean plant Valerian, a ſiſter of the Mountain and Celtick Nard, and of a ſpecies which I ſhould deſcribe in the Linnean ſtyle, *Valeriana Játámansí floribus triandris, foliis cordatis quaternis, radicalibus petiolatis.* The radical leaves, riſing from the ground, and enfolding the young ſtem, are plucked up with a part of the root, and being dried in the ſun or by an artificial heat, are ſold as a drug, which, from its appearance, has been called ſpikenard. The Játámansí is a native of the moſt remote and hilly parts of India, ſuch as NE'PA'L, Marang Butan, near which Ptolemy fixes the native ſoil of the *Nardus Indica.* It grows erect above the ſurface of the ground, reſembling an ear of green wheat ; and when recent, it has a faint odour, which is greatly increaſed by the ſimple proceſs of drying it.

NARES (JAMES), doctor of muſic, an eminent compoſer and teacher in that ſcience, under whom ſome of the firſt muſicians of the preſent day received the whole or part of their education, was the ſon of Mr Nares, who was, for many years, ſteward to Montague and

Biog. Dict. new edit.

(A) In the Memoirs of the Academy of Sciences for 1767, Fougeroux has proved that the giallolino prepared by him produced on porcelain a much more beautiful colour than the Naples yellow ſold in the ſhops.

and Willoughby, earls of Abingdon. He was born, as well as his brother, the late Mr Juſtice Nares, at Stanwell in Middleſex; the former in 1715, the latter in 1716. His muſical education he commenced under Mr Gates, then maſter of the royal choriſters; and completed it under the celebrated Dr Pepuſch. Thus prepared, he officiated, for ſome time, as deputy to Mr Pigott, organiſt of Windſor; but on the reſignation of Mr Saliſbury, organiſt of York, in 1734, was choſen to ſucceed him, being then only nineteen. It is related, on undoubted authority, that, when the old muſician firſt ſaw his intended ſucceſſor, he ſaid, rather angrily, "What! is that child to ſucceed me?" which being mentioned to the organiſt-elect, he took an early opportunity, on a difficult ſervice being appointed, to play it throughout half a note below the pitch, which brought it into a key with ſeven ſharps; and went through it without the ſlighteſt error. Being aſked why he did ſo? he ſaid, that "he only wiſhed to ſhew Mr Saliſbury what a child could do." His knowledge in all branches of his profeſſion was equal to his practical ſkill in this inſtance; and, during his reſidence at York, where he was abundantly employed as a teacher, and where he married, Mr Nares, by his good conduct, as well as profeſſional merit, obtained many powerful friends. Among the foremoſt of theſe was Dr Fontayne, the reſpectable and venerable dean of York; who, when Dr Green died, towards the latter end of 1755, exerted his intereſt ſo ſucceſsfully, that he obtained for him the united places of organiſt and compoſer to his majeſty. He removed therefore to London in the beginning of 1756; and, about the ſame time, was created doctor in muſic at Cambridge.

On the reſignation of Mr Gates, in 1757, Dr Nares obtained alſo the place of maſter of the choriſters; which having been, for a long time, without increaſe, notwithſtanding the increaſe of expences attending it, was, by royal favour, augmented about 1775, firſt with the ſalary of the violiſt; and, on the revival of that place for Mr Croſdill, in 1777, with that of lutaniſt, which was annexed to it for ever. It was in this ſituation that Dr Nares ſuperintended the education of many pupils, who have ſince become famous; particularly Dr Arnold, who, though with him only for a ſhort time, was highly diſtinguiſhed by him for talents and application. The anthems and ſervices which Dr Nares produced, as compoſer to the royal chapel, were very numerous; many of them have ſince been printed, and many which exiſt only in manuſcript ſtill continue to be performed in the choirs with much effect. Having been originally a muſician rather by accident than choice, with very ſtrong talents and propenſities alſo for literature, Dr Nares was particularly attentive to expreſs the ſenſe of the words he undertook to ſet; and was the firſt who attempted to compoſe the Te Deum for the choir-ſervice, in ſuch a manner as to ſet off the ſentiments it contains to advantage. Before his time, it had been ſet rather to a regular ſtrain of chaunt than to any expreſſive melodies. The merits of Dr Nares were not overlooked by his royal patrons, whom he had occaſionally the honour to attend in private, though not a part of his regular duty. To manifeſt his reſpect and gratitude for them, he compoſed his dramatic ode, entitled The Royal Paſtoral, the words of which were written by Mr Bellamy, author of a book, entitled Ethic Amuſements.

In July 1780, Dr Nares was obliged, by declining health, to reſign the care of the choriſters, in which place he was ſucceeded by Dr Ayrton, his pupil and valued friend. In his ſixty-eighth year, a conſtitution, never robuſt, gave way, and he died on February 10. 1783. Teſtimony has been borne to the merits of Dr Nares by ſeveral writers, but more particularly by Mr Maſon, in his preface to a book of anthems, printed for the uſe of York Cathedral; and in his late Eſſays on Church Muſic, page 138. The late Lord Mornington, ſo well known for muſical talents, frequently conſulted him; and Sir John Hawkins derived advantage from his acquaintance, in the progreſs of his Hiſtory of Muſic. Throughout life, he was not leſs reſpected as a man than admired as a muſician; he had a vivacity that rendered his ſociety always pleaſing; and a generous contempt for every thing baſe, that manifeſted itſelf on all proper occaſions, and very juſtly commanded eſteem.

His printed works are theſe: 1. Eight Sets of Leſſons for the Harpſichord; dedicated to the Right Hon. Willoughby Earl of Abingdon. Printed in 1748; reprinted in 1757. 2. Five Leſſons for the Harpſichord, with a Sonata in ſcore for the Harpſichord or Organ; dedicated to the Right Honourable the Counteſs of Carliſle; publiſhed in 1758 or 1759. 3. A Set of Eaſy Leſſons for the Harpſichord, three in number; with a dedication to the public, ſigned J. N. 4. A Treatiſe on Singing, ſmall ſize. 5. Il Principio; or A regular Introduction to playing on the Harpſichord or Organ. This was the firſt ſet of progreſſive leſſons publiſhed on a regular plan. 6. The Royal Paſtoral, a Dramatic Ode; dedicated to his Royal Highneſs the Prince of Wales; printed in ſcore, with an overture and choruſes. 7. Catches, Canons, and Glees; dedicated to the late Lord Mornington. 8. Six Fugues, with Introductory Voluntaries for the Organ or Harpſichord. 9. A Conciſe and Eaſy Treatiſe on Singing, with a Set of Engliſh Duets for Beginners. A different work from the former ſmall treatiſe. 10. Twenty Anthems, in ſcore, for one, two, three, four, and five Voices. Compoſed for the Uſe of his Majeſty's Chapels Royal, 1778. 11. Six Eaſy Anthems, with a favourite Morning and Evening Service, left for publication at his death, and publiſhed in 1788, with a portrait and a conciſe account of the author. Of theſe compoſitions the following ſhort character is given by an eminent muſician, to whom they are all well known: "The leſſons are compoſed in a maſterly and pleaſing ſtyle; free from thoſe tricks and unmeaning ſucceſſions of ſemitones, to which a good ear and ſound judgment never can be reconciled. The treatiſes on ſinging contain duets compoſed for the uſe of the children of the royal chapels, ſuperior to any thing yet publiſhed; and ſuch as every teacher ought to peruſe. His catches, canons, and glees, are natural and pleaſing; eſpecially the glee to all Lovers of Harmony, which gained the prize medal at the catch-club in 1770. The Royal Paſtoral is compoſed throughout in a very maſterly manner; particularly the choruſes, with which each part concludes. This ode, containing 108 pages, was written, and all the vocal and inſtrumental parts tranſcribed for performing, within twelve days. The ſix fugues, with introductory voluntaries for the organ, contain the ſtrongeſt proofs of ingenuity and judgement; few, if any, have ever been written that can be preferred to them. In both ſets of the anthems, the ſame characteriſtics appear; and the ſervice of the latter very juſtly acquired the title of *favourite;* nor can there be any doubt that the works of this author will be admired as long as a taſte for muſic ſhall ſubſiſt."

NAVIGATORS ISLANDS, an archipelago in the South Sea, diſcovered by Bougainville, who gave to them that name, becauſe the natives do not paſs between the different villages, which are all built in creeks and bays, but in their canoes. The Navigators Iſlands are ten in number; namely, *Opoun*, *Leoné*, *Fanfoué*, MAOUANA, *Oyolava*, *Calinaſſé*, *Pola*, *Shika*, *Oſſamo*, and *Ouera*.

We have already given an account of the ſoil and productions of MAOUANA; and as the other iſlands of this cluſter are equally fertile, we need not go over the ſame ground again. It may be proper, however, to obſerve, that in ſome of them the ſugar-cane was found growing ſpontaneouſly, though its juice contained leſs of the ſaccharine ſubſtance than the ſugar cane of the Weſt Indies, which our voyagers attributed to its growing in a richer ſoil and in the ſhade. According to Perouſe, the Navigators Iſlands are ſituated about the 14th degree of ſouth latitude, and between the 171ſt and 175th degrees of longitude weſt from Paris. In Oyolava the ſmoke was ſeen hovering over a village as over a large European town; and the number of canoes which from that iſland ſurrounded the frigates was immenſe. Theſe are very tickliſh veſſels, and would be abſolutely uſeleſs to any body but ſuch excellent ſwimmers as the iſlanders, who are no more ſurpriſed or uneaſy at their overſetting than we are at the fall of a hat. Taking up the canoe on their ſhoulders, they empty it of water, and then get in again, with the certainty of having the ſame operation to perform a ſecond time in half an hour. Sometimes they join two canoes together by means of a croſs piece of wood, in which they make a ſtep to receive the maſt; and in this way they are leſs liable to be overſet, ſometimes performing a long voyage without any ſuch accident. It is needleſs to add, that theſe canoes are very ſmall, generally containing only five or ſix perſons, though ſome few of them may contain as many as fourteen.

The natives of the Navigators Iſlands are tall and well made. Their uſual height is five feet nine, ten, and eleven inches; but their ſtature is leſs aſtoniſhing than the coloſſal proportions of the different parts of their bodies. "Our curioſity (ſays Perouſe), which often led us to meaſure them, gave them an opportunity of making frequent compariſons of their bodily ſtrength with ours. Theſe compariſons were not to our advantage; and we perhaps owe our misfortunes (ſee MAOUANA in this *Suppl.*) to the idea of individual ſuperiority reſulting from repeated trials. Their countenances often appeared to expreſs a ſentiment of diſdain, which I hoped to deſtroy, by ordering our arms to be uſed in their preſence: but my end could only have been gained by directing them againſt human victims; for otherwiſe they took the noiſe for ſport, and the trial for a diverſion.

"Among theſe Indians a very ſmall number is below the height indicated above. I have, however, meaſured ſeveral who were only five feet four inches, but theſe are the dwarfs of the country; and although their ſtature reſembles ours, their ſtrong and nervous arms, their broad cheſts, and their legs and thighs, are of a very different proportion.

"The men have the body painted or tatowed, ſo that any one would ſuppoſe them clad, although they go almoſt naked. They have only a girdle of ſea-weeds encircling their loins, which comes down to their knees, and gives them the appearance of the river gods of fabulous hiſtory, whom it is cuſtomary to depict with ruſhes round their waiſt. Their hair is very long. They often twiſt it round their heads, and thus add to their native ferocity of countenance, which always expreſſes either ſurpriſe or anger. The leaſt diſpute between them is followed by blows of ſticks, clubs, or paddles; and often, without doubt, coſts the combatants their lives. They are almoſt all covered with ſcars, which can only be the conſequence of their individual quarrels. The ſtature of the women is proportioned to that of the men. They are tall, ſlender, and not without grace; but they loſe, while yet in their prime, thoſe elegant forms, of which nature has not broken the mould among this barbarous race, but of which ſhe appears to leave them in poſſeſſion only for a moment, and with reluctance. Among a great number of women that I had an opportunity of ſeeing, I only obſerved three really pretty. The groſs effrontery of the reſt, the indecency of their motions, and the diſguſting offers which they made of their favours, rendered them fit mothers and wives for the ferocious beings that ſurrounded us." Our author gives the following inſtance of indecent manners, which is, perhaps, without a parallel.

The young and pretticſt females ſoon attracted the attention of ſeveral Frenchmen, who, in ſpite of the Commodore's prohibition, endeavoured to form a connection with them, and were ſucceſsful. The looks of the Europeans expreſſing deſires which were ſoon divined, ſome old women undertook the negociation. The altar was prepared in the handſomeſt hut in the village, all the blinds were let down, and the inquiſitive were excluded. The victim was then laid in the arms of an old man, who exhorted her, during the ceremony, to moderate the expreſſion of her pain; while the matrons ſang and howled: the ceremony being performed in their preſence, and under the auſpices of the old man, who ſerved at once as prieſt and altar. All the women and children in the village were round the houſe, gently lifting up the blinds, and ſeeking to enjoy the ſight through the ſmalleſt crevices in the mats. Whatever former navigators may have ſaid, Perouſe was convinced that, in the Navigators Iſlands at leaſt, the young girls, before they are married, are miſtreſſes of their perſons, and that they are not diſhonoured by their complaiſance. It is even more than probable, that in marrying they are called to no account concerning their paſt conduct; but he had no doubt that they are obliged to be more reſerved when provided with a huſband.

Theſe people cultivate certain arts with ſucceſs. Under the article MAOUANA mention has been made of the elegant form which they give to their huts. It is not with ſuch folly as is commonly ſuppoſed that they diſdain our inſtruments of iron; for they finiſh their work very neatly with tools made of a very fine and compact ſpecies of baſaltes in the form of an adze. For a few glaſs beads they ſold to Perouſe large three-legged diſhes of a ſingle piece of wood, and ſo well poliſhed that they ſeemed to have been laid over with a coat of the fineſt varniſh. It would take an European workman ſeveral days to produce one of theſe diſhes, which, for want of proper inſtruments, muſt coſt an Indian ſeveral months labour. They ſet, however, ſcarcely any value upon them, becauſe they ſet little upon the time they employ. The fruit trees and nutritious roots that grow ſpontaneouſly around them, inſure to them their ſubſiſtence, as well as that of their hogs, dogs, and fowls; and if they ſometimes ſtoop to work, it is to procure enjoyments rather agreeable than uſeful. They manufacture very fine mats, and ſome paper ſtuffs. Our author remarked two or three of them, whom he took for chiefs, with a piece of cloth tied round their waiſt like a petticoat, inſtead of a girdle of weeds. It is compoſed of real thread, prepared no doubt from ſome filamentous plant like the nettle or flax; and is manufactured without a ſhuttle, the threads being abſolutely laid over one another like thoſe of their mats. This cloth, which has all the ſuppleneſs and ſolidity of ours, is very fit for the ſails of their canoes; and appeared far ſuperior to the paper ſtuff of the Society and Friendly Iſlands, which they manufacture alſo. Their canoes are well conſtructed, and furniſh a good proof of the ſkill with which they work in wood. For a few glaſs beads they gave to the Frenchmen, among other things, a wooden veſſel filled with cocoa nut oil, exactly of the ſhape of our earthen pots, and ſuch as no European would undertake to faſhion by any other means than a turning lathe. Their ropes are round, and twiſted like watch chains of ribbon: their mats are very fine; but their ſtuffs are inferior to thoſe of the Eaſter and Sandwich Iſlands.

Perouſe derives the natives of thoſe iſlands, whoſe colour, he ſays, nearly reſembles that of the Algerines and other nations on the coaſt of Barbary, from the Malays; and as we do not vouch for the truth of his theory, though we admit it to be ingenious, we ſhall give the reaſoning by which he ſupports it in his own words.

"We did not at firſt diſcover (ſays he) any identity between their language and that of the natives of the Society and Friendly Iſlands, of which we had vocabularies; but a more mature examination convinced us, that they ſpeak a dialect of the ſame language. A fact which tends to prove it, and which confirms the opinion of the Engliſh concerning the origin of theſe people, is, that a young domeſtic, a native of the province of Tagayan in the north of Manilla, underſtood and explained to us the greater part of their words. It is well known that the Tagayan, the Talgal, and the generality of languages ſpoken in the Philippines, are derived from the Malay: a language more diffuſed than were thoſe of the Greeks and Romans, and common to the numerous tribes that inhabit the iſlands of the great Pacific Ocean. It appears to me evident, that all theſe different nations are the progeny of Malay colonies, which, in ſome age extremely remote, conquered the iſlands they inhabit. I ſhould not even wonder, if the Chineſe and Egyptians, whoſe antiquity is ſo much vaunted, were mere moderns in compariſon of the Malays. But however this may be, I am ſatisfied that the aborigines of the Philippine Iſlands, Formoſa, New Guinea, New Britain, the New Hebrides, the Friendly Iſlands, &c. in the ſouthern hemiſphere, and thoſe of the Marianna and Sandwich iſlands in the northern, were that race of woolly headed men ſtill found in the interior of the iſlands of Luconia and Formoſa. They were not to be ſubjugated in New Guinea, New Britain, and the New Hebrides; but being overcome in the more eaſtern iſlands, which were too ſmall to afford them a retreat in the centre, they mixed with the conquering nation. Thence has reſulted a race of very black men, whoſe colour is ſtill ſeveral ſhades deeper than that of certain families of the country, probably becauſe the latter have made it a point of honour to keep their blood unmixed. I was ſtruck with theſe two very diſtinct races in the Iſlands of Navigators, and cannot attribute to them any other origin.

"The deſcendants of the Malays have acquired in thoſe iſlands a degree of vigour and ſtrength, a lofty ſtature, and a Herculean form, which they do not inherit from their forefathers, but which they owe, without doubt, to an abundance of food, to a mild climate, and to the influence of different phyſical cauſes which have been conſtantly acting during a long ſeries of generations. The arts which they perhaps brought with them may have been loſt for want of materials and inſtruments to practiſe them; but the identity of language, like Ariadne's clue, enables the obſerver to follow all the windings of this new labyrinth. The feudal government is alſo preſerved here: that government which little tyrants may regret; which was the diſgrace of Europe for ſeveral centuries; and of which the Gothic remains are ſtill to be found in our laws, and are the medals that atteſt our ancient barbariſm: that government, which is the moſt proper to keep up a ferocity of manners, becauſe the ſmalleſt diſputes occaſion wars of village againſt village, and becauſe wars of this nature are conducted without magnanimity, and without courage. Surpriſes and treachery are employed by turns; and in theſe unfortunate countries, inſtead of generous warriors, nothing is to be found but baſe aſſaſſins (A). The Malays are ſtill the moſt perfidious nation

---

(A) This was written under the old government of France by a man who, like other declaimers in the cauſe of liberty, forgot the excellencies, and inſiſted only on the defects of the feudal inſtitutions. Had Perouſe, however, returned to Europe, and witneſſed the *philoſophic* government of his country, he would have perceived, that *liberty* and *equality*, and *the rights of man*, are as well calculated to generate baſe aſſaſſins, as the Gothic remains of that government by which he ſuppoſed Europe to have been ſo long diſgraced. He might even have lived to regret, that his lot was not caſt among the bold and ferocious inhabitants of Maouana; for the treachery and cruelty of theſe people bears no proportion, even in his affecting narrative, to the ſyſtematic cruelty of thoſe who decreed, that the end ſanctifies the means, and that nothing, however atrocious in the eſtimation of antiquated moraliſts, is to be omitted, which contributes to elevate the mean above the noble.

tion of Aſia; and their children have not degenerated, becauſe the ſame cauſes have led to and produced the ſame effects. It may be objected, perhaps, that it muſt have been very difficult for the Malays to make their way from weſt to eaſt, to arrive at theſe different iſlands; but the weſterly winds blow as frequently as the eaſterly in the vicinity of the equator, along a zone of ſeven or eight degrees from north to ſouth, where the wind is ſo variable, that it is hardly more difficult to navigate eaſt than weſt. Beſides, theſe different conqueſts may not have been effected at the ſame time: the people in queſtion may, on the contrary, have ſpread themſelves by little and little, and gradually have introduced that form of government which ſtill exiſts in the peninſula of Malacca, at Java, Sumatra, and at Borneo, as well as in all the other countries ſubject to that barbarous nation."

NAZER, Nazr, Nezer, Nuzzer, Nuzzerana; a preſent from an inferior; fees of office.

NEBULOUS, or Cloudy, a term applied to certain fixed ſtars which ſhew a dim hazy light; being leſs than thoſe of the ſixth magnitude, and therefore ſcarcely viſible to the naked eye, to which at beſt they only appear like little duſky ſpecks or clouds. Through a moderate teleſcope, theſe nebulous ſtars plainly appear to be congeries or cluſters of ſeveral little ſtars.

NECKAR isle, a ſmall barren iſland, or rather rock, diſcovered by Perouſe in the Pacific Ocean. Though its ſterility renders it of no importance in itſelf, its exact ſituation muſt be intereſting to navigators, who are therefore obliged to the French Commodore for having aſcertained its latitude to be 23° 34′ north, and its longitude to be 166° 52′ weſt from Paris. From the ſoundings the *Neckar* ſeemed to be only the top or nucleus of a much more conſiderable iſland, which, probably from being compoſed of a ſoft and diſſoluble ſubſtance, the ſea had gradually waſhed away. In proportion as the frigates left the ſhore, the depth, which at the diſtance of a mile was very little, gradually increaſed, till, at the diſtance of about ten miles, no bottom was found with a line of 150 fathoms; and over the whole of that ſhore the bottom conſiſted of coral and broken ſhells.

NEPAL, a kingdom of India, ſituated to the north-eaſt of the city of Patna, at the diſtance of ten or twelve days journey. Within the diſtance of four days journey from Nepal the road is good in the plains of Hindoſtan, but in the mountains it is bad, narrow, and dangerous. At the foot of the hills the country is called *Teriani*; and there the air is very unwholeſome from the middle of March to the middle of November; and people in their paſſage catch a diſorder called in the language of that country *aul;* which is a putrid fever, and of which the generality of people, who are attacked with it, die in a few days; but on the plains there is no apprehenſion of it. Although the road be very narrow and inconvenient for three or four days at the paſſes of the hills, where it is neceſſary to croſs and recroſs the river more than fifty times, yet, on reaching the interior mountain before you deſcend, you have an agreeable proſpect of the extenſive plain of Nepal, reſembling an amphitheatre covered with populous towns and villages: the circumference of the plain is about 200 miles, a little irregular, and ſurrounded by hills on all ſides, ſo that no perſon can enter or come out of it without paſſing the mountains.

There are three principal cities in the plain, each of which was the capital of an independent kingdom; the principal city of the three is ſituated to the northward of the plain, and is called *Cat'hmandu:* it contains about 18,000 houſes; and this kingdom, from ſouth to north, extends to the diſtance of twelve or thirteen days journey as far as the borders of Tibet, and is almoſt as extenſive from eaſt to weſt. The king of Cat'hmandu has always about 50,000 ſoldiers in his ſervice. The ſecond city to the ſouth-weſt of Cat'hmandu is called *Lelit Pattan*; it contains near 24,000 houſes. The third principal city to the eaſt of Lelit Pattan is called *B'hatgan:* it contains about 12,000 families; and is the metropolis of a diſtrict which extends towards the eaſt to the diſtance of five or ſix days journey; and borders upon another nation, alſo independent, called *Ciratas*, who profeſs no religion. Beſides theſe three principal cities, there are many other large and leſs conſiderable towns or fortreſſes; one of which is *Timi*, and another *Cipoli*, each of which contains about 8000 houſes, and is very populous. All thoſe towns, both great and ſmall, are well built; the houſes are conſtructed of brick, and are three or four ſtories high; their apartments are not lofty; they have doors and windows of wood well worked and arranged with great regularity. The ſtreets of all their towns are paved with brick or ſtone, with a regular declivity to carry off the water. In almoſt every ſtreet of the capital towns there are alſo good wells made of ſtone, from which the water paſſes through ſeveral ſtone canals for the public benefit. In every town there are large ſquare varandas well built, for the accommodation of travellers and the public: theſe varandas are called *Pali;* and there are alſo many of them, as well as wells, in different parts of the country for public uſe. There are alſo, on the outſide of the great towns, ſmall ſquare reſervoirs of water, faced with brick, with a good road to walk upon, and a large flight of ſteps for the convenience of thoſe who chooſe to bathe.

The religion of Nepal is of two kinds: the more ancient is profeſſed by many people who call themſelves *Baryeſu;* they pluck out all the hair from their heads; their dreſs is of coarſe red woollen cloth, and they wear a cap of the ſame: they are conſidered as people of the religious order, and their religion prohibits them from marrying, as it is with the Lamas of Tibet, from which country their religion was originally brought; but in Nepal they do not obſerve this rule, except at their diſcretion. They have large monaſteries, in which every one has a ſeparate apartment or place of abode. They obſerve alſo particular feſtivals, the principal of which is called *Yatra* in their language, and continues a month or longer according to the pleaſure of the king. The ceremony conſiſts in drawing an idol, which at Lelit Pattan is called *Baghero*, in a large and richly ornamented car, covered with gilt copper: round about the idol ſtand the king and the principal Baryeſus; and in this manner the vehicle is almoſt every day drawn thro' ſome one of the ſtreets of the city by the inhabitants, who run about beating and playing upon every kind of inſtrument their country affords, which make an inconceivable noiſe.

The other religion, the more common of the two, is that of the Brahmens, and is the ſame as is followed in Hindoſtan, with the difference that, in the latter country the Hindus being mixed with the Mahommedans, their religion alſo abounds with many prejudices, and is not ſtrictly obſerved; whereas in Nepal, where there are no Muſſelmans (except one Caſhmirian merchant), the Hindu religion is practiſed in its greateſt purity: every day of the month they claſs under its proper name, when certain ſacrifices are to be performed and certain prayers offered up in their temples: the places of worſhip are more in number in their towns than are to be found in the moſt populous and moſt flouriſhing cities of Chriſtendom; many of them are magnificent according to their ideas of architecture, and conſtructed at a very conſiderable expence; ſome of them have four or five ſquare cupolas, and in ſome of the temples two or three of the extreme cupolas, as well as the doors and windows of them, are decorated with gilt copper.

In the city of Lelit Pattan the temple of Baghero is more valuable, on account of the gold, ſilver, and jewels it contains, than even the houſe of the king. Beſides the large temples, there are alſo many ſmall ones, which have ſtairs, by which a ſingle perſon may aſcend, on the outſide all around them; and ſome of thoſe ſmall temples have four ſides, others ſix, with ſmall ſtone or marble pillars poliſhed very ſmooth, with two or three pyramidal ſtories, and all their ornaments well gilt, and neatly worked according to their ideas of taſte. On the outſide of ſome of their temples there are great ſquare pillars of ſingle ſtones from twenty to thirty feet high, upon which they place their idols ſuperbly gilt. The greateſt number of their temples have a good ſtone ſtaircaſe in the middle of the four ſquares, and at the end of each flight of ſtairs there are lines cut out of ſtone on both ſides: around about their temples there are alſo bells, which the people ring on particular occaſions; and when they are at prayers, many cupolas are alſo quite filled with little bells hanging by cords in the inſide about the diſtance of a foot from each other, which make a great noiſe on that quarter where the wind conveys the ſound. There are not only ſuperb temples in their great cities, but alſo within their caſtles.

To the eaſtward of Cat'hmandu, at the diſtance of about two or three miles, there is a place called *Tolu*, by which there flows a ſmall river, the water of which is eſteemed holy, according to their ſuperſtitious ideas, and thither they carry people of high rank, when they are thought to be at the point of death: at this place there is a temple, which is not inferior to the beſt and richeſt in any of the capital cities. They alſo have it on tradition, that at two or three places in Nepal valuable treaſures are concealed under ground: one of thoſe places they believe is Tolu; but no one is permitted to make uſe of them except the king, and that only in caſes of neceſſity. Thoſe treaſures, they ſay, have been accumulated in this manner: When any temple had become very rich from the offerings of the people, it was deſtroyed, and deep vaults dug under ground one above another, in which the gold, ſilver, gilt copper, jewels, and every thing of value, were depoſited. This was found to be actually the caſe when the miſſionary, from whoſe memoir this account of Nepal is taken, was at Cat'hmandu. One of the kings, or pretenders to the crown, who were then at war with each other, being in the utmoſt diſtreſs for want of money to pay his troops, ordered the vaults at Tolu to be opened; and found in the firſt vault more money, beſides ſilver and gold idols, than he had immediate occaſion for.

To the weſtward alſo of the great city of Lelit Pattan, at the diſtance of only three miles, is a caſtle called *Banga*, in which there is a magnificent temple. No one of the miſſionaries ever entered into this caſtle; becauſe the people who have the care of it, have ſuch a ſcrupulous veneration for the temple, that no perſon is permitted to enter it with his ſhoes on; and the miſſionaries, unwilling to ſhew ſuch reſpect to their falſe deities, never entered it. The author of this memoir, however, who acted as phyſician to the commandant, was of courſe admitted within the caſtle, and got a ſight of the celebrated temple, which he declares, that for magnificence he believes ſuperior to every thing in Europe.

Beſides the magnificence of the temples, which their cities and towns contain, there are many other rarities. At Cat'hmandu, on one ſide of the royal garden, there is a large fountain, in which is one of their idols called *Narayan*. This idol is of blue ſtone, crowned and ſleeping on a mattraſs alſo of the ſame kind of ſtone, and the idol and the mattraſs appear as floating upon the water. This ſtone machine is very large, being about 18 or 20 feet long, and broad in proportion, but well worked, and in good repair.

In a wall of the royal palace of Cat'hmandu, which is built upon the court before the palace, there is a great ſtone of a ſingle piece, which is about fifteen feet long, and four or five feet thick; on the top of this great ſtone there are four ſquare holes at equal diſtances from each other; in the inſide of the wall they pour water into the holes; and in the court ſide, each hole having a cloſed canal, every perſon may draw water to drink. At the foot of the ſtone is a large ladder, by which people aſcend to drink; but the curioſity of the ſtone conſiſts in its being quite covered with characters of different languages cut upon it. Some lines contain the characters of the language of the country, others the characters of Tibet, others Perſian, others Greek, beſides ſeveral others of different nations; and in the middle there is a line of Roman characters, which appears in this form, AVTOMNEW INTER LHIVERT; but none of the inhabitants have any knowledge how they came there, nor do they know whether or not any European had ever been in Nepal before the miſſionaries, who arrived there only the beginning of the preſent century. They are manifeſtly two French names of ſeaſons, with an Engliſh word between them.

There is alſo to the northward of the city of Cat'hmandu a hill called *Simbi*, upon which are ſome tombs of the Lamas of Tibet, and other people of high rank of the ſame nation. The monuments are conſtructed after various forms: two or three of them are pyramidal, very high, and well ornamented; ſo that they have a very good appearance, and may be ſeen at a conſiderable diſtance. Round theſe monuments are remarkable ſtones covered with characters, which probably are the inſcriptions of ſome of the inhabitants of Tibet whoſe bones were interred there. The natives of Nepal not only look upon the hill as ſacred, but imagine it is protected by their idols; and from this erroneous ſuppoſition never think of ſtationing troops there for the defence ſton. defence of it, although it be a poſt of great importance, and only at a ſhort mile's diſtance from the city. During the hoſtilities, however, which prevailed when our author was in the country, this ſacred hill was fortified by one of the armies, who, in digging their ditches among the tombs, found conſiderable pieces of gold, with a quantity of which metal the corpſes of the grandees of Tibet are always interred.

The kingdom of Nepal our author believes to be very ancient, becauſe it has always preſerved its peculiar language and independence. It was completely ruined, however, about thirty or forty years ago by the diſſenſions of its nobles, who, on the death of their ſovereign, and, as it would ſeem, the extinction of the royal line, could not agree in their choice of a proper ſucceſſor. The conſequence was, that different ſovereigns were ſet up by the nobles of different diſtricts; and theſe waged war with each other, with a degree of treachery and ſavage atrocity that has hardly a parallel in the annals of the world. Even the Brahmens, whom we are accuſtomed to conſider as a mild and innocent people, were, in the civil wars of Nepal, guilty of the meaneſt and baſeſt villanies: they brought about treaties between the rival ſovereigns, and then encouraged him whom they favoured, to maſſacre the adherents of the other in cold blood.

NEWTON (John), an eminent Engliſh mathematician, was born at Oundle in Northamptonſhire, 1622. After a proper foundation at ſchool, he was ſent to Oxford, where he was entered a commoner of St Edmund's Hall in 1637. He took the degree of bachelor of arts in 1641; and the year following was created maſter, among ſeveral gentlemen that belonged to the king and court, then reſiding in the univerſity. At which time, his genius being inclined to aſtronomy and the mathematics, he applied himſelf diligently to thoſe ſciences, and made a great proficiency in them, which he found of ſervice during the times of the uſurpation. After the reſtoration of Charles II. he reaped the fruits of his loyalty; being created doctor of divinity at Oxford Sept. 1661, he was made one of the king's chaplains, and rector of Roſs in Herefordſhire, in the place of Mr John Toombes, ejected for nonconformity. He held this living till his death, which happened at Roſs on Chriſtmas-day 1678. Mr Wood gives him the character of a capricious and humourſome perſon: however that may be, his writings are ſufficient monuments of his genius and ſkill in the mathematics. Theſe are, 1. *Aſtronomia Britannica*, &c. in three parts, 1656, in 4to. 2. Help to Calculation; with Tables of Declination, Aſcenſion, &c. 1657, 4to. 3. *Trigonometria Britannica*, in two books, 1658, folio; one compoſed by our author, and the other tranſlated from the Latin of Henry Gellibrand. 4. *Chiliades centum Logarithmorum*, printed with, 5. Geometrical Trigonometry, 1659. 6. Mathematical Elements, three parts, 1660, 4to. 7. A perpetual Diary or Almanac, 1662. 8. Deſcription of the Uſe of the Carpenter's Rule, 1667. 9. Ephemerides, ſhewing the Intereſt and rate of Money at 6 *per cent.* &c. 1667. 10. *Chiliades centum Logarithmorum, et Tabula Partium proportionalium*, 1667. 11. The Rule of Intereſt, or the Caſe of Decimal Fractions, &c. Part II. 1668, 8vo. 12. School-Paſtime for young Children, &c. 1669, 8vo. 13. Art of practical Gauging, &c. 1669. 14. Introduction to the Art of Rhetoric, 1671. 15. The Art of Natural Arithmetic, in whole Numbers, and Fractions Vulgar and Decimal, 1671, 8vo. 16. The Engliſh Academy, 1677, 8vo. 17. Coſmography. 18. Introduction to Aſtronomy. 19. Introduction to Geography, 1678, 8vo *.

Nicole.

NICOLE (Francis), a very celebrated French mathematician, was born at Paris December 23. 1683. His early attachment to the mathematics induced M. Montmort to take the charge of his education; and he opened out to him the way to the higher geometry. He firſt became publicly remarkable by detecting the fallacy of a pretended quadrature of the circle. This quadrature a M. Mathulon ſo aſſuredly thought he had diſcovered, that he depoſited, in the hands of a public notary at Lyons, the ſum of 3000 livres, to be paid to any perſon who, in the judgment of the Academy of Sciences, ſhould demonſtrate the falſity of his ſolution. M. Nicole, piqued at this challenge, undertook the taſk, and expoſing the paralogiſm, the Academy's judgment was, that Nicole had plainly proved that the rectilineal figure which Mathulon had given as equal to the circle, was not only unequal to it, but that it was even greater than the polygon of 32 ſides circumſcribed about the circle. The prize of 3000 livres Nicole preſented to the public hoſpital of Lyons.

The Academy named Nicole, Eleve-Mechanician, March 12. 1707; Adjunct in 1716, Aſſociate in 1718, and Penſioner in 1724; which he continued till his death, which happened the 18th of January 1758, at 75 years of age.

His works were all inſerted in the different volumes of the Memoirs of the Academy of Sciences; and are as follow: 1. A General Method for determining the Nature of Curves formed by the Rolling of other Curves upon any Given Curve; in the volume for the year 1707. 2. A General Method for Rectifying all Roulets upon Right and Circular Baſes, 1708. 3. General Method of determining the Nature of thoſe Curves which cut an Infinity of other Curves given in Poſition, cutting them always in a Conſtant Angle, 1715. 4. Solution of a Problem propoſed by M. de Lagny, 1716. 5. Treatiſe of the Calculus of Finite Differences, 1717. 6. Second Part of the Calculus of Finite Differences, 1723. 7. Second Section of ditto, 1723. 8. Addition to the two foregoing papers, 1724. 9. New Propoſition in Elementary Geometry, 1725. 10. New Solution of a Problem propoſed to the Engliſh Mathematicians, by the late M. Leibnitz, 1725. 11. Method of Summing an Infinity of New Series, which are not ſummable by any other known method, 1727. 12. Treatiſe of the Lines of the Third Order, or the Curves of the Second Kind, 1729. 13. Examination and Reſolution of ſome Queſtions relating to Play, 1730. 14. Method of determining the Chances at Play. 15. Obſervations upon the Conic Sections, 1731. 16. Manner of generating in a Solid Body all the Lines of the Third Order, 1731. 17. Manner of determining the Nature of Roulets formed upon the Convex Surface of a Sphere; and of determining which are Geometric and which are Rectifiable, 1732. 18. Solution of a Problem in Geometry, 1732. 19. The Uſe of Series in reſolving many Problems in the Inverſe Method of Tangents, 1737. 20. Obſervations on the Irreducible Caſe in Cubic Equations, 1738. 21. Obſervations upon Cubic Equations, 1738. 22. On the Triſection of an

---

* Biog. Dict. new edit.

Nieuwland.

an Angle, 1740. 23. On the Irreducible Caſe in Cubic Equations, 1741. 24. Addition to ditto, 1743. 25. His Laſt Paper upon the ſame, 1744. 26. Determination, by Incommenſurables and Decimals, the Values of the Sides and Areas of the Series in a Double Progreſſion of Regular Polygons, inſcribed in and circumſcribed about a Circle, 1747 *.

NIEUWLAND (Peter), profeſſor of mathematics and natural philoſophy in the univerſity of Leyden, was born at Diemermeer, a village near Amſterdam, on the 5th of November, 1764. His father, by trade a carpenter, having a great fondneſs for books, and being tolerably well verſed in the mathematics, inſtructed his ſon himſelf till he attained to his eleventh year. Young Nieuwland appears to have diſplayed ſtrong marks of genius at a very early period. When about the age of three, his mother put into his hand ſome prints, which had fifty verſes at the bottom of them by way of explanation. Theſe verſes ſhe read aloud, without any intention that her ſon ſhould learn them; and ſhe was much ſurpriſed ſome time after to hear him repeat the whole from memory, with the utmoſt correctneſs, on being only ſhewn the prints.

Before he was ſeven years of age he had read more than fifty different books, and in ſuch a manner that he could frequently repeat paſſages from them both in proſe and in verſe. When about the age of eight, Mr Aeneæ at Amſterdam, one of the greateſt calculators of the age, aſked him if he could tell the ſolid contents of a wooden ſtatue of Mercury which ſtood upon a piece of clock-work. "Yes (replied young Nieuwland), provided you give me a bit of the ſame wood of which the ſtatue was made; for I will cut a cubic inch out of it, and then compare it with the ſtatue." Poems which (ſays his eulogiſt) diſplay the utmoſt livelineſs of imagination, and which he compoſed in his tenth year, while walking or amuſing himſelf near his father's houſe, were received with admiration, and inſerted in different poetical collections.

Such an uncommon genius muſt ſoon burſt through thoſe obſtacles which confine it. Bernardus and Jeronimo de Boſch, two of the firſt and wealthieſt men at Amſterdam, became young Nieuwland's benefactors, and contributed very much to call forth his latent talents. He was taken into the houſe of the former in his eleventh year, and he received daily inſtruction from the latter for the ſpace of four years. While in this ſituation he made conſiderable progreſs in the Latin and Greek languages, and he ſtudied philoſophy and the mathematics under Wyttenbach. In the year 1783 he tranſlated the two diſſertations of his celebrated inſtructors, Wyttenbach and de Boſch, on the opinions which the ancients entertained of the ſtate of the ſoul after death, which had gained the prize of the Teylerian theological ſociety.

From the month of September 1784 to 1785, Nieuwland reſided at Leyden as a ſtudent in the univerſity, and afterwards applied with great diligence, at Amſterdam, to natural philoſophy and every branch of the mathematics, under the direction of Profeſſor van Swinden. He had ſcarcely begun to turn his attention to chemiſtry, when he made himſelf maſter of the theory of the much-lamented Lavoiſier, and could apply it to every phenomenon. He could read a work through with uncommon quickneſs, and yet retain in his mind the principal part of its contents.

Nieuwlan

Nieuwland's attention was directed to three principal purſuits, which are ſeldom united; poetry, the pure mathematics, and natural philoſophy. In the latter part of his life he added to theſe alſo aſtronomy. Among the poems which he publiſhed, his Orion alone has rendered his name immortal in Holland. Of the ſmall eſſays which he publiſhed in his youth, the two following are particularly deſerving of notice: 1. A Comparative View of the Value of the different Branches of Science; and, 2. The beſt Means to render general, not Learning, but Soundneſs of Judgment and Good Taſte.

One of his great objects was to bring the pure mathematics nearer to perfection, to clear up and connect their different parts, and in particular to apply them to natural philoſophy and aſtronomy. Cornelius Douwes diſcovered an eaſy method of determining the latitude of a place at ſea, not by the meridian altitude of the ſun, but by two obſervations made at any other period of the day. This method, however, being ſtill imperfect, Nieuwland turned his thoughts towards the improvement of it, and in the beginning of the year 1789 wrote a paper on the ſubject, which he tranſmitted to M. de Lalande at Paris, from whom it met with great approbation. In the year 1792, when Nieuwland reſided two months at Gotha with Major von Zach, theſe two learned men often converſed on this method of finding the latitude, and calculated the reſult of obſervations which they had made with a ſextant and an artificial horizon. The above paper, enlarged by theſe obſervations, was inſerted by Major von Zach with Nieuwland's name in the firſt Supplement to Bode's Aſtronomical Almanack, Berlin, 1793.

This, however, was not the only ſervice which Nieuwland endeavoured to render to aſtronomy. It had been obſerved by Newton, Euler, De la Place, and others, that the axes of the planets do not ſtand perpendicular, but inclined, to the plane of their orbits; and Du Sejour, in his analytical treatiſe on the apparent motion of the heavenly bodies, conſiders it as highly probable that this phenomenon depends on ſome *phyſical* cauſe; which, however, he does not venture to aſſign. Nieuwland proceeded farther, and laid down principles, from which he drew this concluſion, that the above phenomenon is intimately connected with the whole ſyſtem of attraction. On theſe principles he made calculations, the reſult of which was exactly equal to the angle of the inclination of the earth's axis to the plane of its orbit. Nieuwland communicated his diſcovery with much modeſty to the celebrated Profeſſor Damen at Leyden, who propoſed ſome objections to it which diſcouraged Nieuwland, and induced him to reviſe his calculations with more accuracy. Major von Zach tranſmitted the paper which contained them to M. De la Place at Paris, and cauſed it to be printed alſo, for the opinion of the learned, in the Supplement to Profeſſor Bode's Aſtronomical Almanack for the year 1793.

The writer of this article is not acquainted either with the principles which this young aſtronomer aſſumed, or with the calculations which he made from them; but if he holds gravitation to be eſſential to matter, and the inclination of the axes of the planets to be the neceſſary reſult of the law of gravitation, he is undoubtedly

---

* Hutton's Dictionary.

doubtedly in an error. The axes of the planets are not all equally inclined, nor does the inclination vary in exact proportion to the ſquares of the diſtances.

Nieuwland's talents and diligence ſoon recommended him to the notice of his country. In his twenty-ſecond year, he was appointed a member of the commiſſion choſen by the College of Admiralty at Amſterdam for determining the longitude and improving marine charts. On this labour he was employed eight years, and undertook alſo to prepare a nautical almanack, and to calculate the neceſſary tables. The mathematical part was in general entruſted to Nieuwland; but he aſſiſted alſo his two colleagues van Swinden and van Keulen, in the departments aſſigned to them, with ſuch aſſiduity, that moſt of the work publiſhed on the longitude, together with the three additional parts, were the fruits of his labour. In the ſecond edition of the explanation of the nautical almanack, he had alſo the principal ſhare; and he was the author, in particular, of the explanation of the equation of time, the method of determining the going of a time-piece, and of calculating the declination of the moon.

Soon after Nieuwland engaged in this employment, it appeared as if his deſtination was about to be changed. In the year 1787, he was choſen by the States of Utrecht to ſucceed Profeſſor Hennert; but on account of certain circumſtances this appointment did not take place. He was, however, invited to Amſterdam by the magiſtrates of that city, to give lectures on mathematics, aſtronomy, and navigation. While in this ſituation, he wrote his uſeful and excellent treatiſe on navigation, the firſt part of which was publiſhed at Amſterdam in 1793, by George Hulſt van Keulen; and it is much to be wiſhed that M. van Swinden would complete this work from the papers bequeathed to him by his deceaſed friend the author.

In aſtronomical purſuits, Nieuwland applied not only to the theoretical, but alſo to the practical part; and in this ſtudy he was encouraged and aſſiſted by Major von Zach, with whom he reſided ſome time in the courſe of the year 1792, and who inſtructed him in the proper uſe of the ſextant. This affectionate friend publiſhed alſo all his obſervations and calculations in the beforementioned Supplement to Bode's Aſtronomical Almanack.

In the year 1789, Nieuwland was choſen member of a learned ſociety whoſe object was chemical experiments; and ſo apt was his genius for acquiring knowledge, that in a little time he made himſelf completely maſter of the theory of chemiſtry. A proof of this is the treatiſe which he read on the 24th of May 1791, in the ſociety, diſtinguiſhed by the motto of *Felix Meritis*, and which has been printed in the firſt part of the New General Magazine (*Niew Algemeen Magazyn*). At the ſame time he was able to examine the important diſcoveries made by the ſociety, to aſſiſt in preparing an account of them for the preſs, and to publiſh them with ſufficient accuracy in the French language. Three parts of this work appeared under the title of *Recherches Phyſico-chymiques*. The firſt part appeared in 1792, and was afterwards reprinted in the *Journal de Phyſique*. The ſecond was publiſhed in 1793, and the fourth in 1794. Some letters of his on chemiſtry may be found alſo in a periodical work called *The Meſſenger* (*Letterbode*).

This ingenious and diligent man was of great ſervice alſo in the philoſophical department to the above ſociety, *Felix Meritis*, of which he had been choſen a titular member on the 25th of January 1788, and an honorary member on the 15th of March 1791. The papers for which it was indebted to him are as follows:—1. On the Neweſt Diſcoveries in Aſtronomy, and the Progreſs lately made in that Science, 1788. This is an extract from a Latin oration which he intended to deliver at Utrecht when he expected to ſucceed Profeſſor Hennert.—2. On the Figure of the Earth, 1789.—3. On the Courſe of Comets, and the Uncertainty of the Return of the Comet now Expected, 1790.—4. On the Nature of the Mathematics. The principal object of this paper was to illuſtrate the idea, that the mathematics may be conſidered as a beautiful and perfect language.—5. On the Periodical Decreaſe or Increaſe in the Light of Certain Fixed Stars, and Particularly of the Star Algol, 1790.—6. On the Solution of Spherical Trigonometry by Means of a New Inſtrument Invented by Le Guin, 1791. M. le Guin having tranſmitted to the College of Admiralty at Amſterdam an inſtrument which might be uſed with great advantage in trigonometrical operations, and by which, in calculating the longitude, one could deduce the real from the apparent diſtance, the admiralty charged Nieuwland to examine this inſtrument; and he found that it might be of excellent ſervice for the above purpoſe.—7. On the Relative Value or Importance of the Sciences, 1791.—8. On the Syſtem of Lavoiſier, 1792.—9. On the Selenotopographia of Schröder, 1793.—10. On what is Commonly Called Cultivation, Inſtruction, or Enlightening, 1793.

Nieuwland had applied cloſely to the mathematics, aſtronomy, and navigation, for ſix years; during which time he made conſiderable improvements in nautical charts, and filled up his vacant hours with the ſtudy of philoſophy and chemiſtry. In the month of July 1793 he was invited to the univerſity of Leyden, to be profeſſor of philoſophy, aſtronomy, and the higher mathematics, in the room of the celebrated Damen; and the admiralty of Amſterdam requeſted him to continue his nautical reſearches, which he did with great aſſiduity till the period of his death. The only variation which he now made in his ſtudies related to natural philoſophy, for with the mathematics he was already ſufficiently acquainted. He applied therefore to the experimental part, and ſpared no pains nor labour to become perfect in it; which would certainly have been the caſe, had he not been ſnatched from ſcience and his friends at the early age of thirty. He died of an inflammation in his throat, accompanied with a fever, on the 13th of November 1794.

In his external appearance, Nieuwland was not what might be called handſome, nor had he ever been at pains to acquire that eaſe of deportment which diſtinguiſhes thoſe who have frequented polite company. His behaviour and converſation were however agreeable, becauſe he could diſcourſe with facility on ſo many ſubjects, and never wiſhed to appear but under his real character. On the firſt view one might have diſcerned that he was a man of great modeſty and the ſtricteſt morality. His father was a Lutheran, and his mother a baptiſt; but he himſelf was a member of what is called the reformed church, *i. e.* a Calviniſt, and always ſhewed the utmoſt reſpect for the Supreme Being both by his words and his actions.

NIGER, a large river in Africa, of which many erroneous accounts have been publiſhed, and among them that which we have given in the *Encyclopædia Britannica*. By Herodotus, Pliny, Ptolemy, and other ancient authors, it is uniformly ſaid to flow from *weſt* to *eaſt*, dividing Africa as the Danube divides Europe; and from the report of the Africans, the firſt of theſe authors calls it a large river abounding with crocodiles. In the twelfth century, however, Edriſi deſcribes the Niger, which he calls the Nile of the negroes, as running from *eaſt* to *weſt*, and falling into the Atlantic Ocean; and his account was univerſally adopted by ſubſequent writers, till its falſehood was diſcovered by the African Aſſociation. From a number of concurring reports, Major Houghton was led to believe that the courſe of the Niger is from *weſt* to *eaſt*, according to the moſt ancient account; and the truth of theſe reports has been eſtabliſhed beyond all controverſy by Mr Park, who ſaw the Niger himſelf, and actually accompanied it for many miles in its majeſtic courſe as laid down by Herodotus.

This river riſes in or near the country of MANDING (which ſee in this *Supplement*), between the parallels of 10 and 11 degrees of north latitude, and between the 5th and 9th degree of weſt longitude, which comprehends a ſpace the moſt elevated of all this portion of Africa. This is evident from the oppoſite courſes of the three great rivers which riſe in it. Theſe are the Gambia, which runs to the weſt-north-weſt; the Senegal, which runs to the north-weſt; and the Joliba (A), or Niger, running to the eaſt-north-eaſt. The head of the principal branch of the Senegal river is about 80 geographical miles to the weſt of that of the Niger; and the head of the Gambia is again about 100 miles weſt of the Senegal.

Mr Park traced the Niger to Silla, a conſiderable town about 420 miles from its ſource; and it was there larger than the Thames at Weſtminſter. But 420 miles are but a very ſmall part of the courſe of the Niger, which doubtleſs receives many tributary ſtreams before it reach Kaſſina, 700 miles farther eaſtward, where there is every reaſon to believe that it was viewed by the ancient Romans. Our traveller collected at Silla what information he could from the Mooriſh and Negro traders concerning the further courſe of this majeſtic ſtream, as well as of the kingdoms through which it runs; and the following notices he believes to be authentic:

Two ſhort days journey to the eaſtward of Silla, is the town of Jenne, which is ſituated on a ſmall iſland in the river; and is ſaid to contain a greater number of inhabitants than Sego itſelf, or any other town in Bambarra. (See SEGO, *Suppl.*) At the diſtance of two days more, the river ſpreads into a conſiderable lake, called *Dibbie* (or the dark lake); concerning the extent of which, all the information which our author could obtain was, that in croſſing it, from weſt to eaſt, the canoes loſe ſight of land one whole day. From this lake, the water iſſues in many different ſtreams, which terminate in two large branches, one whereof flows towards the north eaſt, and the other to the eaſt; but theſe branches join at Kabra, which is one day's journey to the ſouthward of Tumbuctoo, and is the port or ſhipping-place of that city. The tract of land which the two ſtreams encircle, is called Jinbala, and is inhabited by negroes; and the whole diſtance, by land, from Jenne to Tumbuctoo, is twelve days journey.

From Kabra, at the diſtance of eleven days journey, down the ſtream, the river paſſes to the ſouthward of Houſſa, which is two days journey diſtant from the river. Of the further progreſs of this great river, and its final exit, all the natives with whom Mr Park converſed ſeemed to be entirely ignorant. Their commercial purſuits ſeldom induce them to travel further than the cities of Tumbuctoo and Houſſa; and as the ſole object of thoſe journeys is the acquirement of wealth, they pay but little attention to the courſe of rivers, or the geography of countries. It is, however, highly probable that the Niger affords a ſafe and eaſy communication between very remote nations. All our author's informants agreed, that many of the negro merchants who arrive at Tumbuctoo and Houſſa, from the eaſtward, ſpeak a different language from that of Bambarra, or any other kingdom with which they are acquainted. But even theſe merchants, it would ſeem, are ignorant of the termination of the river; for ſuch of them as can ſpeak Arabic, deſcribe the amazing length of its courſe in very general terms, ſaying only, that they believe *it runs to the world's end*.

Major Rennel, by comparing a great many accounts of the progreſs of this river beyond Houſſa, with the idea which prevails in that city of its termination, has ſhewn it to be in a very high degree probable, that the waters of the Niger have no direct communication with the ſea, but that they are ſpread out into a great lake in Wangara and Ghana, and evaporated by the heat of the ſun. See WANGARA in this *Supplement*.

NILE, the name of a celebrated river, which, as it has been deſcribed in the *Encyclopædia*, ſhould not have been introduced into this place, did we not think ourſelves bound candidly to confeſs that, in our opinion, its ſources, at leaſt thoſe ſources which were the objects of ancient curioſity, have never yet been ſeen by any European. This ſeems to be proved, beyond the poſſibility of controverſy, by Major Rennel in the Appendix to Mr Park's Travels, and by Mr Browne in his account of the *Bahr-el-abiad*, and *Dar-Fur* or *Soudan*. See SOUDAN in this *Supplement*.

Mr Bruce himſelf acknowledges that the Nile, which waters Egypt, is the confluence of two ſtreams, and that the weſtern ſtream, which he, with others, calls *Bahr-el-abiad*, or the *white river*, is the largeſt of the two. Were a man therefore to travel from Cairo up the banks of the Nile in queſt of its ſource, he would, doubtleſs, when he ſhould arrive at the diviſion of the river into two channels, continue his journey up the greater of theſe; for what could induce him to turn aſide with the leſs? Not the *name*; for neither the leſs nor the greater has by itſelf the name which, in Egypt, is given to both when united. The former, which undoubtedly has its ſource in Abyſſinia, is there called the Abay or Abavi; and, in other countries through which

---

(A) This is the negro name of the river, and ſignifies the *great water*.

ile, iquas.

which it runs, the Bahr-el Aſrek; the latter is, from its ſource to its junction with the Abay, called the Bahr-el abiad. Pliny believed that the Nile came from the weſt; and Ptolemy ſays expreſsly that its remote ſource is in the *mountains of the moon*. But this Nile muſt be the White River, which certainly riſes to the weſtward of Abyſſinia, and, according to Abulfeda, in the mountains of Komri or Kummeri; which, in Arabic, ſignifies *lunar*, being the adjective of Kummer, the moon.

In perfect conformity with this ancient account of the ſource of the Nile, Mr Ledyard was told at Cairo by certain perſons from Dar-Fur, that this celebrated river has its coy fountains in their country, at the diſtance of 55 days journey to the weſtward of Senaar, which brings them to the Komri mountains of Abulfeda, who, as well as Ptolemy and Edriſi, places the head of the Nile in a quarter far removed from Abyſſinia. Ptolemy has indeed mentioned both branches; and while he deſcribes the eaſtern in ſuch a way as that it cannot be taken for any other than the Abyſſinian branch, or the Nile of Bruce and the Portugueſe Jeſuits, ſpeaks of a larger branch flowing from a more diſtant ſource, ſituated to the ſouth-weſt. But this can be no other than Bruce's white river, the *Bahr-el-abiad* of Ledyard and Browne. It is true, there is an apparent difference in the account given by theſe two laſt mentioned travellers of the country in which the Bahr-el-abiad riſes; but it is a difference only apparent. Ledyard was told at Cairo that it riſes in Dar-Fur; Mr Browne, who reſided long in Dar-Fur, was there told, that the ſources of the river are near to a place called *Donga*, the reſidence of the chief or king of an idolatrous nation to the ſouthward of Dar-Fur. It is to be obſerved, however, that the ſlave-merchants who trade between Donga and Cairo are always attached to the Soudan or Dar-Fur caravan; and that therefore the perſons who told Ledyard that the Nile riſes in their country were probably from Donga, though he took them for Furians from the name of their caravan. Mr Browne informs us, that the country about Donga is very mountainous, and that in the ſpot where the river riſes there are ſaid to be forty diſtinct hills, which are called *Kumri*. From them iſſues a great number of ſprings, that, uniting into one great channel, form the Bahr-el abiad, which ſuffers the ſame periodical increaſe and diminution as the Nile in Egypt. The people of Donga are quite naked, black, and, as we have already obſerved, idolaters. Major Rennel places the mountains of the moon between 5° 40′ and 8° 10′ N. Lat. and between 24° 30′ and 30° 25′ E. Long. Their latitude and longitude, as laid down by Mr Browne, are ſomewhat, tho' very little, different; whilſt Geeſh, the ſource of Bruce's Nile, lies between the 10th and 11th degree of N. Lat. and in about the 37th degree of E. Long.

NIMIQUAS, a nation, or, more properly, two tribes in South Africa, called by Vaillant the *Leſs* and *Greater* Nimiquas.

Nimiquas.

The country of the Leſs Nimiquas extends in longitude from the mountains of Camis to the ſea on the weſt, *i. e.* from 15° 25′ to 18° 25′ eaſt from London, and in latitude from 28° 12′ to 29° 36′ ſouth. From the information which our author could collect, he thinks that the number of inhabitants throughout the whole of this tract does not exceed 6000 ſouls. Even this number is annually diminiſhed by the frequent attacks of Boſhmen, and the aridity of the ſoil. Of the BOSHMEN we have already given ſuch an account as can leave no doubt of the deſtructive nature of their incurſions; and the ſoil muſt be arid indeed, if it be true, as Vaillant aſſures us, that in the country of the Leſs Nimiquas rain never falls except when it thunders, and that thunder is ſo rare as frequently not to be heard for the ſpace of a whole year.

For this want of rain our author accounts in a ſatiſfactory manner: "The country (he ſays) having neither foreſts nor lofty mountains to arreſt the clouds, thoſe which come from the north paſs freely over it, and proceed on to Camis, where they burſt and fall, either in rain in the valleys, or in ſnow on the ſummits of theſe mountains, which are the loftieſt throughout the ſouth of Africa." The country is of courſe not fruitful, and its ſterility obliges the inhabitants frequently to change their reſidence, ſo that they are the moſt wandering of all the Hottentot tribes. In this barren region the Dutch coloniſts ſuppoſe that gold mines may be found; but our author diſcovered among the hordes no traces of this metal, though he found many indications of rich copper mines.

The Leſs Nimiquas, though of a tolerable ſtature, are not ſo tall as their neighbours to the eaſtward; and indeed Vaillant affirms, that the people to the eaſt in the ſouthern part of Africa are much ſuperior to thoſe of the weſt both in moral and phyſical qualities, while the animals are far inferior. The Leſs Nimiquas are great believers in witchcraft; and our author gives a ridiculous account of an interview that he had with an old witch named *Kakoes*, who had a complete aſcendency, not only over the whole horde, but alſo over the ſavage Boſhmen. Theſe robbers, he ſays, never attempted to plunder the territory where ſhe took up her reſidence; and ſhe has been known, when their thefts came to her knowledge, to proceed alone, and unguarded, to their retreats in the midſt of the woods, to threaten them with her vengeance, and thus compel them to a reſtitution of the ſtolen property. All her influence, however, over her own tribe, could procure for our author and his attendants only ſix ſheep.

The women of the horde received his Hottentots with great kindneſs; and permitted them to diſcover very ſingular charms, of which it is needleſs here to inſert a deſcription. Among this people he ſaw abundance of bracelets, necklaces, and ear-rings of copper; and ſome of theſe ornaments were ſo well made and finely poliſhed, that they muſt have been manufactured in Europe, and the fruits of an intercourſe with the whites. But he ſaw ſeveral others, which, from their groteſque ſhape and rude workmanſhip, evidently ſhewed that they were fabricated by the ſavages themſelves.

"Theſe ornaments (ſays he) are worn by the Nimiquas in the ſame manner as by the other ſavages; yet I obſerved among them ſome whimſical peculiarities. I have ſeen perſons with ſix ear-rings of the ſame ſhape in one ear, and none in the other: I have ſeen ſome with bracelets from the wriſt to the elbow on one arm, while the other arm was bare: I have ſeen others with one ſide of the face painted in compartments of various colours, while on the other ſide both the colours and figures were different. In general, I obſerved great propenſity to ornaments among the Leſs Nimiquas;

for their kroſſes and all their garments were plentifully covered with glaſs and copper beads, ſtrung on threads, and faſtened on every part of their dreſs. They even wore them in their hair, which was plaſtered with greaſe in the moſt diſguſting manner. Many had their heads covered with a reddiſh incruſtation, compoſed of greaſe and a powder reſembling brick duſt, with which their hair was ſo paſted together, that you would have ſworn it to be a cap of red mortar. Thoſe who had it in their power to diſplay this luxury of dreſs, were as proud as are our *petits-maitres*, when they can ſhake a head loaded with powder, perfume, and pomatum. The *nuyp-kros*, or ſhort apron, of the women, was adorned with rows of glaſs beads hanging down to their feet; in other reſpects they were dreſſed like the other Hottentots."

The country of the *Greater Nimiquas* is placed by the author in nearly the ſame longitude with that of the Leſs, and between 25° and 28° ſouth latitude. It is barren like the other; but the people are much taller, being generally about five feet ten inches high. The men are dull and ſtupid, but the women are lively and extremely amorous; and both men and women are comparatively handſome and of a ſlender make. Extravagantly addicted to ſmoking tobacco, the young girls bartered their favours for a ſingle pipe; and as Vaillant was chief of the caravan, a white, and poſſeſſor of tobacco of much better quality, many advances were made to him. "I have do doubt (ſays he) but I might have formed, for a few pipefuls only, an alliance with every family in the horde. I was even preſſed ſo cloſely, as to be obliged to employ ſome reſiſtance: but, at the ſame time, I muſt confeſs, that my refuſals were given in ſuch a way as not to offend; and they who, in conſequence of their advances, had been expoſed to them, having ſoon found other arrangements to make, did not ſhew me the leſs friendſhip. I muſt here add, that the girls alone appeared to me thus free; while the married women on the contrary were modeſt and reſerved. This is a characteriſtic difference, which diſtinguiſhes the Greater Nimiquas from the Hottentot people in general; as likewiſe does the low cringing air they aſſume when they have any thing to aſk."

It has been ſaid by Kolben, that the Nimiqua women, when they bear twins, deſtroy one of the infants; but Vaillant aſſures us that this is a falſehood, as is likewiſe another tale which is current in the colony. It has been ſaid that the fathers, to ſhew what affection they bear their children, feed their eldeſt in a particular manner, as being of right the firſt object of paternal care. For this purpoſe they put him in a coop as it were; that is, they ſhut him up in a trench made under their hut, where, being deprived of motion, he loſes little by perſpiration, while they feed and cram him in a manner with milk and greaſe. By degrees the child fattens, and gets as round as a barrel; and when he is come to ſuch a ſtate as not to be able to walk, but to bend under his own weight, the parents exhibit him to the admiration of the horde; who from that period conceive more or leſs eſteem and conſideration for the family, according as the monſter has acquired more or leſs rotundity.

Such was the account given to our author by a man who affirmed that he had been an eye-witneſs of this mode of cramming the heir-apparent; but whenever any queſtions were aſked on the ſubject of the Nimiquas themſelves, the perſons addreſſed were ready to laugh in our author's face. "Still (ſays he), as it appeared ſtrange to me, that a man ſhould talk of what he had ſeen, when he had in reality ſeen nothing; as it was poſſible that the fable might have ſome foundation, without being true in all particulars—I was willing to convince myſelf what could have given riſe to it; and every time I viſited a horde, I took care, under different pretences, to examine, one after another, all the huts of the kraal, and to aſk which was the eldeſt child of the family: but I nowhere ſaw any thing that indicated either this pretended coop, or this pretended cramming."

The Nimiquas are great cowards; yet, like the ſurrounding nations, they have their aſſagays and poiſoned arrows; and, like them, can handle theſe arms with dexterity. They poſſeſs alſo thoſe war oxen, ſo formidable in battle, and ſo favourable to the cowardice or inactivity of the combatants. They have even a peculiar implement of war, which their neighbours have not. This is a large buckler, of the height of the perſon who bears it, behind which the Nimiqua can completely conceal himſelf. But, beſide that his natural apathy prevents him from giving or taking offence, he is in reality puſillanimous and cowardly from the coldneſs of his diſpoſition. To utter only the name of *Houzouana* before him is ſufficient to make him tremble. See Houzouanas in this *Suppl.*

Notwithſtanding his frigidity, the Nimiqua is not inſenſible to pleaſure. He even ſeeks with avidity thoſe which, requiring but little exertion, are capable of agitating him and procuring agreeable ſenſations. Their muſical inſtruments are the ſame as thoſe of the other Hottentots; but their dancing is very different, and reſembles the temper of the nation. If the countenance have received from nature features that can expreſs our paſſions, the body alſo has its attitudes and movements that paint our temper and feelings. The dance of the Nimiqua is frigid like himſelf, and ſo devoid of grace and hilarity, that, were it not for the extreme gaiety of the women, it might be called the dance of the dead.

Theſe tortoiſes, to whom dancing is a fatigue, ſhew little eagerneſs for any thing but wagers, games of calculation and chance, and all the ſedentary amuſements which require patience and reflection, of which they are more capable than they are of motion. When our author, with great propriety, prohibited gaming in his camp, the Nimiquas, who had ſtaid long with him, took their departure.

NITTA, a ſpecies of the Mimosa, which flouriſhes on the banks of the Senegal in Africa. It is valuable to the inhabitants for its fruit, the pods of which are long and narrow, containing a few black ſeeds enveloped in a fine mealy powder, of a bright yellow colour, which reſembles the flour of ſulphur, and has a ſweet mucilaginous taſte. When eaten by itſelf it is clammy; but when mixed with milk or water, it conſtitutes a very pleaſant and nouriſhing food, ſupplying the place of corn to the negroes.—*Park's Travels.*

NIZOLIUS (Marius), a grammarian of Italy, who by his wit and erudition contributed much to the promotion of letters in the 16th century. He publiſhed, in 1553, *Lib.* 4. *De veris Principiis et vera Ratione philoſo-*

philoſophandi, contra Pſeudo-philoſophos. In this work he attacks, with much vivacity, the ſchoolmen, not only for the barbariſm of their terms, but for many ridiculous opinions which they held. Leibnitz was ſo ſtruck with its ſolidity and elegance, that, to expoſe the obſtinacy of thoſe who were zealouſly attached to Ariſtotle, he gave a new edition of it, with critical notes of his own, 1670, in 4to. Nizolius publiſhed alſo, *Theſaurus Ciceronianus, ſive Apparatus Linguæ Latinæ e Scriptis Tullii Ciceronis collectus*, in folio. This is a good Latin dictionary, compoſed of the words and expreſſions of Cicero; to which, it ſeems, Nizolius ſhewed as much bigotry as the ſchoolmen to their notions; and fell under the character of thoſe pedants whom Eraſmus has ridiculed in his *Ciceronianus*. We do not find the year either of his birth or death.

NOCTURNAL ARCH, is the arch of a circle deſcribed by the ſun, or a ſtar, in the night.

NONAGESIMAL, or NONAGESIMAL *Degree*, called alſo the *Mid-heaven*, is the higheſt point, or 90th degree of the ecliptic, reckoned from its interſection with the horizon at any time; and its altitude is equal to the angle that the ecliptic makes with the horizon at their interſection, or equal to the diſtance of the zenith from the pole of the ecliptic. It is much uſed in the calculation of ſolar eclipſes.

NONAGON, a figure having nine ſides and angles. In a regular nonagon, or that whoſe angles and ſides are all equal, if each ſide be 1, its area will be 6·1818242 = $\frac{9}{4}$ of the tangent of 70°, to the radius 1.

NORMAL, is uſed ſometimes for a perpendicular.

NUEL, or NEWEL, the upright poſt about which ſtairs turn, being that part of the ſtaircaſe which ſuſtains one end of the ſteps.

O.

OASIS (plur. OASES), a fertile ſpot in the midſt of a ſandy deſart. In the SAHARA, or Great Deſart of Africa, there are many *Oaſes* of extreme fertility.

OBLATE, flatted or ſhortened; as an oblate ſpheroid, having its axis ſhorter than its middle diameter; being formed by the rotation of an ellipſe about the ſhorter axis.

OBLIQUE ASCENSION, is that point of the equinoctial which riſes with the centre of the ſun, or ſtar, or any other point of the heavens, in an oblique ſphere.

OBLIQUE *Circle*, in the ſtereographic projection, is any circle that is oblique to the plane of projection.

OBLIQUE *Deſcenſion*, that point of the equinoctial which ſets with the centre of the ſun, or ſtar, or other point of the heavens, in an oblique ſphere.

OBLIQUE *Force*, or *Percuſſion*, or *Power*, or *Stroke*, is that made in a direction oblique to a body or plane. It is demonſtrated, that the effect of ſuch oblique force, &c. upon the body, is to an equal perpendicular one, as the ſine of the angle of incidence is to radius.

OBLONG SPHEROID, is that which is formed by an ellipſe revolved about its longer or tranſverſe axis; in contradiſtinction from the *oblate ſpheroid*, or that which is flatted at its poles, being generated by the revolution of the ellipſe about its conjugate or ſhorter axis.

OBSERVATORY, PORTABLE. See ASTRONOMY, n° 504, *Encycl.*

OCCIDENT EQUINOCTIAL, that point of the horizon where the ſun ſets, when he croſſes the equinoctial, or enters the ſign Aries or Libra.

OCCIDENT *Eſtival*, that point of the horizon where the ſun ſets at his entrance into the ſign Cancer, or in our ſummer when the days are longeſt.

OCCIDENT *Hybernal*, that point of the horizon where the ſun ſets at midwinter, when entering the ſign Capricorn.

OCTANT, the eighth part of a circle.

ODD, in arithmetic, is ſaid of a number that is not even. The ſeries of odd numbers is 1, 3, 5, 7, &c.

ODDLY-ODD. A number is ſaid to be oddly-odd, when an odd number meaſures it by an odd number. So 15 is a number oddly odd, becauſe the odd number 3 meaſures it by the odd number 5.

ODOUR, that quality of certain bodies which excites the ſenſation of ſmell. In the *Annales de Chimie*, Vol. XXI. p. 254, we have a detailed account of certain experiments made by M. Benedict Prevoſt of Geneva, with a view to render the *emanations of odorant bodies perceptible to ſight*. The account is by much too long for a work like ours; eſpecially as we feel not ourſelves inclined to attribute to the experiments all the importance which ſeems to have been allowed to them by the firſt claſs of the French National Inſtitute. We ſhall therefore ſtate only a few of them, which ſeem moſt to favour the author's hypotheſis.

1. A concrete odorant ſubſtance, laid upon a wet glaſs or broad ſaucer, covered with a thin ſtratum of water, immediately cauſes the water to recede, ſo as to form a ſpace of ſeveral inches around it.

2. Fragments of concrete odorant matter, or ſmall morſels of paper or cork, impregnated with an odorant liquor, and wiped, being placed on the ſurface of water, are immediately moved by a very ſwift rotation. Romieu had made this obſervation on camphor, and erroneouſly attributed the effect to electricity. The motion was perceptible even in pieces of camphor of ſeven or eight gros.

3. An odorant liquor being poured on the water, ſtops the motion till it is diſſipated by evaporation. Fixed oil arreſts the motion for a much longer time,

and until the pellicle it forms on the water is taken off.

4. When the ſurface of the water is cleaned by a leaf of metal, of paper, or of glaſs, plunged in and withdrawn ſucceſſively until the pellicle is removed, the gyratory motion is renewed. If a piece of red wax or of taper be dipped in water, and the drops ſhaken off into a glaſs of water containing odorant bodies in motion, the movement will be ſtopped. The ſame effect is not produced by metal.

5. A morſel of camphor, plunged to the depth of three or four lines in water, without floating, excites a movement of trepidation in the ſurrounding water, which repels ſmall bodies in its vicinity, and carries them again to the camphor by ſtarts. The author concludes, that an elaſtic fluid eſcapes from the odorant body in the manner of the fire of a fuſee or the diſcharge of fire-arms.

6. When there is a certain proportion between the height of the water and that of the ſmall fragment of camphor, the water is briſkly driven off, returns again to the camphor, and again retires, as if by an exploſion, the recoil of which often cauſes the camphor to make part of a revolution on its axis.

7. Camphor evaporates thirty or forty times more ſpeedily when placed upon water, than when entirely ſurrounded with air.

8. Camphor, during the act of diſſipation in the air, preſerves its form and its opaque whiteneſs; upon water it is rounded, and becomes tranſparent as if it had undergone a kind of fuſion. It may be inferred, that this ariſes from the acquired motion, which cauſes it to preſent a greater ſurface to the air.

9. When ſmall pieces of camphor are plunged in water, the camphor becomes rounded and tranſparent, does not acquire any motion, and its diſſipation is leſs perceptible than in the air. The concurrence of air and water is therefore neceſſary to diſengage the fluid which is the cauſe of the motion and total diſſipation of odorant bodies.

10. The motion of odorant bodies upon water decays and ceaſes ſpontaneouſly at the end of a certain time; becauſe the water having then contracted a ſtrong ſmell, the volatilization takes place in all the points of its ſurface; and the ſmall maſs being thus ſurrounded by the odorant fluid, which is no longer air, diſſolves, as in the ordinary odorant fluids, without forming the gaſeous jet which is the cauſe of the motion. The author compares the volatilization of the aromatic ſubſtance to a combuſtion excited by water.

M. Prevoſt hopes, that theſe, and other experiments which he explains, will contribute to the theory of odours, which ſo nearly reſembles that of the gaſes. He does not flatter himſelf with having exhauſted this ſubject, but conſiders his diſcoveries as the means of rendering odour perceptible by water, not only to the ſight, but even to the touch, as are likewiſe the vibrations of ſonorous bodies. Men deprived of the ſenſe of ſmell, and even the blind, according to him, may in this manner diſtinguiſh odorant bodies from thoſe which have no ſmell. "Perhaps (ſays he) this kind of odoroſcope may, by improvement, become an odorimeter. The exceptions, ſuch for example as that of the cerumen of the ears, which produces much effect on water without being perceptibly odorant, and that of the fingers when hot or moiſt, are merely apparent; for if our ſenſes do not in thoſe caſes diſcover odour, thoſe of animals more powerfully energetic, ſuch as the dog, perceive and diſtinguiſh individuals by its peculiar character. The odoroſcope may afford the information which is wanting reſpecting theſe effluvia. Thus it is that the fat of game, the ſmell of which is nearly to us imperceptible, is very much ſo to dogs, and exhibits ſenſible marks by the odoroſcope."

Profeſſor Venturi of Modena, who heard Prevoſt's memoir read in the National Inſtitute, had himſelf made ſome experiments with camphor kept ſeparately in the air, in the water, and at the ſurface of the water; whence he deduces, that the moſt active virtue for diſſolving camphor reſides at that part where both the air and the water touch the camphor at the ſame time. Hence he explains why, in like circumſtances, camphor evaporates more quickly in a moiſt than in a dry air; and why the Hollanders uſe water in their proceſs for ſubliming this ſubſtance.

It might be thought that the camphor was decompoſed at the ſurface of the water; that the water might ſeize the acidifying part, which renders the camphor concrete; and that the volatile part is diſſipated in the atmoſphere. The author rejects this notion. He thinks that water with camphor floating on its ſurface becomes charged with no more than a very ſmall portion: 1. Becauſe in theſe circumſtances the water acquires the ſame taſte and ſmell of camphor as it obtains when a ſmall quantity of this ſubſtance is kept plunged in the ſame fluid. This water, by expoſure to the air, loſes the qualities with which it had been charged, and becomes inſipid, and without ſmell. 2. Becauſe when the water is ſaturated with all it can take up, the diſſipation of the camphor continues at its ſurface as before. 3. Becauſe the aerial emanations of camphor made at the ſurface of water do themſelves cryſtallize into camphor.

Camphor at the ſurface of the water does nothing, therefore, but diſſolve; and when diſſolved at the ordinary temperature of the atmoſphere, it is not at firſt in the ſtate of vapour, as has been thought. It is ſimply a liquid which extends itſelf over the ſurface of water itſelf; and by this means coming into contact with a great ſurface of air, it is afterwards abſorbed and evaporated. This is proved by the following facts: 1. The ſolution of camphor at the ſurface of water is more rapid in proportion to the extent of the ſurface. In narrow veſſels, the ſection of the column would not be completed in ten days, even though the water might be extremely pure. 2. When the column of camphor has projecting parts, the liquid may be ſeen iſſuing by preference from certain points of the column, covering the ſurface of the water, and driving ſmall floating bodies before it, in the ſame manner as floating bodies go and return in a baſon into which the water of a canal enters with rapidity. 3. If a ſmall piece of camphor, already wetted at one end, be brought near the edge of water contained in a broad ſaucer, and be made to touch the ſaucer itſelf, it depoſits a viſible liquor, which is oily; and by attaching itſelf to the ſaucer, deſtroys the adheſion between the veſſel and the border of the water, ſo that the water retires on account of the affinity of aggregation, which not being oppoſed by the attraction of the ſaucer, cauſes the water to terminate in a round edge.

Odour, Œconomiſts.

edge. If you remove the piece of camphor, the water will not return to its place until the oily fluid is evaporated. 4. In the ſame manner, when the column of camphor is half immerſed in the water, the oily liquor which iſſues forth deſtroys the adheſion of the water to the column, and produces a ſmall ſurrounding cavity. The ſolution ſtops, or is retarded for a moment, until the fluid, extending itſelf over the water, becomes evaporated: the water then returns to its place, and touches the ſame part of the camphor; the ſolution begins again, and in this manner the proceſs is effected by alternations of contact and apparent repulſion.

Of theſe memoirs by Prevoſt and Venturi, the Engliſh reader will find accurate and full tranſlations in the firſt volume of *Nicholſon's Philoſophical Journal*, together with ſome judicious obſervations on them by the editor, which we ſhall take the liberty to adopt. “The philoſophical conſideration of odorant bodies is ſomewhat obſcured by the old method of generaliſing, or referring the properties of bodies to ſome diſtinct principle or thing ſuppoſed capable of being ſeparated from the body itſelf. Thus the odours of bodies have been ſuppoſed to depend on a ſubſtance imagined in a looſe way to be common to them all and ſeparable from them. Hence the terms, principle of ſmell, ſpiritus rector, and even in the modern nomenclature we find *aroma*. There does not in effect ſeem to be any more reaſon to infer the exiſtence of a common principle of ſmell than of taſte. The ſmell of ammoniac is the action of that gas upon the organ of ſenſe; and this odorant inviſible matter is exhibited to the ſight when combined with an acid gas. But in the ſame manner as ammoniac emanates from water, and leaves moſt part of that fluid behind, ſo will the volatile parts of bodies be moſt eminently productive of this action; and very few, if any, natural bodies will be found which riſe totally. The moſt ſtriking circumſtance in the effect is, that an act of ſuch power ſhould be attended with a loſs by exhalation which is ſcarcely to be appreciated by weight, or in any other method during a ſhort interval of time. But we know ſo little of nervous action, and of other phenomena of electricity, of galvaniſm (See GALVANISM in this *Suppl.*), or even of heat, which ſtrongly affect the ſenſes, but elude admeaſurement by gravitation, that the difficulty of weighing the effluvia of odorant bodies becomes leſs aſtoniſhing.”

ŒCONOMISTS, a ſect of philoſophers in France, who have made a great noiſe in Europe, and are generally believed to have been unfriendly to religion. The founder of this ſect was a *Dr Duqueſnai*, who had ſo well inſinuated himſelf into the favour of Louis XV. that the king uſed to call him his *thinker*. The ſect was called *œconomiſts*, becauſe the œconomy and order to be introduced into the finances, and other means of alleviating the diſtreſſes of the people, were perpetually in their mouths. The Abbé Barruel admits, that there may have been ſome few of them who directed their ſpeculations to no other object; but he brings very ſufficient proof that the great aim of the majority of the ſect was to eradicate from the minds of the people all reverence for divine revelation.

“Duqueſnai (ſays he) and his adepts had more eſpecially undertaken to perſuade their readers, that the country people, and mechanics in towns, were entirely deſtitute of that kind of inſtruction neceſſary for their

Œconomiſts.

profeſſions; that men of this claſs, unable to acquire knowledge by reading, pined away in an ignorance equally fatal to themſelves and to the ſtate; that it was neceſſary to eſtabliſh free ſchools, and particularly throughout the country, where children might be brought up to different trades, and inſtructed in the principles of agriculture. D'Alembert, and the Voltairean adepts, ſoon perceived the advantages they could reap from theſe eſtabliſhments. In union with the œconomiſts, they preſented various memorials to Louis XV. in which not only the temporal but even the ſpiritual advantages of ſuch eſtabliſhments for the people are ſtrongly urged. The king, who really loved the people, embraced the project with warmth. He opened his mind on the ſubject to Mr Bertin, whom he honoured with his confidence, and had entruſted with his privy purſe;” and it was with great difficulty that this miniſter could convince him of the dangerous deſigns of the ſect.

“Determined (ſays he) to give the king poſitive proof that the œconomiſts impoſed upon him, I ſought to gain the confidence of thoſe pedlars who travel through the country, and expoſe their goods to ſale in the villages, and at the gates of country ſeats. I ſuſpected thoſe in particular who dealt in books to be nothing leſs than the agents of philoſophiſm with the good country folks. In my excurſions into the country I fixed my attention above all on the latter. When they offered me a book to buy, I queſtioned them what might be the books they had? Probably catechiſms or prayer-books? Few others are read in the villages? At theſe words I have ſeen many ſmile. No, they anſwered, thoſe are not our works; we make much more money of Voltaire, Diderot, and other philoſophic writings. What! ſaid I; the country people buy Voltaire and Diderot? Where do they find the money for ſuch dear works? Their conſtant anſwer was, we have them at a much cheaper rate than prayer-books; we can ſell them at ten ſols (5d.) a volume, and have a pretty profit into the bargain. Queſtioning ſome of them ſtill farther, many of them owned that thoſe books coſt them nothing; that they received whole bales of them without knowing whence they came, but being ſimply deſired to ſell them in their journeys at the loweſt price.”

“Louis XV. warned by the diſcovery made by his miniſter, was at length ſatisfied that the eſtabliſhment of theſe ſchools, ſo much urged by the conſpirators, would only be a new inſtrument of ſeduction in their hands. He abandoned the plan; but, perpetually haraſſed by the protecting ſophiſters, he did not ſtrike at the root of the evil, and but feebly impeded its progreſs. The pedlars continued to promote the meaſures of the conſpirators; yet this was but one of the inferior means employed to ſupply the want of their free ſchools, as a new diſcovery brought to light one far more fatal.

“About the middle of the month of September 1789, little more than a fortnight antecedent to the atrocious 5th and 6th of October, at a time when the conduct of the National Aſſembly, having thrown the people into all the horrors of a revolution, indicated that they would ſet no bounds to their pretenſions, Mr Le Roy, lieutenant of the King's Hunt, and an academician, being at dinner at the houſe of Mr D'Angevilliers, intendant of the buildings of his majeſty, the

Œconomiſts.

converſation turned on the diſaſters of the revolution, and on thoſe that were too clearly to be foreſeen. Dinner over, the nobleman above-mentioned, a friend of Le Roy, hurt at having ſeen him ſo great an admirer of the ſophiſters, reproached him with it in the following expreſſive words: *Well! this, then, is the work of Philoſophy!* Thunderſtruck at theſe words—Alas! cried the academician, *to whom do you ſay ſo? I know it but too well, and I ſhall die of grief and remorſe!* At the word *remorſe*, the ſame nobleman queſtioned him whether he had ſo greatly contributed towards the revolution as to upbraid himſelf with it in that violent manner? ‘Yes (anſwered he), I have contributed to it, and far more than I was aware of. I was ſecretary to the committee to which you are indebted for it; but I call heaven to witneſs, that I never thought it would go to ſuch lengths. You have ſeen me in the king's ſervice, and you know that I love his perſon. I little thought of bringing his ſubjects to this pitch, *and I ſhall die of grief and remorſe!*’

“Preſſed to explain what he meant by this committee, this ſecret ſociety, entirely new to the whole company, the academician reſumed: ‘This ſociety was a ſort of club that we philoſophers had formed among us, and only admitted into it perſons on whom we could perfectly rely. Our ſittings were regularly held at the Baron D'Holbach's. Leſt our object ſhould be ſurmiſed, we called ourſelves œconomiſts. We created Voltaire, though abſent, our honorary and perpetual preſident. Our principal members were D'Alembert, Turgot, Condorcet, Diderot, La Harpe, and that Lamoignon, keeper of the ſeals, who on his diſmiſſion ſhot himſelf in his park.’

“The whole of this declaration was accompanied with tears and ſighs; when the adept, deeply penitent, continued: ‘The following were our occupations; the moſt of thoſe works which have appeared for this long time paſt againſt religion, morals, and government, were ours, or thoſe of authors devoted to us. They were all compoſed by the members or by the orders of the ſociety. Before they were ſent to the preſs, they were delivered in at our office. There we reviſed and corrected them; added to, or curtailed them, according as circumſtances required. When our philoſophy was too glaring for the times, or for the object of the work, we brought it to a lower tint; and when we thought that we might be more daring than the author, we ſpoke more openly. In a word, we made our writers ſay exactly what we pleaſed. Then the work was publiſhed under the title or name we had choſen, the better to hide the hand whence it came. Many, ſuppoſed to have been poſthumous works, ſuch as *Chriſtianity Unmaſked*, and divers others *attributed to Freret and Boulanger* after their deaths, were iſſued from our ſociety.

‘When we had approved of thoſe works, we began by printing them on fine or ordinary paper, in ſufficient number to pay our expences, and then an immenſe number on the commoneſt paper. Theſe latter we ſent to hawkers and bookſellers free of coſt, or nearly ſo, who were to circulate them among the people at the loweſt rate. Theſe were the means uſed to pervert the people, and bring them to the ſtate you now ſee them in. I ſhall not ſee them long, *for I ſhall die of grief and remorſe!*’

This recital is too well authenticated to be called in queſtion, and too plain to need a commentary. Let it be a warning againſt all ſecret ſocieties, by whatever title of benevolence they may be deſigned by thoſe who form them.

Oil.

OIL-MILL, a mill for expreſſing the oils from fruits, or grains, &c. As theſe kingdoms do not produce the olive, it would be needleſs to deſcribe the mills which are employed in the ſouthern parts of Europe. We ſhall content ourſelves, therefore, with a deſcription of a Dutch oil-mill, employed for grinding and preſſing lintſeed, rape-ſeed, and other oleaginous grains. Farther, to accommodate our deſcription ſtill more to our local circumſtances, we ſhall employ water as the firſt mover; thus avoiding the enormous expence and complication of a windmill.

In Plate XXXVIII. fig. A,

1. Is the elevation of a wheel, over or underſhot, as the ſituation may require.

2. The bell-metal ſocket, ſupported by maſonry, for receiving the outer gudgeon of the water wheel.

3. The water courſe.

Fig. B.

1. A ſpur wheel upon the ſame axis, having 52 teeth.

2. The trundle that is driven by N° 1. and has 78 ſtaves.

3. The *wallower*, or axis for raiſing the peſtles. It is furniſhed round its circumference with *wipers* for lifting the *peſtles*, ſo that each may fall twice during one turn of the water wheel, that is, three *wipers* for each peſtle.

4. A frame of timber, carrying a concave half cylinder of bell-metal, in which the wallower (caſed in that part with iron plates) reſts and turns round. It will be ſeen in profile, fig. G.

5. Maſonry ſupporting the inner gudgeon of the water wheel and the above-mentioned frame.

6. Gudgeon of the wallower, which bears againſt a bell-metal ſtep fixed in the wall. This double ſupport of the wallower is found to be neceſſary in all mills which drive a number of heavy ſtampers.

Fig. C, Is the elevation of the peſtle and preſs-frame, their furniture, the mortars, and the preſs-peſtles.

1. The ſix peſtles.

2. Croſs pieces between the two rails of the frame, forming, with theſe rails, guides for the perpendicular motion of the peſtles.

3. The two rails. The back one is not ſeen. They are checked and bolted into the ſtandards N° 12.

4. The tails of the *lifts*, correſponding to the wipers upon the wallower.

5. Another rail in front, for carrying the *detents* which hold up the peſtles when not acting. It is marked 14 in fig. M.

6. A beam a little way behind the peſtles. To this are fixed the pulleys for the ropes which lift and ſtop the peſtles. It is repreſented by 16 in fig. M.

7. The ſaid pulleys with their ropes.

8. The *driver*, which ſtrikes the wedge that preſſes the oil.

9. The *diſcharger*, a ſtamper which ſtrikes upon the inverted wedge, and looſens the preſs.

10. The lower rail with its croſs pieces, forming the lower guides of the peſtles.

11. A ſmall cog wheel upon the wallower, for turning the *ſpatula*, which ſtirs about the oil-ſeed in the *chauffer-pan*. It has 28 teeth, and is marked N° 6 in fig. M.

12. The four ſtandards, mortiſed below into the *block*, and above into the joiſts and beams of the building.

13. The ſix *mortars* hollowed out of the block itſelf, and in ſhape pretty much like a kitchen pot.

14. The feet of the peſtles, rounded into cylinders, and ſhod with a great lump of iron.

15. A board behind the peſtles, ſtanding on its edge, but inclining a little backwards. There is ſuch another in front, but not repreſented here. Theſe form a ſort of trough, which prevents the ſeed from being ſcattered about by the fall of the peſtles, and loſt.

16. The firſt *preſs-box* (alſo hollowed out of the block), in which the grain is ſqueezed, after it has come for the firſt time from below the milſtones.

17. The ſecond *preſs-box*, at the other end of the block, for ſqueezing the grain after it has paſſed a ſecond time under the peſtles.

18. Frame of timber for ſupporting the other end of the wallower, in the ſame manner as at N° 4. fig B.

19. Small cog wheel on the end of the wallower for giving motion to the milſtones. It has 28 teeth.

20. Gudgeon of the wallower, bearing on a bell metal ſocket fixed in the wall.

21. Veſſels for receiving the oil from the preſs-boxes.

22. Joiſts ſupporting the block.

Fig. D Elevation and mechaniſm of the milſtones.

1. *Upright ſhaft*, carrying the great cog wheel above, and the *runner milſtones* below in their frame.

2. Cog-wheel of 76 cogs, driven by N° 19. of fig C.

3. The frame of the *runners*. This will be more diſtinctly underſtood in N° 4. fig. H.

4. The innermoſt runner, or the one neareſt the ſhaft.

5. Outermoſt ditto, being farther from the ſhaft.

6. The *inner rake*, which collects the grain under the outer runner.

7. The *outer rake*, which collects the grain under the inner runner. In this manner the grain is always turned over and over, and cruſhed in every direction. The inner rake lays the grain in a ſlope, of which fig. O. is a ſection; the runner flattens it, and the ſecond rake lifts it again, as is marked in fig. P; ſo that every ſide of a grain is preſented to the milſtone, and the reſt of the *legger* or *nether milſtone* is ſo ſwept by them, that not a ſingle grain is left on any part of it. The outer rake is alſo furniſhed with a rag of cloth, which rubs againſt the border or hoop that ſurrounds the nether milſtone, ſo as to drag out the few grains which might otherwiſe remain in the corner.

8. The ends of the iron axle which paſſes through the upright ſhaft, and through the two runners. Thus they have two motions: 1*mo*, A rotation round their own axis. 2*do*, That by which they are carried round upon the nether milſtone on which they roll. The holes in theſe milſtones are made a little widiſh; and the holes in the ears of the frame, which carry the ends of the iron axis, are made oval up and down. This great freedom of motion is neceſſary for the runner milſtones, becauſe frequently more or leſs of the grain is below them at a time, and they muſt therefore be at liberty to get over it without ſtraining, and perhaps breaking, the ſhaft.

9. The ears of the frame which lead the two extremities of the iron axis. They are mortiſed into the under ſide of the bars of the ſquare frame, that is carried round with the ſhaft.

10. The border or hoop which ſurrounds the nether milſtone.

11. and 12. The nether milſtone and maſonry which ſupports it.

Fig. E. Form of the wallower, ſhewing the diſpoſition of the wipers along its ſurface.

1. Two parts of this ſhaft, which are nicely rounded, and fortified with iron plates, and which reſt upon the bell-metal concaves, which are repreſented in n° 4. of fig. C.

2. The little wheels at each end, for giving motion to the two ſpatulæ, marked n° 11. fig. C.

3. The wipers for the ſecond preſs.

4. The wipers for the firſt preſs.

5. The wipers for the ſix peſtles.

Fig. F Repreſents the ſurface of the wallower unfolded into a rectangular parallelogram, in order to ſhew the diſtribution of the wipers, and conſequently the ſucceſſion of the ſtrokes given by the different peſtles. This diſtribution has ſomething peculiar. Each peſtle has three wipers; and there are alſo three for the driver and diſcharger of the ſecond preſs. The driver and wiper of the firſt preſs have but one and a half; one for the driver, and the half for the diſcharger; ſo that it ſtrikes twice, and the driver only once, in a turn of the ſhaft. This is the Dutch practice, which differs from that of Flanders. The ſucceſſion of the ſtrokes may be conceived as follows: Reckon the ſtampers, including thoſe of the preſſes, from the water wheel toward the other end of the wallower, and calling them *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, and ſuppoſing that *a* makes the firſt ſtroke, they proceed in the following order for one turn of the wallower:

ab, d, f, h, c, e, g, ab, d, f, h, c, e, g, ab, d, f, h, c, e, g.

Here it may be obſerved that *a* and *b* ſtrike together. They would do ſo if allowed; but one of them is held up by its detent till the workman ſees proper to diſengage it. Each peſtle, and the driver and diſcharger of the ſecond preſs, makes three ſtrokes for one turn of the wallower. But the driver *k* of the firſt preſs makes only one ſtroke in that time, namely, in the interval between the laſt ſtrokes of *e* and *g*. The diſcharger *i* of this preſs makes two ſtrokes; one of them in this ſame interval, and the other along with the firſt ſtroke of *e*. The ſecond preſſing requires a much more violent preſſure than the firſt, becauſe the cake muſt be left perfectly dry and hard.

Fig. G. Profile of the frame of timber which carries the wallower, and greatly contributes to render its motion ſteady.

Fig. H. Is a view of one of the milſtones.

1. The nether milſtones, and the maſonry ſupporting the whole.

2. The runner.

3. A ſort of caſe which encloſes the two wings of the milſtone at a very ſmall diſtance from it, in order to prevent the grain which ſticks to it from being ſcattered. There is another method practiſed at ſome mills.

Fig. I. Repreſents that of Sardamm. AA are two iron rods, about half an inch ſquare, hanging on the axle, on each ſide of the milſtone. Theſe rods are joined by a croſs piece C, which almoſt touches the milſtone. A piece of leather is put between, which rubs upon the milſtone, and clears it of the grain which chances to ſtick to it. N° 4. and 6. repreſent the ears of this frame, by which the end of the iron axle is ſupported, and carried round by the upright ſhaft n° 5.

Fig. K. Plan of the runner milſtones, and the frame which carries them round.

1, 1. Are the two milſtones.

3, 3, 3, 3. The outſide pieces of the frame.

4, 4, 4, 4. The croſs bars of the frame which embrace the upright ſhaft 5, and give motion to the whole.

6, 6. The iron axis upon which the runners turn.

7. The outer rake.

8. The inner ditto.

Fig. L. Repreſents the nether milſtone ſeen from above.

1. The wooden gutter, which ſurrounds the nether milſtone.

2. The border or hoop, about ſix inches high, all round, to prevent any ſeed from being ſcattered.

3. An opening or trap door in the gutter, which can be opened or ſhut at pleaſure. When open, it allows the bruiſed grain, collected and ſhoved along the gutter by the rakes, to paſs through into troughs placed below to receive it.

4. Portion of the circle deſcribed by the outer runner.

5. Portion of the circle deſcribed by the inner one. By theſe we ſee that the two ſtones have different routes round the axis, and bruiſe more ſeed.

6. The outer rake.

7. The inner ditto.

8. The ſweep, making part of the inner rake, occaſionally let down for ſweeping off all the ſeed when it has been ſufficiently bruiſed. The preſſure and action of theſe rakes is adjuſted by means of wooden ſprings, which cannot be eaſily and diſtinctly repreſented by any figure. The oblique poſition of the rakes (the outer point going foremoſt) cauſes them to ſhove the grain inwards or toward the centre, and at the ſame time to turn it over, ſomewhat in the ſame manner as the mould-board of a plough ſhoves the earth to the right hand, and partly turns it over. Some mills have but one ſweeper; and, indeed, there is great variety in the form and conſtruction of this part of the machinery.

Fig. M. Profile of the peſtle frame.

1. Section of the horizontal ſhaft.

2. Three wipers for lifting the peſtles.

3. Little wheel of 28 teeth for giving motion to the ſpatula.

4. Another wheel, which is driven by it, having 20 teeth.

5. Horizontal axle of ditto.

6. Another wheel on the ſame axle, having 13 teeth.

7. A wheel upon the upper end of the ſpindle, having 12 teeth.

8. Two guides, in which the ſpindle turns freely, and ſo that it can be ſhifted higher and lower.

9. A lever, moveable round the piece n° 14, and having a hole in it at 9, through which the ſpindle paſſes, turning freely. The ſpindle has in this place a ſhoulder, which reſts on the border of the hole 9; ſo that by the motion of this lever the ſpindle may be diſengaged from the wheel work at pleaſure. This motion is given to it by means of the lever 10, 10, moveable round its middle. The workman employed at the chauffer pulls at the rope 10, 11, and thus diſengages the ſpindle and ſpatula.

11. A peſtle ſeen ſidewiſe.

12. The *lift* of ditto.

13. The upper rails, marked n° 3. in fig. C.

14. The rail, marked n° 5. in fig. C. To this are fixed the detents, which ſerve to ſtop and hold up the peſtles.

15. A detent, which is moved by the rope at its outer end.

16. A bracket behind the peſtles, having a pulley, through which paſſes the rope going to the detent 15.

17. The ſaid pulley.

18. The rope at the workman's hand, paſſing through the pulley 17, and fixed to the end of the detent 15.

This detent naturally hangs perpendicular by its own weight. When the workman wants to ſtop a peſtle, he pulls at the rope 18, during the riſe of the peſtle. When this is at its greateſt height, the detent is horizontal, and prevents the peſtle from falling by means of a pin projecting from the ſide of the peſtle, which reſts upon the detent, the detent itſelf being held in that poſition by hitching the loop of the rope upon a pin at the workman's hand.

19. The two lower rails, marked n° 10. fig. C.

20. *Great* wooden, and ſometimes ſtone, *block*, in which the mortars are formed, marked n° 21. in fig. C.

21. Veſſel placed below the preſs boxes for receiving the oil.

22. Chauffer, or little furnace, for warming the bruiſed grain.

23. Backet in the front of the chauffer, tapering downwards, and opening below in a narrow ſlit. The hair bags in which the grain is to be preſſed after it has been warmed in the chauffer, are filled by placing them in this backet. The grain is lifted out of the chauffer with a ladle, and put into theſe bags; and a good quantity of oil runs from it through the ſlit at the bottom into a veſſel ſet to receive it.

24. The ſpatula attached to the lower end of the ſpindle, and turning round among the grain in the chauffer-pan, and thus preventing it from ſticking to the bottom or ſides, and getting too much heat.

Fig. N. Plan of part of the works.

1, 1. Furnaces for warming the grain.

2, 2. The backets for holding the ſacks while they are a-filling.

3, 3. The pan in which the bruiſed grain is heated by the chauffer.

4, 4. A trough for receiving the chips, into which the preſſed oil-cakes are cut, to be afterwards put into the pan and warmed.

5. The preſs-box for the ſecond preſſing.

6. The preſs-box for the firſt preſſing.

7. The ſix mortars.

8. The ſloping boards, to hinder the ſcattering of the oil ſeed.

9. The nether milſtone, but out of its place.

10. Its centre a little higher than the reſt.

11. A rib of wood going round the edge of the nether milſtone, and even with its ſurface, but riſing a very little outwards, and ſurrounded with a border or hoop about an inch high, to prevent the ſeed from being ſcattered on the ground.

Fig. Q. A ſection, lengthwiſe, of the great block, with the mortars and preſs-boxes.

1. The ſix peſtles.

2. The ſix mortars, each of which has an iron plate at its bottom.

3. The *driving* ſtamper, which falls on the wedge of the firſt preſſing.

4. Ditto, for the ſecond ditto.

5. The *diſcharger*, which ſtrikes on the inverted wedge in order to free the preſs.

6. Ditto, for the ſecond preſſing.

7. Wedge for freeing the preſs.

8. Wedge for preſſing.

9. Wooden *cheeks*, two inches thick, which are placed between the middle wedge and the *ſliding wedges* on each ſide.

10. Preſs-irons, between which are placed the hair-bags containing the bruiſed grain.

11. Iron plate, called the *fountain*, at the bottom, pierced with holes, correſponding with a hole in the block, for allowing the oil to run off from the preſſed grain.

12. Veſſel for receiving ditto.

13. A long iron plate at the bottom of the preſs box, under the drawing and diſcharging wedges.

Fig. R. Another view of the preſs-irons.

1. The ſide-irons laid flat.

2. The ſame ſeen edgewiſe.

3. The pierced iron plate, upon which the two irons, n° 1. ſtand upright, with the hair-bag between them.

4. One of the hair-bags. It may be obſerved that the ſeams of theſe bags are made on the flat ſides, and not on the edges, where they would be in danger of burſting.

5. A long hair-cloth, in which the bag is wrapped before it is ſet into the preſs. The bag, being filled with bruiſed grain, is placed with its bottom at *a*, and the top at *b*; the part *c a* is lapped over it, reaching to *b*, and then the other end *d* is lapped over that, and reaches to *a*, and the loop at its end ſerves as a handle by which to lift it, and place it properly between the preſs-irons.

Fig. S. The principal pieces of the preſs.

1. The wooden cheeks.

2. The diſcharging wedge.

3. The driving wedge.

4 and 5. The ſliding blocks, which tranſmit the preſſure produced by the driving wedge.

The foregoing enumeration and views of the different parts of a Dutch oil-mill, are ſufficient, we imagine, to enable an intelligent mill-wright, to whom the machine is altogether new, to underſtand its manner of working, and its adaptation to the various parts of the proceſs for extracting the oil from ſeeds or kernels. It would require a very minute deſcription indeed to explain it to a perſon altogether unacquainted with mill-work.

The firſt part of the proceſs is bruiſing the ſeed under the runner ſtones (A). That this may be more expeditiouſly done, one of the runners is ſet about $\frac{2}{3}$ds of its own thickneſs nearer the ſhaft than the other. Thus they have different treads; and the grain, which is a little heaped towards the centre, is thus bruiſed by both. The inner rake gathers it up under the outer ſtone into a ridge, of which the ſection is repreſented in Plate XL. fig. O. The ſtone paſſes over it and flattens it. It is gathered up again into a ridge, of the form of fig. P. under the inner ſtone, by the outer rake, which conſiſts of two parts. The outer part preſſes cloſe on the wooden border which ſurrounds the nether ſtone, and ſhoves the ſeed obliquely inwards, while the inner part of this rake gathers up what had ſpread toward the centre. The other rake has a joint near the middle of its length, by which the outer half of it can be raiſed from the nether ſtone, while the inner half continues preſſing on it, and thus ſcrapes off the moiſt paſte. When the ſeed is ſufficiently bruiſed, the miller lets down the outer end of the rake. This immediately gathers the whole paſte, and ſhoves it obliquely outwards to the wooden rim, where it is at laſt brought to a part that is left unboarded, and it falls through into troughs placed to receive it. Theſe troughs have holes in the bottom, through which the oil drips all the time of the operation. This part of the oil is directed into a particular ciſtern, being conſidered as the pureſt of the whole, having been obtained, without preſſure, by the mere breaking of the hull of the ſeed.

In ſome mills this operation is expedited, and a much greater quantity of this beſt oil is obtained, by having the bed of maſonry which ſupports the legger formed into a little furnace, and gently heated. But the utmoſt care is neceſſary to prevent the heat from becoming conſiderable. This, enabling the oil to diſſolve more of the fermentable ſubſtance of the ſeed, expoſes the oil to the riſk of growing ſoon very rancid; and, in general, it is thought a hazardous practice, and the oil does not bring ſo high a price.

When the paſte comes from under the ſtones, it is put into the hair bags, and ſubjected to the firſt preſſing. The oil thus obtained is alſo eſteemed as of the firſt quality, ſcarcely inferior to the former, and is kept apart (The great oil ciſtern being divided into ſeveral portions by partitions).

The oil cakes of this preſſing are taken out of the bags, broken to pieces, and put into the mortars for the firſt *ſtamping*. Here the paſte is again broken down, and the parenchyma of the ſeed reduced to a fine meal. Thus free egreſs is allowed to the oil from every veſicle in which it was contained. But it is now rendered much more clammy, by the forcible mixture of the mucilage,

---

(A) We are told, that in a mill at Reichenhoffen in Alſace, a conſiderable improvement has been made by paſſing the ſeed between two ſmall iron rollers, before it is put under the milſtones. A great deal of work is ſaid to be ſaved by this preliminary operation, and finer oil produced, which we think very probable. The ſtamping and preſſing go on as in other mills.

cilage, and even of the finer parts of the meal. When ſufficiently pounded, the workman ſtops the peſtle of a mortar, when at the top of its lift, and carries the contents of the mortar to the firſt chauffer pan, where it is heated to about the temperature of melting bees wax (this, we are told, is the teſt), and all the while ſtirred about by the ſpatula. From thence it is again put into hair bags, in the manner already deſcribed; and the oil which drips from it during this operation is conſidered as the beſt of the ſecond quality, and in ſome mills is kept apart. The paſte is now ſubjected to the ſecond preſſing, and the oil is that of the ſecond quality.

All this operation of pounding and heating is performed by one workman, who has conſtant employment by taking the four mortars in ſucceſſion. The putting into the bags and conducting of the preſſing gives equal employment to another workman.

In the mills of Piccardy, Alſace, and moſt of Flanders, the operation ends here; and the produce from the chauffer is increaſed, by putting a ſpoonful or two of water into the pan among the paſte.

But the Dutch take more pains. They add no water to the paſte of this their *firſt ſtamping.* They ſay that this greatly lowers the quality of the oil. The cakes which reſult from this preſſing, and are there ſold as food for cattle, are ſtill fat and ſoftiſh. The Dutch break them down, and ſubject them to the peſtles for the *ſecond ſtamping.* Theſe reduce them to an impalpable paſte, ſtiff like clay. It is lifted out, and put into the *ſecond* chauffer pan; a few ſpoonfuls of water are added, and the whole kept for ſome time as hot as boiling water, and carefully ſtirred all the while. From thence it is lifted into the hare bags of the laſt preſs, ſubjected to the preſs; and a quantity of oil, of the loweſt quality, is obtained, ſufficient for giving a ſatisfactory profit to the miller. The cake is now perfectly dry, and hard, like a piece of board, and is ſold to the farmers. Nay, there are ſmall mills in Holland, which have no other employment than extracting the oil from the cakes which they purchaſe from the French and Brabanters; a clear indication of the ſuperiority of the Dutch practice.

The nicety with which that induſtrious people conduct all their buſineſs is remarkable in this manufacture.

In their oil ciſtern, the parenchymous part, which unavoidably gets through, in ſome degree, in every operation, gradually ſubſides, and the liquor, in any diviſion of the ciſtern, comes to conſiſt of ſtrata of different degrees of purity. The pumps which lift it out of each diviſion are in pairs; one takes it up from the very bottom, and the other only from half depth. The laſt only is barrelled up for the market, and the other goes into a deep and narrow ciſtern, where the dreg again ſubſides, and more pure oil of that quality is obtained. By ſuch careful and judicious practices, the Dutch not only ſupply themſelves with this important article, but annually ſend conſiderable quantities into the very provinces of France and Flanders where they bought the ſeed from which it was extracted. When we reflect on the high price of labour in Holland, on the want of timber for machinery, on the expence of building in that country, and on the enormous expence of wind mill machinery, both in the firſt erection and the ſubſequent wear and tear, it muſt be evident, that oil mills erected in England on water falls, and after the Dutch manner, cannot fail of being a great national advantage. The chatellanie or ſeigneurie of Lille alone makes annually between 30,000 and 40,000 barrels, each containing about 26 gallons.

What is here delivered is only a ſketch. Every perſon acquainted with machinery will underſtand the general movements and operations. But the intelligent mechanic well knows, that operations of this kind have many minute circumſtances which cannot be deſcribed, and which, nevertheleſs, may have a great influence on the whole. The rakes in the bruiſing-mill have an office to perform which reſembles that of the hand, directed by a careful eye and unceaſing attention. Words cannot communicate a clear notion of this; and a mill, conſtructed from the beſt drawings, by the moſt ſkilful workman, may gather the ſeed ſo ill, that the half of it ſhall not be bruiſed after many rounds of the machinery. This produces a ſcanty return of the fineſt oil; and the mill gets a bad character. The proprietor loſes his money, is diſcouraged, and gives up the work.—There is no ſecurity but by procuring a Dutch millwright, and paying him with the liberality of Britons. Such unhoped-for taſks have been performed of late years by machinery; and mechanical knowledge and *invention* is now ſo generally diffuſed, that it is highly probable that we ſhould ſoon excel our teachers in this branch. But this very diffuſion of knowledge, by encouraging ſpeculation among the artiſts, makes it a ſtill greater riſk to erect a Dutch oil-mill without having a Dutchman, acquainted with its moſt improved preſent form, to conduct the work. We do our duty in giving this counſel.

OKU-JESSO. See SEGALIEN in this *Suppl.*

OMPHALOPTER, or OMPHALOPTIC, in optics, a glaſs that is convex on both ſides, popularly called a *convex lens.*

ONISCUS (See *Encycl.*). Two new ſpecies of this genus of inſects were diſcovered by *La Martiniere*, the naturaliſt who accompanied Perouſe on his laſt voyage of diſcovery. For the information of ſuch of our readers as are entomologiſts, we ſhall give the author's deſcription of theſe ſpecies. Of the firſt, which he ſays only *nearly* anſwers to the *generic* character of oniſcus, E (fig. 1.) is a view of the upper part of its body, and at F of the lower. Its body is cruſtaceous, and of an opaque white, with two round ruſt-coloured ſpots on the anterior part of its corſlet; two others, much larger, in the form of a creſcent, are on the *elytræ;* its ſhield is alſo of the ſame colour. The under part of the thorax is furniſhed with four pair of legs: the firſt and third of which are terminated with ſharp claws; the ſecond, from its form, ſerves it to ſwim with; the fourth is very ſmall, conſiſting of two membranaceous threads. Some ſcales, alſo membranaceous and very channelled, may alſo perform the office of legs: of theſe the two lower are the largeſt. Its belly is filled with vermicular inteſtines of the ſize of a hair; its mouth is placed between the firſt and ſecond pair of legs, and is of the form of a ſmall trunk placed between two lips, joined only at the upper extremity.

Plat
XXX

Fig. 2. repreſents an inſect of the genus *oniſcus Linn.* Its body is nearly of the form, conſiſtence, and colour, of the *oniſcus aſellus*, except that it is not divided

Fig A. Fig. B. Fig. C. Fig D

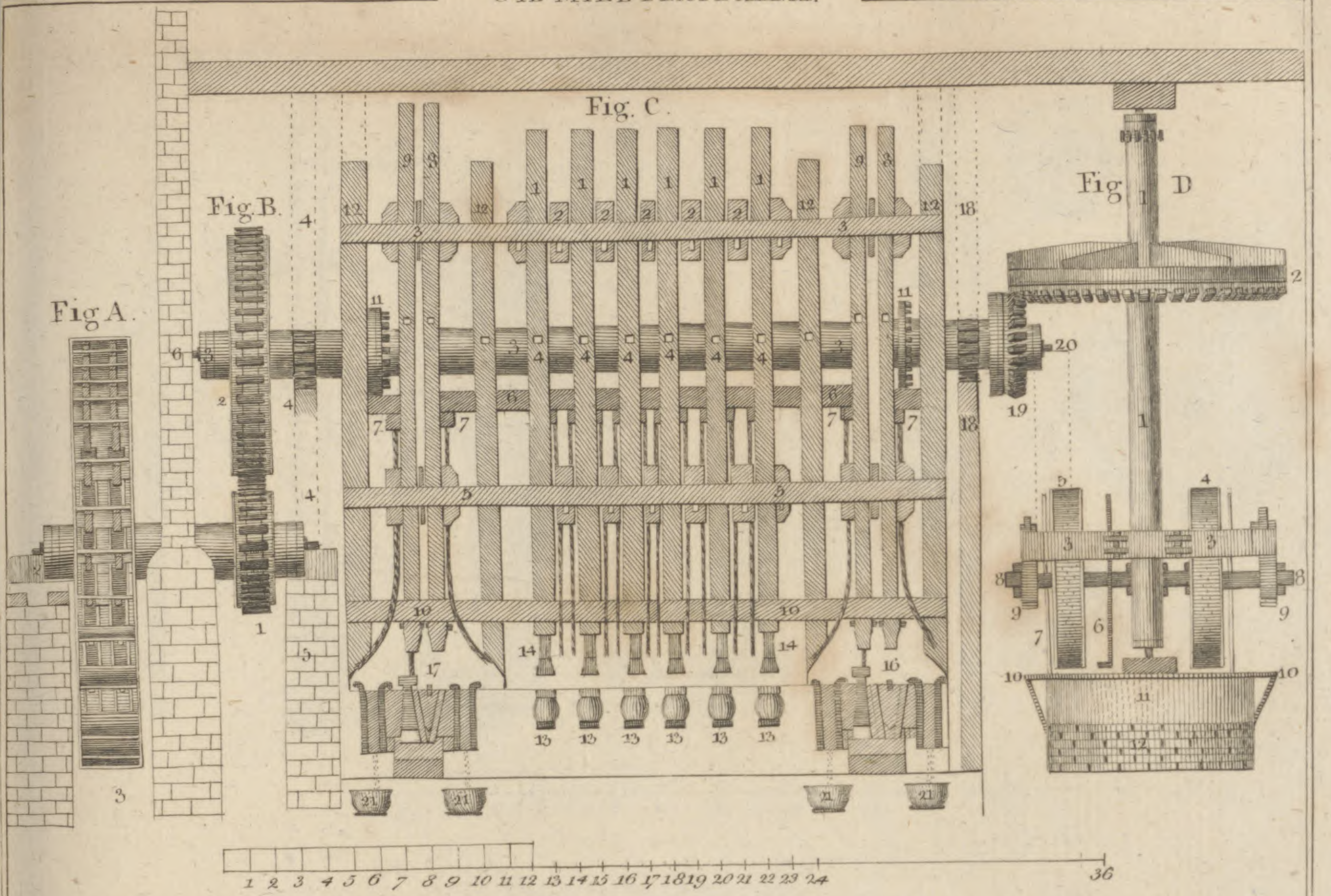


Fig. E.

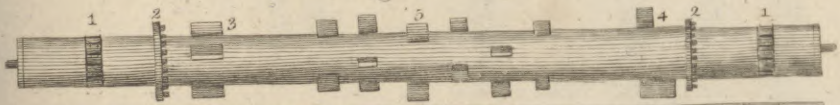


Fig F

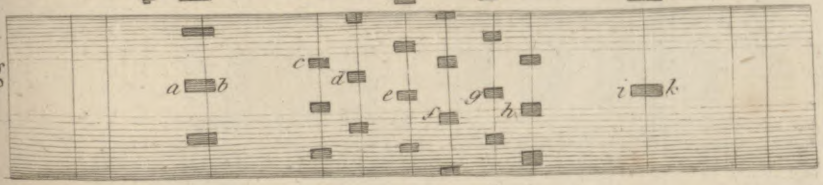



Fig. G.

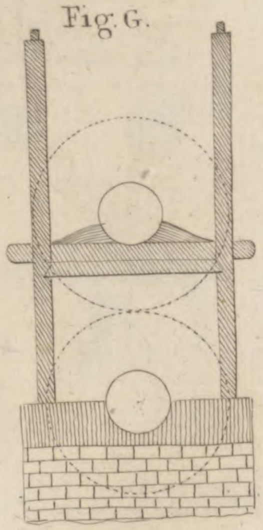


Fig K

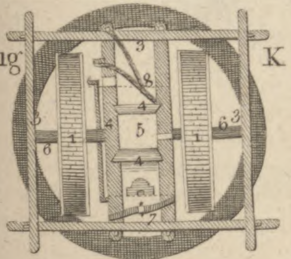


Fig L

Fig H.

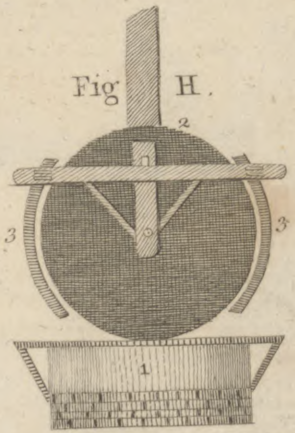
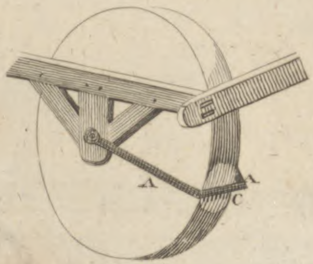
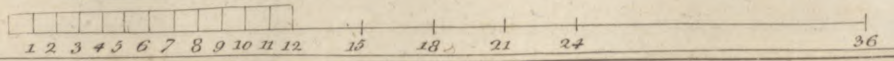


Fig. I.





D. Lizars sculp.

OIL MILL PLATE XXXIX.

Fig. M.

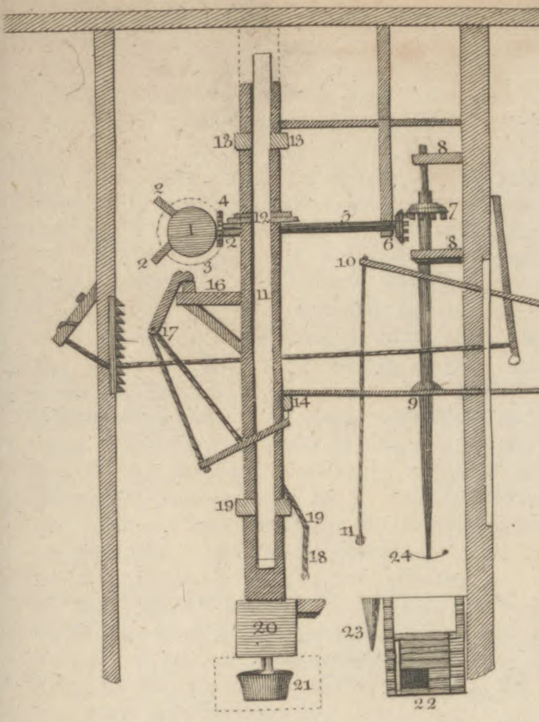


Fig. N.

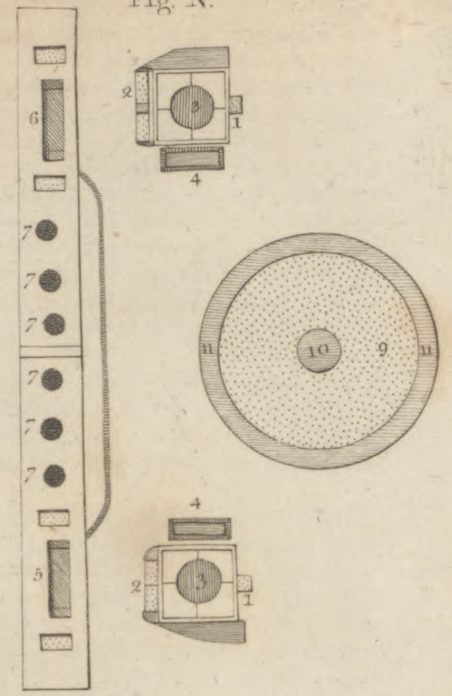


Fig. O.

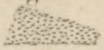


Fig. P.

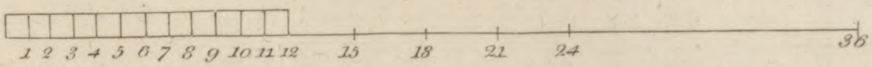


Fig. Q.

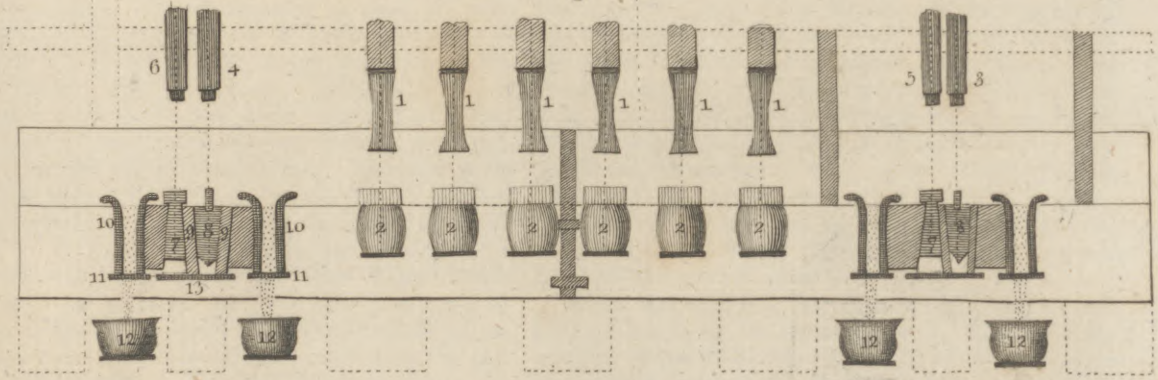


Fig. S.

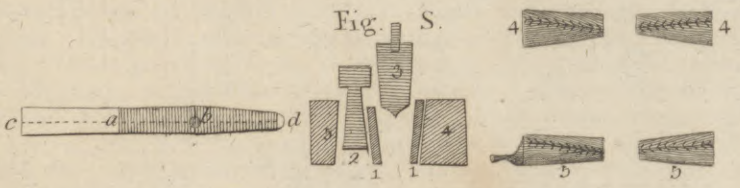
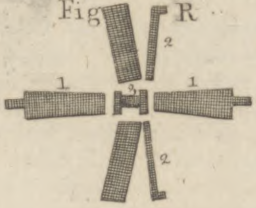
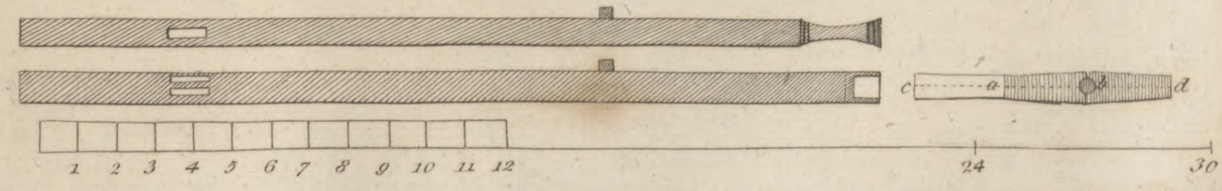


Fig R.





D.Lizars sculpt.

vided by ſegments as this laſt is. It has a double tail, three times as long as the body; from the inſertion of which, at the hinder part of the body, ſpring two legs, uſed chiefly by the animal in ſwimming upon its back. The inſect, viewed on the lower part H, preſents ſix pair of legs; the two firſt of which terminate in very ſharp and thick points; it makes uſe of the third to ſwim with, and to balance its body, together with that pair which is inſerted at the baſe of the tail; the fourth pair, and the largeſt of all, is armed with two very ſharp points, which the animal forces into the body of any fiſh on which it ſeizes; the two laſt pair are nothing more than very finely divided membranes. Between the two firſt is ſituated its trunk, ſmooth, and about half a line long; at the baſe of the third pair are two points, of a horny conſiſtence, very hard, and firmly fixed. The two horns alſo below the large pair of legs are, in like manner, very firmly united to its body. Martiniere imagines it to be by means of theſe darts that it pierces the body of the fiſh on which it is found, and that then, changing its ſituation, it finds means to introduce its trunk into the holes thus formed. When put into a glaſs it ſinks to the bottom, and riſes again to the ſurface with the greateſt eaſe, advancing with the edge of its body, and deſcribing curves. Its two long tails are very eaſily pulled off, without the animal appearing to ſuffer any pain.

OPAQUE, not tranſlucent, nor tranſparent, or not admitting a free paſſage to the rays of light.

OPARO or OPARRO, the name given by Captain Vancouver to a ſmall iſland which he diſcovered in latitude 27° 36′ ſouth, and in longitude 215° 49′ eaſt from Greenwich. It was eſtimated at about 6½ miles in length, and no other land was in ſight. Its principal character is a cluſter of high craggy mountains, forming, in ſeveral places, moſt romantic pinnacles, with perpendicular cliffs nearly from their ſummits to the ſea: the vacancies between the mountains would more properly be termed chaſms than valleys. The tops of ſix of the higheſt hills bore the appearance of fortified places, reſembling redoubts; having a ſort of blockhouſe, in the ſhape of an Engliſh glaſs-houſe, in the centre of each, with rows of palliſadoes a conſiderable way down the ſides of the hills, nearly at equal diſtances. Theſe overhanging, ſeemed intended for advanced works, and apparently capable of defending the citadel by a few againſt a numerous hoſt of aſſailants. On all of them people were noticed as if on duty, conſtantly moving about. What we conſidered (ſays the author) as block-houſes, from their great ſimilarity in appearance to that ſort of building, were ſufficiently large to lodge a conſiderable number of perſons, and were the only habitations we ſaw. Yet, from the number of canoes that in ſo ſhort a time aſſembled round the Engliſh ſhip, it is natural to conclude, that the inhabitants are very frequently afloat; and to infer, that the ſhores, and not thoſe fortified hills which appeared to be in the centre of the iſland, would be preferred for their general reſidence.

Whether the fortified places here deſcribed were intended for defences of the iſlanders againſt each other, or againſt attacks from ſome more powerful neighbours, could only be conjectured; but the latter idea ſeems the moſt probable. From the language of the people, and their reſemblance to the Friendly iſlanders, Captain Vancouver conſiders them all as having ſprung from the ſame original ſtock. The people of Oparo, however, are diſtinguiſhed by two circumſtances, certainly in their favour. Not one of them was tattowed; and though they appeared not to have ever ſeen a European before, they all ſeemed perfectly well acquainted with the uſes to which they could apply iron, and preferred articles of it to looking glaſſes, beads, and other trinkets, with which ſavages are uſually delighted. Though there appeared to be anchoring ground near the north weſt end of the iſland, circumſtances rendered it inconvenient for Captain Vancouver to land on it; ſo that we are yet in a great meaſure ſtrangers to the diſpoſitions of the people, though they appeared to be hoſpitable.

OPEN FLANK, in fortification, is that part of the flank which is covered by the orillon or ſhoulder.

OPENING *of the Trenches*, is the firſt breaking of ground by the beſiegers, in order to carry on their approaches towards a place.

OPERA GLASS, is a diagonal perſpective, of which the following conciſe and perſpicuous deſcription is taken from Dr Hutton's Mathematical Dictionary.—ABCD (Plate XLI.) repreſents a tube about four inches long; in each ſide of which there is a hole EF and GH, exactly againſt the middle of a plane mirror IK, which reflects the rays falling upon it to the convex glaſs LM; through which they are refracted to the concave eye-glaſs NO, whence they emerge parallel to the eye at the hole rs, in the end of the tube. Let PaQ be an object to be viewed, from which proceed the rays Pc, ab, and Qd: theſe rays, being reflected by the plane mirror IK, will ſhew the object in the direction cp, ba, dq, in the image pq, equal to the object PQ, and as far behind the mirror as the object is before it: the mirror being placed ſo as to make an angle of 45 degrees with the ſides of the tube. And as, in viewing near objects, it is not neceſſary to magnify them, the focal diſtances of both the glaſſes may be nearly equal; or, if that of LM be three inches, and that of NO one inch, the diſtance between them will be but two inches, and the object will be magnified three times, being ſufficient for the purpoſes to which this glaſs is applied.

When the object is very near, as XY, it is viewed through a hole xy, at the other end of the tube AB, without an eye-glaſs; the upper part of the mirror being poliſhed for that purpoſe as well as the under. The tube unſcrews near the object-glaſs LM, for taking out and cleanſing the glaſſes and mirror. The poſition of the object will be erect through the concave eye-glaſs.

The peculiar artifice of this glaſs is to view a perſon at a ſmall diſtance, ſo that no one ſhall know who is obſerved; for the inſtrument points to a different object from that which is viewed; and as there is a hole on each ſide, it is impoſſible to know on which hand the object is ſituated which you are viewing. It is chiefly uſed in play-houſes; and hence its name: but we have ſeen it moſt indecently employed by thoſe who ſhould have ſet a better example, even in a cathedral church!

OPHRYS (See *Encycl.*). A new ſpecies of this plant has been lately deſcribed in the *Annual Hampſhire Repoſitory*, by a Fellow of the Linnean Society, in the following words:

“ *Stem*—about 12 inches high, erect, ſtipulate, geniculate, pubeſcent at the upper genicles. *Spike*—ſtrictly ſpiral, flowers ſpirally aſcending, about 24, brightly white. Upper petal ovato-acuminate, pubeſcent, lightly ciliate, ſtraight. Two middle *petals* oblong-recurved. Two lower *petals* oblong-acuminate, lightly ciliate only on the lower ſide near the baſe, projecting like elephant's tuſks. *Nectary*, broad, recurved, ragged, bicipitate. *Leaves floral*—carinate acuminate, ciliate reaching and pointing to the middle of the flowers. *Leaves radical*—five or ſix, about ſix inches long, narrow, attenuate both ways, acuminate, the lower more haſtate. *Leaves cauline*—lanceolate, alternate.

“ Obſervation.—This plant has much the habit, as well as autumnal floreſcence, of Oriental ſpiralis, and is ſo perfectly ſpiral alſo, that the ſpecific name of the other ſhould be altered, as being no longer excluſively ſpiral; at the ſame time that a ſpecific name ſhould be given to this: neither of which (ſays the author) I ſhall preſume to do, but ſhall ſuggeſt it to the Linnean Society, of which I have the honour to be a Fellow.”—This ophrys flowered, for the firſt time, it is believed, in England, in Hampſhire, October 1796.

OPHIUCUS, a conſtellation of the northern hemiſphere; called alſo *Serpentarius*.

OPIUM (See *Encycl.*), is a medicine of ſuch intrinſic value, and of ſo high a price, that every method which promiſes to increaſe the quantity in the market muſt be of importance. It was therefore, with much propriety, that *the Society for the Encouragement of Arts, &c.* ſome time ago, voted 50 guinueas to Mr John Ball of Williton, Somerſetſhire, for the diſcovery of his method of preparing opium from poppies of the growth of England. The poppies, which he recommends as the moſt productive, are the *double* or *ſemi-double*, of a dark colour; the ſeeds of which he adviſes to be ſown the latter end of February, and again about the ſecond week in March, in beds three feet and a half wide (well prepared with good rotten dung, and often turned or ploughed, in order to mix it well, and have it fine), either in ſmall drills, three in each bed, in the manner ſallads are ſown, and when about two inches high, to thin them one foot apart; or otherwiſe, to ſow them in beds, in the broad-caſt way, and thin them to the ſame diſtance. If they be kept free from weeds, they will grow well, and will produce from four to ten heads, ſhewing large and different coloured flowers; and when their leaves die away, and drop off, the pods then being in a green ſtate, is the proper time for extracting the opium, by making ſuch longitudinal inciſions as are, for this purpoſe, made in the eaſt (See OPIUM and PAPAVER, *Encycl.*). Immediately on the inciſion being made, a milky fluid will iſſue out; which is the opium, and which, being of a glutinous nature, will adhere to the bottom of the inciſion; but ſome poppies are ſo productive, that it will drop from the pod on the leaves underneath. The next day, if the weather ſhould be fine, and a good deal of ſunſhine, the opium will be found a greyiſh ſubſtance, and ſome almoſt turning black: it is then to be ſcraped from the pods, and (if any there) from the leaves, with the edge of a knife, or other inſtrument for that purpoſe, into pans or pots; and in a day or two it will be of a proper conſiſtence to make into a maſs, and to be potted.

According to Mr Ball, fields cannot be ſown with any thing more lucrative to the farmer than poppies, eſpecially if thoſe fields have a ſouth expoſure. “ By a calculation (ſays he) which I have made, ſuppoſing one poppy to grow in one ſquare foot of earth, and to produce only one grain of opium, more than L. 50 will be collected from one ſtatute acre of land; but if we conſider, that one poppy produces from three or four to ten heads, that in each head from ſix to ten inciſions may be made, and that from many of them (I mean from one inciſion) I have taken away two or three grains of opium—What muſt then be the produce?”

Mr Ball produced to the Society letters from Dr Latham of Bedford-row, Dr Pearſon of Leiceſter-ſquare, and Mr Wilſon of Bedford-ſtreet, declaring, that, in their opinion, his Engliſh opium is equal in effect, and ſuperior in purity, to the beſt foreign opium.

OPTIC INEQUALITY, in aſtronomy, is an apparent irregularity in the motions of far diſtant bodies; ſo called, becauſe it is not really in the moving bodies, but ariſing from the ſituation of the obſerver's eye. For if the eye were in the centre, it would always ſee the motions as they really are.

OPTIC *Pyramid*, in perſpective, is a pyramid formed by the viſible object which is the *baſe*, and the rays drawn from the perimeter of that object, which meet at the eye in a point, which is the *apex* of the pyramid. Hence, alſo, we may know what is meant by an *optic triangle*.

OPTIC *Rays*, particularly means thoſe by which an optic pyramid, or optic triangle, is terminated.

ORAN, a conſiderable city. occupied by the Spaniards, in the province of *Maſcara*, in the country of Algiers. It has ſtrong and regular fortifications, and can eaſily be ſupplied from Spain with proviſions and warlike ſtores. It lies in 35′ of longitude weſt from Greenwich, and in 35° 55′ north latitude. Since the year 1732, the Spaniards have held uninterrupted poſſeſſion of Oran. It has a pariſh-church, three monaſteries, an hoſpital: and the number of the inhabitants, according to the account given of it by the Spaniards, amount to 12,000. Towards the ſea, the city riſes in the form of an amphitheatre, and is ſurrounded with forts and batteries. Cloſe to the city lies a ſtrong caſtle, *Alcazava*, in which the Spaniſh governor reſides. On the higheſt hill ſtands Fort St Croix, whoſe guns command the city and the adjacent country. From this fort they make ſignals of the approach of ſhips, and carefully watch the motions of the Moors, who often attempt predatory incurſions into the neighbouring diſtricts. A conſiderable number of Mahomedans take refuge in Oran; they dwell in a diſtinct part of the city, receive pay from the court of Spain, and render ſignal ſervices againſt the Moors. The greateſt part of the inhabitants of Oran conſiſts of ſuch as have been baniſhed from Spain; and the ſame may, in a great meaſure, be ſaid of the ſoldiers who compoſe the garriſon. Five regiments are commonly ſtationed here; but, owing to continual deſertion, their ſtrength ſcarcely equals that of four complete regiments. One of them wholly conſiſts of malefactors, who have been condemned to remain here for life; the reſt are ſuch as have been tranſported for one or more years. There is here likewiſe a military ſchool. Around the city are pleaſant gardens; but it is very dangerous to cultivate them, on account of the Moors and Arabs, who frequently lie in ambuſh among them. The ſame reaſon prevents the cultivation of the fields in the vicinity; and the garrirange-Men.

ſon and inhabitants muſt be ſupplied with proviſions immediately from Spain.

ORANGE-MEN, an appellation aſſumed by certain ſocieties in Ireland, of which the firſt was formed in the county of Armagh, on the 21ſt of November 1795, others in ſome towns of Ulſter and Leinſter in the year 1797, another in the city of Dublin 1798; and ſince that period, theſe ſocieties have ſpread over the whole of our ſiſter kingdom. The object of theſe aſſociations is exhibited in the following authentic *Declaration of the Principles of Orange-men*, publiſhed 1799.

"From the various attempts that have been made to poiſon the public mind, and ſlander thoſe who have had the ſpirit to adhere to their king and conſtitution, and to maintain the laws:—

"We, the Proteſtants of Dublin, aſſuming the name of Orange-men, feel ourſelves called upon, not to vindicate our principles, for we know that our honour and loyalty bid defiance to the ſhafts of malevolence and diſaffection, but openly to avow thoſe principles, and declare to the world the objects of our inſtitution.

"We have long obſerved, with indignation, the efforts that have been made to foment rebellion in this kingdom, by the ſeditious, who have formed themſelves into ſocieties, under the ſpecious name of *United Iriſhmen*.

"We have ſeen with pain the lower orders of our fellow-ſubjects, forced or ſeduced from their allegiance, by the threats or machinations of *traitors*.

"And we have viewed with horror the ſucceſsful exertions of *miſcreants*, to encourage a foreign enemy to invade this happy land, in hopes of riſing into conſequence on the downfal of their country.

"We therefore thought it high time to rally round the conſtitution, and there pledge ourſelves to each other, to maintain the laws, and ſupport our good king againſt all his enemies, whether *rebels* to their God or to their country; and by ſo doing, ſhew to the world that there is a body of men in this iſland, who are ready, in the hour of danger, to ſtand forward in defence of that grand palladium of our liberties, the conſtitution of Great Britain and Ireland, obtained and eſtabliſhed by the courage and loyalty of our anceſtors under the Great King William.

"Fellow-ſubjects, we are accuſed with being an *inſtitution*, founded on principles too ſhocking to repeat, and bound together by oaths, at which human nature may ſhudder: but we caution you not to be led away by ſuch malevolent falſehoods; for we ſolemnly aſſure you, in the preſence of the Almighty God, that the idea of injuring any one, on account of his religious opinion, never entered into our *hearts:* we regard every loyal ſubject as our friend, be his religion what it may; we have no enmity but to the enemies of our country.

"We farther declare, that we are ready, at all times, to ſubmit ourſelves to the orders of thoſe in authority under his majeſty, and that we will cheerfully undertake any duty which they ſhall think proper to point out for us, in caſe either a foreign enemy ſhall dare to invade our coaſts, or that a domeſtic foe ſhall preſume to raiſe the ſtandard of rebellion in the land. To theſe principles we are pledged—and in ſupport of them we are ready to ſpend the laſt drop of our blood.—(Signed) Thomas Verner, *Grand Maſter;* John Clau. Beresford, *Grand Secretary;* William James, J. De Joncourt, Edward Ball."

Orchard.

ORCHARD. As an appendix to this article in the *Encycl.* ſome of our readers will be pleaſed with the following means, employed by the Rev. Mr *Germerſhauſen*, for promoting the growth of young trees, and increaſing the ſize and flavour of the fruit in orchards.

Having planted ſeveral young plum-trees in an orchard, he covered the ground, for ſome years, around the trunks, as far as the roots extended, with flax-ſhows (A); by which means theſe trees, though in a graſs-field, increaſed in a wonderful manner, and far excelled others planted in cultivated ground. As far as the ſhows reached, the graſs and weeds were choaked; and the ſoil under them was ſo tender and ſoft, that no better mould could have been wiſhed for by a floriſt.

When he obſerved this, he covered the ground with the ſame ſubſtance, as far as the roots extended, around an old plum-tree, which appeared to be in a languiſhing ſtate, and which ſtood in a graſs-field. The conſequences were, that it acquired a ſtrong new bark; produced larger and better-taſted fruit; and that thoſe young ſhoots, which before grew up around the ſtem, and which it was every year neceſſary to deſtroy, were prevented from ſprouting forth, as the covering of flax-ſhows impeded the free acceſs of air at the bottom of the trunk.

In the year 1793, he tranſplanted, from ſeed-beds, into the nurſery, ſeveral fruit-trees; the ground around ſome of which he covered, as above, with flax-ſhows. Notwithſtanding the great heat of the ſummer, none of thoſe trees where the earth was covered with ſhows died or decayed; becauſe the ſhows prevented the earth under them from being dried by the ſun. Of thoſe trees, around which the ground was not covered as before mentioned, the fourth part miſcarried; and thoſe that continued alive were far weaker than the former.

The leaves which fall from trees in autumn may alſo be employed for covering the ground in like manner; but ſtones, or logs of wood, muſt be laid on them, to prevent their being diſperſed by the wind. In graſs-land, a ſmall trench may be made around the roots of the tree, when planted, in order to receive the leaves. If flax ſhows are uſed, this is not neceſſary; they lie on the ſurface of the ground ſo faſt as to reſiſt the force of the moſt violent ſtorm. The leaves which our author found moſt effectual in promoting the growth and fertility of fruit trees, are thoſe of the walnut-tree. Whether it is, that, on account of their containing a greater abundance of ſaline particles, they communicate manure to the ground, which thereby becomes tender under them; or that they attract nitrous particles from the atmoſphere; or that, by both theſe means, they tend to nouriſh the tree both above and below.

Thoſe who are deſirous of raiſing tender exotic trees from the ſeed, in order to accuſtom them to our climate, may, when they tranſplant them, employ flax-ſhows

---

(A) Shows are the refuſe of flax when it is ſcutched or heckled.

with great advantage. This covering will prevent the froſt from making its way to the roots; and rats and mice, on account of the ſharp prickly points of the flax-ſhows, will not be able to ſhelter themſelves under them.

ORCHILLA, a weed uſed in dyeing, which grows in the Canary iſlands, and is monopolized by the government. "It is a minute vegetable (ſays Sir George Staunton), of the lichen kind, growing chiefly upon rocks of a looſe texture, and produces a beautiful violet blue colour."

ORDEAL. See this article in the *Encyclopædia*, at the end of which we have given, from Dr Henry's Hiſtory of England, ſome ſtrong reaſons for ſuſpecting that the ordeal, by fire at leaſt, was a groſs impoſition on the credulity of an ignorant and ſuperſtitious age. This ſuſpicion of impoſture is raiſed to certainty by Profeſſor Beckmann, who, in his Hiſtory of Inventions, gives us the whole proceſs by which the clergy conducted the trial, and brought proofs of innocence or of guilt at their pleaſure. The perſon accuſed was put entirely under their management for three days before the trial, and for as many after it. They covered his hands (when he was to lift red-hot iron) both before and after the proof; ſealed and unſealed the covering. The former was done, as they pretended, to prevent the hands from being prepared any how by art; the latter, that it might be accurately known whether or not they were burnt.

Some artificial preparation was therefore known, elſe no precautions would have been neceſſary. It is highly probable, that during the three firſt days the preventative was applied to thoſe perſons whom they wiſhed to appear innocent; and that the three days after the trial were requiſite to let the hands reſume their natural ſtate. The ſacred ſealing ſecured them from the examination of preſumptuous unbelievers; for to determine whether the hands were burnt, the three laſt days were certainly not wanted. When the ordeal was aboliſhed, and this art rendered uſeleſs, the clergy no longer kept it a ſecret. In the 13th century, an account of it was publiſhed by Albertus Magnus, a Dominican monk (A). If his receipt be genuine, it ſeems to have conſiſted rather in covering the hands with a kind of paſte than in hardening them. The ſap of the *althæa* (marſhmallow), the ſlimy ſeeds of the flea-bane, which is ſtill uſed for ſtiffening by the hat-makers and ſilk-weavers, together with the white of an egg, were employed to make the paſte adhere. And by theſe means the hands were as ſafe as if they had been ſecured by gloves.

Hutton's Dictionary.

ORFFYREUS's WHEEL, in mechanics, is a machine ſo called from its inventor, which he aſſerted to be a perpetual motion. This machine, according to the account given of it by Graveſande, in his *Oeuvres Philoſophiques*, publiſhed by Allemand, Amſt. 1774, conſiſted externally of a large circular wheel, or rather drum, 12 feet in diameter, and 14 inches deep; being very light, as it was formed of an aſſemblage of deals, having the intervals between them covered with waxed cloth, to conceal the interior parts of it. The two extremities of an iron axis, on which it turned, reſted on two ſupports. On giving a ſlight impulſe to the wheel, in either direction, its motion was gradually accelerated; ſo that, after two or three revolutions, it acquired ſo great a velocity as to make 25 or 26 turns in a minute. This rapid motion it actually preſerved during the ſpace of two months, in a chamber of the Landgrave of Heſſe, the door of which was kept locked, and ſealed with the Landgrave's own ſeal. At the end of that time it was ſtopped, to prevent the wear of the materials. The Profeſſor, who had been an eye witneſs to theſe circumſtances, examined all the external parts of it, and was convinced that there could not be any communication between it and any neighbouring room. Orffyreus, however, was ſo incenſed, or pretended to be ſo, that he broke the machine in pieces; and wrote on the wall, that it was the impertinent curioſity of Profeſſor Graveſande which made him take this ſtep. The Prince of Heſſe, who had ſeen the interior parts of this wheel, but ſworn to ſecrecy, being aſked by Graveſande, whether, after it had been in motion for ſome time, there was any change obſervable in it, and whether it contained any pieces that indicated fraud or deception? anſwered both queſtions in the negative, and declared, that the machine was of a very ſimple conſtruction.

ORICOU, a new ſpecies of the vulture, diſcovered by Vaillant at Orange river in South Africa. As he thinks it unqueſtionably the moſt beautiful of its genus, and tells, as uſual with him, a wonderful ſtory about it, we have given a figure of this vulture in Plate XLI. Our traveller ſays, that it is more than three feet high, and eight or nine in breadth of wing. Its feathers, the general hue of which is a light brown, are of a particular kind on the breaſt, belly, and ſides, where they are of unequal lengths, pointed, curved like the blade of a ſabre, and briſtle up diſtinct from each other. The feathers being thus ſeparated, would diſcloſe to view the ſkin on the breaſt, if it were not completely covered with a very thick and beautiful white down, which is eaſily ſeen between the ruffled plumage.

A celebrated naturaliſt has ſaid, that "no bird has eye-laſhes or eye-brows, or, at leaſt, hair round the eyes like that in quadrupeds." This aſſertion, advanced as a general law of Nature, is a miſtake. Not only the oricou has this peculiarity, but we know of many other ſpecies in which it exiſts; ſuch as, in general, all the calaos, the ſecretary, and ſeveral other birds of prey. Beſide theſe eye laſhes, the vulture in queſtion has ſtiff black hairs on its throat. All the head and part of the neck are bare of feathers; and the naked ſkin, which is of a reddiſh colour, is daſhed in certain places with blue, violet, and white. The ear, in its external circumference, is bounded by a prominent ſkin, which forms a

---

(A) In his work *De Mirabilibus Mundi*, at the end of his book *De Secretis Mulierum*, Amſtelod. 1702, 12mo, p. 100. Experimentum mirabile quod facit hominem ire in ignem ſine læſione, vel portare ignem vel ferrum ignitum ſine læſione in manu. Recipe ſuccum biſmalvæ, et albumen ovi, et ſemen pſylli et calcem, et pulveriza, et confice cum illo albumine ovi ſuccum raphani; commiſce; ex hac confectione illineas corpus tuum vel manum, et dimitte ſiccari, et poſtea iterum illineas, et poſt hoc poteris audacter ſuſtinere ignem ſine nocumento.

ſort of rounded conch, that muſt neceſſarily heighten the faculty of hearing in this ſpecies. This kind of conch is prolonged for ſome inches, and deſcends down the neck; which induced our author to give it the name of *oricou*.

Its ſtrength, he ſays, muſt be very conſiderable, if we may judge from its muſcles and ſinews; and he is perſuaded, that there is not a ſtronger among the whole order of carnivorous birds, not excepting the famous condor, which ſo many travellers have ſeen, but of which their deſcriptions are ſo different as to render its exiſtence extremely doubtful. But there was no occaſion for this reaſoning, and thoſe inferences, if what he relates as facts deſerve any credit. The oricou which he deſcribes, he firſt perceived perched on the carcaſe of a hippopotamos, eagerly devouring its fleſh. He ſhot at it, and wounded it ſlightly; upon which, "though it had already gorged itſelf with a conſiderable quantity of fleſh (for upon opening it, he found in its ſtomach no leſs a quantity than *ſix pounds and a half*), yet its hunger and voracity were ſuch, that it ſtruck its beak into the carcaſe when attempting to take wing, as if deſirous of carrying the whole of it away.

"On the other hand, the weight of the fleſh it had devoured rendering it the more heavy, it could not eaſily riſe; ſo that we had time (ſays he) to reach it before it was on the wing, and we endeavoured to knock it on the head with the but-ends of our muſkets. It defended itſelf a long time with great intrepidity. It bit or ſtruck at our weapons with its beak, and its ſtrength was ſtill ſo great, that every ſtroke made a mark on the *barrel of the piece*."

ORIENT, the eaſt, or the eaſtern point of the horizon.

ORIENT *Equinoctial*, is uſed for that point of the horizon where the ſun riſes when he is in the equinoctial, or when he enters the ſigns Aries and Libra.

ORIENT *Aeſtival*, is the point where the ſun riſes in the middle of ſummer, when the days are longeſt.

ORIENT *Hybernal*, is the point where the ſun riſes in the middle of winter, when the days are ſhorteſt.

OROTAVA, a town in the iſland of Teneriffe, at the bottom of thoſe mountains out of which the Peek riſes, neatly built of ſtone, on an irregular ſurface. The moſt remarkable object near it is a dragon's blood tree, of which the trunk meaſures, at the height of ten feet from the ground, 36 feet in girth. Concerning this tree there is a tradition current in the iſland, that it exiſted, of no inconſiderable dimenſions, when the Spaniards made the conqueſt of Teneriffe, about three centuries ago; and that it was then, what it ſtill is, a landmark, to diſtinguiſh the boundaries of landed poſſeſſions near it.

Diſtant about three miles on the ſea-coaſt is the puerto, or ſea-port, of Orotava, where is carried on a conſiderable degree of commerce, principally for the exportation of wine. It is chiefly, as at Madeira, in the hands of a few Britiſh commercial houſes, which import, in return, the manufactures of Great Britain. Within a mile is a collection of living plants from Mexico, and other parts of the Spaniſh dominions in America. From hence they are to be tranſplanted into Spain. It is an eſtabliſhment of ſome expence; and, whatever may be its ſucceſs, it ſhews a laudable attention, on the part of that government, to the promotion of natural knowledge.

OROTCHYS and BITCHYS, two tribes of Tartars, who were viſited by La Perouſe in 1787, and of whoſe manners he gives ſuch an account as renders it difficult to ſay whether they have the beſt claim to be called a ſavage or a civilized people. He fell in with a ſmall village of them on the eaſt coaſt of Tartary, in a bay to which he gave the name of *Baie de Caſtrie*, in Lat. 51° 29′ North, and Lon. 139° 39′ Eaſt from Paris.

Their village, their employment, their dreſs, and their apparent ignorance of all religion, beſpoke them ſavages. Their village was compoſed of four cabins, built in a ſolid manner, of the trunks of fir-trees, and covered with bark. A wooden bench compaſſed the apartment round about; and the hearth was placed in the middle, under an opening large enough to give vent to the ſmoke.

This village was built upon a tongue of low marſhy land, which appeared to be uninhabitable during the winter; but on the oppoſite ſide of the gulf, on a more elevated ſituation, and expoſed to the ſouth, there was, at the entrance of a wood, another village, conſiſting of eight cabins, much larger and better built than the firſt. Above this, and at a very ſmall diſtance, were three yourts, or ſubterraneous houſes, perfectly ſimilar to thoſe of the Kamtſchadales, deſcribed in the third volume of Captain Cook's laſt voyage; they were extenſive enough to contain the inhabitants of the eight cabins during the rigour of the cold ſeaſon; beſides, on ſome of the ſkirts of this village were ſeen ſeveral tombs, which were larger and better built than the houſes; each of them encloſed three, four, or five biers, of a neat workmanſhip, ornamented with Chineſe ſtuffs, ſome pieces of which were brocade. Bows, arrows, lines, and, in general, the moſt valuable articles of theſe people, were ſuſpended in the interior of theſe monuments, the wooden door of which was cloſed by a bar, ſupported at its extremities by two props.

Their ſole employment ſeemed to be the killing and curing of ſalmon, of which they eat raw, the ſnout, the gills, the ſmall bones, and ſometimes the entire ſkin, which they ſtript off with infinite dexterity. When the ſtript ſalmon were carried to the huts, the women, in the moſt diſguſting manner, devoured the mucilaginous part of them, and ſeemed to think it the moſt exquiſite food. Every cabin was ſurrounded with a drying place for ſalmon, which remain upon poles, expoſed to the heat of the ſun, after having been during three or four days ſmoked round the fire, which is in the middle of their cabin; the women, who are charged with this operation, take care, as ſoon as the ſmoke has penetrated them, to carry them into the open air, where they acquire the hardneſs of wood.

The bones of the ſalmon ſo cured were ſcattered, and the blood ſpread round the hearth; greedy dogs, though gentle and familiar enough, licked and devoured the remainder. The naſtineſs and ſtench of this people are diſguſting. There is not perhaps anywhere a race of people more feebly conſtituted, or whoſe features are more different from thoſe forms to which we attach the idea of beauty; their middle ſtature is below four feet ten inches, their bodies are lank, their voices thin and feeble, like that of children; they have high cheek bones, ſmall blear eyes, placed diagonally; a large mouth, flat noſe, ſhort chin, almoſt beardleſs, and an olive-coloured ſkin, varniſhed with oil and ſmoke. They ſuffer their hair to grow, and tie it up nearly the ſame as we do; that of the women falls looſe about their ſhoulders, and the portrait which has juſt been drawn agrees equally well with their countenances as thoſe of the men, from whom it would be difficult to diſtinguiſh them, were it not for a ſlight difference in the dreſs, and a bare neck; they are not, however, ſubjected to any labour, which might, like the American Indians, change the elegance of their features, if nature had furniſhed them with this advantage. Their whole cares are limited to the cutting and ſewing their clothes, diſpoſing of their fiſh to be dried, and taking care of their children, to whom they give the breaſt till they are three or four years of age.

With reſpect to dreſs, the men and little boys are clothed with a waiſtcoat of nankeen, or the ſkin of a dog or a fiſh, cut in the ſhape of a waggoner's frock. If it reach below the knee, they wear no drawers; if it do not, they wear ſome in the Chineſe ſtyle, which fall as low as the calf of the leg. All of them have boots of ſeal's ſkin, but they keep them for the winter; and they at all times, and of every age, even at the breaſt, wear a leather girdle, to which are attached a knife in a ſheath, a ſteel to ſtrike a light with, a pipe, and a ſmall bag to contain tobacco. The dreſs of the women is ſomewhat different; they are wrapped up in a large nankeen robe, or ſalmon's ſkin, which they have the art of perfectly tanning, and rendering extremely ſupple. This dreſs reaches as low as the ankle-bone, and is ſometimes bordered with a fringe of ſmall copper ornaments, which make a noiſe ſimilar to that of ſmall bells. Thoſe ſalmon, the ſkins of which ſerve for clothing, are never caught in ſummer, and weigh thirty or forty pounds.

Though they had neither prieſts nor temples, they ſeemed to be believers in ſorcery, and took the motion of the Frenchmens hands, when writing, for ſigus of magic. Thus far they appeared ſavages.

Their ſacred regard of property, their attention to their women, and the delicacy of their politeneſs to ſtrangers, would, on the other hand, do honour to the moſt civilized nation. While Perouſe and his people were in the bay, one of the families took its departure on a voyage of ſome length, and did not return during their ſtay. When he went away, the maſter of the family put ſome planks before the door of his houſe, to prevent the dogs from entering it, and in this ſtate left it full of their effects. "We were ſoon (ſays our author) ſo perfectly convinced of the inviolable fidelity of theſe people, and their almoſt religious reſpect for property, that we left our ſacks full of ſtuffs, beads, iron tools, and, in general, every thing we uſed as articles of barter, in the middle of their cabins, and under no other ſeal of ſecurity than their own probity, without a ſingle inſtance of their abuſing our extreme confidence; and on our departure from this bay, we firmly entertained the opinion, that they did not even ſuſpect the exiſtence of ſuch a crime as theft."

Their attention to their women, ſo uncommon among ſavages, was diſplayed in their exempting them from hard labour; in their never concluding a bargain with the Frenchmen without previouſly conſulting their wives; and in their reſerving the pendent ſilver ear-rings and copper trinkets, which they purchaſed, for their wives and daughters. Of the delicacy of their manners to ſtrangers, we ſhall give the following intereſting inſtance in the words of Perouſe's tranſlator:

Obſerving with what repugnance they received preſents, and how often they refuſed them with obſtinacy, "I imagined (ſays Perouſe) I could perceive, that they were perhaps deſirous of more delicacy in the manner of offering them; and to try if this ſuſpicion were well founded, I ſat down in one of their houſes, and after having drawn towards me two little children, of three or four years old, and made them ſome trifling careſſes, I gave them a piece of roſe-coloured nankeen, which I had brought in my pocket. The moſt lively ſatisfaction was viſibly teſtified in the countenances of the whole family, and I am certain they would have refuſed this preſent, had it been directly offered to themſelves. The huſband went out of his cabin, and ſoon afterwards returning with his moſt beautiful dog, he entreated me to accept of it. I refuſed it, at the ſame time endeavouring to make him underſtand, that it was more uſeful to him than to me; but he inſiſted; and perceiving that it was without ſucceſs, he cauſed the two children, who had received the nankeen, to approach, and placing their little hands on the back of the dog, he gave me to underſtand, that I ought not to refuſe his children.

"The delicacy of ſuch manners cannot exiſt but among a very poliſhed people. It ſeems to me, that the civilization of a nation, which has neither flocks nor huſbandry, cannot go beyond it. It is neceſſary to obſerve, that dogs are their moſt valuable property; they yoke them to ſmall and very light ſledges, extremely well made, and exactly ſimilar to thoſe of the Kamtſchadales. Theſe dogs, of the ſpecies of wolf dogs, and very ſtrong, though of a middle ſize, are extremely docile, and very gentle, and ſeem to have imbibed the character of their maſters."

ORTHODROMICS, in navigation, is great-circle ſailing, or the art of ſailing in the arch of a great circle, which is the ſhorteſt courſe: For the arch of a great circle is *orthodromia*, or the ſhorteſt diſtance between two points or places.

ORYCTEROPUS, the name given by M. Geoffroy, profeſſor of zoology in the French muſeum of natural hiſtory, to the animal called by other zoologiſts *Myrmecophaga Capenſis*. (See MYRMECOPHAGA, *Encycl.*) He conſiders it as a diſtinct genus, and ſeems indeed to have proved, by a compariſon of the organs of the orycteropus with thoſe of the *tatous daſipus* of Linnæus, and of the *myrmecophagi*, that this genus is intermediate, by its forms and habits, between thoſe two families. It approaches to the *tatous* in its organs of maſtication, and the form of the toes and nails, and in having a ſhort and ſingle cæcum, whilſt that of the myrmecophagi is double, as in birds, by the reuniting of the bones of the os pubis, which are not articulated together in the myrmecophagi. The orycteropus, however, bears a relation to the laſt, ſince it has, like them, a very ſmall mouth, whence its tongue, covered with hair, may be protruded to a conſiderable length. Finally, the habits of the orycteropus reſemble thoſe of the animals to which it approaches the moſt; it does not climb trees, but lives under the earth like the tatous;

ctero pus ‖ delim.

tous; it feeds like them on roots, but alſo it hunts after anthills, like the myrmecophagi. Its ſnout terminates in a blunt callous; a character which is peculiar to it. It may be diſtinguiſhed in the works of naturaliſts by the following deſcription:

Oryćteropus. Molar teeth (ſix) with flat vertices; the body covered with hair.

The orycteropus, as appears from the preceding, connects the tatous with the myrmecophagi and with the *pangolin manis* of Linnæus. The large foſſile ſpecies found in Paraguay, for which Citizen Cuvier has eſtabliſhed a new genus, under the name of *megaterium*, is intermediate between the ſloth and the myrmecophagus; and, laſtly, the aſtoniſhing animal of New Holland, covered with briſtles like the porcupine, ſupported by very ſhort legs, and of very ſingular conformation, and with a head round at the occiput, terminating in a ſnout, without teeth, very ſlender, long, and cylindrical, and deſcribed by Mr George Shaw under the name of myrmecophaga aculeata, appears to have very ſtriking relations to the pangolin and the orycteropus: from hence it follows, that in conſequence of theſe important acquiſitions, we ought for the future to count, in the number of our natural orders, that of the *edentated*, or *edented*, conſiſting of the following genera: *Daſipus*, *orycteropus myrmecophaga*, and *aculeata*, *manis*, *myrmecophaga*, *megaterium* et *bradypus*.

OSCILLATION, in mechanics, vibration, or the reciprocal aſcent and deſcent of a pendulum.

Axis of Oscillation, is a line parallel to the horizon, ſuppoſed to paſs through the centre or fixed point about which the pendulum oſcillates, and perpendicular to the plane in which the oſcillation is made.

Centre of Oscillation, in a ſuſpended body, is a certain point in it, ſuch that the oſcillations of the body will be made in the ſame time as if that point alone were ſuſpended at that diſtance from the point of ſuſpenſion. Or it is the point into which, if the whole weight of the body be collected, the ſeveral oſcillations will be performed in the ſame time as before: the oſcillations being made only by the force of gravity of the oſcillating body.

OSCULATION, in geometry, denotes the contact between any curve and its oſculatory circle; that is, the circle of the ſame curvature with the given curve, at the point of contact or of oſculation. See Involution in this *Suppl.*

Osculation alſo means the point of concourſe of two branches of a curve which touch each other. For example, if the equation of a curve be $y = \sqrt{x} + \sqrt[4]{x^3}$, it is eaſy to ſee that the curve has two branches touching one another at the point where $x = 0$, becauſe the roots have each the ſigns + and —.

OUADELIM and Labdesseba, two tribes of Arabs inhabiting the *Sahara* or Great Deſart of Africa, of whom almoſt nothing was known to Europeans till the publication of Briſſon's narrative of his ſhipwreck and captivity among the latter tribe. He deſcribes the Ouadelim and Labdeſſeba as the moſt formidable of all the interior tribes of Arabs, and as often extending their ravages to the very gates of Morocco. "Their hordes (he ſays) are frequently intermingled with thoſe of the Rouſege, Rathidium, Chelus, Tucanois, and Ouadeli tribes, as they have no diſtinct boundaries, and change their habitations as the deſart affords paſturage and water. They are tall, handſome, ſtout, and vigorous men. Their hair is briſtled, and their nails, which they often uſe in battle, as long as claws; large hanging ears and a long beard give them a ſtern ferocious air. The Ouadelim in particular are fierce, arrogant, and warlike, but ſoon diſpirited by obſtinate reſiſtance, eſpecially when they have not a decided ſuperiority in numbers. In their hordes they lodge by families, in tents which are covered with a thick cloth of camels hair, which the women ſpin and weave upon a loom ſo ſmall, that they work ſitting on the ground. The furniture of their tents conſiſt of two large ſacks of leather, in which they keep old clothes and pieces of old iron, three or four goat ſkins for holding milk and water, two large ſtones for grinding their barley, a ſmaller one for driving the pins of their tents, an ozier matting which ſerves for a bed, a thick carpet for a covering, a ſmall kettle, and ſome wooden diſhes, with pack-ſaddles for their camels. The perſon who, beſides theſe articles, poſſeſſes a few horſes, camels, ſheep, and goats, is reckoned wealthy, as there are many Arabs who only poſſeſs ſheep and goats. Except ſore eyes and the cholic, they are ſubject to few endemic diſeaſes. The firſt diſorder is cauſed by the reflection of light from the burning ſands of the deſart, the other proceeds from the verdigreaſe which contaminates all their victuals. Their kettles are not tinned, and never waſhed, ſo that they are quite cruſted over with verdigreaſe, the virulence of which is probably diminiſhed by the quantity of milk they uſe. When they reſide long in one place, they ſometimes plough the ſpots which are moiſtened by the rain, and ſprinkle them with ſeed in a careleſs manner. Plentiful crops are often thus produced; but inſtead of waiting till the grain attains maturity, they cut it down, and dry it over hot cinders. Treachery and perfidy are the innate vices of the Arabs; aſſaſſinations are frequent; no man truſts the promiſe of another; no man makes a written agreement, as the poignard cancels all bonds and obligations. The men often relate their exploits to each other; the embelliſhing of a ſtory is ſucceeded by a charge of falſehood, and the poignard ſolves every difficulty. The ancient rites of hoſpitality, however, are practiſed among theſe tribes in their utmoſt extent. The Arab, who in the field is a rapacious plunderer, becomes liberal and generous as ſoon as he enters his tent. War is only a ſpecies of rapine, and the victory is decided at the firſt ſhock. The Arab is devoid of ſanguinary courage; he attacks only to plunder, and never thinks that booty is to be put in competition with his life. When the battle is ended, each party makes graves for the ſlain, and encloſe the tombs with mounds of ſtones. The ages of the warriors are denoted by the ſpace of ground which the grave occupies, and the funeral proceſſion is cloſed by the howls of the females.

Ouadelim.

"The women never aſſume the name of their huſbands, and never eat with them at meals. They are faithful to their huſbands, and cannot be divorced except by the decree of the ſeniors of the horde. The Arabs diſplay their opulence by the ornaments of their women, whoſe ears, arms, and legs, are generally adorned with rings of gold and ſilver. An Arab beauty muſt have long teeth ſhooting out of her mouth, a body extremely thick, and limbs of the longeſt ſize. At the birth of a ſon, every woman, to teſtify her joy, blackens

Ouadelim.

ens her face for 40 days. At the birth of a daughter, ſhe only daubs the half of her face during the ſpace of 20 days. A mother treats her ſon with the ſame reſpect as her huſband, almoſt as ſoon as he is able to walk; ſhe prepares his food, ſerves him, and eats when he has finiſhed his repaſt. In the education of their young men, the moſt important acquiſitions are, dexterity in the uſe of the poignard, ſkill in embowelling their enemies with their long nails, and a plauſible air in uttering a falſehood. More rude and ferocious than the tribes whoſe territories lie upon the ſhore of the ſea, the Labdeſſeba and Ouadelim Arabs are alſo more confined and illiberal in their ideas, not only believing that they are the firſt nation in the world, but fancying that the ſun riſes only for them. Briſſon relates, that ſome of them expreſſed this idea in unequivocal terms. 'Behold (ſaid they) that luminary, which is unknown in thy country. During the night, thou art not enlightened, as we are, by that heavenly body, which regulates our days and our faſts. His children (the ſtars) point out to us the hours of prayer. You have neither trees nor camels, ſheep, goats, nor dogs. Are your women ſimilar to ours?' 'How long didſt thou remain in the womb of thy mother (ſaid another)?' 'As long (replied Briſſon) as thou in that of thine.' 'Indeed (ſaid a third, counting the fingers and toes of the Frenchman) he is made like us; he differs only in his colour and language.' 'Do you ſow barley in your houſes?' ſaid the Arabs, alluding to the ſhips of the Europeans. 'No (ſaid Briſſon), we ſow our fields almoſt in the ſame ſeaſon as you.' 'How! (cried ſeveral) do you inhabit the earth? we believed that you were born and lived upon the ſea.' Theſe Arabs, according to the Turkiſh proverb, believe that all the world is like their father's houſe: unacquainted with the manners of other nations, and unaccuſtomed to reflect upon the cauſes of national character, every variation from their own cuſtoms appears not only ridiculous, but monſtrous; every difference of opinion not only abſurd, but criminal. This ignorance of the Arabs, conjoined with their local and religious prejudices, enables us to account for the inſulting treatment which Briſſon and his companions received, without having recourſe to inherent depravity of nature." That treatment was indeed ſhocking.

Briſſon had ſurrendered himſelf, on his ſhipwreck, to Sidi Mahomet, a *Talbe* or prieſt of the tribe of Labdeſſeba. During the abſence of the prieſt, the Labdeſſeba, who guarded the captives, were attacked and maltreated by a party of the Ouadelims, and during the battle which enſued, Briſſon had almoſt loſt his life. Inſtead of compaſſionating his forlorn ſituation, the women threw ſand into his eyes, as they ſaid, to dry his eye-lids. The Arabs, into whoſe hands he had fallen, had only come down to the ſea-coaſt to gather wild grain, three days before the ſhipwreck; and to preſerve their booty, they immediately retreated to the interior part of the deſart. A guide preceded the horde, to place at intervals ſmall pyramids of ſtone, to direct their courſe, at a diſtance from every hoſtile tribe. After paſſing ſome very high mountains, wholly covered with ſmall greyiſh pebbles as ſharp as flints, they deſcended into a ſandy plain overſpread with thorns and thiſtles. When Briſſon was unable to walk, on account of the bleeding of his feet, he was mounted on a camel; the briſtly hair and hard trot of which ſoon excoriated him ſo much, that the blood run copiouſly down its flanks. By throwing heated ſtones into a wooden veſſel, filled with barley meal, diluted with water procured on the ſea-ſhore, preſerved in a goat's ſkin, and mixed with pitch to prevent putrefaction, the Arabs prepared a kind of ſoup, which they kneaded with their hands, and ate unchewed. They roaſted a goat in heated ſand, ate its fat raw, and, after having devoured the fleſh, gnawed the bones, and ſcraped them with their nails, threw them to Briſſon and his companions, deſiring them to eat quickly, and load the camels, that the journey might not be impeded. Proceeding eaſtward, they croſſed a vaſt plain, covered with ſmall ſtones white as ſnow, round and flat as a lentil, where not a ſingle plant was produced. The earth beneath their feet reſounded dull and hollow, and the ſmall ſtones pricked them like ſparks of fire. The reflection of the rays of the ſun from the ſand was ſcorching; the atmoſphere was loaded with a red vapour, and the country appeared as if filled with flaming volcanoes. Neither birds nor inſects could be ſeen in the air. The profound ſilence was frightful. If a gentle breeze ever aroſe, it produced extreme languor, chopping of the lips, burning heat of the ſkin, with ſmall ſmarting pimples. This plain was even ſhunned by wild beaſts. After traverſing this plain, they entered another, where the wind had thrown up in furrows the ſand, which was of a reddiſh colour. On the tops of the furrows grew a few ſweet-ſcented plants, which were devoured by the camels. On quitting this ſandy plain, they entered a valley ſurrounded by mountains, where the ſoil was white and ſlimy, and where they found water of a noxious ſmell, covered with green moſs, and ſoon after diſcovered a horde of the friendly tribe Rouſſye.

After another journey of ſixteen days, they arrived at the tents of the Labdeſſeba horde, to which Sidi Mahomet belonged. The tents pitched among thick buſhy trees, and the numerous flocks feeding along the ſides of the hills, preſented at a diſtance an aſpect of happineſs and paſtoral ſimplicity. On approaching near, the trees of beautiful green foliage proved to be only old gummy ſtumps, almoſt void of branches, ſo encircled with thorns that their ſhade was inacceſſible. The women approached, with loud cries and the moſt fawning ſervility, to welcome their tyrants, to throw ſtones at the Chriſtians, and ſpit in their faces, while the children imitated the example of their mothers. Briſſon, who endeavoured to ingratiate himſelf with his maſter's favourite, not only failed in this, but incurred her implacable reſentment, through his irritability, which to the Arab women ſeemed extremely to reſemble petulance. During his reſidence with Sidi Mahomet, the hardſhips he endured were almoſt incredible. With the exceſſive heat, the milk of the ſheep, goats, and camels, diminiſhed, and then the dogs fared better than the Chriſtians, who were forced to ſubſiſt on wild herbs and raw ſnails. When the rains fell, and the leaſt preſſure made the water to ſpring up through the ſandy ſoil, the Chriſtians ſlept behind a buſh, unſheltered, on the bare ground. Briſſon and his maſter ſometimes reaſoned about religion; when the latter always anſwered the harangues of the former by declaring, that he preferred a bowl of churned milk to ſuch abſurdities. Several of his companions periſhed, and were left by the Arabs to be devoured by the ravens, while in the ſtruggles of death. One of them was ſuppoſed to be murdered by his maſter for milking his camels clandeſtinely. An application made by Briſſon to the conſul at Mogador, by a letter entruſted to a Jewiſh merchant, was fruſtrated through the negligence of the vice-conſul; and the Labdeſſeba Arabs thought the journey too dangerous to be encountered for the ranſom of their ſlaves. He was, however, at laſt relieved, through the humanity of his maſter's brother-in-law, who carried him to Morocco, where his ranſom was paid by the Emperor, and whence he returned to France. For a fuller account of theſe two ſavage tribes, ſee *Saugnier's and Briſſon's Narratives*; or a very pleaſing *Hiſtorical and Philoſophical Sketch of the Diſcoveries, &c. of the Europeans in Northern and Weſtern Africa*, publiſhed 1799 by *Symington* Edinburgh, and *Vernor* and *Hood* London.

OXYGLYCUS CERASUS, the name given by the editor of Dalzel's Hiſtory of Dahomy to a very ſingular fruit produced in that country, as well as in ſome other parts of Africa. It reſembles a ſmall olive in every reſpect but the colour; being of a duſky reddiſh hue, changing at the end next the ſtalk to a faint yellow. The pulp is firm, and almoſt inſipid; the ſtone is hard like that of the olive. After having chewed one or more of ſuch berries, and ſpit out or ſwallowed the pulp at pleaſure, a glaſs of vinegar will taſte, to the perſon trying the experiment, like ſweet wine; a lime will ſeem to have the flavour of a very ripe China orange; and the ſame change is produced on other acids, the ordinary effects of which upon the palate is deſtroyed in a very unaccountable manner, without effervеſcence or any ſenſible motion. Indeed, the effect is very different from neutralization, ariſing from the mixture of acid and alkali; ſuch combination producing a neutral ſaline liquor, whilſt this miraculous berry ſeems to convert acids to ſweets. Food or drink, not containing any acid, ſuffer no change by the previous uſe of this fruit; its effect upon acids continues, even after a meal, though in a much ſmaller degree. The natives uſe it to render palatable a kind of gruel called *guddoe*, which is made of bread after it becomes too ſtale for any other purpoſe. They deſcribe it as the fruit of a large tree.

Plants ſix or ſeven inches high were raiſed from this fruit by Mr Dalzel, who tried to carry them from Angola to the botanic garden at St Vincent's; but they died on the paſſage. He preſerved the berries in ſpirits, in ſyrup, and in a dry form; but they loſt their ſingular quality in all thoſe preparations. The plant is an evergreen, and the leaves in this infant ſtate are like thoſe of the olive.

OXY-MURIATIC ACID (See CHEMISTRY-*Index* in this *Suppl.*), is the principal agent in the new proceſs of bleaching (ſee BLEACHING, *Suppl.*); but, till very lately, at leaſt, if not even at preſent, the bleachers were in the practice of adding ſome alkali to the acid, notwithſtanding the ſtrong objections which M. Bertholet made to that addition, and notwithſtanding the proofs urged by Mr Rupp, that it increaſes the expence of bleaching about 40 *per cent.* The chief reaſon for perſiſting in a practice to which ſuch objections were urged was, that the addition of the alkali deprives the liquor of its ſuffocating effects without deſtroying its bleaching powers. Mr Rupp, however, has contrived the following apparatus, in which may be ſafely uſed the pure oxy muriatic acid ſimply diſſolved in water, which is at once its cheapeſt and beſt vehicle.

Figure 1. (Plate XLI.) is a ſection of the apparatus. It conſiſts of an oblong deal ciſtern ABCD, made water-tight. A rib EE of aſh or beech wood is firmly fixed to the middle of the bottom CD, being mortiſed into the ends of the ciſtern. This rib is provided with holes at FF, in which two perpendicular axes are to turn. The lid AB has a rim GG, which ſinks and fits into the ciſtern. Two tubes HH are fixed into the lid, their centres being perpendicularly over the centres of the ſockets FF when the lid is upon the ciſtern. At I, is a tube by which the liquor is introduced into the apparatus. As it is neceſſary that the ſpace within the rim GG be air tight, its joints to the lid, and the joints of the tubes, muſt be very cloſe; and, if neceſſary, ſecured with pitch. Two perpendicular axes KL, made of aſh or beech wood, paſs thro' the tubes HH, and reſt in the ſockets FF. A piece of ſtrong canvas M is ſewed very tight round the axis K, one end of it projecting from the axis. The other axis is provided with a ſimilar piece of canvas. N are pieces of cloth rolled upon the axis L. Two plain pulleys OO are fixed to the axes, in order to prevent the cloth from ſlipping down. The ſhafts are turned by a moveable handle P. Q is a moveable pulley, round which paſſes the cord R. This cord, which is faſtened on the oppoſite ſide of the lid (ſee fig. 2.), and paſſes over the ſmall pulley S, produces friction by means of the weight T. By the ſpigot and fauſſet V, the liquor is let off when exhauſted.

The dimenſions of this apparatus are calculated for the purpoſe of bleaching twelve or fifteen pieces of $\frac{4}{3}$ calicoes, or any other ſtuffs of equal breadth and ſubſtance. When the goods are ready for bleaching, the axis L is placed on a frame in an horizontal poſition, and one of the pieces N being faſtened to the canvas M by means of wooden ſkewers, in the manner repreſented in fig. 1. it is rolled upon the axis by turning it with the handle P. This operation muſt be performed by two perſons; the one turning the axis and the other directing the piece, which muſt be rolled on very tight and very even. When the firſt piece is on the axis, the next piece is faſtened to the end of it by ſkewers, and wound on in the ſame manner as the firſt. The ſame method is purſued till all the pieces are wound upon the axis. The end of the laſt piece is then faſtened to the canvas of the axis K. Both axes are afterwards placed into the ciſtern, with their ends in the ſockets FF, and the lid is put on the ciſtern by paſſing the axes through the tubes HH. The handle P is put upon the empty axis, and the pulley Q upon the axis on which the cloth is rolled, and the cord R, with the weight T, is put round it and over the pulley S. The uſe of the friction, produced by this weight, is to make the cloth wind tight upon the other axis. But as the effect of the weight will increaſe as one cylinder increaſes and the other leſſens, Mr Rupp recommends that three or four weights be ſuſpended on the cord, which may be taken off gradually as the perſon who works the machine may find it convenient. As the weights hang in open hooks, which are faſtened to the

Oxy-Muriatic Acid.

the cord, it will be little or no trouble to put them on and to remove them.

Things being thus diſpoſed, the bleaching liquor is to be transferred from the veſſels in which it has been prepared into the apparatus, by a moveable tube paſſing through the tube I, and deſcending to the bottom of the ciſtern. This tube being connected with the veſſels, by means of leaden or wooden pipes provided with cocks, hardly any vapours will eſcape in the transfer. When the apparatus is filled up to the line *a*, the moveable tube is to be withdrawn, and the tube I cloſed. As the liquor riſes above the edge of the rim G, and above the tubes HH, it is evident that no evaporation can take place, except where the rim does not apply cloſely to the ſides of the box; which will, however, form a very trifling ſurface if the carpenter's work be decently done. The cloth is now to be wound from the axis L upon the axis K, by turning this; and when this is accompliſhed, the handle P and pulley Q are to be changed, and the cloth is to be wound back upon the axis L. This operation is, of courſe, to be repeated as often as neceſſary It is plain, that by this proceſs of winding the cloth from one axis upon the other, every part of it is expoſed, in the moſt complete manner, to the action of the liquor in which it is immerſed. It will be neceſſary to turn, at firſt, very briſkly, not only becauſe the liquor is then the ſtrongeſt, but alſo becauſe it requires a number of revolutions, when the axis is bare, to move a certain length of cloth in a given time, though this may be performed by a ſingle revolution when the axis is filled. Experience muſt teach how long the goods are to be worked; nor can any rule be given reſpecting the quantity and ſtrength of the liquor, in order to bleach a certain number of pieces. An intelligent workman will ſoon attain a ſufficient knowledge of theſe points. It is hardly neceſſary to obſerve, that, if the liquor ſhould retain any ſtrength after a ſet of pieces are bleached with it, it may again be employed for another ſet.

With a few alterations, this apparatus might be made applicable to the bleaching of yarn. If, for inſtance, the pulley O were removed from the end of the axis K, and fixed immediately under the tube H;—if it were perforated in all directions, and tapes or ſtrings paſſed through the holes, ſkains of yarn might be tied to theſe tapes underneath the pulley, ſo as to hang down towards the bottom of the box. The apparatus being afterwards filled with bleaching liquor, and the axis turned, the motion would cauſe every thread to be acted upon by the liquor. Several axes might thus be turned in the ſame box, and being connected with each other by pulleys, they might all be worked by one perſon at the ſame time; and as all would turn the ſame way and with the ſame ſpeed, the ſkains could not poſſibly entangle each other.

P.

Painting.

ENCAUSTIC PAINTING is an art of very high antiquity, which, after being loſt for many ages, was reſtored, as is commonly believed, by the celebrated Count Caylus, whoſe method was greatly improved, firſt by Mr Joſiah Colebrooke, and afterwards by Miſs Greenland, who brought the rudiments of her knowledge from Italy (See ENCAUSTIC, *Encycl.*). In that country encauſtic painting had employed the attention of various artiſts and men of learning, ſuch as Requeno, Lorgna, and Aſtori, &c.; but the beſt account of it that has fallen under our notice, is in that valuable miſcellany called the *Philoſophical Magazine*, taken from a work of Giov. Fabbroni, publiſhed at Rome in the year 1797.

According to this author, "the knowledge and uſe of encauſtic painting is certainly older than the time of the Greeks and the Romans, to whom the learned Requeno ſeems to aſſign the excluſive poſſeſſion of this art; becauſe the Egyptians, who, with the Etruſcans, were the parents of the greater part of the inventions known among mankind, and from whom the Greeks learned ſo much, were acquainted with and employed encauſtic painting in the ancient ages of their greatneſs and ſplendour, as is proved by the valuable fragments of the bandages and coverings of ſome mummies which he had examined. No oil-painting (he ſays), of only two or three hundred years old, exhibits a white paint which has kept ſo well as that ſeen on theſe fragments; and this circumſtance ſufficiently proves the ſuperiority of the encauſtic method over the common oil-painting, which, notwithſtanding the general opinion, cannot, he thinks, have been unknown to the ancients.

"It is impoſſible (ſays he) that in Egypt and Phœnicia, where ſo much uſe was made of flax, the oil procured in abundance from that plant ſhould have been unknown. Thoſe who have kept oil, or who have ſpilt any of it, whether nut or lintſeed oil, muſt have remarked that it poſſeſſes the property of ſoon drying by the effects of the atmoſphere; and therefore it may be eaſily believed that mankind muſt ſoon have conceived the idea of employing it, particularly for ſhips, which, as Herodotus ſays, were painted with red ochre in the earlieſt periods, and adorned with figures and ornaments. The uſe of oil afforded painting a much ſimpler and eaſier method than that of wax; it muſt therefore have been firſt adopted, and the tranſition from oil to wax muſt be conſidered as a ſtep towards bringing the art to perfection; becauſe encauſtic painting is not expoſed to the irremediable inconveniences that ariſe in oil-painting, the value of which we extolled through ignorance, and praiſed as a new invention.

"Oil in general, and in particular drying oil which the painters uſe, has naturally a ſtrong inclination to combine itſelf with the vital air or oxygen of the atmoſphere, and by imbibing oxygen it becomes dry, and aſſumes the character of reſin; but the colour then becomes darker, as is the caſe with tranſparent turpentine, which gradually becomes a black pitch.

"Accord-

“ According to the new and more accurate method of decompoſing bodies, oil conſiſts principally of hydrogen and carbon. By coming into contact with the atmoſphere, and abſorbing its oxygen and light, it undergoes a ſlow and imperceptible combuſtion, which is not eſſentially different from the ſpeedy and violent one which it would undergo in the common mode of burning. It firſt paſſes, by imbibing oxygen, into the ſtate of a more or leſs dark reſin ; loſes gradually its eſſential hydrogen, which makes a new combination, and afterwards the oxygen itſelf which has attracted the carbon ; and at length leaves behind a thin layer of actual carbon, which in the end becomes black in the courſe of time, and conſiderably obſcures the oil painting. By a continuance of the before-mentioned ſlow combuſtion, the carbon itſelf, as it were, burns alſo : if it be ſtrongly acted upon by the light, it attracts the oxygen of the atmoſphere, and again brings forward the carbonic acid or fixed air, which gradually flies off. By this, which I may call the ſecond degree of combuſtion, the painting muſt become duſty and friable, like crayon *painting*.

“ Hence it appears (ſays our author) that one can hope only for a tranſient or deceitful effect from the refreſhing of oil-paintings with oil; becauſe the harmony of the tones, which the painter eſtabliſhes as ſuited for the moment, does not proceed with equal ſteps, and cannot preſerve itſelf in the like meaſure for the courſe of a few years, as each tint, as they ſay, ought to increaſe, or, to ſpeak more properly, to burn in proportion to its antiquity. It thence follows, that mere waſhing may be prejudicial to an old painting ; and that the method of refreſhing paintings, as it is called, by daubing over the ſurface, from time to time, with new drying oil, is highly prejudicial and ill calculated for the intended purpoſe, ſince the oil when it becomes dry contracts in its whole ſurface, carries with it the paint under it, and occaſions cracks in the painting. New oil of this kind gives occaſion to mineral paints to be reſtored ; but covers the picture with a new coat of reſin, and then of carbon, which ariſes from the gradual combuſtion, and always cauſes more blackneſs, and the decay of the painting which one wiſhes to preſerve.

“ Wax, on the other hand, undergoes a change which is very different from that of drying oil. The wax, inſtead of becoming black by the contact of the atmoſphere, increaſes in whiteneſs, and, according to its natural quality, is not decompoſed in the air, and it does not ſtrongly attract the oxygen of the calces or metallic aſhes which are commonly uſed in painting. Moreover, the ſo called earths, which are in themſelves white, and are never variable either by the preſence or abſence of oxygen, cannot be employed in oil-painting, becauſe that fluid makes them almoſt tranſparent, and cauſes them to remain as it were without body, and not to produce the wiſhed-for effect. That beautiful white, which may be obſerved on the before-mentioned Egyptian encauſtic, is nothing elſe than a ſimple earth, and according to our author's chemical experiments, a chalk which is alſo unalterable.”

That the ancients were once acquainted with the uſe of oil-painting, and neglected it on account of the great ſuperiority of the encauſtic method, our author thinks farther evident from the different accounts which we have of the ancient paintings. “ Thus Petronius praiſes the freſh appearance which the valuable works of Zeuxis and Apelles had, even in his time ; but Cicero, on the other hand, ſpeaks of the paintings of the ancients having ſuffered from blackneſs. The former ſpeaks of wax-painting, and the latter certainly alludes to paintings in oil. It is well known that paintings with wet chalks or water colours do not become black by age, and that this is the caſe alſo with encauſtic. Of this any one may be convinced, not only by the expreſſions of the above quoted authors, but by one's own eyes on ſurveying the Egyptian fragment alluded to. Galland proves, on various grounds, that a painting was made with oil ſo early as the reign of Marcus Aurelius ; and if no ſpecimens of that period have reached us, this is perhaps to be aſcribed to the frail and periſhable nature of this ſpecies of painting.”

Sign. Fabbroni, after ſome farther obſervations, calculated to prove that metallic oxyds or calces could not have been employed as pigments on ſuch mummies as ſtill retain their colours freſh, proceeds thus : “ Thoſe who are acquainted with the accuracy and certainty of the method not long ſince introduced into chemical operations, will be convinced, that in 24 grains of the encauſtic painting, which I ventured to detach from the above-mentioned Egyptian fragment, in order to ſubject it to examination, the mixture of an hundredth part of a foreign ſubſtance would have been diſcovered with the greateſt certainty ; that the reſin of Requeno muſt undoubtedly have been perceptible to me, and that the alkali of Bachelier and Lorgna could not have eſcaped the counteracting medium. But in this Egyptian encauſtic I found nothing except very pure wax, though I varied my analyſis in every known method. I muſt therefore conclude, that modern learned writers, at leaſt in reſpect to this Egyptian mode of painting, were as far from the truth as the accounts of ancient authors appear to me preciſe and ſatisfactory ; and that the encauſtum with which formerly the fore part of ſhips and the walls of houſes and temples were painted, was ſomething different from ſoap or reſinous crayons.

“ I am well aware that it will be aſked, In what manner can wax at preſent be rendered ſufficiently liquid for the ſtrokes of the pencil, if it be not converted into powder or ſoap ? This queſtion, in my opinion, can be fully anſwered from the words of an ancient author, and, in the next place, by experience.

“ Vitruvius in particular, book vii. chap. ix. expreſſes himſelf in the following clear manner :

‘ Thoſe (ſays he) who wiſh to retain cinnabar on walls, cover it, when it has been well laid on and dried, with Punic wax diluted in a little oil (let this be well remarked) ; and after they have ſpread out the wax with a hair bruſh, they heat the wall by means of a brazier filled with burning coals (hence it is called encauſtic painting), and then make it ſmooth and level by rubbing it with wax tapers and clean cloths, as is done when marble ſtatues are covered with wax. The effect of this wax cruſt is, that the colour is not deſtroyed by the light of the ſun or the moon (A).’

(A) The reader will find the original of this paſſage, with a tranſlation ſomewhat different, in the article Encaustic, *Encycl.*

“ It here appears, that the Romans, who copied the Grecian proceſs, which the latter borrowed from the Egyptians, mixed the wax with an oil to make it pliable under the bruſh ; but no maſtic, alkali, or honey, as has been ingeniouſly imagined, and which ſome have thought might be employed with ſucceſs. The difficulty now will be confined to point out in what manner this oil was employed. It does not appear that they uſed thoſe fat oils which are commonly called drying oils; becauſe they could have employed theſe as we do, without the addition of wax, which, in ſuch a caſe, would have been entirely ſuperfluous. Fat oils which do not dry would not have been proper for that purpoſe, as they would have kept the wax continually in the ſtate of a ſoft pomade or ſalve. Beſides, my experiments (continues the author) would without doubt have ſhewn me the exiſtence of any oily matter.

“ With regard to eſſential or volatile oils, a knowledge of them is not allowed to the ancients, as the invention of diſtilling is not older than the eighth or ninth century, and therefore falls in with the period of Geber or Avicenna.” Yet it is certain, that, in order to uſe wax in their encauſtic painting, they muſt have combined it with an ethereal volatile oil, of which no traces ſhould afterwards remain ; becauſe this was neceſſary for the ſolidity of the work, and becauſe no oil was found in the fragment that was examined. But naphtha is ſuch an oil, much lighter (ſays our author) than ether of vitriol itſelf. It is exceedingly volatile, and evaporates without leaving a trace of it behind. On this account it is uſed when ſignatures and manuſcripts are to be copied ; becauſe the paper, which is moiſtened by it, and ſo rendered tranſparent, quickly becomes white and opaque as before by the complete evaporation of the naphtha. That the Aſſyrians, Chaldeans, and Perſians, were well acquainted with the properties of naphtha is known to every ſcholar ; and hence our author thinks it highly probable that it was uſed by thoſe nations to render wax fit for painting. “ It appears to me (ſays he) that the Greeks, as was the caſe with many other things, learned encauſtic from the Egyptians, who probably derived it from the Aſſyrians or Chaldeans ; and if ſo, we have diſcovered the real mixture uſed for ancient encauſtic painting.”

To put the matter, however, beyond a doubt, Sign. Fabbroni prepared, for an eminent Saxon painter, a ſolution of Venetian wax in highly purified naphtha, deſiring him to mix up with it the colours neceſſary for a painting. The artiſt complied ; and both he and our author were aſtoniſhed, as well as all their friends, at the high tone which the colours aſſumed, and the agreeable luſtre which the painting afterwards acquired when it had been rubbed over with a ſoft cloth. A ſimilar ſolution of wax was made for another artiſt, in which the ſpirit of turpentine was uſed inſtead of naphtha with equal ſucceſs. Our author therefore concludes, we think with reaſon, that if he has not diſcovered the real compoſition employed by the ancients in their encauſtic paintings, he has at leaſt approached much nearer to that diſcovery than any of his predeceſſors who have employed their learned labours in the ſame field of inveſtigation.

PAINTINGS, or PICTURES, are often done upon objects from which, when they are valuable, it would be deſirable to tranſfer them. Thus, a connoiſſeur in painting might naturally wiſh to tranſfer an old and valuable picture from the ceiling or walls of his room to ſtretched canvas ; and ſuch a man would conſider himſelf as deeply indebted to the artiſt who ſhould perform ſo arduous a taſk. This taſk has actually been performed by Mr *Robert Salmon* of Woburn, Bedfordſhire, who was honoured by the *Society for the Encouragement of Arts, &c.* with the greater ſilver pallet, for communicating the method by which he accompliſhed it.

“ The firſt thing (ſays Mr Salmon) to be attended to with reſpect to paintings, either on plaſtered walls or ceilings, or on boards, is, that the place in which they are be ſecure from wet or damp. If the paintings are on old walls in large buildings, or other places where this cannot be attained by art, then the ſummer ſeaſon ſhould be taken for the purpoſe, as the picture will rarely eſcape damage, if wet or damp gets at it while under the proceſs. At the ſame time, care ſhould be taken that the room, or other place, be not overheated ; as that would produce equally bad effects.

“ Theſe precautions being taken, the next thing is to examine the ſurface of the painting. If there are any holes in the ſame, they muſt be carefully filled up with a paſte or putty, made of glue and whiting : this, if the holes are large, ſhould be twice or thrice done, ſo as entirely to fill them up, and leave the ſurface even and ſmooth ; but if there are any bruiſed places, with paint ſtill remaining on the ſurface of the bruiſed parts, then this ſtopping muſt not be applied, but the ſecuring-canvas, hereafter deſcribed, muſt be preſſed down into theſe places. In the places that are ſtopped, there will of courſe appear blemiſhes when the picture is transferred ; but the proceſs is rendered much more certain and ſure by being ſo done. Attention muſt next be paid to lay down any bliſters, or places where the paint is leaving the ground : this is done by introducing, between the paint and the ground. ſome very ſtrong paſte of flour and water ; and the ſurface of the bliſtered paint being damped with a wet ſponge or bruſh, it may be preſſed with the hand home to the ground, to which it will then adhere.

“ All the unſound places being thus ſecured, care muſt be taken to clear the ſurface of any greaſe or dirt, as alſo of any particles of the paſte that may happen to be left on it. The next thing is, to determine the ſize of the painting meant to be taken off : If it is on a plain ſurface, a board of the ſize of the picture muſt be procured, not leſs than an inch in thickneſs, and framed together with well-ſeaſoned wood, in ſmall pannels, ſmooth and fluſh on one ſide. This done, a piece of fine open canvas muſt be provided, ſuch as the fineſt ſort uſed for hanging paper on ; which canvas is to be ſomewhat larger than the picture, and ſo ſewed together, and the ſeam ſo preſſed, that it be perfectly ſmooth and even. This is what Mr Salmon calls the ſecuring canvas ; which, being ſo prepared, is to be ſtuck on the ſurface of the picture with a paſte made of ſtrong beer, boiled till it is half reduced, and then mixed with a ſufficient quantity of flour to give it a very ſtrong conſiſtence. To large pictures on walls or ceilings, the canvas muſt for ſome time be preſſed, and rubbed with the hand as ſmooth as poſſible, working it from the middle to the outſide, ſo as to make it tolerably tight ; obſerving, as it dries, to preſs it, with the hand or a cloth, into any hollow or bruiſed places, ſo that it may adhere to every part of the painting: this done, it is left to dry; which it will generally do in a day or two. When dry, a ſecond canvaſs, of a ſtronger and cloſer ſort, and of the ſame ſize as the other, is in like manner to be attached on the top of the firſt. This laſt will want very little attention, as it will readily adhere to the firſt; and, being dry, attention muſt be paid to take off any ſmall knots or unevenneſs that may be upon the ſurface of it; which done, the whole ſhould be again covered with a thin paſte of ſize and whiting; which is to be pumiced over when dry, ſo as to make the whole perfectly ſmooth and even.

“ The painting being thus ſecured, the board, already prepared to the ſize of the picture, is to be put with the ſmooth ſide againſt the ſurface thereof, ſo as exactly to cover as much as is intended to be transferred. The edges of the canvas, which, as before directed, is to be larger than the painting, are then to be pulled tight over, and cloſely nailed to the edge of the board. If the painting is large, and either on a ceiling or wall, the board muſt, by proper ſupports, be firmly fixed againſt it, ſo that it can readily be lowered down when the plaſter and painting are detached.

“ The canvas and board being fixed, the painting is to be freed from the wall or ceiling, together with a certain portion of the plaſtering: this, with proper care and attention, may be readily done. If on a ceiling, the firſt thing is to make ſome holes through the plaſtering, round the outſide of the board and painting; and, with a ſmall ſaw, to ſaw the plaſtering from one hole to another, till the whole is diſunited from the other parts of the ceiling: this done, the workman muſt get at the upper ſide of the ceiling, where he muſt free the plaſtering from the laths, by breaking off the keys thereof, and with a chiſel cut out the laths; whereby the plaſtering, together with the picture, will be left reſting on the board and ſupports.

“ If the painting is on a brick or ſtone wall, the wall muſt be cut away at top, and down the ſides of the painting; and then, by means of chiſels or ſaws in wooden handles, of different lengths, the wall muſt be cut away quite behind the painting; leaving the ſame, together with the plaſtering, reſting on the board. This operation may ſometimes be done with a ſaw; or, if the wall be not thick, nor the other ſide of much conſequence, the bricks or ſtones may be taken out from that ſide, leaving the plaſtering and painting as before. This laſt method (ſays the author) I have not practiſed: the other, of cutting away ſome part of the wall, I have, and ſee no difficulty, or very great labour, in the operation; but that, of courſe, muſt be various, according to the texture of the wall and mortar.

“ If the paintings are on curved ſurfaces, ſuch as the coves of ceilings, then the only difference of operation is, that ſome ribs of wood muſt be cut out, and boarded ſmooth to the curve of the ſurface of the painting, and then fixed up thereto, in place of the before deſcribed bearing-board; the painting is then to be freed, and left with the plaſtering, reſting on the bearers.

“ For paintings on wainſcot or boards, the ſame ſecuring and proceſs is to be exactly followed; only that, as the wainſcot or board can always be cut to the ſize wanted, and laid horizontal, the ſecuring-canvas is to be ſtretched thereon, and turned over the edges of the ſame, till it is dry; after which, the edges are again to be turned up, and nailed to the board, in the ſame manner as with reſpect to paintings from walls.

“ Having, as before deſcribed, in any of the aforementioned caſes, freed the paintings from their original places, you have got them ſecured to two thickneſſes of canvas, with their ſurfaces on the board prepared for that purpoſe; this being the caſe, they can readily be removed to any room or ſhop, to be finiſhed as follows: Having carried the painting into the ſhop or room, which ſhould be moderately warm and dry, but by no means overheated, lay the board on a bench or treſſels, ſo that the back of the picture be uppermoſt: the plaſtering or wood, as may happen, is then to be cleared away, leaving nothing but the body of paint, which will be firmly attached to the ſecuring-canvaſs. To perform this, a large raſp, a narrow plane, and chiſels, will be requiſite. This operation, though difficult to be deſcribed, would ſoon be learned by any one who ſhould make the attempt; nor is it very tedious; and being performed, the picture is ready to be attached to its new canvas, as follows.

“ The painting being cleared, and lying on the board, the back thereof is to be painted three or four times over ſucceſſively, with any good ſtrong-bodied paint; leaving one coat to dry before another comes on: a day or two between each will generally be found ſufficient. Each of theſe coats, and particularly the firſt, ſhould be laid on with great care, taking but a ſmall quantity in the bruſh at a time, and laying it very thin. This precaution is neceſſary, to prevent any of the oil or paint from paſſing through any ſmall cracks or holes in the ſurface of the picture; as ſuch oil or paint would run into the paſte, and ſo attach the ſecuring-canvas to the picture, as to prevent its being afterwards got off. If any ſuch holes or cracks are obſerved, they ſhould be ſtopped up with the glue and whiting paſte, and the painting then repeated, till a complete coat is formed on the back of the picture. It is then ready for attaching to its canvas, which is done by ſpreading all over the picture a paſte made of copal varniſh, mixed with ſtiff white lead, and a ſmall quantity of any other old fat paint; all which being ſpread equally over with a pallet-knife, ſuch a canvas as the firſt ſecuring-canvas is laid thereon, and ſtrained and nailed round the edges of the board; in which ſtate it is left till it becomes tolerably dry: then a ſecond canvas, of a ſtronger ſort, muſt be in like manner attached on the firſt, and left till it is perfectly dry and hard. This generally takes about two months; and the longer the painting is left, the more ſecurely it will be attached to its canvas, and leſs liable to crack or fly therefrom. When ſufficiently dry, all the four canvaſſes are to be unnailed from the board, and the edges turned up the reverſe way, and nailed to a proper ſtretching-frame. This is done by unnailing from the board a part on each ſide at a time, and immediately nailing it to the ſtretching-frame, ſo as never to leave the canvas to crack or partially ſtretch, which would damage the picture. In this manner, by degrees, the cloths are entirely detached from the board, and firmly fixed on the ſtretching-frame. The ſuperfluous canvas, left larger than the frame, may then be cut off, and the wedges put in the frame, and moderately tightened up. There remains then only to clear the ſurface of the painting from the ſecuring-canvaſs; which is done by repeatedly waſhing the ſurface with a ſponge and moderately warm water. In doing this, no violence or force muſt be uſed; and, by frequent and gentle waſhings, the paſte will all be worked out with the ſponge. The edges of the outer canvas are then to be cut round, and ſtripped off: the other, next the ſurface of the picture, is to be ſerved in like manner; which done, nothing remains but to take the paſte clean off, and repair any defects: the picture will then be as ſtrong as if painted on the canvas.

“ For taking pictures off walls, without taking the walls down, or cutting away more thereof than the plaſtering, the following proceſs is propoſed:

“ The ſurface of the picture is to be firſt ſecured, in the manner before deſcribed; but inſtead of the plain board, a bearer ſhould be prepared with a convex ſurface, compoſed of ribs, boarded over, ſo as to form part of a cylinder, of not leſs than five feet radius, and as long as the height of the picture. This bearer being prepared, in order to apply it, a floor or platform ſhould be erected, and placed horizontally, with its ſurface level, and its edge immediately in contact with the bottom of the picture meant to be transferred. The uſe of this platform is for the above deſcribed bearer to reſt and move upon; which bearer ſhould be ſet on its end, with one edge in contact with the wall, at one ſide of the picture; conſequently the other edge will be at ſome diſtance from the wall, according to the ſize of the picture and convexity of the bearer. Being thus placed, the ſuperfluous edge of the ſecuring-canvas ſhould be turned over, and nailed to that edge of the bearer that is next the wall: This done, the operation of cutting away the plaſtering ſhould be begun; which may he done with the corner and end of a ſhort ſaw; ſawing between the brick-work and plaſtering, and leaving the thickneſs, or part of the thickneſs, of the plaſtering on the painting faſtened to the bearer. When this edge of the picture is freed, the whole height, for nine or ten inches under the edge of the bearer that is fartheſt from the wall, muſt then be gently forced nearer; conſequently the other edge, together with the painting and plaſter that is freed, will leave the wall, and give an opportunity of introducing the ſaw behind, and cutting away the ſame to a certain diſtance farther under; and, by repeating this, the whole of the picture will at length be freed, and left on the bearer. Each time the bearer is removed, and, as it were, rolled on the vertical ſurface of the wall, care muſt be taken to turn and nail the ſecuring-canvas on the top and bottom edges of the bearer, ſo as to ſecure the freed plaſtering and picture from moving about; and, laſtly, before the bearer and plaſtering be moved, to nail the other edge of the picture in the ſame way, which will ſecure the whole to the bearer. This done, the picture and bearer are at liberty to be moved to a proper place, in order to be freed from the remaining plaſter. The edges may then be unnailed; the painting and canvas ſlipped from this bearer on to a plain board; and the new canvas may be then put on; which is to remain till dry, as in other caſes.

“ It may appear, that the bending of the canvas and plaſtering to the convex bearer will crack the plaſter, and damage the painting; but, from experience (ſays Mr Salmon) I have obſerved, that, to a curve of ſuch or even leſs radius, plaſtering will bend, without any viſible crack, even on the exterior part thereof; and that part next the bearer, not having occaſion, in bending, to extend its parts, will conſequently be much leſs liable to be diſturbed by ſuch bending.”

In clearing the wood from the paintings, our author never made uſe of aquafortis, or any other liquid; the uſe of which he conceives would be very tedious, and attended with danger, leſt it ſhould get through the paint, and wet or damp the paſte by which the ſecuring canvaſs is fixed. In working off the wood, he generally made uſe of ſuch planes as by the joiners are called the *levelled rabbit-plane*, and *ſmall rounds*. By the corners of the former, and proper handling of the latter, the wood is cleared off without force or violence: even the ſmalleſt particles may, in general, be got off; although in ſome paintings, and in particular parts of others, he has met with places on which he thought it beſt to leave ſome particles, or fine ſplinters, of wood, but nothing more. Raſps, and ſometimes a fine chiſel, are uſeful, to clear off ſuch parts as may be in hollow places, or where particles of wood are left, as above. The time required will be various, according to the manner in which the painting was originally done; ſome being painted on boards previouſly prepared with a water colour; others immediately painted with oil on the wood. This laſt ſort is by much the moſt difficult; the other is more eaſy, as the previous preparation prevents the wood from imbibing the oil, and conſequently admits it to be more eaſily ſeparated.

PALILICUM, the ſame as Aldebaran, a fixed ſtar of the firſt magnitude, in the eye of the bull, or ſign Taurus.

PALLIFICATION, or Piling, in architecture, denotes the piling of the ground-work, or the ſtrengthening it with piles, or timber driven into the ground; which is practiſed when buildings are erected upon a moiſt or marſhy ſoil.

PALM, an ancient long meaſure, taken from the extent of the hand. See Palmus, *Encycl.*

PALMÆ, palms. See *Encyclopædia*. The ſubject is introduced here to notice a kind of palm, the product of North America, of which we have the following account by Dr Barton.

“ There grows upon the river Mobile a ſpecies of palm, which is but little known to naturaliſts, but which promiſes to be an important article of food to man. It has no ſtalk or ſtem above ground. The leaves ſpread regularly all round, and when fully expanded are flabelliform. In the centre of theſe leaves is produced the receptacle of the fruit, which is of the form and ſize of a common ſugar-loaf. This receptacle conſiſts of a vaſt number of drupes, or berries, of the ſize and ſhape of common plums: each is covered with a fibrous, farinaceous, pulpy coating, of conſiderable thickneſs. This ſubſtance is ſaid to reſemble manna in texture, colour, and taſte; or, perhaps, it ſtill more reſembles moiſt brown ſugar, with particles of loaf ſugar mixed with it. It is a moſt delicious and nouriſhing food, and is diligently ſought after in the places where it grows. Upon firſt taſting it, it is ſomewhat bitter and pungent.

PANORAMA, a word derived from παν and οραμα; and therefore employed of late to denote a painting, whether in oil or water colours, which repreſents an entire view of any country, city, or other natural objects, as they appear to a perſon ſtanding in any ſituation, and turning quite round. To produce this effect, the

the painter or drawer muſt fix his ſtation, and delineate correctly and connectedly every object which preſents itſelf to his view as he turns round, concluding his drawing by a connection with where he began. He muſt obſerve the lights and ſhadows, how they fall, and perfect his piece to the beſt of his abilities. There muſt be a circular building or framing erected, on which this drawing or painting may be performed; or the ſame may be done on canvas, or other materials, and fixed or ſuſpended on the ſame building or framing, to anſwer the purpoſe complete. It muſt be lighted entirely from the top, either by a glazed dome, or otherwiſe as the artiſt may think proper. There muſt be an incloſure within the ſaid circular building or framing, which ſhall prevent an obſerver going too near the drawing or painting, ſo as it may, from all parts it can be viewed, have its proper effect. This incloſure may repreſent a room, or platform, or any other ſituation, and may be of any form thought moſt convenient; but the circular form is particularly recommended. Of whatever extent this inſide incloſure may be, there muſt be over it (ſupported from the bottom, or ſuſpended from the top) a ſhade or roof; which, in all directions, ſhould project ſo far beyond this incloſure, as to prevent an obſerver from ſeeing above the drawing or painting when looking up; and there muſt be without this incloſure another interception, to repreſent a wall, paling, or other interception, as the natural objects repreſented, or fancy, may direct, ſo as effectually to prevent the obſerver from ſeeing below the bottom of the drawing or painting; by means of which interception, nothing can be ſeen on the outer circle but the drawing or painting intended to repreſent nature. The entrance to the inner incloſure muſt be from below, a proper building or framing being erected for that purpoſe, ſo that no door or other interruption may diſturb the circle on which the view is to be repreſented. And there ſhould be, below the painting or drawing, proper ventilators fixed, ſo as to render a current circulation of air through the whole; and the inner incloſure may be elevated, at the will of an artiſt, ſo as to make obſervers, on whatever ſituation he may wiſh they ſhould imagine themſelves, feel as if really on the very ſpot.

1800.

PAPER is an article of ſuch importance, and at preſent* of ſo enormous a price, that no improvement in its manufacture ſhould paſs unnoticed in a work of this nature. The diſcovery made in France by M. Bertholet of the efficacy of oxy-muriatic acid in expediting the proceſs of BLEACHING (ſee that article in this *Suppl.*), has contributed eſſentially to facilitate the manufactures, not only of cotton and linen cloths, but alſo of paper, of which it has even increaſed the materials. Formerly writing paper could be made of *unprinted* linen alone; but by means of the proceſs of M. Bertholet even printed linen may be made into the fineſt and whiteſt paper. In the year 1795 a patent was granted to Mr Elias Carpenter of Bermondſay, Surrey, for a method of bleaching paper of ſuch materials in the *water-leaf* or *ſheet*, and ſizing it without drying:

In the preparation of the pulp, the coarſer rags are to be macerated for two or three days in a cauſtic alkaline ley, and wrought into ſheets of paper in the uſual way; a ſtrong wooden box or trough is then to be procured, of a ſize proportioned to that of the paper, lined on the inſide with white paint, and furniſhed with ſeveral ſtages of croſs bars of glaſs: the bottom of the box is to be covered with a ſtratum about one inch deep of cauſtic ley, and the paper laid by quarter reams, or leſs, acroſs the glaſs bar. A hole muſt be made in the box to admit the beak of an earthen-ware retort, into which muſt be put manganeſe and ſea ſalt, in powder, ſulphuric acid, and an equal quantity of water impregnated with the ſteams of burning ſulphur (ſulphureous acid). The cover of the box is to be made air-tight by luting or ſlips of paper dipped in paſte. The apparatus being thus prepared, the belly of the retort is to be plunged in water, kept boiling, and in a ſhort time the oxy-muriatic gas will be driven into the box, will penetrate the paper, and render it of a dazzling whiteneſs, while the alkaline ley at the bottom will, by gradually abſorbing it, prevent its becoming ſo concentrated as to deſtroy or injure the texture of the paper. From three to four pounds of ſulphuric acid will ſuffice for one hundred weight of paper, and the operation will be completed in about eight hours. The ſheets as they are taken out of the box are to be ſized with the following mixture:

To 1 cwt. of clippings of ſkin add 14lb. of alum, 7 of calcined vitriol, and 1 lb. of gum arabic, with a ſufficient quantity of water to ſize 50 reams of fools-cap.

The ſame method will ſerve equally well to clean engravings or printing; for though the oxy-muriatic acid diſcharges all ſtains, dirt, &c. yet it is incapable of acting on printers ink.

This, however, is not the only improvement in the manufacture of paper derived from modern chemiſtry. In Crell's *Chemical Annals* for the year 1797, we have an account of ſome curious experiments made by M. L. Brugnatelli, with the view of rendering

Paper.

PAPER incombuſtible, and the writing on it, of courſe, indeſtructible by fire. Of all the ſubſtances which he tried, he found the liquor of flints the moſt proper to ſecure paper from deſtruction by fire. He dipped a ſheet of paper ſeveral times in the above liquor freſh made, or daubed it ſeveral times over the whole paper with a hair bruſh, and dried it in the ſun or in an oven. Paper prepared in this manner loſt ſome of its ſoftneſs, became a little rougher than before, and acquired a lixivious cauſtic taſte. In other reſpects it was not different from common white paper. When this paper was laid upon glowing coals, it did not burn like common paper, but became red, and was converted to a coal, which however did not fall into aſhes like the coal of common paper, ſo that it might therefore be conſidered as petrified paper. This coal, however, is exceedingly friable; for when it is taken between the fingers, or preſſed together in any manner whatever, it drops to pieces. Still the diſcovery muſt be a valuable one, if there be any kind of ink of ſuch a nature as that the characters written with it continue viſible on this coal. Such an ink M. Brugnatelli made by combining diſſolved nitrite of zinc with common ink; and found, that the colour of this mixture, though it appeared ſomewhat pale on common paper, became ſo dark on prepared paper, that words written with it appeared more conſpicuous than words written with common ink. When the paper was burnt, or reduced to a coal, thoſe characters were ſo viſible, in a clear *white* colour on a *dark* ground, that they could be read with as much eaſe as characters written with the beſt ink on white

white paper. If the ingenious author ſucceed in his attempts to diſcover a method of rendering his prepared paper leſs friable when burnt, his diſcovery will be one of the moſt important of the preſent age.

PARABOLIC Conoid, is a ſolid generated by the rotation of a parabola about its axis. This ſolid is equal to half its circumſcribed cylinder; and therefore if the baſe be multiplied by the height, half the product will be the ſolid content.

Parabolic Pyramidoid, is a ſolid figure, thus named by Dr Wallis from its geneſis or formation, which is thus: Let all the ſquares of the ordinates of a parabola be conceived to be ſo placed, that the axis ſhall paſs perpendicularly through all their centres; then the aggregate of all theſe planes will form the parabolic pyramidoid. This figure is equal to half its circumſcribed parallelopipedon. And therefore the ſolid content is found by multiplying the baſe by the altitude, and taking half the product; or the one of theſe by half the other.

Parabolic Space, is the ſpace or area included by the curve line and baſe or double ordinate of the parabola.

Parabolic Spindle, is a ſolid figure conceived to be formed by the rotation of a parabola about its baſe or double ordinate.

Parabolic Spiral, is a curve ariſing from the ſuppoſition that the common or Apollonian parabola is bent or twiſted till the axis come into the periphery of a circle, the ordinates ſtill retaining their places and perpendicular poſitions with reſpect to the circle, all theſe lines ſtill remaining in the ſame place. This figure is ſometimes called the *Helicoid parabola*.

PARABOLOIDES, parabolas of the higher orders. The equation for all curves of this kind being $a^{m-n}x^{n}=y^{m}$, the proportion of the area of any one to the complement of it to the circumſcribing parallelogram, will be as *m* to *n*.

PARACENTRIC Motion, denotes the ſpace by which a revolving planet approaches nearer to, or recedes farther from, the ſun, or centre of attraction.

Paracentric Solicitation of Gravity, is the ſame as the vis centripeta.

PARACHUTE, a kind of large and ſtrong umbrella, contrived to break a perſon's fall from an air-balloon, ſhould any accident happen to the balloon at a high elevation. This contrivance was firſt thought of by Blanchard, who at different times, by means of the parachute, let fall from his balloon dogs and other animals. He ventured even to deſcend in this manner himſelf; but, whether from the bad conſtruction of his parachute, or from falling among trees, he had the misfortune to break one of his legs. Citizen Garnerin, as he chooſes to be called, was more ſucceſsful. On the 21ſt of October 1797, he aſcended from the garden de Mauſſeux at half paſt five in the evening; between the balloon and the car, in which he ſat, was placed the parachute, half opened, and forming a kind of tent over the aërial traveller; and when the whole apparatus was at a conſiderable height, he ſeparated the parachute and car from the balloon. The parachute unfolding itſelf, was, by his weight and that of the car, drawn of courſe towards the earth. Its fall was at firſt ſlow and vertical; but ſoon afterwards it exhibited a kind of balancing or vibration, and a rotation gradually increaſing, which might be compared with that of a leaf falling from a tree. The aëronaut, however, reached the ground unhurt.

This parachute was of cloth, and its diameter, when unfolded, about twenty-five feet. To uſe ſuch inſtruments with ſucceſs, it is neceſſary that the car be ſuſpended at a conſiderable diſtance from the parachute, ſo as that the centre of gravity of the whole ſhall be vertically below the centre of reſiſtance made by the air to the deſcent of the parachute; for if the car be otherwiſe placed, it is evident that the parachute will incline to one ſide, deſcend obliquely, oſcillate, and the ſmalleſt irregularity in its figure will cauſe it to turn round its vertical axis.

PARAGUATAN, a kind of wood which grows in Guiana, and promiſes to be of great utility as a dye ſtuff. We have ſeen no botanical deſcription of the tree; but from the report made to the Council of Trade and Mines, by D. Dominique Garcia Fernandez, inſpector of coinage, we learn that its bark, boiled in water, affords a coloured extract which reſiſts the agency of acids for a longer time than brazil or logwood; that the colour may be revived by means of alkalies, after it has been deſtroyed by combination with acids; that vinegar, lemon-juice, and tartar, render this colour more brilliant, while they entirely deſtroy the colours of brazil and logwood; that the fecula of the bark of paraguatan fixes and attaches itſelf to wool, cotton, and ſilk; and that the colour is brighter on ſilk than on wool, and brighter on wool than on cotton. The ſame fecula dried is afterwards ſoluble in alcohol, to which it communicates a tinge ſimilar to that afforded by cochineal; but it muſt be confeſſed, that the colour obtained from paraguatan has not the force of that of cochineal, though it is ſuperior to thoſe of madder, brazil wood, and logwood. From theſe facts D. Fernandez conſiders the paraguatan as one of the moſt valuable productions which America furniſhes to Spain.

PARALLAX (ſee *Encycl.*) is uſed, not only in aſtronomy, but alſo in levelling. for the angle contained between the line of true level, and that of apparent level. And, in other branches of ſcience, for the difference between the true and apparent places.

PARALLEL Ruler, is a mathematical inſtrument, conſiſting of two equal rulers, either of wood or metal, connected together by two ſlender croſs bars or blades of equal length, moveable about the points of junction with the rulers. There are other forms of the inſtrument; ſome, for inſtance, having the two blades croſſing in the middle, and fixed only at one end of them, the other two ends ſliding in grooves along the two rulers, &c.

The uſe of this inſtrument is obvious. For the edge of one of the rulers being applied to any line, the other opened to any extent will be always parallel to the former; and conſequently any parallels to this may be drawn by the edge of the ruler, opened to any extent.

PARALLELS, or Places of Arms, in a ſiege, are deep trenches, 15 or 18 feet wide, joining the ſeveral attacks together; and ſerving to place the guard of the trenches in, to be at hand to ſupport the workmen when attacked. There are uſually three in an attack: the firſt is about 600 yards from the covert-way, the ſecond between 3 and 400, and the third near or on ralleliſm ‖ Paramaribo

Paramaribo.

the glacis. It is ſaid they were firſt invented or uſed by Vauban.

PARALLELISM of the Earth's Axis, is that invariable ſituation of the axis, in the progreſs of the earth thro' the annual orbit, by which it always keeps parallel to itſelf; ſo that if a line be drawn parallel to its axis, while in any one poſition, the axis, in all other poſitions or parts of the orbit, will always be parallel to the ſame line.

PARAMETER, a certain conſtant right line in each of the three conic ſections; otherwiſe called alſo *latus rectum*.

PARAMARIBO, the capital of the Dutch ſettlement at Surinam, is ſituated on the right ſide of the beautiful river Surinam, at about 16 or 18 miles diſtance from its mouth. It is built upon a kind of gravelly rock, which is level with the reſt of the country, in the form of an oblong ſquare; its length is about a mile and a half, and its breadth about half as much. All the ſtreets, which are perfectly ſtraight, are lined with orange, ſhaddock, tamarind, and lemon trees, which appear in everlaſting bloom; while, at the ſame time, their branches are weighed down with the richeſt cluſters of odoriferous fruit. Neither ſtone nor brick is made uſe of here for pavement; the whole being one continued gravel, not inferior to the fineſt garden walks in England, and ſtrewed on the ſurface with ſea ſhells. The houſes, which are moſtly of two and ſome of three ſtories high, are all built of fine timber, a very few excepted; moſt of the foundations are of brick, and they are roofed with thin ſplit boards, called *ſhingles*, inſtead of ſlates or tiles. Windows are very ſeldom ſeen in this country, glaſs being inconvenient on account of the heat; inſtead of which they uſe gauze frames: ſome have only the ſhutters, which are kept open from ſix o'clock in the morning until ſix at night. As for chimneys, there are none in the colony; no fires being lighted except in the kitchens, which are always built at ſome diſtance from the dwelling houſe, where the victuals are dreſſed upon the floor, and the ſmoke let out by a hole made in the roof: theſe timber houſes are, however, very dear in Surinam, one of them having coſt above L. 15,000 ſterling. There is no ſpring water to be met with in Paramaribo; moſt houſes have wells dug in the rock, which afford but a brackiſh kind of beverage, only uſed for the negroes, cattle, &c. and the Europeans have reſervoirs or ciſterns, in which they preſerve rain-water for their own conſumption; thoſe of nicer taſte let it firſt drop through a filtering-ſtone into large jars or earthen pots, made by the native Indians on purpoſe, which they barter at Paramaribo for other commodities. The inhabitants of this country, of every denomination, ſleep in hammocks, the negro ſlaves excepted, who moſtly lie on the ground: the hammocks uſed by thoſe in ſuperior ſtations are made of cotton, ornamented with rich fringe; theſe are alſo made by the Indians, and ſometimes worth above twenty guineas; neither bedding nor covering is neceſſary, except an awning to keep off the muſquitoes. Some people indeed lie on bedſteads; in that caſe they are ſurrounded, inſtead of curtains, with gauze pavilions, which admit the air freely, and at the ſame time keep off the ſmalleſt inſect. The houſes in general at Paramaribo are elegantly furniſhed with paintings, gilding, cryſtal chandeliers, china jars, &c.; the rooms are never papered or plaſtered, but beautifully wainſcotted with cedar, and Brazil, and mahogany wood.

The number of buildings in Paramaribo is computed at about 1400, of which the principal is the governor's palace, whence there is a private paſſage through the garden which communicates with Fort Zelandia. This houſe, and that of the commandant, which has lately been burnt, were the only brick buildings in the colony. The town-hall is an elegant new building, and covered with tiles; here the different courts are held, and underneath are the priſons for European delinquents, the military excepted, who are confined in the citadel of Fort Zelandia. The Proteſtant church, where divine worſhip is performed both in French and Low Dutch, has a ſmall ſpire with a clock; beſides which there is a Lutheran chapel, and two elegant Jewiſh ſynagogues, one German the other Portugueſe. Here is alſo a large hoſpital for the garriſon, and this manſion is never empty. The military ſtores are kept in the fortreſs, where the ſociety ſoldiers are alſo lodged in barracks, with proper apartments for ſome officers. The town of Paramaribo has a noble road for ſhipping, the river before the town being above a mile in breadth, and containing ſometimes above 100 veſſels of burden, moored within a piſtol-ſhot of the ſhore. Before Holland became a province of France, and thereby loſt her trade, there were ſeldom fewer than 80 ſhips at Paramaribo, loading coffee, ſugar, cocao, cotton, and indigo, for the mother country, including alſo the Guinea-men that bring ſlaves from Africa, and the North American and Leeward Iſland veſſels, which bring flour, beef, pork, ſpirits, herrings, and mackarel ſalted, ſpermaceti candles, horſes, and lumber; for which they receive chiefly molaſſes to be diſtilled into rum. This town is not fortified, but is bounded by the river on the ſouth-eaſt; by a large ſavannah on the weſt; by an impenetrable wood on the north-eaſt; and is protected by Fort Zelandia on the eaſt. This citadel is only ſeparated from the town by a large eſplanade, where the troops parade occaſionally. The fort is a regular pentagon, with one gate fronting Paramaribo, and two baſtions which command the river; it is very ſmall but ſtrong, being made of rock or hewn ſtone, ſurrounded by a broad foſſe well ſupplied with water, beſides ſome outworks. On the eaſt ſide, fronting the river, is a battery of 21 pieces of cannon. On one of the baſtions is a bell, which is ſtruck with a hammer by the centinel, who is directed by an hour-glaſs. On the other is planted a large enſign-ſtaff, upon which a flag is hoiſted upon the approach of ſhips of war, or on public rejoicing days. The walls are ſix feet thick, with embraſures, but no parapet.

Paramaribo is a very lively place, the ſtreets being generally crowded with planters, ſailors, ſoldiers, Jews, Indians, and Negroes, while the river is covered with canoes, barges, &c. conſtantly paſſing and repaſſing like the wherries on the Thames, often accompanied with bands of muſic; the ſhipping alſo in the road adorned with their different flags, guns firing, &c not to mention the many groupes of boys and girls playing in the water, altogether form a pleaſing appearance; and ſuch gaiety and variety of objects ſerve, in ſome meaſure, to compenſate for the many inconveniences of the climate. Their carriages and dreſs are truly magnificent; ſilk embroidery, Genoa velvets, diamonds, gold and ſilver

Paramaribo, Paris.

lace, being daily worn, and even the maſters of trading ſhips appears with buttons and buckles of ſolid gold. They are equally expenſive at their tables, where every thing that can be called delicate is produced at any price, and ſerved up in plate and china of the neweſt faſhion, and moſt exquiſite workmanſhip. But nothing diſplays the luxury of the inhabitants of Surinam more than the number of ſlaves by whom they are attended, often twenty or thirty in one family. White ſervants are ſeldom to be met with in this colony.

The current money are ſtamped cards of different value, from five ſhillings to fifty pounds: gold and ſilver is ſo ſcarce, that the exchange premium for ſpecie is often above 10 *per cent.* A baſe Dantzic coin called a *bit*, value ſomething leſs than ſixpence, is alſo current in Surinam. Engliſh and Portugueſe coin are ſometimes met with, but moſtly uſed as ornaments by the Mulatto, Samboe, Quaderoon, and Negro girls. The Negro ſlaves never receive any paper money; for as they cannot read, they do not underſtand its value; beſides, in their hands it would be liable to many accidents, from fire or children, and particularly from the rats, when it becomes a little greaſy.

This town is well ſupplied with proviſions, *viz.* butchers meat, fowls, fiſh, and veniſon. Vegetables in particular the country abounds with; beſides the luxuries peculiar to this climate, they import whatever Europe, Africa, and Aſia can afford. Proviſions, however, are exceſſively dear in general, eſpecially thoſe imported, which are moſtly ſold by the Jews and maſters of ſhips. The firſt enjoy extraordinary privileges in this colony; the latter erect temporary warehouſes for the purpoſe of trade, during the time their ſhips are loading with the productions of the climate. Wheat flour is ſold from four-pence to one ſhilling per pound; butter, two ſhillings; butcher's meat never under one ſhilling, and often at one ſhilling and ſixpence; ducks and fowls from three to four ſhillings a couple. A ſingle turkey has ſometimes coſt one guinea and a half; eggs are ſold at the rate of five, and European potatoes twelve, for ſixpence. Wine three ſhillings a bottle. Jamaica rum a crown a gallon. Fiſh and vegetables are cheap, and fruit almoſt for nothing.

PARIS (Francis), a man more famous after his death than during his life, by the miracles which were ſaid to be performed at his tomb. He is generally known by the name of Abbé Paris; and his pretended miracles, with others of like manufacture, have furniſhed deiſtical writers, and Mr Hume in particular, with a kind of argument againſt the reality of the miracles of which we have an account in the Goſpel. It is merely that we may ſtate his pretenſions fairly, that we have introduced him to the notice of our readers; for in every other reſpect he is wholly unworthy of their regard. He was the ſon of a counſellor in Parliament, and had the proſpect, if he had choſen it, of ſucceeding to his father's appointment; but he choſe rather to become an eccleſiaſtic, and he became a very zealous one. He gave up all his poſſeſſions to his brother, refuſed preferment intended for him by the cardinal de Noailles, devoted himſelf entirely to retirement, and made ſtockings for his own ſupport, and for the aſſiſtance of the poor. He died, perhaps in conſequence of his rigorous mode of life, May 1. 1727, at the age of only 37. His brother raiſed a monument to him in the ſmall churchyard of St Medard, to which the poor and the pious ſoon began to flock; and after a time it was reported, that, in conſequence of their prayers at that tomb, ſome ſick perſons had received cures. As Paris had been a rigorous Janſeniſt, this was a fine opportunity for that ſect to gain credit to their cauſe; the miracles were therefore multiplied, and a variety of perſons affected the moſt ſingular convulſions.

Paris.

The minds of the people becoming inflamed by theſe extravagancies, the court found it neceſſary to ſhut up the churchyard, which was done on the 27th of January 1732. On this occaſion, ſome profane wit wrote upon the wall of the place,

> De par le Roy, defenſe a Dieu,
> De faire miracles en ce lieu.

The convulſions were continued, for a little while, in private houſes, but by degrees the matter ſubſided, and the Abbé Paris was forgotten.

The diſtinction between miracles exhibited to ſerve a party, and atteſted only by thoſe who are zealous in its ſupport, and miracles performed in the ſight of unbelievers, who, in ſpite of their deep-rooted prejudices, were converted by them, is too ſtriking to be overlooked by any, but thoſe who are deſirous of drawing a falſe and impious parallel; yet has Mr Hume dared to repreſent the miracles performed at the tomb of this ſaint as outvying in number, nature, and evidence, the miracles of Chriſt and his apoſtles—with what truth, the following obſervations will ſhew:

1*ſt*, It was often objected by the enemies of the ſaint, and the objection was never confuted by his friends, that the *proſtrations* at his ſepulchre, like animal magnetiſm more lately, *produced* more diſeaſes than they *cured*. Such, ſurely, was not the nature of our Saviour's miracles.

2*dly*, Though the crowds of ſick and infirm perſons who flocked to the tomb for relief were, by all accounts, innumerable; yet all the cures, of which the zealous hiſtorian of the Miracles could procure vouchers, amounted only to NINE! Now, were thouſands, and ten thouſands of diſeaſed perſons to apply to ſome circumforaneous quack, in full aſſurance of his extraordinary abilities and ſkill in phyſic, could it ſurpriſe any perſon, if the diſtempers of *eight* or *nine* of them ſhould take a favourable turn while they were under a courſe of his uſeleſs medicines?

3*dly*, We do not read that of thoſe nine who were cured by the dead Abbé, the greater part were Jeſuits and enemies to the Janſeniſts; whereas the greater part of our Saviour's miracles were performed upon unconverted Jews, and one of them upon the ſervant of the high prieſt, who was thirſting for his blood.

4*thly*, The cures reported to have been performed at the grave of Paris were all ſuch as might have been accompliſhed by natural means. Thus, a Spaniard who had loſt one eye, and was diſtreſſed with an inflammation in the other, had the inflamed eye gradually cured, but not the loſt eye reſtored. Another perſon having pricked his eye with an awl, loſt the ſight of it in conſequence of the aqueous humour dropping out; but his ſight was reſtored *whilſt* he was paying his devotions to the Abbé—and ſo it would have been while he was curſing the Abbé, had he continued his execrations for a ſufficient length of time.

5*thly*,

5thly, None of the cures ſaid to have been performed were *inſtantaneous*. *All* the worſhippers at the tomb perſiſted for *days*, ſeveral of them for *weeks*, and ſome for *months*, daily imploring the interceſſion of the Abbé *before* they received relief from their complaints.

6thly, Moſt of the devotees had been uſing *medicines* before they applied to the ſaint, and continued to uſe them *during the whole time* of their application; whilſt it is confeſſed that the diſtempers of others had *abated* before they determined to ſolicit his help.

7thly, Some of the cures atteſted were *incomplete*, and only of a temporary duration. Thus, the Spaniard was relieved only from the moſt inconſiderable part of his complaint, and that too but for a very ſhort period; for ſoon after his return home he relapſed into his former malady, as was fully atteſted by certificates and letters from Madrid. All this has been completely proved by the Archbiſhop of Sens; who in his *Paſtoral Inſtruction*, publiſhed at the time the miracles were making a noiſe, has,

8thly, Clearly detected the deceit and little artifices by which theſe pretended miracles were ſo long ſupported. To that work we refer our readers; requeſting them, after they have read it, to compare the evidence for the miracles of Paris with the evidence which in the article MIRACLE (*Encycl.*) we have ſtated for the reality of the Goſpel miracles, and to judge for themſelves with the impartiality of philoſophers.

Paris wrote a few very indifferent books of annotations on the Epiſtles to the Romans, to the Galatians, and the Hebrews; but few have ever read them, nor would they have reſcued the author from oblivion, without the aid of his lying wonders.

PARKHURST (the Rev. John), was the ſecond ſon of John Parkhurſt, Eſq; of Cateſby in Northamptonſhire. His mother was Ricarda Dormer, daughter of Judge Dormer. He was born in June 1728, was educated at the ſchool of Rugby in Warwickſhire, and was afterwards of Clare-hall, Cambridge; B. A. 1748, M. A. 1752; and many years fellow of his college.

Being a younger brother, he was intended for the church; but not long after his entering into holy orders his elder brother died. This event made him the heir of a very conſiderable eſtate; though, as his father was ſtill living, it was ſome time before he came into the full poſſeſſion of it; and when he did come into the poſſeſſion of it, the acquiſition of fortune produced no change on his manners or his purſuits. He continued to cultivate the ſtudies becoming a clergyman; and from his family connections, as well as from his learning and piety, he certainly had a good right to look forward to preferment in his profeſſion; but betaking himſelf to retirement, and to a life of cloſe and intenſe ſtudy, he ſought for no preferment; and, according to the author of the biographical ſketch of him publiſhed in the Gentleman's Magazine, he lived not in an age when merit was urged forward. Yet, in the capacity of a curate, but without any ſalary, he long did the duty, with exemplary diligence and zeal, in his own chapel at Cateſby, which, after the demolition of the church of the nunnery there, ſerved as a pariſh-church, of which alſo he was the patron.

When, ſeveral years after, it fell to his lot to exerciſe the right of preſentation, he was ſo unfaſhionable as to conſider church-patronage as a truſt rather than a property; and, accordingly, reſiſting the influence of intereſt, favour, and affection, preſented to the vicarage of Epſom, in Surrey, the Rev. Jonathan Boucher, who ſtill holds it. This gentleman was then known to him only by character; but having diſtinguiſhed himſelf in America, during the revolution, for his loyalty, and by teaching the unſophiſticated doctrines of the church of England to a ſet of rebellious ſchiſmatics at the peril of his life, Mr Parkhurſt thought, and juſtly thought, that he could not preſent to the vacant living a man who had given better proofs of his having a due ſenſe of the duties of his office.

In the year 1754, Mr Parkhurſt married Suſanna Myſter, daughter, and, we believe, heireſs of John Myſter, Eſq; of Epſom. It was thus that he became patron of the living which he beſtowed on Mr Boucher. This lady died in 1759, leaving him a daughter and two ſons; both the ſons are now dead. In the year 1761, he married again Millicent Northey, daughter of Thomas Northey, Eſq; by whom he had one daughter, now married to the Rev. Joſeph Thomas.

In the year 1753, he began his career of authorſhip, by publiſhing, in 8vo, "A friendly Addreſs to the Rev. Mr John Weſley, in relation to a principal Doctrine maintained by him and his Aſſiſtants." This work we have not ſeen; but though we have no doubt of its value, we may ſafely ſay that it was of very little importance, when compared with his next publication, which was "An Hebrew and Engliſh Lexicon, without Points; to which is added, a methodical Hebrew Grammar, without Points, adapted to the uſe of Learners, 1762," 4to. To attempt a vindication of all the etymological and philoſophical diſquiſitions which are ſcattered through this dictionary, would be very fruitleſs; but it is not perhaps too much to ſay, that we have nothing of the kind equal to it in the Engliſh language. He continued, however, to correct and improve it; and in 1778 another edition of it came out much enlarged, and a third in 1792.

His philological ſtudies were not confined to the Hebrew language; for he publiſhed a Greek and Engliſh Lexicon to the New Teſtament; to which is prefixed, a plain and eaſy Greek Grammar, 1769, 4to; a ſecond edition, 1794: and at his death there was in the preſs a new edition of both theſe lexicons, in a large 8vo, with his laſt corrections; for he continued to reviſe, correct, add to, and improve, theſe works, till within a few weeks of his death. As, from their nature, there cannot be ſuppoſed to be any thing in dictionaries that is particularly attractive and alluring, this continued increaſing demand for theſe two ſeems to be a ſufficient proof of their merit.

He publiſhed, "The Divinity and Pre-exiſtence of our Lord and Saviour Jeſus Chriſt, demonſtrated from Scripture; in Anſwer to the firſt Section of Dr Prieſtley's Introduction to the Hiſtory of early Opinions concerning Jeſus Chriſt; together with Strictures on ſome other Parts of the Work, and a Poſtſcript relating to a late Publication of Mr Gilbert Wakefield, 1787," 8vo. This work was very generally regarded as completely performing all that its title-page promiſed; and accordingly the whole edition was ſoon ſold off. The brief, evaſive, and very unſatisfactory notice taken of this able pamphlet by Dr Prieſtley, in "A

Parkhurſt.

Letter to Dr Horne," &c. ſhewed only that he was unable to anſwer it.

Mr Parkhurſt was a man of very extraordinary independency of mind and firmneſs of principle. In early life, along with many other men of diſtinguiſhed learning, it was alſo objected to him, that he was an Hutchinſonian; and on this account alone, in common with them, it has been ſaid that he was neglected and ſhunned.

There is not, in the hiſtory of the times, ſays the biographer already quoted, a circumſtance more difficult to be accounted for than the unmerited, but increaſing, diſcountenance ſhewn to thoſe perſons to whom Hutchinſonianiſm was then objected. Methodiſts, Papiſts, and ſectaries of any and of every name, all ſtood a better chance of being noticed and eſteemed than Hutchinſonians. Had it even been proved that the few peculiar tenets by which they were diſtinguiſhed from other Chriſtians were erroneous, the oppoſition they experienced might have been deemed *hard meaſure*, becauſe even their opponents allowed their principles to be inoffenſive, and themſelves to be learned.

Is this a fair ſtate of the caſe? We think not. The early Hutchinſonians had imbibed all the peculiar notions of their maſter, and maintained them with a degree of acrimony which would have diſgraced any cauſe. Being in general very little acquainted with the higher mathematics, as Mr Hutchinſon himſelf ſeems likewiſe to have been, they cenſured dogmatically works which, without that knowledge, they could not fully underſtand; whilſt they maintained, with equal dogmatiſm, as matters of fact, hypotheſes, which a moderate ſhare of mathematical ſcience would have ſhewn them to be impoſſible. Had they ſtopt here, no harm would have been done; they might have enjoyed their favourite notions in peace: but unfortunately they accuſed of Atheiſm, Deiſm, or Socinianiſm, all who thought not exactly as *they* thought, both in natural philoſophy and in theology. Becauſe Newton and Clarke had demonſtrated that the motions of the planets cannot be the effect of the impulſion of any material fluid, Hutchinſon, with ſome of his followers, affirmed, that theſe two illuſtrious men had entered into a ſerious deſign to overturn the Chriſtian religion, and eſtabliſh in England the worſhip of the Heathen Jupiter, or the Stoical *anima mundi*. Becauſe the Biſhops Pearſon, Bull, and others, who had uniformly been conſidered as the ableſt defenders of the Catholic faith, thought not exactly as Hutchinſon thought of the filiation of the Son of God, they were condemned by the pupils of his ſchool as *Arians*, or at leaſt *Semi-arians;* and the writer of this ſketch has heard a living Hutchinſonian pronounce the ſame cenſure, and for the ſame reaſon, on the preſent illuſtrious Biſhop of Rocheſter, and the no leſs illuſtrious Whitaker.

That men, who thus condemned all that before them had been deemed great and good in phyſical ſcience and Chriſtian theology, ſhould meet with ſome diſcountenance while they continued of ſuch a ſpirit, needs not ſurely excite much wonder; but that the diſcountenance is increaſing, we believe not to be true. The Hutchinſonians, as ſoon as they became leſs violent againſt thoſe who differed from them, had their ſhare of preferment, in proportion to their number, with others; and we doubt not they will continue to have it, while they allow that a man may be no heretic, though he believe not Mr Hutchinſon to have been infallible. The late excellent Biſhop Horne was an avowed Hutchinſonian, though not an outrageous one like Julius Bate; and we have been told, and have reaſon to believe, that the Biſhop of St Aſaph is likewiſe a moderate favourer of the ſame ſyſtem. There may be others on the epiſcopal bench; but perhaps two out of twenty-ſix is the full proportions of Hutchinſonian divines of eminence in England. It is true that Mr Parkhurſt was a man of great learning and great worth; but before we attribute his want of preferment in the church to his Hutchinſonianiſm, it is incumbent upon us to ſay why Mr Whitaker, who is no Hutchinſonian, is ſtill nothing more than the rector of Ruan-Lanyhorne.

Mr Parkhurſt, however, was not, if his biographer deſerves credit, a thorough-paced Hutchinſonian; for though he continued to read Hutchinſon's writings as long as he read at all, he was ever ready to allow, that he was oftentimes a confuſed and bad writer, and ſometimes unbecomingly violent. To have been deterred from reading the works of an author, who, with all his faults, certainly throws out many uſeful hints, for fear of being thought a Hutchinſonian, would have betrayed a puſillanimity of which Mr Parkhurſt was incapable. What he believed he was not afraid to profeſs; and never profeſſed to believe any thing which he did not very ſincerely believe. An earneſt lover of truth, he ſought it where only it is to be found—in the Scriptures (A) The ſtudy of theſe was at once the buſineſs and the pleaſure of his life; from his earlieſt to his lateſt years, he was an hard ſtudent; and had the daily occupations of every 24 hours of his life been portioned out, as it is ſaid thoſe of king Alfred were, into three equal parts, there is reaſon to believe that a deficiency would rarely have been found in the eight hours allotted to ſtudy. What the fruits have been of a life ſo conducted, few theologians, it is preſumed, need to be informed, it being hardly within the ſcope of a ſuppoſition, that any man will now ſit down to the ſtudy of the Scriptures without availing himſelf of the aſſiſtance to be obtained from his learned labours. Theſe labours ceaſed at Epſom in Surrey, where this great and good man died, on March the 21ſt, 1797. Beſides the works which we have mentioned, there is in the Gentleman's Magazine, for Auguſt 1797, a curious letter of his on the Confuſion of Tongues at Babel.

Mr Parkhurſt's character may be collected with tolerable accuracy even from this imperfect ſketch of his life. His notions of church patronage do him honour; and as a farther inſtance of the high ſenſe he entertained

---

(A) This is vague language, which is the ſource of much uſeleſs controverſy, and therefore ought to be avoided. If by *truth*, in this paſſage, be meant *religious* truth, we admit the aſſertion in the only ſenſe in which we think it can have been made. If the author means *all* truth, he writes nonſenſe; for the Scriptures treat not of *geometry* or *algebra*, where truth is certainly to be found; and *we think* that they have a higher object than even *mechanics* and *aſtronomy*.

ed of ſtrict juſtice, and the ſteady reſolution with which he practiſed it on all occaſions, an incident which occurred between him and one of his tenants, within theſe ten years, may here be mentioned. This man falling behind hand in the payment of his rent, which was L. 500 *per annum*, it was repreſented to his landlord that it was owing to his being over rented. This being believed to be the caſe, a new valuation was made; and it was then agreed that, for the future, the rent ſhould not be more than L. 450. Juſtly inferring, moreover, that if the farm was *then* too dear, it muſt neceſſarily have been *always* too dear, unaſked, and of his own accord, he immediately ſtruck off L. 50 from the commencement of the leaſe; and inſtantly refunded all that he had received more than L. 450 *per annum*.

Mr Parkhurſt was in his perſon rather below the middle ſize, but remarkably upright, and firm in his gait. He was all his life of a ſickly habit: and his leading ſo remarkably ſtudious and ſedentary a life (it having, for many years, been his conſtant practice to riſe at five, and, in winter, to light his own fire) to the very verge of David's limits of the life of man, is a conſolatory proof to men of ſimilar habits, how much, under many diſadvantages, may ſtill be effected by ſtrict temperance and a careful regimen. He alſo gave leſs of his time to the ordinary interruptions of life than is common. In an hoſpitable, friendly, and pleaſant neighbourhood, he viſited little; alleging, that ſuch a courſe of life neither ſuited his temper, his health, nor his ſtudies. Yet he was of ſociable manners; and his converſation always inſtructive, often delightful: for his ſtores of knowledge were ſo large, that he too has often been called a walking library. He belonged to no clubs; he frequented no public places; and there are few men who, towards the cloſe of life, may not, on a retroſpect, reflect with ſhame and ſorrow, how much of their precious time has thus been thrown away, or, perhaps, worſe than thrown away.

Like many other men of infirm and ſickly frames, Mr Parkhurſt was alſo irritable, and quick, warm, and earneſt, in his reſentments, though never unforgiving. But whether it be or be not a matter of reproach to poſſeſs a mind ſo conſtituted, it certainly is much to any man's credit to counteract and ſubdue it by an attention to the injunctions of religion. This Mr Parkhurſt effectually did: and few men have paſſed through a long life more at peace with his neighbours, more reſpected by men of learning, more beloved by his friends, or more honoured by his family.

PARKINSON (John). Of this ingenious Engliſh botaniſt, one of the firſt and moſt induſtrious cultivators of that ſcience among us, the memorials that remain are very ſcanty. He was born in 1567, was bred an apothecary, and reſided in London. He roſe to ſuch reputation in his profeſſion as to be appointed apothecary to King James I.; and, on the publication of his Theatre of Plants, he obtained from the unfortunate ſucceſſor of that prince the title of *Botanicus Regis primarius*. The time of his death cannot be exactly aſcertained; but, as his Herbal was publiſhed in 1640, and it appears that he was living at that time, he muſt have attained his 73d year.

Parkinſon's firſt publication was, his 1. *Paradiſi in Sole Paradiſus terreſtris*, or, A Garden of all Sorts of Pleaſant Flowers which our Engliſh Ayre will permit to be nurſed up: with a Kitchen-garden of all manner of Herbes, Roots, and Fruits, for Meat or Sauſe, &c. &c. Collected by John Parkinſon apothecary, of London, 1629, folio, 612 pages. In this work the plants are arranged without any exact order: nearly 1000 plants are ſeparately deſcribed, of which 780 are figured on 129 tables, which appear to have been cut expreſsly for this work. Parkinſon was, it is conceived, the firſt Engliſh author who ſeparately deſcribed and figured the ſubjects of the flower garden; and this book is therefore a valuable curioſity, as exhibiting a complete view of the extent of the Engliſh garden at the beginning of the laſt century. It may, perhaps, be neceſſary to inform the reader, that Paradiſus in Sole, is meant to expreſs the author's name, *Park in-ſun*. 2. In 1640 he publiſhed his *Theatrum Botanicum*; or Theatre of Plants, or an Herbal of a large extent: containing therein, a more ample and exact Hiſtory and declaration of the Phyſical Herbs and Plants than are in other Authors, &c. &c. London, folio, 1746 pages. This work had been the labour of the author's life; and he tells us that, owing to "the diſaſtrous times," and other impediments, the printing of it was long retarded. Dr Pulteney is of opinion, that, allowing for the defects common to the age, Parkinſon will appear "more of an original author than Gerard or Johnſon, independent of the advantages he might derive from being poſterior to them. His theatre was carried on through a long ſeries of years, and he profited by the works of ſome late authors, which Johnſon, though they were equally in his power, had neglected to uſe. Parkinſon's deſcriptions, in many inſtances, appear to be new. He is more particular in pointing out the places of growth. Johnſon had deſcribed about 2850 plants, Parkinſon has near 3800. Theſe accumulations rendered the *Theatrum Botanicum* the moſt copious book on the ſubject in the Engliſh language; and it may be preſumed, that it gained equally the approbation of medical people, and of all thoſe who were curious and inquiſitive in this kind of knowledge."

PARSONS (James), an excellent phyſician and polite ſcholar, was born at Barnſtaple, in Devonſhire, in March 1705. His father, who was the youngeſt of nine ſons of Colonel Parſons, and nearly related to the baronet of that name, being appointed barrack-maſter at Bolton in Ireland, removed with his family into that kingdom ſoon after the birth of his then only ſon James, who received at Dublin the early part of his education, and, by the aſſiſtance of proper maſters, laid a conſiderable foundation of claſſical and other uſeful learning, which enabled him to become tutor to Lord Kingſton. Turning his attention to the ſtudy of medicine, he went afterwards to Paris, where (to uſe his own words) "he followed the moſt eminent profeſſors in the ſeveral ſchools, as Aſtruc, Dubois, Lemery, and others; attended the anatomical lectures of the moſt famous [Hunaud and De Cat]; and chemicals at the King's Garden at St Come. He followed the phyſicians in both hoſpitals of the Hotel Dieu and La Charité, and the chemical lectures and demonſtrations of Lemery and Bouldoc; and in botany Juſſieu. Having finiſhed theſe ſtudies, his profeſſors gave him honourable atteſtations of his having followed them with diligence

Biog. Dict.

gence and induſtry, which intitled him to take the degrees of doctor and profeſſor of the art of medicine, in any univerſity in the dominions of France. Intending to return to England, he judged it unneceſſary to take degrees in Paris, unleſs he had reſolved to reſide there; and as it was more expenſive, he therefore went to the univerſity of Rheims, in Champaign, where, by virtue of his atteſtations, he was immediately admitted to three examinations, as if he had finiſhed his ſtudies in that academy; and there was honoured with his degrees June 11. 1736, In the July following he came to London, and was ſoon employed by Dr James Douglas to aſſiſt him in his anatomical works, where in ſome time he began to practiſe. He was elected a member of the Royal Society in 1740; and, after due examination, was admitted a licentiate of the college of phyſicians April 1. 1751; paying college fees and bond ſtamps of different denominations to the amount of L. 41 : 2 : 8, ſubject alſo to quarterage of L. 2 *per annum*. In 1755 he paid a farther ſum of L. 7, which, with the quarterage money already paid, made up the ſum of L. 16, in lieu of all future payments." On his arrival in London, by the recommendation of his Paris friends, he was introduced to the acquaintance of Dr Mead, Sir Hans Sloane, and Dr James Douglas. This great anatomiſt made uſe of his aſſiſtance, not only in his anatomical preparations, but alſo in his repreſentations of morbid and other appearances; a liſt of ſeveral of which was in the hands of his friend Dr Maty, who had prepared an *eloge* on Dr Parſons, which was never uſed, but which, by the favour of Mrs Parſons, Mr Nichols has preſerved at large. Though Dr Parſons cultivated the ſeveral branches of the profeſſion of phyſic, he was principally employed in the obſtetrical line. In 1738, by the intereſt of his friend Dr Douglas, he was appointed phyſician to the public infirmary in St Giles's. In 1739 he married Miſs Elizabeth Reynolds, by whom he had two ſons and a daughter, who all died young. Dr Parſons reſided for many years in Red Lion Square, where he frequently enjoyed the company and converſation of Dr Stukely, Biſhop Lyttleton, Mr Henry Baker, Dr Knight, and many other of the moſt diſtinguiſhed members of the Royal and Antiquarian Societies, and that of Arts, Manufactures, and Commerce; giving weekly an elegant dinner to a large but ſelect party. He enjoyed alſo the literary correſpondence of D'Argenville, Buffon, Le Cat, Beccaria, Amb. Bertrand, Valltravers, Aſcanius, Turberville Needham, Dr Garden, and others of the moſt diſtinguiſhed rank in ſcience. As a practitioner, he was judicious, careful, honeſt, and remarkably humane to the poor; as a friend, obliging and communicative; chearful and decent in converſation, ſevere and ſtrict in his morals, and attentive to fill with propriety all the various duties of life. In 1769, finding his health impaired, he propoſed to retire from buſineſs and from London; and with that view diſpoſed of a conſiderable number of his books and foſſils, and went to Briſtol. But he returned ſoon after to his old houſe, and died in it after a week's illneſs, on the 4th of April, 1770. By his laſt will, dated in October 1766, he gave his whole property to Mrs Parſons; and in caſe of her death before him, to Miſs Mary Reynolds her only ſiſter, "in recompence for her affectionate attention to him and to his wife, for a long courſe of years, in ſickneſs and in health." It was his particular requeſt, that he ſhould not be buried till ſome change ſhould appear in his corpſe; a requeſt which occaſioned him to be kept unburied 17 days, and even then ſcarce the ſlighteſt alteration was perceivable. He was buried at Hendon, in a vault which he had cauſed to be built on the ground purchaſed on the death of his ſon James, where his tomb had a very commendatory inſcription.

It would carry us beyond our uſual limits to enter into an enumeration of the many curious articles at various times communicated to the public by Dr Parſons, which may be ſeen in the Anecdotes of Bowyer. We ſhall therefore cloſe this article with an extract from Dr Maty's eulogium: "The ſurpriſing variety of branches which Dr Parſons embraced, and the ſeveral living as well as dead languages he had a knowledge of, qualified him abundantly for the place of aſſiſtant ſecretary for foreign correſpondences, which the council of the Royal Society beſtowed upon him about the year 1750. He acquitted himſelf to the utmoſt of his power of the functions of this place, till a few years before his death, when he reſigned in favour of his friend, who now gratefully pays this laſt tribute to his memory. Dr Parſons joined to his academical honours thoſe which the Royal College of Phyſicians of London beſtowed upon him, by admitting him, after due examination, licentiate, on the firſt day of April 1751. The diffuſive ſpirit of our friend was only equalled by his deſire of information To both theſe principles he owed the intimacies which he formed with ſome of the greateſt men of his time. The names of Folkes, Hales, Mead, Stukely, Needham, Baker, Collinſon, and Garden, may be mentioned on this occaſion, and many more might be added. Weekly meetings were formed, where the earlieſt intelligence was received and communicated of any diſcovery both here and abroad; and new trials were made, to bring to the teſt of experience the reality or uſefulneſs of theſe diſcoveries. Here it was that the microſcopical animals found in ſeveral infuſions were firſt produced; the propagation of ſeveral inſects by ſection aſcertained; the conſtancy of Nature amidſt theſe wonderful changes eſtabliſhed. His Remains of Japhet, being Hiſtorical Enquiries into the Affinity and Origin of the European Languages, are a moſt laborious performance, tending to prove the antiquity of the firſt inhabitants of theſe iſlands as being originally deſcended from Gomer and Magog, above 1000 years before Chriſt, their primitive and ſtill ſubſiſting language, and its affinity with ſome others. It cannot be denied but that there is much ingenuity, as well as true learning, in this work, which helps conviction, and often ſupplies the want of it. But we cannot help thinking that our friend's warm feelings now and then miſlead his judgment, and that ſome at leaſt of his conjectures, reſting upon partial traditions, and poetical ſcraps of Iriſh filids and Welſh bards, are leſs ſatisfactory than his tables of affinity between the ſeveral northern languages, as deduced from one common ſtock. Literature, however, is much obliged to him for having in this, as well as in many of his other works, opened a new field of obſervations and diſcoveries. In enumerating our learned friend's diſſertations, we find ourſelves at a loſs whether we ſhould follow the order of ſubjects or of time; neither is it eaſy to account

account for their ſurpriſing variety and quick ſucceſſion. The truth is, that his eagerneſs after knowledge was ſuch, as to embrace almoſt with equal facility all its branches, and with equal zeal to aſcertain the merit of inventions, and aſcribe to their reſpective, and ſometimes unknown, authors, the glory of the diſcovery. Many operations, which the ancients have tranſmitted to us, have been thought fabulous, merely from our ignorance of the art by which they were performed. Thus the burning of the ſhips of the Romans at a conſiderable diſtance, during the ſiege of Syracuſe, by Archimedes, would perhaps ſtill continue to be exploded, had not the celebrated M. Buffon in France ſhewn the poſſibility of it, by preſenting and deſcribing a model of a ſpeculum, or rather aſſemblage of mirrors, by which he could ſet fire at the diſtance of ſeveral hundred feet. In the contriving, indeed, though not in the executing of ſuch an apparatus, he had in ſome meaſure been foreſtalled by a writer now very little known or read. This Dr Parſons proved in a very ſatisfactory manner; and he had the pleaſure to find the French philoſopher did not refuſe to the Jeſuit his ſhare in the invention, and was not at all offended by the liberty he had taken. Another French diſcovery, I mean a new kind of painting fathered upon the ancients, was reduced to its real value, in a paper which ſhewed our author was poſſeſſed of a good taſte for the fine arts: and I am informed that his ſkill in muſic was by no means inferior, and that his favourite amuſement was the flute. Richly, it appears from theſe performances, did our author merit the honour of being a member of the Antiquarian Society, which long ago had aſſociated him to its labours. To another ſociety, founded upon the great principles of humanity, patriotiſm, and natural emulation, he undoubtedly was greatly uſeful (A). He aſſiſted at moſt of their general meetings and committees, and was for many years chairman to that of agriculture; always equally ready to point out and to promote uſeful improvements, and to oppoſe the intereſted views of fraud and ignorance, ſo inſeparable from very extenſive aſſociations. No ſooner was *this* ſociety (B) formed, than Dr Parſons became a member of it. Intimately convinced of the nobleneſs of its views, though from his ſtation in life little concerned in its ſucceſs, he grudged neither attendance nor expence. Neither ambitious of taking the lead, nor fond of oppoſition, he joined in any meaſure he thought right; and ſubmitted cheerfully to the ſentiments of the majority, though againſt his own private opinion. The juſt ideas he had of the dignity of our profeſſion, as well as of the common links which ought to unite all its members, notwithſtanding the differences of country, religion, or places of education, made him bear impatiently the ſhackles laid upon a great number of reſpectable practitioners: he wiſhed, fondly wiſhed, to ſee theſe broken; not with a view of empty honour and dangerous power, but as the only means of ſerving mankind more effectually, checking the progreſs of deſigning men and illiterate practitioners, and diffuſing through the whole body a ſpirit of emulation. Though by frequent diſappointments he foreſaw, as well as we, the little chance of a ſpeedy redreſs, he nobly perſiſted in the attempt; and had he lived to the final event, would undoubtedly, like Cato, ſtill have preferred the conquered cauſe to that ſupported by the gods. After having tried to retire from buſineſs and from London, for the ſake of his health, and having diſpoſed of moſt of his books with that view, he found it inconſiſtent with his happineſs to forſake all the advantages which a long reſidence in the capital, and the many connections he had formed, had rendered habitual to him. He therefore returned to his old houſe, and died in it, after a ſhort illneſs, April 4. 1770. The ſtyle of our friend's compoſition was ſufficiently clear in deſcription, tho' in argument not ſo cloſe as could have been wiſhed. Full of his ideas, he did not always ſo diſpoſe and connect them together, as to produce in the minds of his readers that conviction which was in his own. He too much deſpiſed thoſe additional graces which command attention when joined to learning, obſervation, and ſound reaſoning. Let us hope that his example and ſpirit will animate all his colleagues; and that thoſe practitioners who are in the ſame circumſtances will be induced to join their brethren, ſure to find amongſt them thoſe great bleſſings of life, freedom, equality, information, and friendſhip. As long as theſe great principles ſhall ſubſiſt in this ſociety, and I truſt they will outlaſt the longeſt liver, there is no doubt but the members will meet with the reward honeſt men are ambitious of, the approbation of their conſcience, the eſteem of the virtuous, the remembrance of poſterity."

PARODICAL DEGREES, in an equation, a term that has been ſometimes uſed to denote the ſeveral regular terms in a quadratic, cubic, biquadratic, &c. equation, when the indices of the powers aſcend or deſcend orderly in an arithmetical progreſſion. Thus, $x^3 + mx^2 + nx = p$ is a cubic equation where no term is wanting, but having all its parodic degrees; the indices of the terms regularly deſcending thus, 3, 2, 1, 0.

PARTY ARCHES, in architecture, are arches built between ſeparate tenures, where the property is intermixed, and apartments over each other do not belong to the ſame eſtate.

Party Walls, are partitions of brick made between buildings in ſeparate occupations, for preventing the ſpread of fire. Theſe are made thicker than the external walls: and their thickneſs in London is regulated by act of Parliament of the 14th of George III.

PASSIGRAPHY, the art of writing on any ſubject ſo as to be underſtood by all nations (See *Univerſal Characters* in this *Supplement*). In France, where every thing is admired that is new, and every vagary of the imagination of a pretended philoſopher thought practicable, a propoſal has lately been made to introduce one univerſal language into the world, conſtructed by a few metaphyſicians on the laws of human thought. And to this language, in its written form, is to be given the name of *paſſigraphy*. Such readers as think this idle dream

---

(A) The Society for the Encouragement of Arts, Manufactures, and Commerce. He likewiſe was aſſociated to the Economical Society at Berne, Dec. 26. 1763.

(c) A Medical Society inſtituted by Dr Fothergill, and other reſpectable phyſicians, licentiates, in vindication of their privileges; where, it ſhould ſeem, this eulogy was intended to be pronounced.

Path, Pearl.

dream worthy their attention (which is far from being the caſe with us), will find ſome ingenious thoughts on the hiſtory of a philoſophical language, in the 2d volume of *Nicholſon's Journal of Natural Philoſophy, &c.*

PATH of the vertex, a term frequently uſed by Mr Flamſteed, in his Doctrine of the Sphere, denoting a circle, deſcribed by any point of the earth's ſurface as the earth turns round its axis. This point is conſidered as vertical to the earth's centre; and is the ſame with what is called the vertex or zenith in the Ptolomaic projection.

PEARL Fish, is commonly conſidered as an *aſcidia* (ſee Mytilus, *Encycl.*); but this is denied by a late author, who ſeems to have paid great attention to the pearl-fiſhery at Ceylon. It has never, he ſays, been accurately deſcribed. It does not reſemble the *aſcidia* of Linnæus; and as he thinks it may form a new genus, he gives the following account of it:

"The fiſh is faſtened to the upper and lower ſhells by two white flat pieces of muſcular ſubſtance, which have been called ears, and extend about two inches from the thick part of the body, growing gradually thinner. The extremity of each ear lies looſe, and is ſurrounded by a double brown fringed line. Theſe lie almoſt the third part of an inch from the outer part of the ſhell, and are continually moved by the animal. Next to theſe, above and below, are ſituated two other double fringed moveable ſubſtances, like the bronchiæ of a fiſh. Theſe ears and fringes are joined to a cylindrical piece of fleſh of the ſize of a man's thumb, which is harder and of a more muſcular nature than the reſt of the body. It lies about the centre of the ſhells, and is firmly attached to the middle of each. This, in fact, is that part of the pearl-fiſh which ſerves to open and ſhut the ſhells. Where this column is faſtened, we find on the fleſh deep impreſſions, and on the ſhell various nodes of round or oblong forms, like imperfect pearls. Between this part and the hinge (*cardo*) lies the principal body of the animal, ſeparated from the reſt, and ſhaped like a bag. The mouth is near the hinge of the ſhell, enveloped in a veil, and has a double flap or lip on each ſide; from thence we obſerve the throat (*œſophagus*) deſcending like a thread to the ſtomach. Cloſe to the mouth there is a curved browniſh tongue, half an inch in length, with an obtuſe point; on the concave ſide of this deſcends a furrow, which the animal opens and ſhuts, and probably uſes to convey food to its mouth. Near its middle are two bluiſh ſpots, which ſeem to be the eyes. In a pretty deep hole, near the baſe of the tongue, lies the beard (*byſſus*), faſtened by two fleſhy roots, and conſiſting of almoſt 100 fibres, each an inch long, of a dark green colour, with a metallic luſtre; they are undivided, parallel, and flattened. In general, the *byſſus* is more than three quarters of an inch without the cleſt (*rima*); but if the animal is diſturbed, it contracts it conſiderably. The top of each of theſe threads terminates in a circular gland or head, like the *ſtigma* of many plants. With this *byſſus* they faſten themſelves to rocks, corals, and other ſolid bodies; by it the young pearl-fiſh cling to the old ones, and with it the animal procures its food, by extending and contracting it at pleaſure. Small ſhell fiſh, on which they partly live, are often found clinging to the former. The ſtomach lies cloſe to the root of the beard, and has, on its lower ſide, a protracted obtuſe point. Above the ſtomach are two ſmall red bodies, like lungs; and from the ſtomach goes a long channel or gut, which takes a circuit round the muſcular column above-mentioned, and ends in the anus, which lies oppoſite to the mouth, and is covered with a ſmall thin leaf, like a flap. Though the natives pretend to diſtinguiſh the ſexes by the appearance of the ſhell, calling the flat ones males, and thoſe which are thick, concave, and vaulted, females, our author, on a cloſe inſpection, could not perceive any viſible ſexual difference."

Pearl, Pedom

The pearls are only in the ſofter part of the animal, and never in the firm muſcular column above-mentioned. They are found, in general, near the earth, and on both ſides of the mouth. From the appearance of the ſhell a judgment may be formed, with greater or leſs probability, whether it contains pearls or not. Thoſe which have a thick calcareous cruſt upon them, to which *ſerpulæ* (ſea tubes) *Tubuli marini irregulariter intorti, Criſta-gali Chamar lazuras, Lepas tintinabulum, Madreporee, Millipore, Cellipore, Gorgontæ, Spongiæ*, and other Zoophytes, are faſtened, have arrived at their full growth, and commonly contain the beſt pearls; but thoſe that appear ſmooth, contain either none, or ſmall ones only.

In the article (*Encycl.*) intitled, *Manner of Fiſhing for Pearls in the Eaſt Indies*, we have moſt unaccountably ſaid, that "the beſt divers will keep under water near *half an hour*, and the reſt not leſs than a quarter!" This is a very great miſtake; for M. *Le Beck* aſſures us, that the time during which a diver is able to remain under water ſeldom exceeds two minutes; and that, even after that ſhort period, he diſcharges, on emerging from the ſea, a quantity of water, and ſometimes a little blood, from his mouth and noſe. We have mentioned the danger which the divers run of becoming a prey to monſtrous fiſhes. Theſe fiſhes are ſharks; of which ſuch a dread is juſtly entertained, that the moſt expert divers will not, on any account, deſcend, till the conjurer has performed his ceremonies of inchantment. Theſe conſiſt in a number of prayers, learned by heart, that nobody, probably not even the conjurer himſelf, underſtands, which he, ſtanding on the ſhore, continues muttering and grumbling from ſun riſe until the boats return. During this period, he is obliged to abſtain from food and ſleep, otherwiſe his prayers would have no avail: he is, however, allowed to drink; which privilege he indulges in a high degree, and is frequently ſo giddy, as to be rendered very unfit for devotion. Some of the conjurers accompany the divers in their boats; which pleaſes them very much, as they have their protectors near at hand.

PEDOMETER (ſee *Encycl.*), is the name given by Mr Lewin Thugwell to an inſtrument, which is rather an improved perambulator than the inſtrument which we have noticed by the name of Pedometer. The chief improvement made by him on the perambulator (ſee that article, *Encycl.*) is in the ſize of the wheel, of which the circumference meaſures 16½ feet, or one pole, adapted to Gunter's conciſe method of arithmetic, and divided into 25 equal parts, correſponding to the links of his chain for land meaſuring. There is likewiſe a contrivance in Mr Thugwell's pedometer, for compelling the attention of the traveller to the inſtrument at the end of every mile. It is very ingenious, and abundantly ſimple; but we hardly think it of ſufficient

cient importance to fill the ſpace which a complete deſcription of it would occupy in this Work. It is fully deſcribed in the *Letters and Papers of the Bath and Weſt of England Society, for the Encouragement of Agriculture*, and likewiſe in the 6th volume of the *Repertory of Arts and Manufactures*.

PEGUE, the ancient capital of the kingdom of the ſame name (ſee Pegu, *Encycl.*), appears to have been a quadrangle, each ſide meaſuring about a mile and a half. It was ſurrounded by a ditch and wall; which, before the latter tumbled down, and the former was filled up, muſt have furniſhed no contemptible defence. The breadth of the ditch appears to be about 60 yards; its depth, where not choked up, about ten or twelve feet; and there is ſtill in it water enough to impede an eaſtern ſiege. The wall has been at leaſt 25 feet high, and its breadth at the baſe not leſs than 40. It is compoſed of brick, badly cemented together with clay mortar, and has had on it ſmall equidiſtant baſtions, about 300 yards aſunder.

Nothing can exhibit a more ſtriking picture of deſolation than the inſide of this wall. We have elſewhere given an account of the almoſt inceſſant wars between the kings of Pegue and Birma or Barma. In the year 1757, the Birman ſovereign carried the city of Pegue by aſſault, razed every dwelling to the ground, and diſperſed, or led into captivity, all the inhabitants. The pagodas, which are very numerous, were the only buildings that eſcaped the fury of the conqueror; and of theſe the great pagoda of Shoemadoo has alone been attended to, and repaired.

This extraordinary edifice is built on a double terrace, one raiſed upon another. The lower and greater terrace is about ten feet above the natural level of the ground. It is quadrangular. The upper and leſſer terrace is of a like ſhape, raiſed about 20 feet above the lower terrace, or 30 above the level of the country. Theſe terraces are aſcended by flights of ſtone ſteps, broken and neglected. On each ſide are dwellings of the *Rahaans* or prieſts, raiſed on timbers four or five feet from the ground. Their houſes conſiſt only of a ſingle hall. The wooden pillars that ſupport them are turned with neatneſs. The roof is of tile, and the ſides of ſheathing-boards. There are a number of bare benches in every houſe, on which the *Rahaans* ſleep. They appear to have no furniture.

Shoemadoo is a pyramid, compoſed of brick and plaſter, with fine ſhell mortar, without excavation or aperture of any ſort; octagonal at the baſe, and ſpiral at the top. Six feet from the ground there is a wide ledge, which ſurrounds the baſe of the building; on the plane of which are 57 ſmall ſpires, of equal ſize, and equidiſtant. One of them meaſured 27 feet in height, and 40 in circumference at the bottom. On a higher ledge there is another row, conſiſting of 53 ſpires, of ſimilar ſhape and meaſurement. A great variety of mouldings encircles the building; and ornaments, ſomewhat reſembling the *fleur de lys*, ſurround what may be called the baſe of the ſpire. Circular mouldings likewiſe gird this part to a conſiderable height; above which there are ornaments in ſtucco, not unlike the leaves of a Corinthian capital; and the whole is crowned by a *tee*, or umbrella of open iron-work, from which riſes an iron rod with a gilded penant.

The extreme height of the building, from the level of the country, is 361 feet; and above the interior terrace, 331 feet. On the ſouth-eaſt angle of the upper terrace there are two handſome ſaloons, or *keouns*, lately erected. The roof is compoſed of different ſtages, ſupported by pillars. Captain Symes, from whoſe memoir in the Aſiatic Reſearches this account is taken, judged the length of each ſaloon to be about 60 feet, and the breadth 30. The ceiling of one of them was already embelliſhed with gold leaf, and the pillars lacquered; the other, when he ſaw it, was not completed. They are made entirely of wood. The carving on the outſide is very curious. He ſaw ſeveral unfiniſhed figures, intended to be fixed on different parts of the building; ſome of them not ill ſhapen, and many exceedingly groteſque. Splendid images of Gaudma (the *Birman* object of adoration) were preparing, which he underſtood were deſigned to occupy the inſide of theſe *keouns*.

At each angle of the interior terrace is a pyramidical pagoda, 67 feet in height, reſembling, in miniature, the great pagoda. In front of the one in the ſouth-weſt corner are four gigantic repreſentations in maſonry of Palloo, or the *man deſtroyer*, half beaſt, half human, ſeated on their hams, each with a large club on the right ſhoulder.

Nearly in the centre of the eaſt face of the area are two human figures in ſtucco beneath a gilded umbrella. One ſtanding, repreſents a man with a book before him, and a pen in his hand. He is called *Thagiamee*, the recorder of mortal merits and mortal miſdeeds. The other, a female figure kneeling, is *Maha Sumdere*, the protectreſs of the univerſe, as long as the univerſe is doomed to laſt: but when the time of general diſſolution arrives, by her hand the world is to be overwhelmed, and deſtroyed everlaſtingly.

On the north ſide of the great pagoda are three large bells, of good workmanſhip, ſuſpended near the ground between pillars. Several deers horns are ſtrewed around. Thoſe who come to pay their devotions firſt take up one of the horns, and ſtrike the bell three times, giving an alternate ſtroke to the ground. This act is to announce to the ſpirit of Gaudma the approach of a ſuppliant. There are ſeveral low benches near the bottom of the pagoda, on which the perſon who comes to pray places his offering; which generally conſiſts of boiled rice, a plate of ſweetmeats, or cocoa-nut fried in oil. When it is given, the devotee cares not what becomes of it. The crows and dogs commonly eat it up in the preſence of the donor, who never attempts to prevent or moleſt the animals.

There are many ſmall pagodas on the areas of both terraces, which are neglected, and ſuffered to fall into decay. Numberleſs images of Gaudma lie indiſcriminately ſcattered. A pious Birman who purchaſes an idol, firſt procures the ceremony of conſecration to be performed by the *Rahaans*, then takes his purchaſe to whatever ſacred building is moſt convenient, and there places it either in the ſhelter of a *keoun*, or on the open ground before the temple: nor does he ever after ſeem to have any anxiety about its preſervation, but leaves the divinity to ſhift for itſelf.

From the upper ledge that ſurrounds the baſe of Shoemadoo, the proſpect of the country is extenſive and pictureſque; but it is a proſpect of Nature in her rudeſt ſtate. There are few inhabitants, and ſcarcely any cultivation. The hills of *Martaban* riſe to the eaſtward; and the *Sitang* river, winding along the plains, gives here and there an interrupted view of its waters. To the north-north weſt, above 40 miles, are the *Galladzet* hills, whence the Pegue river takes its riſe; hills remarkable only for the noiſome effects of their atmoſphere. In every other direction the eye looks over a boundleſs plain, chequered by a wild intermixture of wood and water.

The preſent king of the Birmans has entirely altered the ſyſtem of his predeceſſors. He has turned his attention to the population and improvement, rather than the extenſion, of his dominions; and ſeems more deſirous to conciliate his new ſubjects by mildneſs, than to rule them through terror. He has abrogated ſeveral ſevere penal laws impoſed upon the *Taliens* or Peguers: juſtice is now diſtributed impartially; and the only diſtinction at preſent between a Birman and Talien conſiſts in the excluſion of the latter from all public offices of truſt and power.

No act of the Birman government is more likely to reconcile the Taliens to the Birman yoke than the reſtoration of their ancient place of abode. and the preſervation and embelliſhment of the pagoda of Shoemadoo. So ſenſible was the king of this, as well as of the advantages that muſt accrue to the ſtate from an increaſe of culture and population, that ſome years ago he iſſued orders to rebuild Pegue, encouraged new ſettlers by liberal grants, and invited the ſcattered families of former inhabitants to return and repeople their deſerted city.

Pegue, in its renovated ſtate, ſeems to be built on the plan of the former city. It is a ſquare, each ſide meaſuring about half a mile. It is fenced round by a ſtockade, from 10 to 12 feet high. There is one main ſtreet running eaſt and weſt, which is interſected at right angles by two ſmaller ſtreets, not yet finiſhed. At each extremity of the principal ſtreet there is a gate in the ſtockade, which is ſhut early in the evening. After that hour, entrance during the night is confined to a wicket. Each of theſe gates is defended by a ſorry piece of ordnance, and a few muſqueteers, who never poſt centinels, and are uſually aſleep. There are alſo two other gates on the north and ſouth ſides of the ſtockade.

The houſes of the inhabitants of Pegue are far from commodious, agreeably to European notions of accommodation; but they are at leaſt as much ſo as the houſes of other Indian towns. There are no brick buildings in Pegue, except ſuch as belong to the king, or are dedicated to Gaudma. The king has prohibited the uſe of brick or ſtone in private buildings, from the apprehenſion, that if people got leave to build brick houſes, they might erect brick fortifications, dangerous to the ſecurity of the ſtate. The houſes, therefore, are all made of mats or ſheathing boards, ſupported on bamboos or poſts. Being compoſed of ſuch combuſtible materials, the inhabitants are under continual dread of fire, againſt which they take every precaution. The roofs are lightly covered; and at each door ſtands a long bamboo, with a hook at the end, to pull down the thatch: alſo another pole, with a grating of ſplit bamboo at the extremity, about three feet ſquare, to ſuppreſs flame by preſſure. Almoſt every houſe has earthen pots of water on the roof. And there is a particular claſs of people, whoſe buſineſs it is to prevent and extinguiſh fires.

PEISHCAR, in Bengal, principal in office.

PEISHCUSH, a fine, tribute, or preſent.

PELL (Dr John), an eminent Engliſh mathematician, deſcended from an ancient family in Lincolnſhire, was born at Southwick in Suſſex, March 1. 1610, where his father was miniſter. He received his grammar education at the free ſchool at Stenning in that county. At the age of 13 he was ſent to Trinity college in Cambridge, being then as good a ſcholar as moſt maſters of arts in that univerſity; but though he was eminently ſkilled in the Greek and Hebrew languages, he never offered himſelf a candidate at the election of ſcholars or fellows of his college. His perſon was handſome; and being of a ſtrong conſtitution, uſing little or no recreations, he proſecuted his ſtudies with the more application and intenſeneſs.

In 1629 he drew up the "Deſcription and Uſe of the Quadrant, written for the Uſe of a Friend," in two books; the original manuſcript of which is ſtill extant among his papers in the Royal Society. And the ſame year he held a correſpondence with Mr Briggs on the ſubject of logarithms.

In 1630, he wrote *Modus ſupputandi Ephemerides Aſtronomicas, &c. ad an.* 1630 *accommodatus*; and, A Key to unlock the meaning of Johannes Trithemius, in his Diſcourſe on Steganography: which Key he imparted to Mr Samuel Hartlib and Mr Jacob Homedæ. The ſame year he took the degree of Maſter of Arts at Cambridge. And the year following he was incorporated in the univerſity of Oxford. June the 7th, he wrote A Letter to Mr Edmond Wingate on Logarithms: and, Oct. 5. 1631, *Commentationes in Coſmographiam Alſtedii.*

In 1632 he married Ithamaria, ſecond daughter of Mr Henry Reginolles of London, by whom he had four ſons and four daughters.—March 6. 1634, he finiſhed his "Aſtronomical Hiſtory of Obſervations of Heavenly Motions and Appearances;" and April the 10th, his *Ecliptica Prognoſtica*, or Foreknower of the Eclipſes, &c. In 1634 he tranſlated "The Everlaſting Tables of Heavenly Motions," grounded upon the Obſervations of all Times, and agreeing with them all, by Philip Lanſberg, of Ghent in Flanders. And June the 12th, the ſame year, he committed to writing "The Manner of Deducing his Aſtronomical Tables out of the Tables and Axioms of Philip Lanſberg."—March the 9th, 1625, he wrote "A Letter of Remarks on Gellibrand's Mathematical Diſcourſe on the Variation of the Magnetic Needle." And the 3d of June following, another on the ſame ſubject.

His eminence in mathematical knowledge was now ſo great, that he was thought worthy of a Profeſſor's chair in that ſcience; and, upon the vacancy of one at Amſterdam in 1639, Sir William Boſwell, the Engliſh Reſident with the States General, uſed his intereſt, that he might ſucceed in that Profeſſorſhip. It was not filled up, however, till 1642, when Pell was choſen to it; and he read with great applauſe public lectures upon Diophantus.—In 1644 he printed at Amſterdam, in two pages 4to, "A Refutation of Longomontanus's Diſcourſe," *De Vera Circuli Menſura.*

In 1646, on the invitation of the Prince of Orange, he removed to the new college at Breda, as Profeſſor of Mathematics, with a ſalary of 1000 guilders a year. His *Idea Matheſeos*, which he had addreſſed to Mr Hartlib, who in 1639 had ſent it to Des Cartes and Merſenne, was printed 1650 at London, in 12mo, in Engliſh, with the title of *An Idea of Mathematics*, at the end of Mr John Durie's Reformed Library keeper. It is alſo printed by Mr Hook, in his Philoſophical Collections, N° 5. p. 127.; and is eſteemed our author's principal work.

In 1652 Pell returned to England; and in 1654 he was ſent by the protector Cromwell agent to the Proteſtant Cantons in Switzerland; where he continued till June 23. 1658, when he ſet out for England, where he arrived about the time of Cromwell's death. His negociations abroad gave afterwards a general ſatisfaction, as it appeared he had done no ſmall ſervice to the intereſt of King Charles II. and of the church of England; ſo that he was encouraged to enter into holy orders: and in the year 1661 he was inſtituted to the rectory of Fobbing in Eſſex, given him by the king. In December that year, he brought into the upper houſe of convocation the calendar reformed by him, aſſiſted by Sancroft, afterwards archbiſhop of Canterbury. In 1673 he was preſented by Sheldon, biſhop of London, to the rectory of Laingdon in Eſſex; and, upon the promotion of that biſhop to the ſee of Canterbury ſoon after, became one of his domeſtic chaplains. He was then doctor of divinity, and expected to be made a dean; but his improvement in the philoſophical and mathematical ſciences was ſo much the bent of his genius, that he did not much purſue his private advantage. The truth is, he was a helpleſs man, as to worldly affairs; and his tenants and relations impoſed upon him, cozened him of the profits of his parſonage, and kept him ſo indigent, that he wanted neceſſaries, even ink and paper, to his dying day. He was for ſome time confined to the King's bench priſon for debt; but, in March 1682, was invited by Dr Whitler to live in the college of phyſicians. Here he continued till June following; when he was obliged, by his ill ſtate of health, to remove to the houſe of a grandchild of his in St Margaret's church-yard, Weſtminſter. But he died at the houſe of Mr Cothorne, reader of the church of St Giles's in the Fields, December the 12th, 1685, in the 74th year of his age, and was interred at the expence of Dr Buſby, maſter of Weſtminſter ſchool, and Mr Sharp, rector of St Giles's, in the rector's vault under that church.—Dr Pell publiſhed ſome other things not yet mentioned; a liſt of which is as follows, *viz.*

1. An Exercitation concerning Eaſter; 1644, in 4to. 2. A Table of 10,000 ſquare numbers, &c.; 1672, folio. 3. An Inaugural Oration at his entering upon the Profeſſorſhip at Breda. 4. He made great alterations and additions to Rhonius's Algebra, printed at London 1668, 4to, under the title of An Introduction to Algebra, tranſlated out of the High Dutch into Engliſh by Thomas Branker, much altered and augmented by D. P. (Dr Pell). Alſo a Table of Odd Numbers, leſs than 100,000, ſhewing thoſe that are incompoſite, &c. ſupputated by the ſame Thomas Branker. 5. His Controverſy with Longomontanus concerning the Quadrature of the Circle; Amſterdam, 1646, 4to.

He likewiſe wrote a Demonſtration of the 2d and 10th books of Euclid; which piece was in MS. in the library of Lord Brereton in Cheſhire: as alſo Archimedes's Arenarius, and the greateſt part of Diophantus's ſix books of Arithmetic; of which author he was preparing, Auguſt 1644, a new edition, in which he intended to correct the tranſlation, and make new illuſtrations. He deſigned likewiſe to publiſh an edition of Apollonius; but laid it aſide, in May 1645, at the deſire of Golius, who was engaged in an edition of that author from an Arabic manuſcript, given him at Aleppo 18 years before. Letters of Dr Pell to Sir Charles Cavendiſh, in the Royal Society.

Some of his manuſcripts he left at Brereton in Cheſhire, where he reſided ſome years, being the ſeat of William Lord Brereton, who had been his pupil at Breda. A great many others came into the hands of Dr Buſby; which Mr Hook was deſired to uſe his endeavours to obtain for the Society. But they continued buried under duſt, and mixed with the papers and pamphlets of Dr Buſby, in four large boxes, till 1755; when Dr Birch, ſecretary to the Royal Society, procured them for that body, from the truſtees of Dr Buſby. The collection contains, not only Pell's mathematical papers, letters to him, and copies of thoſe from him, &c. but alſo ſeveral manuſcripts of Walter Warner, the mathematician and philoſopher, who lived in the reigns of James I. and Charles I.

Dr Pell invented the method of ranging the ſeveral ſteps of an algebraical calculus, in a proper order, in ſo many diſtinct lines, with the number affixed to each ſtep, and a ſhort deſcription of the operation or proceſs in the line. He alſo invented the character ÷ for diviſion, ⊚ for involution, ɯ for evolution *.

PELLETIER (Bertrand), was born at Bayonne in 1761, and very ſoon began to diſplay an inſatiable thirſt of ſcience. It frequently happens, however, that young men, ſincerely deſirous of inſtruction, have no means or place where they can be aſſiſted in the developement of their natural talents, no maſter who may point out the direct road to ſcience, and that order and method, without which the efforts of the individual too often lead him from the object of his purſuit, inſtead of bringing him nearer to it. This was not the caſe with young Pelletier. He found every advantage in his father's houſe, where he received the firſt elements of the art of which he was afterwards the ornament; and his ſubſequent progreſs was made under Darcet, who having remarked in him that ſagacity which may be called the inſtinct of ſcience, admitted him among the pupils attached to the chemical laboratory of the college of France. Five years of conſtant application and ſtudy under ſuch a maſter, who was himſelf formed by nature, perfected by experience, and affectionately diſpoſed towards his pupil, afforded this young man a ſtock of knowledge very unuſual at his age. He ſoon gave a convincing proof of this, by publiſhing, at the age of 21, a ſet of very excellent obſervations on the arſenical acid. Macquer, by mixing nitre with the oxyd of arſenic, had diſcovered in the reſidue of this operation a ſalt ſoluble in water, ſuſceptible of cryſtallization in tetrahedral priſms, which he denominated the neutral

---

* *Hutton's Mathematical Dictionary.*

arſenical ſalt. It is the arſeniat of potaſh. He was of opinion that no acid could decompoſe it; but Pelletier ſhewed, that the ſulphuric acid diſtilled from it does diſengage the acid of arſenic. He ſhewed the true cauſe why the neutral arſenical ſalt is not decompoſable in cloſed veſſels; and particularly the order of affinity by which the ſalt itſelf is formed in the diſtillation of the nitrate of potaſh, and the white oxyd of arſenic. He explains in what reſpects this ſalt differs from what Macquer called the liver of arſenic. Pelletier had been anticipated in this work by Scheele, by Bergman, by the academicians of Dijon, and by Berthollet; but he poſſeſſed at leaſt the merit, in the firſt eſſay of his powers, of having clearly developed all the phenomena of this operation, by retaining and even determining the quantity of gas it was capable of affording. After the ſame principles it was that he decompoſed the arſenico-ammoniacal ſalt, by ſhewing how, in the decompoſition of this laſt, the pure arſenical acid is obtained in the form of a deliqueſcent glaſs. In this work we may obſerve the ſagacity with which he was enabled to develope all the phenomena of theſe compoſitions and decompoſitions, by tracing thoſe delicate threads of ſcientific relation which connect the ſeries of facts, and are imperceptible to ordinary minds.

Encouraged by the ſucceſs of theſe firſt works, which he preſented with the ſenſibility of grateful attachment to his inſtructor, he communicated his obſervations on the cryſtallization of ſulphur, cinnabar, and the deliqueſcent ſalts; the examination of zeolites, particularly the falſe zeolite of Fribourg in Briſgaw, which he found to be merely an ore of zinc; obſervations on the dephlogiſticated or oxygenated muriatic acid, relative to the abſorption of oxygen; on the formation of ethers, particularly the muriatic and the acetous; and ſeveral memoirs on the operation of phoſphorus made in the large way; its converſion into phoſphoric acid, and its combination with ſulphur and moſt metallic ſubſtances.

It was by his operations on that moſt aſtoniſhing production of chemiſtry, phoſphorus, that he burned himſelf ſo dangerouſly as nearly to have loſt his life. After the cure of his wound, which confined him to his bed for ſix months, he immediately began the analyſis of the various plumbagos of France, England, Germany, Spain, and America, and found means to give novelty and intereſt to his work, even after the publication of Scheele on the ſame object. The analyſis of the carbonat of barytes led him to make experiments on animals; which prove that this earth is a true poiſon, whether it be adminiſtered in the form of the native carbonat of barytes, or whether it be taken from the decompoſition of the ſulphat, even though again combined with another acid.

Chemiſts have given the name of *ſtrontian* to a newly diſcovered earth, from the name of the place where it was firſt found. Pelletier analyſed it, and diſcovered it in the ſulphat of barytes. He likewiſe analyſed the verditer of England, of which painters and paper-hangers make ſo much uſe. He diſcovered a proceſs for preparing it in the large way, by treating with lime the precipitate obtained from the decompoſition of nitrat of copper by lime. By his proceſs, verditer is afforded equal in beauty to that which comes from England. He was likewiſe one of the firſt chemiſts who ſhewed the poſſibility of refining bell metal, and ſeparating the tin. His firſt experiments were made at Paris; after which he repaired to the foundry at Romilly, to verify them in the large way. The following year he was received a member of the Academy of Sciences at Paris, and ſhortly afterwards went to La Fere, with Borda and General Daboville, to aſſiſt in experiments upon a new gunpowder. Being obliged, in order to render his experiments more deciſive, to paſs great part of the day in the open air during a cold and humid ſeaſon. his health, which was naturally delicate, became conſiderably impaired. He began to recover his health, when he again became the victim of his zeal for the ſcience he ſo ſucceſsfully cultivated. He had nearly periſhed by reſpiring the oxygenated muriatic acid gas. A violent attack of convulſive aſthma, which returned during ſeveral days, was the firſt conſequence of this unhappy accident. The diſorder then ſeemed to abate; but it was incurable. The aſſiſtance of art was inſufficient to ſave him; and he died in Paris, on the 21ſt of July 1797, of a pulmonary conſumption, in the flower of his age.

PENDULUM (See *Encycl.*). Beſides the effects of heat and cold on the length of the pendulum rod, and of courſe on its iſochroniſm, it may certainly be worth while, in the conſtruction of clocks intended to meaſure time with the utmoſt poſſible exactneſs, to take into conſideration the reſiſtance of the air, which, by its unequal denſity, varying the weight of the pendulum, muſt in a ſmall degree accelerate or retard its motion. The celebrated David Rittenhouſe, who paid particular attention to this ſubject, eſtimates the extreme difference of velocity, ariſing from this cauſe, at half a ſecond a day; and he obſerves, that a remedy dependent on the barometer will not be ſtrictly accurate, as the weight of the entire column of air does not preciſely correſpond with the denſity of its baſe. He propoſes, therefore, as a very ſimple and eaſy remedy, that the pendulum ſhall, as uſual, conſiſts of an inflexible rod carrying the ball beneath, and continued above the centre of ſuſpenſion to an equal (or an unequal) diſtance upwards. At this extremity is to be fixed another ball of the ſame dimenſions (or greater or leſs, according as the continuation is ſhorter or longer), but made as light as poſſible. The oſcillations of this upper ball will be accelerated by its buoyancy by the ſame quantity as thoſe of the lower would be retarded; and thus, by a proper adjuſtment, the two effects might be made to balance and correct each other.

Our author made a compound pendulum on theſe principles, of about one foot in its whole length. This pendulum, on many trials, made in the air 57 vibrations in a minute. On immerſing the whole in water, it made 59 vibrations in the ſame time; ſhewing evidently, that its returns were quicker in ſo denſe a medium as water than in the air. (This is contrary to what takes place with the common pendulum). When the lower bob or pendulum only was plunged in water, it made no more than 44 vibrations in a minute.

PENNANT (Thomas, Eſq.), ſo well known in the republic of letters as a writer of travels and of natural hiſtory, was an ancient Briton by birth, having drawn his firſt breath in Flintſhire, in 1726. His family has been ſettled in that county for many centuries; we learn from himſelf that he received the rudiments of his education at Wrexham, whence he was removed to Fulham. Soon after this he was ſent to Oxford; and having

ving made a conſiderable proficiency in the claſſics, he applied himſelf within the walls of that univerſity to attain a knowledge of juriſprudence; but we do not find that he ever entered himſelf of any of the inns of court, or followed the law as a profeſſion.

The ruling paſſions of mankind are excited, and the future current of their lives frequently directed, by trivial circumſtances. One of the greateſt painters of our age was attracted with an irreſiſtible impulſe towards his art by the peruſal of a treatiſe on it; and we have the authority of the ſubject of this memoir for aſſerting, that a preſent of Willughby's Ornithology, at an early period, firſt gave him a turn for natural hiſtory, which has never once abandoned him through the courſe of a very long life.

Mr Pennant commenced his travels with great propriety at home, where he made himſelf acquainted with the manners, productions, and curioſities, of his native country, before he ſallied forth to inſpect thoſe of other nations. He then repaired to the continent; and not only acquired conſiderable additional knowledge relative to his favourite ſtudies, but became acquainted, and eſtabliſhed a correſpondence, with ſome of the greateſt men of the age.

On his return he married, and had two children, but did not come into the family fortune until he was thirty-ſeven years of age, at which time he was ſettled at Downing.

Having loſt his wife, he appears to have ſet out once more for the continent, and to have formed an acquaintance with Voltaire, Buffon, Haller, Pallas, &c. He had by this time acquired conſiderable reputation as a ſcientific man, having commenced his career as an author ſo early as 1750. His Britiſh Zoology * eſtabliſhed his reputation as a naturaliſt; and this received a freſh acceſſion of celebrity in conſequence of his acquaintance with Linnæus, and his intercourſe by letters with all the celebrated naturaliſts in Europe.

Early in life he had undertaken a moſt intereſting tour to Cornwall; and he now entertained an ardent deſire to ſurvey the works of nature in the northern extremities of the iſland. He accordingly ſet out for Scotland, and in 1771 favoured the public with an entertaining account of his Tour †, which was ſo well received as to paſs through ſeveral editions. Not content with the main land of Great Britain, he was ambitious to ſurvey the iſlands in the vicinity, and accordingly penetrated to the Hebrides, and viſited Man.

It is not to be ſuppoſed that he would leave his own country unexplored; on the contrary, he minutely deſcribed all its wonders. He did not fail on this occaſion to preſent the world with the reſult of his enquiries, for in 1778 he commenced the publication of his Welch Tour §.

In four years after this (1782) appeared the account of the Journey from Cheſter to London ‡, in which he refutes the vulgar opinion that it is unintereſting; and in two years more his Arctic Zoology, an admirable work, greatly prized both here and in other countries.

In 1790 appeared a quarto volume, ſimply entitled Of London; in which he obſerves that this work is compoſed from obſervations, originally made without any view of publication. "Let me requeſt (ſays he in the preface) the good inhabitants of London and Weſtminſter not to be offended at my having ſtuffed their Iliad into a nutſhell; the account of the city of London and liberties of Weſtminſter into a quarto volume. I have condenſed into it all I could; omitted nothing that ſuggeſted itſelf; nor amplified any thing to make it a guinea book. In a word, it is done in my own manner, from which I am grown too old to depart.

"I feel within myſelf a certain monitor that warns me (adds he) to hang up my pen in time, before its powers are weakened, and rendered viſibly impaired. I wait not for the admonition of friends. I have the Archbiſhop of Grenada in my eye; and fear the imbecility of human nature might produce in long-worn age the ſame treatment of my kind adviſers as poor Gil Blas had from his moſt reverend patron. My literary bequeſts to future times, and more ſerious concerns, muſt occupy the remnant of my days. This cloſes my public labours."

Notwithſtanding his parting addreſs, the example of the Archbiſhop of Grenada, and the concluding ſentence of "*Valete & Plaudite*," we find Mr Pennant adventuring once more in the ocean of literature, at a late period of his life, and trying his fortune again with all the eagerneſs of a young author.

He accordingly publiſhed the Natural Hiſtory of the pariſhes of Holywell and Downing *, within the precincts of the latter of which he had reſided about half a century.

He alſo preſented the public, a very ſhort time before his death, with a ſplendid work, conſiſting of 2 vols. 4to. entitled The View of Hindooſtan; in the preface to which he candidly ſtates his motives for this new attempt. "I had many ſolicitations from private friends (ſays he), and a few wiſhes from perſons unknown, delivered in the public prints, to commit to the preſs a part, in the form in which the poſthumous volumes might hereafter make their appearance. I might have pleaded the imprudence of the attempt at my time of life, of beginning ſo arduous an undertaking in my 71ſt year.

"I happily, till very lately, had ſcarcely any admonition of the advanced ſeaſon. I plunged into the ſea of trouble, and with my papers in one hand, made my way through the waves with the other, and brought them ſecure to land. This, alas! is finite boaſting. I muſt ſubmit to the judgment of the public, and learn from thence how far I am to be cenſured for ſo grievous an offence againſt the maxim of Ariſtotle, who fixes the decline of human abilities to the 49th year.

"I ought to ſhudder, when I conſider the wear and tear of 22 years; and feel ſhocked at the remark of the elegant Delanty, who obſerves, 'that it is generally agreed among wiſe men, that few attempts, at leaſt in a learned way, have ever been wiſely undertaken and happily executed after that period!'

"I cannot defend the wiſdom: yet from the good fortune of my life I will attempt the execution."

Theſe valuable volumes are drawn up by Mr Pennant in the manner of his introduction to the Arctic Zoology. The plates, 23 in number, are admirably engraved, and one (the Napaul pheaſant) is beautifully coloured.

In addition to the liſt of literary labours already enumerated, is a letter on an earthquake felt at Downing, in Flintſhire, in 1753; another inſerted in the ſame publi-

---

* F vols 4to.

† Th vols 4to.

§ Tw vols 4to.

‡ On vol. 4to.

* One vol. 4to.

publication *, in 1756, on coralloid bodies (κοραλλοειδης) collected by him: his Synopſis of Quadrupeds, publiſhed in 1771; a pamphlet on the Militia; a paper on the Turkey; and a volume of Miſcellanies.

Mr Pennant attained academical honours of all kinds, having had the degree of LL. D. conferred on him by the univerſity in which he was educated, he was a Fellow of the Royal Society, and a member of the Society of Antiquaries, a Fellow of the Royal Society of Upſal in Sweden, a member of the American Philoſophical Society, an honorary member of the Anglo-Linnæan Society, &c.

The ample fortune left him by his father enabled Mr Pennant to keep an hoſpitable table, and alſo to preſent the profits of ſeveral of his works to public inſtitutions, particularly the Welſh charity-ſchool in Gray's-inn-lane. He encouraged ſeveral engravers by his patronage, and was not a little ſerviceable to the advancement of the fine arts.

In 1776 he married a ſecond time; on which occaſion he became united to Miſs Moſtyn, ſiſter of his neighbour, the late Sir Roger Moſtyn, in Flintſhire. The latter part of his life was chearful, and he ſcarcely felt the approaches of old age. He died at his ſeat at Downing in his 72d year.

He has left ſeveral works behind him in MS. under the title of Outlines of the Globe; and as a proof that it will be a very voluminous and intereſting publication, it is only neceſſary to obſerve, that The View of Hindooſtan compoſed the xivth and xvth volumes.

Mr Pennant poſſeſſed a well-compacted frame of body, an open and intelligent aſpect, an active and chearful diſpoſition, and a vivacity which rendered him always entertaining, as well in converſation as in writing. Though not without a ſhare of iraſcibility, his heart was kind and benevolent. He was exemplary in the relations of domeſtic life, and ſenſibly felt for the diſtreſſes of his poor neighbours, whoſe relief in ſeaſons of hardſhip he promoted with great zeal and liberality. His candour and freedom from ordinary prejudices, are ſufficiently diſplayed in his writings; and Scotland was forward to confeſs, that he was the firſt traveller from this ſide the Tweed, who had viſited the country with no unfriendly ſpirit, and had fairly preſented it under its favourable as well as its leſs pleaſing aſpects. As a writer, his ſtyle is lively and expreſſive, but not perfectly correct. His principles of arrangement in zoology are judicious, and his deſcriptions characteriſtic. If in ſome of his later works a little vanity appears, and a propenſity to think that important to the world which was ſo to himſelf, it may readily be pardoned to one who has afforded ſuch copious and valuable entertainment to the public. His name will live with honour in the literary hiſtory of his country, and his memory will be cheriſhed with reſpect and affection by his ſurviving friends.

PENNATULA (See *Encycl.*). A ſpecies of this animal, hitherto undeſcribed, was diſcovered by La Martiniere near Nootka. Its body is of a cartilaginous ſubſtance, and a cylindrical form; its head, armed with two little horns of the ſame ſubſtance, preſents a ſpherical figure flatted at its anterior extremity. This part is covered with ſmall papillæ, ſome of which are viſible at D, and which ſerve the purpoſe of ſmall mouths, by means of which this animal ſucks the blood of fiſhes, making its way as far as poſſible into the fleſh: the extremity of its body, which always projects from the fiſh, appears like the feathers of a pen; theſe feather-like ſubſtances ſerve as excretory veſſels; for on making a ſlight preſſure on the animal, from the greater part of theſe cartilaginous barbs iſſued ſmall drops of a very limpid liquor: at the baſe of theſe barbs, and beneath the body, are placed two large cartilaginous threads, of which our author could not imagine the uſe, for they are not univerſally met with in each individual. The circulation of its blood is readily obſerved, it forms a complete revolution about once in a minute. It is probable that this animal is only able to make its way into the bodies of different fiſh when it is very young; and when it has once buried itſelf there, having abundance of nouriſhment, its head increaſes conſiderably, and the two horns with which it is furniſhed neceſſarily form an obſtacle to its regreſs, which is a remarkable inſtance of the foreſight of Nature, ſince it is deſtined to be nouriſhed at the expence of another. The pennatula, of which we have given from Martiniere a figure, was found by him at the depth of more than an inch and an half in the body of a *diodon*.

Plate XLI.

PEPUSCH (John Chriſtopher), one of the greateſt theoretic muſicians of modern times, as we are told, was born at Berlin about 1667; and became ſo early a proficient on the harpſichord, that at the age of 14 he was ſent for to court, and appointed to teach the prince, father of the late King of Pruſſia. About 1700, he came over to England, and was retained as a performer at Drury Lane: it is ſuppoſed that he aſſiſted in compoſing the operas which were performed there. While he was thus employed, he forebore not to proſecute his private ſtudies; and theſe led him to enquire into the muſic of the ancients, and the peruſal of the Greek authors upon that ſubject. The abilities of Pepuſch, as a practical compoſer, were not likely to become a ſource of wealth to him: his muſic was correct, but it wanted variety of modulation. Beſides, Handel had got poſſeſſion of the public ear, in the opinion of whoſe ſuperior merit he readily acquieſced; and choſe a track for himſelf, in which he was almoſt ſure to meet with no obſtruction. He became a teacher of muſic, not the practice of any particular inſtrument, but muſic in the abſolute ſenſe of the word, that is to ſay, the principles of harmony and the ſcience of practical compoſition; and this, not to children or novices, but in very many inſtances to profeſſors of muſic themſelves.

In 1713, he was admitted to the degree of Doctor in Muſic at Oxford, and continued to proſecute his ſtudies with great aſſiduity. In 1724, he accepted an offer from Dr Berkeley to accompany him to the Bermudas, and to ſettle as profeſſor of muſic in his intended college there; but the ſhip in which they ſailed being wrecked, he returned to London, and married Franceſca Margarita de l'Epine. This perſon was a native of Tuſcany, and a celebrated ſinger, who performed in ſome of the firſt of the Italian operas that were repreſented in England. She came hither with one Greber, a German, and from this connection became diſtinguiſhed by the invidious appellation of *Greber's Peg*. Afterwards ſhe commenced a new connection with Daniel Earl of Nottingham, who had defended the orthodox notion of the Trinity againſt the heretic Whiſton; and to this connection Rowe, in imitation of

Horace's,

---

* *Phil. Tranſ.*

Horace's, "Ne ſit ancillæ tibi amor pudori," thus alludes :

Did not baſe Greber's Peg inflame
The ſober Earl of Nottingham,
  Of ſober ſire deſcended ?
That, careleſs of his ſoul and fame,
To play-houſes he nightly came,
  And left church undefended.

She continued to ſing on the ſtage till about 1718 ; when having, at a modeſt computation, acquired above ten thouſand guineas, ſhe retired from the theatre, and afterwards married Dr Pepuſch. She was remarkably tall, and remarkably ſwarthy ; and, in general, ſo deſtitute of perſonal charms, that Pepuſch ſeldom called her by any other name than Hecate, to which ſhe is ſaid to have anſwered very readily.

The change in Pepuſch's circumſtances by Margarita's fortune was no interruption to his ſtudies : he loved muſic, and he purſued the knowledge of it with ardour. At the inſtance of Gay and Rich, he undertook to compoſe, or rather to correct, the muſic for the Beggar's Opera. His reputation was now at a great height He had peruſed with great attention thoſe ſeveral ancient treatiſes on Harmonics, publiſhed by Meibomius, and that of Ptolemy by Dr Wallis ; and the difficulties which occurred to him on the peruſal, were in a great meaſure removed by his friend De Moivre the mathematician, who aſſiſted him in making calculations for demonſtrating thoſe principles on which the harmonic ſcience is founded. In conſequence of theſe ſtudies, he was eſteemed, in matters of theory, one of the beſt muſicians of his time. In 1737, he was choſen organiſt of the Charter-houſe, and retired, with his wife, to that venerable manſion. The wife died in 1740, before which he loſt a ſon, his only child ; ſo that he had no ſource of delight left, but the proſecution of his ſtudies, and the teaching of a few favourite pupils, who attended him at his apartments. Here he drew up that account of the ancient genera which was read before the Royal Society, and is publiſhed in the Philoſophical Tranſactions for October, November, and December, 1746 ; and, ſoon after the publication of that account, he was choſen a Fellow of the Royal Society.

He died the 20th of July, 1752, aged 85 ; and was buried in the chapel of the Charter-houſe, where a tablet with an inſcription is placed over him *

PERCUSSION, Force of Percussion, is the name by which mechanicians diſtinguiſh that faculty of producing motion, or making other ſenſible mechanical impreſſions on bodies, by means of the ſtroke of a body in motion. It is nearly the ſame with *impulſe* ; only, it would ſeem that the very ſcrupulous and refined affect to limit the attention to the *immediate* cauſe of the motion, or other effect produced ; to the ſomething that is different, both from the force ſuppoſed to be inherent in the moving body (a hammer for example), and the ſubſequent motion and penetration of the nail which is driven by it. We may venture to ſay that it is needleſs to attempt any inveſtigation of this object. It is hid, with all other cauſes of all other effects in the univerſe, in impenetrable darkneſs. If we reflect on the conſtitution of our own mind, ſo far as we can know it by experience and obſervation, and on the manner in which we draw concluſions, we muſt ſee that the knowledge of the efficient cauſe of any effect is unattainable ; for were the intervening ſomething pointed out to us, and clearly conceived by us, we ſhould find it juſt as neceſſary to find out why and how this ſomething is connected with each of the events which we obſerve it invariably to connect.

But a knowledge of the force of percuſſion, in as far as it may or may not be diſtinguiſhable from other forces, is not unattainable. We can learn as much, and no more, concerning this, as concerning any other force ; and we can contemplate that circumſtance which, in our opinion, is common to it with all other forces, and may perhaps diſcover other circumſtances in which it differs from them. But in all this diſquiſition, it is plain that it is only events, which we conceive to be the characteriſtic effects of the cauſe, that we contemplate.

Percuſſion, conſidered as an effect, characteriſtic of a particular faculty of moving bodies, became an object of anxious reſearch, almoſt as ſoon as philoſophers began to think of motion and moving forces at all. The ancients (as has been obſerved in the article Impulsion, *Suppl.*) contented themſelves with very vague ſpeculations on the ſubject. Galileo was the firſt who conſidered it as a meaſurable thing, the object of mathematical diſcuſſion ; being encouraged by his precious diſcovery of the laws of accelerated motion, and the very refined meaſure which theſe gave him of the power of gravity. It was a meaſure of the heavineſs, not of the weight, of the body ; and this was meaſured by its acceleration, and not by its preſſure. Encouraged by this, he hoped to find ſome ſuch meaſure of the force of percuſſion, which he ſaw ſo intimately connected with motion ; whereas its connection with preſſure was far from being obvious. He therefore tried to convert the terms ; and as he had found a meaſure of the preſſure of gravity in the acceleration of motion, he endeavoured to find in preſſure a meaſure of the force of percuſſion ariſing from this acceleration. He endeavoured to find the number of pounds, whoſe preſſure is equal to the blow of a given body, moving with a given velocity. The velocity was known to him with great preciſion, by means of the height from which the ball muſt fall in order to acquire it. It ſeems pretty clear that percuſſion may be meaſured in this way ; for a body falling from a height will pierce an uniformly tenacious body to a certain degree, and no further ; and experiment ſhews that this degree of penetration is very preciſe and conſtant. The ſame body, being merely laid on the tenacious body, will penetrate to a ſmall depth by its weight. Laying more weight on it, will make it penetrate deeper ; and a certain weight will make it penetrate as deep as the fall did, and no deeper. Thus, percuſſion ſeems very eaſily meaſurable by weight, or by any preſſure ſimilar to that of weight. It appears that Galileo made experiments with this view, and that he was diſappointed, and obliged to acquieſce in the opinion of Ariſtotle, that percuſſion and weight are incomparable. He propoſes, therefore, another experiment, namely, to drop a body into the ſcale of a balance from greater and greater heights, till at laſt the blow on the ſcale raiſes a weight that lies in the other ſcale. This offers itſelf ſo plauſibly, that we are perſuaded that Galileo tried it : but as he makes no mention

tion of the reſults, we preſume that they were unſatisfactory.

Neither of theſe experiments *could* give us a meaſure of the force of percuſſion, if this force be any thing different from the forces which are excited or brought into action by percuſſion, in the manner deſcribed in the article Impulsion, *Suppl.* When the ball comes into phyſical contact with the ſcale, it begins to compreſs it. This compreſſion begins to ſtretch the ſtrings by which the ſcale is ſupported. Theſe pull at the arm of the balance, and cauſe it to preſs the centre-pin a little harder on its ſupport, and to bend the balance a little, and cauſe it to pull at the cords which ſupport the other ſcale. That ſcale is pulled upwards, diminiſhing a little its preſſure on the ground, and preſſing it harder to the incumbent weight. Theſe forces are excited *in ſucceſſion* from the one ſcale to the other, and a ſmall moment of time elapſes. The reaction of the ſcale diminiſhes, but does not inſtantaneouſly annihilate, the velocity of the falling ball. It therefore compreſſes the ſcale ſtill more, ſtretches the threads, preſſes the fulcrum, and bends the balance ſtill more (becauſe the weight in the other ſcale keeps it down). The velocity of the falling ball is rapidly diminiſhed; the balance is more bent, and pulls more ſtrongly upwards at the threads of the other ſcale; and thus preſſes that ſcale more ſtrongly againſt the incumbent weight, gradually communicating more and more motion to it, removing it farther from the ground, till, at laſt, the motion becomes ſenſible, or ſo conſiderable as to diſengage ſome delicate catch as a ſignal. The experiment is now finiſhed; and the mechanician fondly thinks that, at this inſtant, the preſſure excited by the percuſſion, between the oppoſite ſcale and the under ſide of the incumbent weight, is juſt equal, or but a very little ſuperior, to the preſſure of the incumbent weight: and, ſince the arms of the balance are equal, and therefore the preſſures on the two ſcales are equal, he imagines that that weight exerts a preſſure equal to the percuſſion of the falling ball.

But all this is miſconception, and alſo falſe reaſoning. It is not percuſſion that we are meaſuring, but the preſſures, excited by percuſſion, on the two ſcales. And theſe preſſures are the forces of elaſticity or expanſiveneſs, belonging to, or inherent in, the particles of the balls and the ſcales; forces which are brought into action by the approach of thoſe bodies to each other. This reaſoning is alſo erroneous; and we ſhould be miſtaken if we think that the preſſure actually exerted is equal to that of the weight in the oppoſite ſcale. It is greater than the mere preſſure of that weight. The reaction of the oppoſite ſcale on its load was preciſely equal to that weight before the ball was dropped from the hand; and, had the ball been equal to that weight, and ſimply laid into the ſcale on which it falls, it would have made no change on the mutual preſſures of the ſcale and the other weight; it would only have relieved the ground from the preſſure of that weight, and would have brought it on the threads which ſupport its ſcale. The preſſure of this ſcale upwards muſt be increaſed, before it can ſtart the weight ſenſibly from the ground. How much it muſt be increaſed depends on the ſpringineſs of the ſcales, cords, and beam. By a proper adjuſtment of theſe particulars, the apparatus will give us almoſt any meaſure of percuſſion that we chooſe. For this reaſon, the improvements made on it by Graveſande are of no value. The ſame reaſoning, nearly, may be applied to the meaſurements of the force of percuſſion by means of the penetration of ſoft bodies.

Galileo mentions another very curious experiment, by which he thought that he had obtained a juſt meaſure of percuſſion. A veſſel, filled with water, was ſuſpended on the arm of a balance, with another veſſel hanging from it, a great way below. All was exactly balanced by a weight in the oppoſite ſcale. By means of a ſuitable contrivance, a hole was opened in the bottom of the upper veſſel, without diſturbing the equilibrium. As ſoon as the water iſſued, and while it was falling through the air, that end of the balance roſe; but when the water ſtruck the lower veſſel, the equilibrium was reſtored, and continued during the whole time of the efflux. Hence Galileo concluded, that the force of the ſtroke was equal to the weight of the falling water. But we apprehend that the obſervations made on this in the article Impulsion, *Suppl.* will convince the reader that this concluſion is far from being legitimate. Beſides, the ſtroke, in any one inſtant, is made by thoſe particles only which ſtrike in that inſtant, while the whole vein of water between the veſſels is neither acting by its weight on the upper veſſel, nor by its ſtroke on the lower; and we ſhould conclude from the experiment, that the force of percuſſion is infinitely greater than the weight of the ſtriking body. Indeed this is the inference made by Galileo. But if we have recourſe to the experiments and reaſonings of Daniel Bernoulli, in the article *Resistance of Fluids*, *Encycl.* we ſhall find that the ſeeming impulſe on the lower veſſel is really a moſt complicated pure preſſure, and of moſt uncertain determination. The experiment is valuable, and gives room for curious reflections. We have repeated it, in a great variety of forms, and with great changes of impulſe, and ſometimes in ſuch a manner that no impulſe whatever can obtain, while at the ſame time a quantity of water was falling, unſupported by either veſſel. In all the trials the equilibrium remained undiſturbed. We were obliged to conclude, therefore, that the experiment afforded no meaſure of percuſſion. Indeed we were of this opinion before making the trial, for the reaſons juſt now given.

We cannot ſay that the ſubſequent labours of philoſophers have added much to our knowledge of this matter. Mr Leibnitz had contrived his whimſical doctrine of *living* and *dead* forces. The action of gravity, or of a ſpring, is a *vis viva*, when it actually produces motion in the body on which it acts: but when a ſtone lies on a table, and preſſes on it, this preſſure is a *vis mortua*. Its exertion is made, and in the ſame inſtant deſtroyed, by an oppoſite *vis mortua*. Each of theſe exertions would have produced *a beginning* of motion (ſomething different from any the ſmalleſt local motion); and the ſum of all would, after a certain time, have amounted to a ſenſible motion and velocity. There ſeems no diſtinct conception to accompany, or that can accompany, this language. And, as a proof that Leibnitz had no diſtinct conceptions of the matter, he has recourſe to this very experiment of Galileo in ſupport of his geneſis of a ſenſible motion from the continual exertions of the *vis mortua*; and he concludes that the force of percuſſion is infinitely, or incomparably, greater than preſſure, becauſe it is the ſum total of an infinity of individual

dual exertions of *vis mortua*. Nothing but the authority which Leibnitz has acquired on the continent, by the zealous efforts of his partizans, could excuſe our taking up any time in conſidering this unintelligible diſcourſe. Surely, if there is ſuch a thing as a *vis viva*, it exiſts in the moving water, and its impulſions are not continual exertions of a *vis mortua*. Nor is it poſſible to conceive continual impulſe, nor a beginning of motion that is not motion, &c. &c. It is paradoxical (and Leibnitz loved to raiſe the wonder of his followers by paradoxes) to ſay that percuſſion is infinitely greater than preſſure, when we ſee that preſſure can do every thing that can be done by percuſſion. Nay, Euler, by far the moſt able ſupporter of the doctrines of Leibnitz about the force of bodies in motion, actually compares theſe two forces; and, in his Commentary on Robins's Artillery, demonſtrates, in his way, that when a muſket ball, moving with the velocity of 1700 feet per ſecond, penetrates five inches into a block of elm, the force of its percuſſion is 107,760 times its weight. John Bernoulli reſtricts the infinite magnitude of percuſſion to the caſe of perfectly hard bodies; and, for this reaſon alone, ſays, that there can be none ſuch in the univerſe. But, as this juſtly celebrated mathematician ſcouts with ſcorn the notion of attractions and repulſions, he muſt allow, that an ultimate atom of matter is unchangeable in its form; which we take to be ſynonymous with ſaying that it is perfectly hard. What muſt be the reſult of one atom in motion hitting another at reſt? Here muſt be an inſtantaneous production of a finite velocity, and an infinite percuſſion. A doctrine which reduces its abetters to ſuch ſubterfuges, and engages the mind in ſuch puzzling contemplations, cannot (to ſay the beſt of it) be ſtyled an EXPLANATION of the laws of Nature. The whole language on the ſubject is full of paradoxes and obſcurities. In order to reconcile this infinite magnitude of percuſſion with the obſerved finite magnitude of its effects, they ſay that the preſſure, or inſtantaneous effort, has the ſame relation to the force of percuſſion that an element has to its integral; and in maintaining this aſſertion, they continually conſider this integral under the expreſs denomination of a *ſum total*, robbing Leibnitz's great diſcovery of the infiniteſimal calculus of every ſuperiority that it poſſeſſed over Wallis's Arithmetic of Infinites, and really employing all the erroneous practices of the method of indiviſibles. We look upon the ſtrange things which have been inculcated, with pertinacious zeal, in this doctrine of percuſſion and *vires vivæ*, as the moſt remarkable example of the errors into which the unguarded uſe of Cavalerius's Indiviſibles, and of the Leibnitzian notion of the infiniteſimal calculus, have led eminent mathematicians. It is not true that the preſſure, and the ultimate force of percuſſion, have this relation; nor has the preſſure and the reſulting motion, which is miſtaken for the meaſure of this ultimate force, any mathematical relation whatever. The relation is purely phyſical; it is the relation of pure cauſe and effect; and all that we know of it is their conſtant conjunction. The relation of fluxion and fluent is not a mathematical or meaſurable relation, but a connection in thought; which is ſufficient for making the one an indication of the other, and the meaſures of the proportions of the one a mean for obtaining a meaſure of the proportions of the other. In this point of view, the relation of preſſure to motion, as the meaſure of the force of percuſſion, *reſembles* that of fluxion and fluent, but is not the ſame.

Much has been ſaid by the partizans of Mr Leibnitz about the incomparableneſs of preſſure and percuſſion, and many experimental proofs have been adduced of the incomparable ſuperiority of the latter. Bulfinger ſays, that the preſſure of many tons will not cauſe a ſpike to penetrate a block of hard oak half ſo far as it may be driven by a weak man with one blow of a mallet; and that a moderate blow with a ſmall hammer will ſhiver to powder a diamond, which would carry a mountain without being hurt by its preſſure. Nay, even Mr Camus, of the Academy of Paris, a ſtaunch Carteſian, and an eminent mechanician, ſays that he beat a leaden bullet quite flat with a hammer of one pound weight, without much force; and that he found that 200 pounds weight would not have flattened it more than this blow: and he concludes from thence, that the force of the blow exceeded 200 pounds. Theſe, to be ſure, are remarkable facts, and juſtify a more minute conſideration of a power of producing certain effects, which is ſo frequently and ſo uſefully employed. But, at the ſame time, theſe are all very vague expreſſions, and they do not authoriſe any preciſe concluſions from them. Mr Camus ſaying "without much force," makes his pound weight, and his 200 pound weight, of no uſe for determining the force of the blow. He would have given more preciſe and applicable data for his deciſion, had he told us from what height the hammer ſhould fall in order to flatten the bullet to this degree. But even then we ſhould not have obtained any notion of the force in actual exertion during the flattening of the bullet; for the blow which could flatten the bullet in a longer or a ſhorter time, would unqueſtionably have been leſs or greater.

All the paradoxes, obſcurities, and puzzling difficulties, in this ſubject diſappear, if we leave out of our conſideration that unintelligible force, which is ſuppoſed to preſerve a body in motion or at reſt; and if we conſider both of theſe ſtates of body as conditions which will continue, unleſs ſome adequate cauſe operate a change; and if we farther grant, that ſuch cauſes do really exiſt in the univerſe, however unknown their nature may be by us; and, laſtly, if we acknowledge, that the phenomena of elaſticity, expanſiveneſs, coheſion, gravity, magnetiſm, electricity, are indications of the agency of ſuch cauſes, and that their actual exertions, and the motions and changes conſequent on theſe exertions, are ſo invariably connected with particular bodies, that they always accompany their appearance in certain mutual relations of diſtance and poſition:—if we proceed thus, all the phenomena of colliſion will be explained by theſe cauſes alone, without ſuppoſing the exiſtence and agency of a cauſe diſtinct from them all, and incomparable with them, called the FORCE OF PERCUSSION.

For it has been ſufficiently demonſtrated in the article IMPULSION (*Suppl.*), that that property of tangible coherent matter, which we call *perfect elaſticity*, operates as a preſſure during a certain ſmall portion of time on both bodies, diminiſhing more and more the motion of the one, and augmenting that of the other, as the compreſſion of one or both increaſes, till at laſt they ſeparate with ſenſible velocities. In ſome very ſimple or perſpicuous

Plate XLI.

ſpicuous caſes, we know what this preſſure is in every inſtant of the action. We can tell how many pounds weight, at reſt, will exert the ſame preſſure. We can tell the whole duration of this preſſure, and the ſpace along which it is exerted; and, in ſuch a caſe, we can ſay with preciſion what motion will be generated by this continued and varied preſſure on the body which was at reſt, and what diminution will be made in the motion of the other. All this can be done in the caſe of a ball A (fig. 1.), moving like a pendulum with a ſmall velocity, and ſtriking a ſlender elaſtic hoop B, alſo ſuſpended like a pendulum. We can aſcertain by experiment, before the colliſion, what preſſure is neceſſary for compreſſing it one inch, one-half, one-fourth, &c. Knowing this, and the weight of the hoop, and the weight and velocity of the ball, we can tell every circumſtance of the colliſion—how long the compreſſion continues—what is the greateſt compreſſion—how far the bodies have moved while they were acting on each other—and what will be the final motion of each:—in ſhort, every thing that affords any mark or meaſure of a force of percuſſion. And we know that all this is produced by a force, familiarly known to us by the name of elaſticity. Which of all theſe circumſtances ſhall be called the percuſſion, or the force of percuſſion? Is it the ultimate or greateſt preſſure occaſioned by the compreſſion? This cannot be, becauſe this *alone* will not be proportional to the final change of motion, which is generally taken as a meaſure of the percuſſion when a change of motion is its only obſerved effect.

We know that another perfectly elaſtic body, of the ſame weight, and ſtruck by the ſame blow, and acquiring the ſame final velocity by the ſtroke, may not have ſuſtained the tenth part of the preſſure, in any one inſtant of the colliſion, if it has only been much more compreſſible. The greateſt mutual preſſure in the colliſion of a billiard ball is perhaps 1000 times greater than it is in a ſimilar colliſion of a foot-ball of the ſame weight.

We alſo know what degree of compreſſion will break this hoop, and what preſſure will produce this compreſſion. Therefore, ſhould the fracture of the body be conſidered as the mark and meaſure of the percuſſion, we know what blow will juſt produce it, and be exhauſted by ſo doing. In ſhort, we know every mark and meaſure of percuſſion which this hoop can exhibit.

We can increaſe the ſtrength of this hoop till it becomes a ſolid diſk; and we ſee clearly, that in all theſe forms the mode of acting is the ſame. We ſee clearly that it is the ſame when, inſtead of the ſolid diſk, it is an elaſtic ball; therefore every thing that can indicate or meaſure the percuſſion of an elaſtic ball, is explained without the operation of a peculiar force of percuſſion, even when the ball is ſhivered to pieces by the blow.

Nor is the caſe materially different when the bodies are ſoft, or imperfectly elaſtic. When the ſtruck body is uniformly tenacious, it oppoſes a uniform reſiſtance to penetration, and its motion will be uniformly accelerated by the action of its own tenacity during the whole time of mutual action, except a trifling variation occaſioned by the mere motion of the internal parts, independent of their tenacity. If we knew the weight neceſſary for merely penetrating this maſs, and the weight and velocity of the penetrating body, we can tell how long it muſt be reſiſted by this force before its initial velocity will be annihilated, and therefore how far it will penetrate. We have tried this with deal, birch, willow, and other ſoft woods of uniform texture, and with nails having the body ſomewhat ſlenderer than the end, that there might not be an irregularity occaſioned by a friction on the ſides of the nail, continually increaſing as the penetration advanced. We made the hammer fall from a conſiderable height, and hit the nail with great accuracy in the direction of its length, by fixing it to the end of a long lath, moveable round an axis. The reſults correſponded with the calculation with all the preciſion that could be deſired.

But it does not reſult from all this agreement, that the force, exertion, or effect, of a blow with a hammer is equal to the preſſure of any number of pounds whatever. They are things that cannot be compared; and yet the force operating in the penetration by a blow is no way different from a preſſure. It is a phyſical blunder to compare the area of the curve, whoſe abſciſſa is the depth of penetration, and the ordinates are as the reſiſtances, with any preſſure whatever. This area expreſſes the ſquare of a velocity, and its ſlips, bounded by parallel ordinates indefinitely near each other, are as the decrements of this ſquare of a velocity, occaſioned by a preſſure, acting almoſt uniformly along a very ſmall ſpace, or during a very ſmall time. It is an abſurdity therefore to ſum up theſe ſlips as ſo many preſſures, and to conſider the ſum total as capable of expreſſing any weight whatever. Such a parallogiſm is peculiar to Leibnitz's way of conceiving his infiniteſimal method, and it could have no place in the genuine method of fluxions. It is this miſconception that has made Mr Leibnitz and his followers ſuppoſe that a body, accelerated by gravity, retains in it a ſum total of all the preſſures of gravity accumulated during its fall, and now forming a *vis viva*. Suppoſing that it requires a preſſure of twenty pounds to preſs a ſix pound ſhot ſlowly through a maſs of uniformly reſiſting clay; this preſſure would carry it from the top to the bottom of a mountain of ſuch clay. Yet this ball, if diſcharged horizontally from a cannon, would penetrate only a few yards, even though the clay ſhould reſiſt by tenacity only, independent of the motion loſt by giving *motion* to its internal parts. In this experiment, the utmoſt preſſure exerted during the motion of the ball did not much exceed the preſſure of twenty pounds. In this compariſon, therefore, percuſſion, ſo far from appearing infinitely greater than preſſure, would appear much leſs. But there is perhaps no body that reſiſts penetration with perfect uniformity, even though uniformly tenacious. When the ball has penetrated to ſome depth, the particles which are before it cannot be ſo eaſily diſplaced, even although they had no tenacity, becauſe the particles adjoining are more hemmed in by thoſe beyond them. We have always obſerved, that a ball impelled by gunpowder through water riſes toward the ſurface (having entered horizontally through the ſide of the veſſel at ſome depth), and this ſo much the more rapidly as it entered nearer to the ſurface. The reaſon is plain. The particles which muſt be diſplaced before the ball, eſcape more eaſily upwards than in any other direction. It is for this reaſon chiefly that a greater weight laid on the head of a nail will cauſe it ſink deeper into the wood; and thus a great weight appears to to be commenſurable with a great force of percuſſion. Alſo, while a bullet is flattening more and more under a hammer during the progreſs of a blow, it is ſpreading under the hammer; more particles are reſiſting at once, and they find more difficulty in effecting their eſcape, being harder ſqueezed between the hammer and the anvil. The ſame increaſed reſiſtance muſt obtain while it is flattening more and more under the quiet preſſure of a weight; and thus, too, a greater weight appears to be commenſurable with a greater blow.

After all, however, a blow given by a falling body muſt excite a preſſure greater than its mere weight can do, and this in any degree. Thus, ſuppoſe AB (fig. 2.) to repreſent a ſpiral ſpring in its natural unconſtrained dimenſions, ſtanding upright on a table. Let ab be the abſciſſa of a line $adhk$, whoſe ordinates cd, gh, ik, &c. are as the elaſtic reaction of the ſpring when it is compreſſed into the lengths cb, gb, ib, &c. Suppoſe that, when it is compreſſed into the form CD, it will juſt ſupport the weight of a ball lying on C. Then cd will be a reaction equal to the weight of the ball, and the rectangle $acdf$ will expreſs the ſquare of the velocity which this ball would acquire by falling freely through ac. If therefore the ball be gently laid on the top of the ſpring at A, and then let go, it will deſcend, compreſſing the ſpring. It will not ſtop when the ſpring has acquired the form CD, which enabled it to carry the weight of the ball gently laid on it. For in this ſituation it has acquired a velocity, of which the ſquare is repreſented by the figure adf (See DYNAMICS, *Suppl.* n° 95.). It will compreſs the ſpring into the length gb, ſuch that the area $cghd$ is equal to the area adf If the ball, inſtead of being gently laid on A, be dropped from M, it will compreſs the ſpring into ſuch a length ib, that the area aik is equal to the rectangle $mcdn$; and, if the ſpring cannot bear ſo great compreſſion, it will be broken by this very moderate fall.

Thus we ſee that a blow may do things which a conſiderable preſſure cannot accompliſh. The accounts which are given of theſe remarkable effects of percuſſion, with the view of impreſſing notions of its great efficacy, are generally in very indefinite terms, and often without mentioning circumſtances which are acceſſory to the effect. It would be very unfair to conclude an almoſt infinite power of percuſſion, from obſerving, that a particle of ſand, dropped into a thick glaſs bottle which has not been annealed, will ſhiver it to pieces. When Mr Bulfinger ſays that a moderate blow will break a diamond which could carry a mountain, he not only ſays a thing of which he cannot demonſtrate the truth, and which, in all probability, is not true; but he omits noticing a circumſtance which he was mechanician enough to know would have a conſiderable ſhare in the effect. We mean the rapidity with which the excited preſſure increaſes to its maximum in the caſe of a blow. In the experiment in queſtion, this happens in leſs than the millionth part of a ſecond, if the velocity of the hammer has been ſuch as a man would generate in it by a very moderate exertion. For the blow which will drive a good lath nail to the head in a piece of ſoft deal with an ordinary carpenter's hammer, muſt be accounted moderate. This we have learned by experiment to be above 25 feet per ſecond. The connecting forces exerted between the particles of the diamond may not have time ſufficient for their excitation in the remote parts, ſo as to ſhare the derangement among them all, in ſuch a manner that it may be ſo moderate in each as not to amount to a diſunion in any part of the diamond. We ſee many inſtances of this in the abrupt handling of bodies of tender and friable texture. It is partly owing to this that a ball diſcharged from a piſtol will go through a ſheet of paper ſtanding on edge without throwing it down, which it would certainly do if thrown at it by the hand. The connecting forces, having time to act in this laſt caſe, drag the other parts of the paper along with them, and their union is preſerved. Alſo, when a great weight is laid on the diamond, it is gradually dimpled by it; and thus incloſing many parts together in the dimple, it obliges them to act in concert, and the derangement of each is thus diminiſhed.

We flatter ourſelves that the preceding obſervations and reflections will contribute ſomewhat towards removing the paradoxes and myſteries which diſcredit, in ſome degree, our mechanical ſcience. If we will not pertinaciouſly conjure up ideal phantoms, which, perhaps, *cannot* exiſt, but content ourſelves with the ſtudy of that tangible matter which the Author of Nature has preſented to our view, we ſhall have abundant employment, and ſhall perceive a beautiful harmony thro' the whole of natural operations; and we ſhall gradually diſcover more and more of thoſe mutual adaptations which enable an atom of matter, although of the ſame preciſe nature wherever it is found, to act ſuch an unſpeakable variety of parts, according to the diverſity of its ſituations and the ſcene on which it is placed. If a mind be "not captivated by the harmony of ſuch ſweet ſounds," we may pronounce it "dark as Erebus, and not to be truſted"

PERFECT NUMBER, is one that is equal to the ſum of all its aliquot parts when added together. Eucl. lib. 7, def. 22. As the number 6, which is $= 1 + 2 + 3$, the ſum of all its aliquot parts; alſo 28, for $28 = 1 + 2 + 4 + 7 + 14$, the ſum of all its aliquot parts. It is proved by Euclid, in the laſt prop. of book the 9th, that if the common geometrical ſeries of numbers 1, 2, 4, 8, 16, 32, &c. be continued to ſuch a number of terms, as that the ſum of the ſaid ſeries of terms ſhall be a prime number, then the product of this ſum by the laſt term of the ſeries will be a perfect number.

PERGUNNA, in Bengal, the ſubdiviſion of a diſtrict.

PERKINISM, the proper name of what we muſt think an impoſition attempted to be put upon the world by Dr Perkins of North America.

Though the phenomena of electricity had been long familiar to the philoſophers of Europe, it is well known that a philoſophical theory of theſe phenomena was firſt formed by a tranſatlantic philoſopher. In like manner, though the diſcovery of Galvani, under the name of *animal electricity* (ſee GALVANISM in this *Supplement*), had occupied the attention of many of the firſt phyſicians and philoſophers of the old world, it was reſerved for a phyſician of the new, to apply it to the cure of a number of diſeaſes. Every philoſopher of America, however, has not the ſagacity of the Philadelphian ſage; nor muſt Dr Perkins or his admirers be ſurpriſed, if we treat not incomprehenſible myſticiſm with the reſpect due to a theory founded on facts.

Perkiniſm.

We are told by the ſon (A) of this rival of Franklin, that before the news of Galvani's diſcovery had reached America, he had obſerved ſeveral phenomena pointing out the influence of metals in caſes of pain. The firſt remarkable incident that preſented itſelf to his notice was the ſudden contraction of a muſcle when he was performing a chirurgical operation. This, he obſerved, regularly took place whenever the point of the metallic inſtrument was put in contact with the muſcle. Struck with the *novelty* of the appearance (Is Mr Perkins ſure that the appearance was new?), he was induced to try the points of wood and other ſubſtances; and no contraction taking place on theſe experiments, he thence inferred that the phenomena could be aſcribed only to the influence of the metal. About the ſame time, he obſerved that, in one or two caſes (and if his practice had been great he might have obſerved that in a thouſand caſes), a ceſſation of pain had enſued when a knife or lancet was applied to ſeparate the gum from a tooth previous to extracting it; and in the ſame year he diſcovered, that *momentary* eaſe was given, in a few inſtances, by the accidental application of a metallic inſtrument to inflamed and painful tumors previous to any inciſion.

Theſe are the judicious reaſonings and aſſertions of a dutiful child, who, having probably heard of Leibnitz's claims to ſome of Newton's diſcoveries, was determined to put in a ſimilar claim for his father, to a *ſhare*, at leaſt, of the diſcovery made by the celebrated profeſſor at Bologna. He has not, however, copied with ſervility the conduct of the Leibnitzians. We do not remember an inſtance where any of them attempted to elevate the fame or the merits of their maſter *above* the fame and merits of Newton; but, according to our author, the purſuits of Galvani and his European pupils ſink into inſignificance, when compared with thoſe of the tranſatlantic phyſician.

This is evident; for when the phyſiologiſts of Europe were engaged in experimenting on the denuded nerves and muſcles of the ſmaller animals, with a view to aſcertain the agency of this incomprehenſible property in them, Dr Perkins was proſecuting a ſeries of experiments, which conſiſted in applying externally, to parts affected with diſeaſe, metals, and compounds of metals of every deſcription which occurred to him, and conſtructed into various forms and ſizes. The reſult proved, that on drawing lightly over the parts affected certain inſtruments, termed *tractors*, which he formed from metallic ſubſtances into pointed ſhapes, he could remove moſt of thoſe topical diſeaſes of the human body, where an extra degree of nervous energy or vital heat was preſent; unleſs ſuch diſeaſe was ſituated in ſome of the internal viſcera, too remote from the part where the inſtruments could be applied.

The diſeaſes which have been found moſt ſuſceptible of the influence of the tractors are, rheumatiſm, ſome gouty affections, pleuriſy, ophthalmias, eryſipelas, violent ſpaſmodic convulſions, as epileptic fits and the locked jaw, the pain and ſwelling attending contuſions, inflammatory tumors, the pains from a recent ſprain, the painful effects of a burn or ſcald, pains in the head, teeth, and indeed moſt kinds of painful topical affections, excepting where the organic ſtructure of the part is deſtroyed, as in wounds, ulcers, &c. and excepting alſo where oils or ſome other non conducting ſubſtances are preſent.

But we have other teſtimonies than thoſe of Dr Perkins and his ſon for the influence of the tractors. Mr Meigs, profeſſor of natural philoſophy at Newhaven, in a letter on Dr Perkins's diſcovery, conceives the principles of metallic irritability as ſo little underſtood, that he will not pretend to explain how the tractors produce their effects; but ſeems ſatisfied in finding that the effects are produced. After ſtating an experiment on his own child, eight years of age, very dangerouſly ill with a peripneumonic complaint, and to which the tractors gave almoſt inſtantaneous relief, he ſays, "I have uſed the tractors with ſucceſs in ſeveral other caſes in my own family; and although, like Naaman the Syrian, I cannot tell why the waters of Jordan ſhould be better than Abana and Pharpar, rivers of Damaſcus; yet, ſince *experience* has proved them ſo, no reaſoning can change the opinion. Indeed, the cauſes of all common facts are, *we think*, perfectly well known to us; and it is very probable, fifty or an hundred years hence, we ſhall as well know why the metallic tractors ſhould in a few minutes remove violent pains, as we now know why cantharides and opium will produce oppoſite effects: viz. we ſhall know but *very little* about either, excepting *facts*."

Mr Woodward, profeſſor of natural philoſophy at Dartmouth, in a letter alſo on the ſame ſubject, has ſtated a number of ſucceſsful experiments in pains of the head, face, teeth, and in one caſe of a ſprain.

Dr Vaughan, a member of the Philadelphia medical ſociety, has lately publiſhed an ingenious tract on Galvaniſm, the object of which is to account for the influence of the tractors in removing diſeaſes. After a citation of numerous experiments made on the nerves and muſcles of animals, he obſerves, "If we only take an impartial view of the operations of Nature herſelf, and attend diligently to the analytical inveſtigations of the aforementioned experimentaliſts on this ſublime ſubject, I think the ſceptic muſt admit that the principle of nervous energy is a modification of electricity. As ſenſation is dependant on this energy, a pleaſurable ſenſation, or what may be termed a natural or healthy degree thereof; then certainly pain, or ſuperſenſation, can only depend on an accumulation of the electric fluid, or extra degree of energy in the part affected. On this principle the problem admits of eaſy ſolution; namely, that the metals, being ſuſceptible of this fluid, conduct the extra degree of energy to parts where it is diminiſhed, or out of the ſyſtem altogether, reſtoring the native law of electric equilibrium."

We truſt we are not ſceptics; and yet we feel not ourſelves inclined to admit any part of this theory. We have ſeen no proof that nervous energy is a modification of electricity; and we think that we have ourſelves proved, that *galvaniſm* and *electricity* are in many reſpects different; but we ſhall not be much ſurpriſed if we ſoon ſee a *demonſtration* by ſome American or German philoſopher,

---

(A) See a pamphlet, entitled The Influence of Metallic Tractors on the Human Body, &c. by Benjamin Douglas Perkins, A. M. ſon to the diſcoverer; or a very good abridgement of it in the firſt volume of the Philoſophical Magazine.

philosopher, that the ſoul of man is a compoſition of ſilver and zinc. One of theſe ſages has lately diſcovered, that the ſymptoms of *putrefaction* do not conſtitute an *infallible* evidence of death, but that the application of *metals* will in all caſes aſcertain it beyond the poſſibility of doubt! A proper application certainly will; for when the Perkiniſt is doubtful whether his patient be dead or alive, he has only to apply the muzzle of a loaded piſtol to his temple, and blow out his brains; after which he may ſafely ſwear that the man is dead.

From the *Philoſophical Magazine*, we learn that Profeſſor Schumacher at Copenhagen made experiments with tractors of braſs and iron on ten patients in Frederick's hoſpital at Copenhagen. He tried alſo tractors of ebony and ivory, which are ſaid to have cured a pain in the knee; with others of ſilver and zinc; and ſome of copper and lead. By the two laſt, pains in the knee, arm, and face, are ſaid to have been mitigated. According to M. Klingberg's experiments, this remedy was of uſe in *malum iſchiaticum*; and according to thoſe of M. Steffens, in *malum iſchiaticum* and megrim. According to M. Bang, the pains in ſome caſes were increaſed, and in others allayed. According to M. Blech, the tractors were of uſe in *hemicrania* and gouty pains in the head; and, according to M. Hahn, in rheumatic pains in both ſhoulders. The principal document in the Daniſh collection relating to Perkiniſm, appears to be a letter of Profeſſor Abilgaard, in whoſe opinion Perkins's tractors will never acquire much value in medicine, and ſcarcely even have the merit of being a palliative; but, in a phyſical point of view, he thinks they deſerve the attention of phyſicians, and particularly of phyſiologiſts. Mankind (he ſays) hitherto have paid too little attention to the influence which electricity has on the human body; otherwiſe they would know that the effects produced on it by our beds is no matter of indifference. If the feather beds and hair mattreſſes, &c. are perfectly dry, the perſon who ſleeps on them is in an inſulated ſtate; but the contrary is the caſe if they are moiſt. He three times removed a pain in the knee, by ſticking the tractors, one on each ſide of the knee, ſo deep through the ſtockings that the points touched the ſkin. He removed a rheumatic pain in the head from a lady by the ſame means. M. Kafn, by the tractors, relieved, in others, gouty pains of the head and megrim; and in himſelf, a rheumatic pain of the back, which, according to his ſenſations, was like a conſtriction in the cellular tiſſue. M. Herholdt, from his experiments, conſiders the effect of the tractors as indefinite and relative as that of other remedies. He, however, ſaw relief given by them in the ſtrangury in a caſe of ſyphilis. M. Bang alſo, at Soroe, freed a man from a violent gouty pain in the thigh, by drawing the tractors 200 times over the affected part. M. Jacobſen likewiſe found benefit derived from theſe tractors ſeveral times in the common hoſpital at Copenhagen. M. Tode tried them alſo in rheumatic pains, tooth-ache, and inflammation of the eyes; and obſerved that they neither did good nor harm.

On ſome of the atteſted cures mentioned in Mr Perkins's pamphlet, an able writer in the Monthly Review has made remarks ſo very pertinent, that we cannot refuſe ourſelves the pleaſure of tranſcribing them.

"At page 54 of the pamphlet, we meet (ſays the reviewer) with a ſtrong proof of the confidence placed in this remedy by ſeveral tranſatlantic philoſophers. Dr Willard, it ſeems, applied a red-hot piece of iron to a wart on his finger, and burnt himſelf very ſeverely, in order that he might be relieved by the tractors; which are ſaid to have given him eaſe in two ſucceſſive experiments. The author adds, 'many have ſubmitted to ſimilar meaſures, in order to *experience* the effects. I once formed one of five, who burned ourſelves ſo that bliſters were raiſed, to make the experiment; we all obtained relief in a few minutes.'

"This zeal for knowledge is truly edifying; eſpecially as the tractors are generouſly preſented to the public at *only* five guineas a pair; and it is clear that one pair would ſuffice to cure all the burns and ſcalds of a large pariſh. Why are not ſuch luculent experiments repeated here? If Mr Perkins, or any admirer of the diſcovery, would ſubmit to have a red hot poker run into ſome part of his body not neceſſary to life (into *that part where honour's lodged*, according to Butler, for example), in any public coffee houſe within the bills of mortality, and would afterward heal the wound in preſence of the company, in ten minutes, or in half as many hours, by means of the tractors, the moſt ſtony-hearted infidel could not reſiſt ſuch a demonſtration. Why trifle with internal inflammations, when ſuch an outward and viſible ſign might be afforded?

"Mr Perkins has taken ſome pains, in the firſt part of his pamphlet, to ſhew that the operation of his rods is not derived from animal magnetiſm. In our opinion, this is an unneceſſary piece of trouble in England, where there is a conſtant ſucceſſion of ſimilar pretenſions. The *virgula divinatoria*, and the *baguette* of the juggler, are the genuine prototypes of this myſtery. We were, indeed, rejoiced, on Dr Perkins's account, to find that the Connecticut Society had only denounced him as a Meſmeriſt: we trembled leſt he ſhould have been put into the inquiſitorial hands of the old women as a white witch."

This may be thought too ludicrous a treatment of a diſcovery which profeſſes to benefit mankind; but to have treated this diſcovery with ſeriouſneſs, would have degraded the profeſſion of a ſcientific critic. As if the very cures pretended to have been performed did not of themſelves throw ſufficient ridicule over the diſcovery, Mr Perkins informs us, "that in ſome inſtances the metallic influence, when excited by different perſons, produces different effects. Experiments made to aſcertain the point, proved that there were perſons who might uſe the tractors for any length of time, in diſeaſes which were ſuitable for the operation, and produce no perceptible effect; when by placing them in the hands of another perſon, who ſhould perform the operation preciſely in the ſame manner as before, the pain or inflammation would be removed directly." Hence he endeavours to prove that the influence of the tractors is Galvanic, by an argument as abſurd as the pretended fact on which it is founded.

"On the application (ſays he) of zinc and ſilver to the tongue, the ſenſation of taſte is very ſlight to ſome, while with others it is very ſtrong:—when the experiment is applied to the ſenſe of ſight, ſome are hardly ſenſible of it, while others obſerve a ſtrong flaſh." But, not to mention that neither ebony nor ivory can form part of the excitatory arc in *Galvaniſm*, though we have ſeen them both employed *ſucceſsfully* as tractors by a Daniſh Perkiniſt, it is enough to obſerve, that the different effects of the Galvanic metals on different perſons depend upon the difference of ſtructure of the organs of ſenſation in the *patients ;* whereas the different effects of the metallic tractors reſult, according to this account, from the difference of ſtructure in the organs of ſenſe of the various *operators !* Nay, what is ſtill more extraordinary, if any thing can be more extraordinary than this, is, that the value of the tractors depends, not upon the *materials* of which they are made, or the *ſkill* of the manufacturer, but upon ſome inconceivable virtue conveyed by Mr Perkins to the *perſon* of him by whom they are *ſold.* This we learn from a pamphlet publiſhed by Charles Cunningham Longworthy, ſurgeon in Bath ; who informs us, that he ſells tractors by *commiſſion* from Mr Perkins the original manufacturer in London."

After this article was ſent to the preſs, and thus much of it printed, we received, from a friend in London, a copy of Mr Perkins's laſt publication on the ſubject * ; in which he endeavours to repel the objections urged by Dr Haygarth and others againſt the influence of the metallic tractors. Had we not been previouſly convinced of the falſity of Perkiniſm, the peruſal of this pamphlet would have removed from our minds every doubt ; for we will venture to ſay, that it is not in the power of Dr Haygarth, and the whole faculty united, to bring more complete proof than Mr Perkins has here brought, that what he calls his father's *diſcovery* has no claim to rank otherwiſe than with the diſcovery of Meſmer. See *Animal* MAGNETISM, Encycl.

He gives indeed 250 caſes, which are atteſted to have been ſucceſsfully treated by the tractors ; but at leaſt an equal number of caſes were atteſted to have been ſucceſsfully treated by Meſmer and his partiſans ; and ſix times that number of cures were ſaid to have been miraculouſly performed at the tomb of the Abbé Paris (See PARIS in this *Suppl.)* We would willingly allow, however, that theſe atteſtations ought to draw the attention of men of ſcience to the ſubject, did not the author himſelf betray a want of confidence in the tractors, by his own arguments in their favour, and by his caution to the public againſt *counterfeits.* He ſeems indeed to conſider their ſanative influence as reſulting entirely from his *patent.*

Dr Haygarth having ſaid that he performed cures of the ſame kind with thoſe of which Mr Perkins boaſts, by the proper application of tractors made of *wood ;* and having added, that "if any perſon would repeat theſe experiments, it ſhould be done with due ſolemnity," in order to work upon the imagination ; our author replies, by putting the following queſtion: "Is there a ſingle poſſeſſor of the *patent metallic* tractors in England, who has frequently uſed them, and will ſay that this fraud is neceſſary to make *them* perform *cures ?"* Inſtead of anſwering for the Engliſh poſſeſſors of theſe valuable inſtruments, we beg leave, in our turn, to aſk, if there be a ſingle expert chemiſt in Great Britain who can underſtand this queſtion in any other ſenſe, than as implying that the virtue of the tractors reſides in the *patent ?* This, however, appears ſtill more palpable in the caution to the public.

"Among the various artifices (ſays Mr Perkins) which have been employed by certain intereſted perſons, I have to mention the mean attempt to circulate *falſe tractors*, and from the failure of theſe to throw diſcredit upon the diſcovery. Three inſtances of this kind have occurred lately. Complaints having been made to me that my tractors would not cure the diſeaſes for which they are recommended, I was led to make inquiry reſpecting the caſes alluded to ; and conceiving them fit ſubjects for the tractors, I called on the patients to apply them myſelf. In *both* inſtances (it was juſt now in *three* inſtances) I found they had been uſing *counterfeit* tractors. Had not this been diſcovered, the *merit* of the *patent* tractors muſt have ſuffered extremely !"

This is very extraordinary. The *character* or *fame* of any thing may indeed be injured by a counterfeit ; but we believe this is the firſt inſtance of the *merit* or *demerit* of one inanimate ſubſtance being increaſed or diminiſhed by another at a diſtance from it,—of the hardneſs of ſteel, for inſtance, being diminiſhed by the ſoftneſs of lead ! But we beg Mr Perkins's pardon. The *merit* of his tractors conſiſts in their putting money into his pocket ; and *that* merit might certainly be injured by the uſe of *counterfeits.* Hence, with great propriety, he informs the public, that every *genuine ſet* is ſtamped with the words PERKINS'S PATENT TRACTORS, accompanied with a receipt for the five guineas, numbered and ſigned in the handwriting of the patentee. From theſe facts we infer (and he muſt acknowledge the inference to be juſt), that the virtue of the tractors reſides in the *patent*, reſtricting the making of them to *Benjamin Douglas Perkins*, and not to the *metal* of which they are made. This is indeed moſt obvious ; for he cannot be ſuch a ſtranger to the ſtate of chemical ſcience in this country, as to ſuppoſe that his tractors may not be analyſed into their component principles, and, of courſe, that others may not be made poſſeſſing all their virtues except ſuch as reſult from the patent.

We ſhall conclude this article in the words of the reviewer already quoted : "To trace the relations and dependencies of projects ſimilar to that of Dr Perkins, would now be a work of more labour than utility. The fund of public credulity is an inexhauſtible reſource for thoſe who can reſolve to levy contributions on it. In vain is the ſpirit of quackery exorciſed in one form ; it riſes again immediately, 'with twenty ghaſtly murders on its head, to puſh us from our ſtools.' We, who have contemplated the progreſs of real knowledge during a long courſe of years, have ſeen many bubbles like this glitter for a moment, and then diſappear for ever. People may talk of Meſmeriſm, or Perkiniſm, but we conſider all ſuch varieties as belonging to the old and extenſive claſs of Charlataniſm."

PEROUSE (John Francis Galoup de la), the celebrated, though unfortunate, French navigator, was born at Albi in 1741. Of the rank or condition of his father, M. *Milet-Marsau* has given us no information in that meagre eulogy of Perouſe which he has inſerted in the introduction to his laſt voyage. It appears, however, that he intended to make his ſon a ſeaman, and ſent him, at a very early period of life, to the marine ſchool, where the young man became enthuſiaſtically fond of his profeſſion, and laudably ambitious to emulate the fame of the moſt celebrated navigators.

Being

---

* *The Efficacy of Perkins's Patent Metallic Tractors, &c.* 1800.

Perpendicular
||
Peterſburgh.

Being appointed a midſhipman on the 19th of November 1756, he behaved, we are told, with great bravery in that ſtation, and was ſeverely wounded in the engagement between the admirals Hawke and Conflans, on the 20th of November 1759. The Formidable, in which he ſerved, was taken, after a vigorous reſiſtance; and it is probable that Perouſe reaped ſome advantage from his acquaintance with Britiſh officers.

On the 1ſt of October 1764 he was promoted to the rank of lieutenant; and deſpiſing a life of eaſe and idleneſs, he contrived to be employed in ſix different ſhips of war during the peace that ſubſiſted between Great Britain and France. In 1767 he was promoted to the rank of what, in our navy, is called *maſter* and *commander*. In 1779 he commanded the *Amazone*, belonging to the ſquadron of Vice-admiral Count d'Eſtaing; and when that officer engaged Admiral Byron, the poſt of La Perouſe was to carry his Admiral's orders to the whole of the line. He afterwards took the ſloop *Ariel*, and contributed to the capture of the *Experiment*—exploits which his eulogiſt ſeems to conſider as inſtances of very uncommon heroiſm; but he ſoon after performed a greater.

Being, on the 4th of April 1780, appointed captain of the frigate *Aſtrea*, and being on a cruiſe with the *Hermione*, theſe two frigates attacked ſix Engliſh veſſels of war, of from 28 to 14 guns each, and took two of them. The French certainly reaped more laurels about that period than they have been accuſtomed to do in naval wars with Great Britain; but as we have completely forgotten the particulars of this fight, we ſuſpect that it was not altogether ſo very brilliant a buſineſs as M. Milet-Mureau is pleaſed to repreſent it.

In the year 1782, La Perouſe was diſpatched with the Sceptre of 74 guns, and two frigates of 36 guns each, having ſome troops and field pieces on board, to deſtroy the Engliſh ſettlements in Hudſon's Bay. This taſk was eaſily accompliſhed; for when he had ſurmounted the difficulties of navigation in a frozen ſea, he found nothing on ſhore to oppoſe the ſmalleſt force. Having deſtroyed the ſettlements, he learned that ſome of the Engliſh had fled at his approach into the woods; and his eulogiſt conſiders it (ſuch are the diſpoſitions of French republicans) as a moſt wonderful inſtance of humanity, that he left to theſe unfortunate men proviſions to preſerve them from periſhing by hunger, and arms to protect them from the fury of the ſavages! Perouſe, we dare anſwer for him, was conſcious of nothing heroic or extraordinary in this act of beneficence, which he certainly could not have omitted, without incurring both infamy and guilt.

In the year 1785, he was appointed to the command of a voyage round the world; which was unfortunately deſtined to be his laſt. Of this voyage, as far as it was accompliſhed, there is a full account in the hands of every French and Engliſh reader; and from that account it appears, that Perouſe was admirably qualified to diſcharge ſuch a truſt. He ſeems to have been an experienced and ſkilful ſeaman; a man of conſiderable mathematical and phyſical ſcience, uncorrupted by that philoſophiſm which diſgraced many of his attendants; and capable of the utmoſt perſeverance in every laudable purſuit. To theſe qualities he united a proper combination of caution and courage, with a diſpoſition truly benevolent to the various tribes of ſavages whom he viſited. The diſaſters which occurred on the voyage were all, except the laſt, of which nothing is known, occaſioned by the diſobedience of his officers, or their neglecting to follow his advice.

The laſt diſpatches of this great and good man were dated from Botany Bay, February the 7th 1788; and ſince that period, no account of him has been received which is intitled to the ſmalleſt confidence. *M. Milet-Mureau* has indeed given us, at ſome length, the childiſh conjectures of the Society of Natural Hiſtory reſpecting his fate, which, in language equally childiſh, were delivered at the bar of the National Aſſembly; and he has added the ridiculous decree which that body of legiſlative ſcioliſts paſſed in conſequence of ſo extraordinary a ſpeech. We will not diſgrace our pages, or inſult the memory of Perouſe, by contributing to the circulation of nonſenſe, which, we are perſuaded, would have made him bluſh for his country.

PERPENDICULAR, in gunnery, is a ſmall inſtrument, uſed for finding the centre line of a piece in the operation of pointing it to a given object.

PERSIAN or PERSIC, in architecture, a name common to all ſtatues of men, ſerving inſtead of columns to ſupport entablatures.

PERWANNAH, in the language of Bengal, an order of government, or a letter from a perſon in authority.

PETERSBURGH (St), the capital of Ruſſia, is a city, of which a pretty full hiſtorical detail has been given in the *Encyclopædia*. It is introduced here merely on account of its police, which, according to the anonymous author of the life of Catharine II. has a very ſimple and competent organization, and deſerves to be adopted in other great capitals. Excepting the governor, whoſe office naturally extends to all objects of public welfare, the head police-maſter is the proper chief of the whole ſyſtem of police. His office takes in the great compaſs of this department, but confined to the general objects of public ſecurity and order. He is not here, as in ſome large towns, the formidable copartner of family ſecrets, and the inviſible witneſs of the actions of the private man. Under the head police-maſter is the police office, where ſit a police-maſter, two preſidents, the one for criminal, the other for civil caſes, and two conſulters, choſen from the burgher claſs. To this is committed the care to maintain decorum, good order, and morals: alſo it is its buſineſs to ſee to the obſervance of the laws, that the orders iſſued by government, and the deciſions of the courts of juſtice, are put in force. The attainment of theſe purpoſes is effected by the following mechaniſm:

The reſidence is divided into ten departments Each of theſe has a preſident, appointed to watch over the laws, the ſecurity, and the order of his diſtrict. The duties and rights of this office are not leſs extenſive than important. A preſident muſt have exact knowledge of the inhabitants of his department, over which a ſort of parental authority is committed to him; he is the *cenſor morum* of his department; his houſe muſt not be bolted or barred by night or day, but muſt be a place of refuge, continually open to all that are in danger or diſtreſs; he himſelf may not quit the town for the ſpace of two hours, without committing the diſcharge of his office to ſome other perſon. The police-commando (conſtables), and the watchmen of his department, are

under

Peterſburgh.

under his orders ; and he is attended on all affairs of his office by two ſerjeants. Complaints againſt unjuſt behaviour in the preſident may be brought to the police office.

Each department is again divided into three, four, or five ſubdiviſions, called quarters, of which, in the whole reſidence, are 42. Each of theſe has a quarter-inſpector, in ſubordination to whom is a quarter-lieutenant. The duty of theſe police-officers is in harmony with that of the preſident, only that their activity is confined to a ſmaller circle. They ſettle low affairs and ſlight altercations on the ſpot, and keep a watchful eye on all that paſſes.

The number of the nightly watch in the city amounts to 500. They have their ſtations aſſigned them in watch-houſes at the corners of ſtreets; and, beſides their proper deſtination, are to aſſiſt in the taking up of offenders, and in any ſervice, by day or night, as their commanders ſhall require. Beſides theſe, for the execution of the police orders, and to act as patroles, there is alſo a commando of 120 men, who, in caſes of emergency, are ſupported by a company of koſaks, or a regiment of huſſars.

This machine, conſiſting of ſo many ſubordinate parts, preſerves in its orderly courſe that ſecurity and peace which excite the admiration of all foreigners. The activity of every individual member is unobſerved in the operation of the whole ; and by ſuch a diſtribution alone is the attainment of ſo complicated an aim practicable.—All the quarter-inſpectors of a department repair every morning, at ſeven o'clock, to their inſpector's houſe, to lay before him the report of all that has happened in their quarters during the laſt 24 hours ; and at eight o'clock, all the inſpectors bring together theſe ſeveral reports into the police-office, whereupon they firſt and immediately take into examination the caſes of perſons taken into cuſtody during the night. On urgent occaſions, the police-office aſſembles at all hours.

This organization, and the extraordinary vigilance of the police, which is found competent to the buſineſs of a numerous and reſtleſs people, render all ſecret inquiſitions unneceſſary. The police has knowledge of all perſons in the reſidence ; travellers who come and go are ſubject to certain formalities, which render it extremely difficult to conceal their place of abode, or their departure from the city. To this end, every houſeholder and innkeeper is obliged to declare to the police, who lodges with him, or what ſtrangers have put up at his houſe. If a ſtranger or lodger ſtays out all night, the landlord muſt inform the police of it at lateſt on the third day of his abſence from his houſe. The cautionary rules, in regard to travellers quitting the town, are ſtill more ſtrict. Theſe muſt publiſh in the newſpapers their name, their quality, and their place of abode, three ſeveral times, and produce the newſpapers containing the advertiſement, as a credential in the government from which they then receive their paſſport ; without which, it is next to impoſſible to get out of the empire. This regulation not only ſecures the creditor of the perſon about to depart, but alſo enables the police to keep a cloſer inſpection over all ſuſpected inhabitants.

If individuals may be ſuſpected by the government, becauſe their means of ſupport, the company they keep, and their whole courſe of action, are cloſely wrapped up in myſtery ; ſo likewiſe may whole ſocieties be leſs indifferent to it, if they carefully conceal the object of their connection, or their very exiſtence, from the eye of the public. The police watches here, with laudable attention, over ſecret ſocieties of all kinds ; and frequently as the fanatical ſpirit of religious or political ſectaries, or the enthuſiaſm of pretended myſtagogues, have attempted to neſtle here, they have never been able to proceed, or only for a very ſhort time. Animal magnetiſm, Martiniſm, Roſycrutianiſm, and by whatever other name the conceits of diſtempered imaginations may be called, have always been attended with the ſame bad ſucceſs on this ſtage.

From this ſketch it will be readily imagined, that the number of impoſtors and diſturbers of the public peace can be but ſmall. Quarrels and affrays in the ſtreet or in the cabaks but ſeldom happen. The perſon attacked calls the neareſt watchman ; and in a moment both the aggreſſor and the aggrieved are taken into cuſtody, and led to the next ſieja (police-watch-houſe), where the cauſe of their quarrel is inquired into, and the aggreſſor is puniſhed. For matters of ſome deſcriptions, there is a peculiar tribunal, under the denomination of the oral court, which, on account of its ſingularity, deſerves to be briefly noticed.

In each quarter of the town are one or more judges of the oral court, who are choſen from the claſs of burghers, and with whom are aſſociated a few jurats. This court ſits daily in the forenoon, and proceeds orally in all the differences that come before it. It, however, keeps a day-book, in which are entered all the cauſes and deciſions of the court, and which muſt be every week laid before the magiſtrate. When a charge is brought, the court declares it orally to the preſident of the quarter : whereupon the accuſed muſt not delay his appearance before the police longer than one day after he has received the ſummons. Every cauſe muſt be determined in one day, or, if the examinations require more time in collecting, in three days. The oral court communicates the deciſion to the preſident of the quarter by means of his day-book, in order to its ratification. If either party is not ſatisfied with the ſentence, he may appeal to the court as appointed in the regulations.

This is a very favourable account of the police of St Peterſburgh ; but it is differently repreſented in *Beaujolin's Travels of two Frenchmen through Ruſſia*, in 1790—1792. According to him, the police of the capital of that empire is far from being on the moſt reſpectable footing. There happen, indeed, but few accidents in the night ; yet ſometimes murders are committed, and eſpecially thefts ; for which, according to our author, it is exceedingly rare to obtain juſtice. When a perſon has been aſſaſſinated in ſome place of bad repute, the police-officer is engaged to ſecrecy by means of a few rubles ; ſo that the affair is ſoon huſhed up, unleſs the deceaſed belonged to ſome powerful family, whoſe intereſt makes it neceſſary that inquiries ſhould be inſtituted. When two perſons quarrel, either in the ſtreet or in a public-houſe, he who *pays* the inquirer is always in the right : the inferior police-officers are never proof againſt money ; and the *poor* individual, whether he be in the right or wrong, is almoſt ſure of a beating.

PETIVER (James), a famous Engliſh botaniſt, was con-

tiver,
ſianus.

contemporary with Plukenet; but the exact time of his birth is not known, nor is much intelligence concerning him at preſent to be obtained. His profeſſion was that of an apothecary, to which he was apprenticed under Mr Feltham, then apothecary to St Bartholomew's hoſpital *. When he entered into buſineſs for himſelf, he ſettled in Alderſgate-ſtreet, and there continued for the remainder of his life. He obtained conſiderable buſineſs, and after a time became apothecary to the charter houſe. After the Tradeſcants, he appears to have been the only perſon, except Mr Courten and Sir Hans Sloane, who made any conſiderable collection in natural hiſtory, previous to thoſe of the preſent day. He engaged the captains and ſurgeons of ſhips to bring him home ſpecimens, and enabled them to ſelect proper objects, by printed directions which he diſtributed among them. By theſe means his collection became ſo valuable, that ſome time before his death, Sir Hans Sloane offered him L. 4000 for it. After his death, it was purchaſed by the ſome collector. His muſeum extended his fame both at home and abroad. He was elected into the Royal Society; and becoming acquainted with Ray, aſſiſted him in arranging the ſecond volume of his Hiſtory of Plants. He died April 20. 1718; and much honour was ſhewn to him at his funeral, by the attendance of Sir Hans Sloane, and other eminent men, as pall bearers, &c. By future botaniſts, his name was given to a plant. See PETIVERIA, *Encycl.*

* ult- s Sket- of Bo- in E and.

He gave the world ſeveral publications on various ſubjects of natural hiſtory: 1. *Muſei Petiveriani Centuriæ decem*, 1692—1703, 8vo. 2. *Gazophylacii Naturæ et Artis, Decades decem*, folio, 1702, with 100 plates. 3. A Catalogue of Mr Ray's Engliſh Herbal, illuſtrated with figures, folio, 1713, and continued in 1715. 4. Many ſmall publications, which may be found enumerated in Dr Pultney's book. 5. Many papers in the Philoſophical Tranſactions, and a material article in the third volume of Ray's work, entitled, *Plantæ Rariores Chinenſes Madraſpatanæ, et Africanæ, a Jacobo Petivero ad opus Conſummandum Collatæ*, &c. Many of his ſmaller tracts having become very ſcarce, his works were collected and publiſhed, excluſive of his papers in the Tranſactions, in 2 vols folio, and one 8vo, in the year 1764.

PHASIANUS (See *Encycl.*). A ſpecies of this genus of birds, formerly not deſcribed, was ſent from Batavia to England by Lord Macartney, or ſome of his attendants, when they were on their voyage to China. The ſpecies to which it ſeemed to be moſt nearly allied, in point of general habit or appearance, was the *phaſianus curviroſtris*, or Impeyan pheaſant; an Eaſt Indian bird, deſcribed and figured both in Mr Latham's Ornithology, and in the Muſeum Leverianum. From that bird, however, it differs very conſiderably. The tail of the latter being in a mutilated ſtate, it was ſcarce poſſible to determine, with abſolute preciſion, whether it ſhould be referred to that ſubdiviſion of pheaſants, which contains thoſe with long or cuneiform tails, or thoſe with rounded ones, as in the Impeyan pheaſant. The general colour of this moſt elegant bird was black, with a gloſs of blue, or what, in the language of natural hiſtory, may be termed chalybean black, or black accompanied by a ſteel blue luſtre. The lower part of the back was of a peculiarly rich colour, which, according to the different directions of the light, appeared either of a deep ferruginous or of the brighteſt fiery orange-red. This beautiful colour paſſed in the manner of a broad zone round the whole body; but on the abdomen was of a much more obſcure appearance than on the back, as well as ſomewhat broken or irregular, eſpecially on the ſides. The throat was furniſhed with a large, and ſomewhat angular, pair of wattles, uniting with the bare ſpaces on the cheeks. The feathers on the top of the head, which was of a lengthened form, ran a little backward, ſo as to give the appearance of an indiſtinct occipital creſt. The beak was remarkable for a more lengthened and curved aſpect than in any other bird of this genus, except the Impeyan pheaſant. The feathers on the neck, back, and breaſt, were rounded, and of the ſame ſhell-like or ſcaly habit as thoſe of the turkey. The legs very ſtout, and were armed with a pair of extremely ſtrong, large, and ſharp ſpurs. Both legs and beak were of a pale colour. Whether this bird be really new or not to the ornithologiſts of Europe, it may at leaſt be affirmed with ſafety, that it had never been properly deſcribed; nor can the character of any ſpecies, hitherto introduced into the books of any ſyſtematic naturaliſt, be conſidered as a juſt or competent ſpecific character of the preſent bird. . It may be called the *fire-backed pheaſant*; and its eſſential character may be delineated in the following terms: Black pheaſant with a ſteel-blue gloſs; the ſides of the body rufous; the lower part of the back fiery ferruginous; the tail rounded; the two middle feathers pale yellow brown.—*Sir George Staunton's Account of an Embaſſy to China, &c.*

Phaſianus, Philoſophiſt.

PHILOSOPHIST, a lover of ſophiſtry or falſe reaſoning, in contradiſtinction to *philoſopher*, who is a lover of ſound reaſoning, true ſcience, and practical wiſdom.

CRITICAL PHILOSOPHY.

1
in of
ſcience.

CRITICAL PHILOSOPHY, is the appellation given to a ſyſtem of ſcience, of which the founder is *Immanuel Kant*, regius profeſſor of logic and metaphyſics in the univerſity of Koenigſberg. Of this ſyſtem, which is very generally admired in Germany, we promiſed, in our Proſpectus, to gratify our ſpeculative readers with a ſhort view; and that promiſe we are enabled to fulfil, by the kind communication of an illuſtrious foreigner, who, after acting a conſpicuous part on the theatre of the world, and ſtriving in vain to ſtem the torrent of democratic innovation, is now living an exile from his wretched country, and cultivating the ſciences and the arts of peace.

2
Obſcurity of its language.

"To explain (ſays he) the philoſophy of Kant in all its details, would require a long and a painful ſtudy, without producing any real advantage to the reader. The language of the author is equally obſcure, and his reaſonings equally ſubtle, with thoſe of the commentators of Ariſtotle in the 15th century."

The truth of this aſſertion will be denied by none, who have endeavoured to make themſelves maſters of the works of *Willich* and *Nitſch* on the critical philoſophy; and the ſource of this obſcurity ſeems to be ſufficiently obvious. Beſides employing a vaſt number of words of his own invention, derived from the Greek language, Kant uſes expreſſions, which have long been familiar to metaphyſicians, in a ſenſe different from that in which they are generally received; and hence a large portion of time is requiſite to enable the moſt ſagacious mind to aſcertain with preciſion the import of his phraſeology.

The difficulty of comprehending this philoſophy has contributed, we believe, more than any thing elſe, to bring it into vogue, and to raiſe the fame of its author. Men are aſhamed, after ſo laborious and fatiguing a ſtudy, to acknowledge that all their labour has been thrown away; and vanity prompts almoſt every man to raiſe the importance of that branch of ſcience which is underſtood but by a few, and in which he is conſcious that his own attainments have been great. "We acknowledge, however, that in the ſyſtem of Kant there is diſplayed much genius, combination, and ſyſtematic arrangement; but this only affords one of the many reaſons which it preſents, for our regretting that the author has not directed his mind to more uſeful reſearches, and that he has waſted the ſtrength of his genius in rendering uncertain the moſt comfortable truths, and in giving the appearance of novelty to opinions for the moſt part taught long before his day.

The following analyſis, we believe, will ſufficiently enable any one, at all converſant with metaphyſical ſcience, to form a judgment of this celebrated ſyſtem; and our correſpondent, on whoſe word the reader may rely, aſſures us, that, in detailing the principles of Kant, he has taken ſpecial care to exhibit them with the utmoſt poſſible exactneſs, having ſeveral times preferred the obſcurity of the author's reaſonings and language, to the danger of a falſe, though more perſpicuous, interpretation.

3 Diviſion of human knowledge. "Kant divides all our knowledge into that which is *a priori*, and that which is *a poſteriori*. Knowledge *a priori* is conferred upon us by our nature. Knowledge *a poſteriori* is derived from our ſenſations, or from experience; and is by our author denominated *empyric.* One would at firſt be induced, by this account of the origin of human knowledge, to believe that Kant intended to revive the ſyſtem of *innate ideas;* but we very quickly diſcover that ſuch is not his ſyſtem. He conſiders all our knowledge as acquired. He maintains, that experience is the *occaſional cauſe* or *productrice* of all our knowledge; and that without it we could not have a ſingle idea. Our ideas *a priori*, he ſays, are produced *with* experience, and could not be produced *without* it; but they are not produced *by* it, or do not proceed *from* it. They exiſt in the mind; they are the *forms* of the mind. They are diſtinguiſhed from other ideas by two marks, which are eaſily diſcerned; *i. e.* they appear *univerſal* and *neceſſary*; or, in other words, they admit of no exception, and their *converſe* is impoſſible. Ideas which we derive from experience have no ſuch characters. We can ſuppoſe, that what we have ſeen, or felt, or heard once, we may ſee, or feel, or hear again; but we do not perceive any impoſſibility in its being otherwiſe. For inſtance, a houſe is on fire in my view: I am certain of this fact; but it affords me no *general* or *neceſſary* knowledge. It is altogether *a poſteriori*; the materials are furniſhed by the individual impreſſion which I have received; and that impreſſion might have been very different.

"But if I take twice two ſmall balls, and learn to call twice two *four*, I ſhall be immediately convinced, that any two bodies whatever, when added to any two other bodies, will conſtantly make the ſum of bodies *four*. Experience has indeed afforded me the *opportunity* of acquiring this knowledge; but it has not given it to me; for how could experience prove to me that this truth ſhall never vary? Experience muſt always be *limited*; and therefore cannot teach us that which is *neceſſary* and *univerſal*. It is not experience which diſcovers to us, that we ſhall always have the ſurface of the whole pyramid by multiplying its baſe by the third part of its height; or that two parallel lines, extended *in infinitum*, ſhall never meet.

"All the truths of pure mathematics are, in the language of Kant, *a priori*. Thus, that a ſtraight line is the ſhorteſt of all poſſible lines between two fixed points; that the three angles of a triangle are always equal to two right angles; that we have the ſame ſum, whether we add 5 to 7 or 7 to 5; and that we have the ſame remainder when we ſubtract 5 from 10 as when we ſubtract 10 from 15—are ſo many propoſitions, which are true *a priori*.

4 Pure knowledge *a priori*. "Pure *knowledge a priori*, is that which is abſolutely without any mixture of experience. *Two and two men* make *four men*, is a truth, of which the knowledge is *a priori*; but it is not PURE knowledge, becauſe the truth is particular. The ideas of *ſubſtance*, and of *cauſe* and *effect*, are *a priori*; and when they are ſeparated from the objects to which they refer (we ſuppoſe from this or that *particular* object), they form, in the language of Kant, *void ideas* (A). It is our knowledge *a priori*, *i. e.* that knowledge which precedes experience as to its origin, which renders experience poſſible (B). Our faculty of knowledge has an effect on our ideas of ſenſation analogous to that of a veſſel, which gives its own form to the liquor with which it is filled. Thus, in all our knowledge *a poſteriori*, there is ſomething *a priori* derived from our faculty of knowledge. All the operations of our minds; all the impreſſions which our external and internal ſenſes receive and retain, are brought into effect by the *conditions*, the *forms*, which exiſt in us by the pure ideas *a priori*, which alone render all our other knowledge certain.

5 Time and ſpace. "*Time* and *ſpace* are the two eſſential forms of the mind:

(A) In the language of Locke *abſtract ideas*.

(B) In our correſpondent's manuſcript, this ſentence runs thus: "It is our knowledge *a priori*, or that knowledge which *entirely precedes experience* as to its origin, which experience renders poſſible;" but here muſt be ſome miſtake, either by the tranſlator or by the amanuenſis. Kant's philoſophy is abundantly obſcure and paradoxical; but it ſurely never entered into his head to repreſent the effect as prior in its origin to the very cauſe which alone renders it poſſible. The context, too, ſeems to us to agree better with the meaning of the ſentence as we have printed it in the text.

mind : the former for impreſſions received by the internal ſenſe ; the ſecond for thoſe received by our external ſenſes. Time is neceſſary in all the *immediate* (perhaps *intuitive*) perceptions of objects ; and ſpace in all *external* perceptions.

6 xtenſion. “ *Extenſion* is nothing real but as the form of our ſenſations. If extenſion were known to us only by experience, it would then be poſſible to conceive that there might be ſenſible objects without ſpace.

7 mpenetrability, &c “ It is by means of the form *ſpace* that we are enabled, *a priori*, to attribute to external objects *impenetrability, diviſibility, mobility*, &c. ; and it is by means of the form *time* that we attribute to any thing *duration, ſucceſſion, ſimultaneity, permanence*, &c.

8 Origin of rithmetic nd geometry. “ *Arithmetic* is derived from the form of our internal ſenſe, and *geometry* from that of our external.

9 Unifying power of the mind. “ Our underſtanding collects the ideas received by the impreſſions made on our organs of ſenſe, confers on theſe ideas *unity* by a particular *force* (we ſuppoſe energy) *a priori* ; and thereby forms the repreſentation of each object. Thus, a man is ſucceſſively ſtruck with the impreſſions of all the parts which form a particular garden. His underſtanding unites theſe impreſſions, or the ideas reſulting from them ; and in the unity produced by that unifying act, it acquires the idea of the garden. If the objects which produce the impreſſions afford alſo the *matter* of the ideas (c), then the ideas are *empyric* ; but if the objects only unfold the *forms of the thought*, the ideas are *a priori*. The act of the underſtanding which unites the perceptions of the various parts of an object into the perception of one whole, is the ſame with that which unites the attribute with its ſubject.

10 Analytic judgments. “ Judgments are divided into two ſpecies ; *analytic* and *ſynthetic*. An analytic judgment is that in which the attribute is the mere developement of the ſubject, and is found by the ſimple analyſis of the perception ; as *bodies are extended* ; *a triangle has three ſides*.

11 Synthetic judgments. “ A ſynthetical judgment is that where the attribute is connected with the ſubject by a cauſe (or baſis) taken from the faculty of knowledge, which renders this connection neceſſary : as, *a body is heavy* ; *wood is combuſtible* ; *the three angles of a triangle are equal to two right angles*. There are ſyntheſes *a priori* and *a poſteriori* ; and the former being formed by experience, we have the ſure means of avoiding deception.

“ It is a problem, however, of the utmoſt importance, to diſcover how ſynthetic judgments *a priori* are poſſible. How comes it, for example, that we can affirm that all the radii of a circle are equal, and that two parallel lines will never meet ? It is by ſtudying the *forms* of our mind that we diſcover the poſſibility of making theſe affirmations. In all objects there are things which muſt neceſſarily be THOUGHT (be ſupplied by thought) ; as, for example, that there is *a ſubſtance*, an *accident*, a *cauſe*, and certain *effects*.

12 Forms of the underſtanding. “ The *forms* of the underſtanding are, *quantity, quality, relation, modality*.

“ Quantity, Kant diſtinguiſhes into *general, particular*, and *individual* ; quality, into *affirmation, negation, infinite* ; relation, into *categoric, hypothetic*, and *disjunctive* ; and modality, into *problematic, certain*, and *neceſſary*. He adds alſo to theſe properties of the four principal forms of the underſtanding, a table of *categories*, or fundamental ideas *a priori*.

13 Categories. “ Quantity, gives *unity, plurality, totality*. Quality, gives *reality, negation, limitation*. Relation, gives *inherence, ſubſtance, cauſe, dependence, community, reciprocity*. Modality, gives *poſſibility, impoſſibility, exiſtence, nothing, neceſſity, accident*. Theſe categories can only be applied to experience. When, in the conſideration of an object, we abſtract all that regards ſenſation, there remain only the pure ideas of the underſtanding, or the *categories*, by which a *thing* is conceived as a *thing*.

“ Pure reaſon is the faculty of tracing our knowledge *a priori*, to ſubject it to principles, to trace it from its neceſſary conditions, till it be entirely without condition, and in complete unity. This pure reaſon has certain fundamental rules, after which the neceſſary connection of our ideas is taken for the determination of the objects in themſelves ;—an illuſion which we cannot avoid, even when we are acquainted with it. We can conclude from what we know to what we do not know ; and we give an *objective* reality to theſe concluſions from *an appearance* which leads us on.

14 Critique of pure reaſon. “ The writings of Kant are multifarious ; but it is in his work entitled the *Critique of Pure Reaſon* that he has chiefly expounded his ſyſtem. This work is a treatiſe on a pretended ſcience, of which Kant's ſcholars conſider him as the founder, and which has for its objects the *natural forces*, the *limits of our reaſon*, as the ſource of our pure knowledge *a priori*, the *principles of all truth*. Kant does not propoſe to give even an expoſition of theſe branches of knowledge, but merely to examine their origin ; not to extend them, but to prevent the bad uſe of them, and to guard us againſt error. He denominates this ſcience *tranſcendental criticiſm* ; becauſe he calls all knowledge, of which the object is not furniſhed by the ſenſes, and which concerns the kind and origin of our ideas, *tranſcendental knowledge*. The Criticiſm of Pure Reaſon, which gives only the fundamental ideas and maxims *a priori*, without explaining the ideas which are derived from them, can lead (ſays Kant) to a complete ſyſtem of pure knowledge, which ought to be denominated *tranſcendental philoſophy*, of which it (the *Criticiſm*, &c.) preſents the *architectonic* plan, *i. e.* the plan regular and well diſpoſed.

“ The work entitled *The Critique of Pure Reaſon*, is divided into ſeveral parts or ſections, under the ridiculous titles of *Æſthetic tranſcendental* ; of *tranſcendental logic* ; of *the pure ideas of the underſtanding* ; of *the tranſcendental judgment* ; of *the paralogiſm of pure reaſon* ; of *the ideal tranſcendental* ; of *the criticiſm of ſpeculative theologies* ; of *the diſcipline of pure reaſon*, &c.

15 We cannot know objects as they are in themſelves. “ But to proceed with our abſtract of the ſyſtem. We know objects only by the manner in which they affect us ; and as the impreſſions which they make upon us are only certain *apparitions* or *phenomena*, it is impoſſible for us to know what an *object is in itſelf*. In conſequence of this aſſertion, ſome have ſuppoſed that Kant is an *idealiſt* like Berkeley and ſo many others, who have thought that ſenſations are only *appearances*, and

---

(c) This is wonderful jargon ; but the reader will reflect that it is not ours.

and that there is no truth but in our reaſon; but ſuch is not the opinion of Kant (D). According to him, our underſtanding, when it conſiders the apparitions or phenomena, acknowledges the *exiſtence* of the objects in themſelves, inaſmuch as they ſerve for the baſes of thoſe apparitions; though we know nothing of their *reality*, and though we can have no certitude but in experience.

“When we apply the *forms* of our underſtanding, ſuch as *unity*, *totality*, *ſubſtance*, *caſuality*, *exiſtence*, to certain ideas which have no object in *ſpace* and *time*, we make a fallacious and arbitrary application. All theſe forms can bear only on ſenſible objects, and not on the *world of things in itſelf*, of which we can THINK, but which we CAN NEVER KNOW. Beyond things ſenſible we can only have *opinions* or a *belief* of our reaſon.

16 Objective and ſubjective truths.

“The motives to conſider a propoſition as true, are either *objective*, *i. e.* taken from an *external* object, ſo that each man ſhall be obliged to acknowledge them; and then there is a truth *evident* and ſuſceptible of *demonſtration*, and it may be ſaid that we are *convinced;* or the motives are *ſubjective*, *i. e.* they exiſt only in the mind of him who judges, and he is *perſuaded*.

“TRUTH, then, conſiſts in the agreement of our *notions* with the *objects*, in ſuch a manner as that all men are obliged to form the ſame judgment; BELIEF conſiſts in holding a thing for true in a *ſubjective manner*, in conſequence of a perſuaſion which is entirely perſonal, and has not its baſis in an object ſubmitted to experience.

17 Belief.

“There is a *belief of doctrine*, of which Kant gives, as an example, this aſſertion—‘there are inhabitants in the planets.’ We muſt acknowledge (he adds) that the ordinary mode of teaching the exiſtence of God belongs to *the belief of doctrine*, and that it is the ſame with *the immortality of the ſoul*. *The belief of doctrine* (he continues) has in itſelf ſomething *ſtaggering;* but it is not the ſame with *moral belief*. In moral belief there is ſomething *neceſſary;* it is (ſays he), that I ſhould obey the law of morality in all its parts. The end is ſtrongly eſtabliſhed; and I can perceive only one condition, by means of which this end may be in accord with all the other ends, *i. e.* that *there is a God*. I am certain that no man knows any other condition which can conduct to the ſame unity of end under the moral law; which law is a law of my reaſon. I will conſequently believe certainly the *exiſtence of God*, and a *future life;* becauſe this perſuaſion renders immoveable my moral principles—principles which I cannot reject without rendering myſelf contemptible in my own eyes. I wiſh for happineſs, but I do not wiſh for it without morality; and as it depends on *nature*, I cannot wiſh it with this condition, except by believing that nature depends on a Being who cauſes this connection between morality and happineſs. This ſuppoſition is founded on the *want* (or *neceſſity*) of my reaſon, and not on my duty.

18 Proof of the exiſtence of God, &c.

“We have, however, no *certainty* (ſays Kant) in our knowledge of God, becauſe certainty cannot exiſt except when it is founded on an object of experience. The philoſopher acknowledges, that *pure reaſon* is too weak to prove the exiſtence of a being beyond the reach of our ſenſes. The neceſſity of believing in God is therefore only *ſubjective*, although neceſſary and general for all thoſe beings who conform to their duty. This is not *knowledge*, but only a *belief* of reaſon, which ſupplies the place of a knowledge which is impoſſible (E).

“The proofs of natural theology (ſays our philoſopher) taken from the order and beauty of the univerſe, &c. are proofs only in *appearance*. They reſolve themſelves into a bias of our reaſon to *ſuppoſe* an Infinite Intelligence as the author of all that is poſſible; but from this bias it does not follow that there really is ſuch an Author. To ſay, that whatever exiſts muſt have a cauſe, is indeed a maxim *a priori;* but it is a maxim applicable only to experience, for one knows not how to ſubject to the laws of our perceptions that which is abſolutely independent of them. It is as if we were to ſay, that whatever exiſts in experience muſt have an experience; but the world, taken as a whole, is without experience as well as its cauſe. It is much better to draw the proof of the exiſtence of God from morality, than to weaken it by ſuch reaſoning. This proof is relative. It is impoſſible to *know* that God exiſts; but we can comprehend how it is poſſible to act morally on the *ſuppoſition* of the exiſtence (although incomprehenſible) of an intelligent Creator—an exiſtence which PRACTICAL REASON forces THEORETICAL *reaſon* to adopt. This proof not only *perſuades*, but even acts on the CONVICTION, in proportion as the motives of our actions are conformable to the law of morality.

“Religion ought to be the *means* of virtue and not its object. Man has not in himſelf the idea of religion as he has that of virtue. The latter has its principle in the mind; it exiſts in itſelf, and not as the means of happineſs; and it may be taught without the idea of a God, for the pure law of morality is *a priori*.

19 Morality.

“He who does good by inclination does not act *morally*. The converſe of the principle of morality is to make perſonal happineſs the baſis (F) of the will. There are compaſſionate minds which feel an internal pleaſure in communicating joy around them, and who thus enjoy the ſatisfaction of others; but their actions, however juſt, however good, have no moral merit, and may be compared to other inclinations; to that of honour

---

(D) We muſt requeſt the reader to obſerve that this is the language of our correſpondent. We have ſhewn elſewhere, that Berkeley did not deny the reality of ſenſations; and we hope to ſhew by and bye, that Kant is as much an *idealiſt* as he was, if this be a fair view of the Critical Philoſophy.

(E) We have here again taken the liberty to alter the language of our correſpondent. He makes Kant ſay, “It is not this knowledge, but a *belief* of reaſon, &c.;” but this is ſurely not the author's meaning. From the context, it is apparent that Kant means to ſay, that we have not, and cannot have, what can be properly called a *knowledge* of the exiſtence of God, but only ſuch a belief of his exiſtence as ſupplies the place of this impoſſible knowledge.

(F) This is a very abſurd phraſe. We ſuppoſe Kant's meaning to be, that the principles of him whoſe actions and volitions are influenced by the proſpect of perſonal happineſs, are the reverſe of the pure principles of morality.

honour (for example), which, whilſt it meets with that which is juſt and uſeful, is worthy of praiſe and encouragement, but not of any high degree of eſteem. According to Kant, we ought not even to *do good*, either for the pleaſure we feel in doing it, or in order to be happy, or to render others happy; for any one of theſe additions (perhaps motives) would be *empyric*, and injure the purity of our morals. A reaſonable being ought to deſire to be exempted from all *inclinations*, and never to do his duty but for his duty's ſake.

"We ought to act after the maxims derived *a priori* from the faculty of knowledge, which carry with them the idea of neceſſity, and are independent of all experience; after the maxims which, it is to be wiſhed, could be erected into GENERAL LAWS for all beings endowed with reaſon."

20 lity of ſyſtem

If this be a correct view of the object and the reſults of the critical philoſophy, and the character of him from whom we received it permits us not to doubt of its being nearly correct, we confeſs ourſelves unable to diſcover any motive which ſhould induce our countrymen, in their reſearches after truth, to prefer the dark lantern of Kant to the luminous torch of Bacon. The metaphyſical reader will perceive, that, in this abſtract, there is little which is new except the phraſeology; and that what is new is either unintelligible or untenable.

21 which funda- ral ciples not

The diſtinction between knowledge *a priori* and knowledge *a poſteriori*, is as old as ſpeculation itſelf; and the mode in which Kant illuſtrates that diſtinction differs not from the illuſtrations of Ariſtotle on the ſame ſubject. The Stagyrite talked of *general forms*, or *formal cauſes*, in the mind, as well as the profeſſor at Koenigſberg; and he or his diſciples (for we quote from memory) compared them to the form of the ſtatue in the rough block of marble. As that form is brought into the view of the ſpectator by the chiſſel of the ſtatuary, ſo, ſaid the peripatetics, are the general *forms* in the mind brought into the view of conſciouſneſs by ſenſation and experience.

Such was the doctrine of Ariſtotle and his diſciples, and ſuch ſeems to be the doctrine of Kant and his followers; but it is either a falſe doctrine, or, if it be true, a doctrine fooliſhly expreſſed. A block of marble is capable of being cut into any form that the ſtatuary pleaſes; into the form of a man, a horſe, an ox, an aſs, a fiſh, or a ſerpent. Not one of theſe forms therefore can be inherent in it, or eſſential to it, in oppoſition to the reſt; and a general form, including all the animals under it, is inconceivable and impoſſible. In like manner, the human mind is capable of having the ideas of a circle, a triangle, a ſquare, of black, white, red, of four, ſweet, bitter, of the odour of a roſe, and the ſtench of a dunghill, of proportion, of muſical ſounds, and of a thouſand other things. None of theſe ideas therefore can be eſſential to the mind in oppoſition to the reſt; and every man, who is not an abſolute ſtranger to the operations of his own intellect, knows well that he cannot think of a thouſand things at once; or, to uſe the language of philoſophers, have in his mind a general idea, comprehending under it a thouſand things ſo diſcordant as colours and ſounds, figures, and ſmells. If therefore Kant means to affirm, with Plato, that, previous to all experience, there are *actually* in the mind *general forms*, or *general ideas*, to which ſenſation, or experience, gives an opportunity of coming into view, he affirms what all men of reflection know to be falſe. If he means only to affirm, what ſeems to have been the meaning of Ariſtotle, that particular ſenſations give occaſion to the intellect to form general ideas, he expreſſes himſelf indeed very ſtrangely; but his doctrine on this ſubject differs not eſſentially from that of Locke and Reid, and many other eminent metaphyſicians of modern times. Of abſtraction and general ideas we have given our own opinion elſewhere (See METAPHYSICS, *Encycl.* Part I. Chap. iv.), and ſhall not here reſume the ſubject.

22 Improper uſe of terms;

But when Kant ſays that his ideas *a priori* are *univerſal*, and *neceſſary*, and that their converſe is *impoſſible*, he ſeems by the word *idea* to mean what more accurate writers expreſs by the term *propoſition*. There are indeed two kinds of propoſitions, of which both may be true, though the one kind expreſſes neceſſary and univerſal truths, and the other ſuch truths as are contingent and particular. (See METAPHYSICS, *Encycl.* Part I. Chapter vii.) Propoſitions directly contrary to thoſe which expreſs particular and contingent truths may be eaſily conceived; whilſt ſuch as are contrary to neceſſary and univerſal truths are inconceivable and impoſſible; but we doubt whether *any idea*, in the proper ſenſe of the word, has a *contrary* or, as he expreſſes it, a *converſe*. *Nothing* is not contrary to *ſubſtance*, nor *black* contrary to *white*, nor *four* contrary to *ſweet*, nor an *inch* contrary to an *ell*. Nothing is the negation of ſubſtance, and black the negation of white; four is different from ſweet, and an inch is leſs than an ell; but between theſe different ideas we perceive no contradiction.

That Kant uſes the term *idea* inſtead of *propoſition*, or ſome word of ſimilar import, is farther evident from his inſtances of *the houſe on fire*, and the manner in which we learn that any two bodies added to any two other bodies will conſtantly make the ſum of *four bodies*. If it be his will to uſe the terms *a priori* and *a poſteriori* in the ſenſe in which other metaphyſicians uſe the terms *neceſſary* and *contingent*, we can make no other objection to his diſtinction between theſe two propoſitions, but that it is expreſſed in very improper language. The houſe might certainly be *on fire* or *not* on fire; but twice two bodies *muſt* always make the ſum of four bodies, and cannot poſſibly make any other ſum.

The truth of this laſt propoſition (he ſays) we cannot have learned from *experience*, becauſe experience, being always limited, cannot poſſibly teach us what is *neceſſary* and *univerſal*. But this is egregious trifling. The experience employed here is not limited A child unqueſtionably learns the import of the terms of numeration, as he learns the import of all other terms, by experience. By putting two little balls to two little balls, he learns to call the ſum *four* balls. After two or three leſſons of this kind with different bodies, his own reflection ſuggeſts to him, that the ſum four has no dependance upon the ſhape or conſiſtence of the bodies, but merely upon the *individuality* of each or their numerical difference; and individuality, or numerical difference, is as completely exemplified in two bodies of any kind as in two thouſand.

23 With its conſequences.

All the truths of pure mathematics (ſays Kant) are *a priori*. If he means that they are all *neceſſary*, and that the contrary of any one of them is *inconceivable*, he affirms nothing but what is true, and has been known

to

to all mathematicians theſe two thouſand years. But, if he means that they are *innate* truths, not diſcovered by induction or ideal meaſurement, his meaning is demonſtrably falſe. (See INDUCTION in this *Supplement.*) When he ſays, that it is not *experience* which diſcovers to us that we ſhall always have the ſurface of the pyramid, by multiplying its baſe by the third part of its height, he is right, if by experience he means the actual meaſurement of all poſſible pyramids; but ſurely he cannot mean that the truth of this meaſurement is innate in the mind, for it is in fact not a true but a falſe meaſurement (G). The baſe of a pyramid multiplied by the third part of its height gives, not the ſurface, but the ſolid contents of the pyramid; and he who underſtands the propoſition on which this truth is immediately built, knows perfectly that Euclid proved it by a ſeries of ideal meaſurements of thoſe particulars in which all pyramids neceſſarily agree.

Kant ſeems often to confound ſenſation with experience; and if by experience he means *ſenſation*, when he ſays that *pure knowledge, a priori*, is that which is abſolutely without any mixture of experience, he talks nonſenſe; for the moſt ſpiritual notions which men can form are derived from the operations of the mind on ideas of ſenſation. To the reſt of the paragraph, reſpecting pure knowledge, we have hardly any objection to make. Locke, the great enemy of innate ideas, taught, before Kant was born, that our knowledge depends upon our organization and the faculties of our minds, as much as upon impreſſions made on the ſenſes *ab extra;* that if our organs of ſenſe were different from what they are, the taſte of ſugar might be bitter, and that of wormwood ſweet; and that if we had not memory, and could not modify and arrange our ideas, all progreſs in knowledge would be impoſſible.

24 Groundleſs or falſe aſſertions.

When our author talks of *time* and *ſpace* as the two eſſential *forms* of the mind, we are not ſure that we underſtand him. We have ſhewn elſewhere, that a conſcious intelligence may be conceived which has no ideas either of ſpace or of time (ſee METAPHYSICS, *Encycl.* n° 182, &c. and 209, &c.); and he who can affirm, that if extenſion were known to us only by *experience*, it would be poſſible to conceive ſenſible objects *without ſpace*, has never attended to the force of what philoſophers call *the aſſociation of ideas in the mind.* But what is here meant by ſenſible objects? Are they objects of touch, taſte, or ſmell? Objects of touch cannot indeed be conceived without ſpace; but what extent of ſpace is ſuggeſted by the taſte of ſugar or the odour of a roſe?

When Kant talks of the *form* ſpace enabling us to attribute to external objects *impenetrability, mobility*, &c. he talks at random; and another man may, with as much propriety, and perhaps more truth, affirm the converſe of his propoſitions, and ſay, that it is the impenetrability and mobility, &c. of external objects that enable us to form the idea called *ſpace*, and the ſucceſſion of ſome objects, compared with the permanence of others, that enables us to form the notion or mode called *time*.

25 Bad logic

On the two or three next paragraphs it is not worth while to detain the reader with many remarks. They abound with the ſame uncouth and obſcure phraſeology, and the ſame idle diſtinctions between ideas *a priori* and *a poſteriori*. In n° 11. he affirms, that the three following propoſitions (*a body is heavy, wood is combuſtible*, and *the three angles of a triangle are equal to two right angles*) are all neceſſary judgments. In one ſenſe this affirmation is true, and in another it is falſe. We cannot, without ſpeaking unintelligibly, give the name *body* to any ſubſtance which is not heavy; and we are not acquainted with any kind of *wood* which is not combuſtible; but ſurely it is not impoſſible to conceive a ſubſtance extended and diviſible, and yet *not* heavy, to which the name *body* might be given without abſurdity, or to conceive wood as incombuſtible as the mineral called *aſbeſtos*. That the three angles, however, of a plane triangle can be either more or leſs than equal to two right angles, is obviouſly impoſſible, and muſt be perceived to be ſo by every intelligence from the Supreme down to the human. The three propoſitions, therefore, are not of the ſame kind, and ſhould not have been claſſed under the ſame genus of *neceſſary* ſynthetic judgments.

In the critique of pure reaſon, Kant ſeems to teach that all demonſtrative ſcience muſt proceed from general principles to particular truths. Hence his *forms* of the underſtanding, and his *categories*, which, according to one of his pupils*, "lie in our underſtanding as pure notions *a priori*, or the foundation of all our knowledge. They are *neceſſary forms, radical* notions, of which all our knowledge *muſt* be compounded." But this is directly contrary to the progreſs of the human mind, which, as we have ſhewn in the article INDUCTION, already referred to, proceeds, in the acquiſition of every kind of knowledge, from particular truths to general principles. This *tranſcendental philoſophy* of Kant's, therefore, inverts the order of nature, and is as little calculated to promote the progreſs of ſcience as the ſyllogiſtic ſyſtem of Ariſtotle, which was likewiſe built on *categories* or *general forms*. His *tranſcendental æſthetic*, which, according to Dr Willich, is the knowledge *a priori* of the *rules of ſenſation*, ſeems to be a contradictory expreſſion, as it implies that a man may know the laws of ſenſation, without paying the ſmalleſt attention to the organs of ſenſe.

That we know objects only by the manner in which they affect us, and not as they are in themſelves, is a truth admitted, we believe, by all philoſophers, and certainly by Locke and Reid; but when Kant ſays that we know nothing of the *reality* of the objects which affect our ſenſes, he ſeems to be ſingularly paradoxical. Berkeley himſelf, the moſt ingenious idealiſt perhaps that ever wrote, contends ſtrenuouſly for the exiſtence of a *cauſe* of our ſenſations diſtinct from our own minds; and becauſe he thinks inert matter a cauſe inadequate

---

* *Dr W lich.*

(G) This may look like cavilling, as the blunder may be either Kant's or our correſpondent's, though neither of them can be ſuppoſed ignorant of the method of meaſuring the ſurface of a pyramid. We aſſure the reader, however, that we do not mean to cavil. We admit that both Kant and our correſpondent know perfectly well how to meaſure the ſurface of a pyramid; but had that knowledge been *innate* in their minds, we cannot conceive the poſſibility of their falling into the blunder. The blunder, therefore, though the offspring of mere inadvertence, ſeems to be a complete confutation of the doctrine.

inadequate to this effect, he concludes, that every ſenſation of which we are conſcious is a proof of the immediate agency of the Deity. But Kant, as we ſhall perceive by and bye, makes the exiſtence of God and of matter equally problematical. Indeed he ſays expreſsly, that beyond things ſenſible we can only have *opinions* or *belief;* but things ſenſible, as every one knows, are nothing more than the *qualities* of objects.

Ten cy of th yſ- tem ward the- iſm.

It ſhould ſeem that the greater number of wonders which Kant has found in our primitive knowledge and in the faculties of our mind, the greater number of proofs ought he to have found of the exiſtence and attributes of one Firſt Cauſe: but ſo far is this from being the caſe, that we have ſeen him reſting the evidence of this moſt important of all truths, either upon the *moral ſenſe,* which our paſſions and appetites ſo eaſily alter, or upon the intuitive perception of *abſtract moral rectitude;* a perception which thouſands, as virtuous and as profound as he, have conſidered as impoſſible. Our philoſopher's proof of a God is nothing more than his perſuaſion that happineſs is connected with virtue by a Being upon whom nature depends; and he ſays expreſsly, that this proof carries conviction to the mind in proportion as the motives of a man's actions are conformable to the law of morality. This being the caſe, the reader cannot be much ſurpriſed, when he is informed that ſeveral of Kant's diſciples on the continent have avowed themſelves Atheiſts or Spinoziſts. We have elſewhere (ſee ILLUMINATI, n° 37.) mentioned one of thoſe gentlemen who was lately diſmiſſed from his profeſſorial chair in the univerſity of Jena, for making GOD nothing more than an *abſtract idea,* derived from our relations with the moral world. His ſucceſſor, a Kantiſt likewiſe, when it was told in his preſence, that, during one of the maſſacres in Paris, David the Painter ſat with his pencil in his hand, enjoying the ſufferings of the unfortunate wretches, and trying to paint the expreſſions of their agonies, exclaimed—"What force of character! What ſublimity of ſoul!" That this wretch muſt be an Atheiſt, likewiſe, follows of courſe from Kant's principles; for it is not conceivable that he perceives any connection between happineſs and virtue.

That Kant is an atheiſt himſelf, we have not learned, though his doctrine leads thus naturally to atheiſm, and though in his work called TUGEND LEHRE, page 180, he makes the following ſtrange obſervation upon oaths: "As it would be abſurd to ſwear that God exiſts, it is ſtill a queſtion to be determined, whether an oath would be poſſible and obligatory if one were to make it thus—*I ſwear on the ſuppoſition that God exiſts.* It is extremely probable (ſays he), that all *ſincere* oaths, taken with *reflection,* have been taken in no other ſenſe!"

It is not our intention to plunge deeper into this mire of atheiſm, or to enter into a formal confutation of the deteſtable doctrines which have been dragged from its bottom. Enough has been ſaid elſewhere to convince the *theoretical* reaſon of the ſound minds of our countrymen of the exiſtence of one omnipotent, infinitely wiſe, and perfectly good Being, the author and upholder of all things (See *Encycl.* METAPHYSICS, Part III. Chap. vi. and THEOLOGY, Part I. Sect. 1.). It may not, however, be altogether uſeleſs to point out to the reader how completely Kant confutes himſelf, even in the ſhort abſtract that we have given of his ſyſtem.

27 Kant confutes himſelf.

Among his *categories,* or fundamental ideas, which are *neceſſarily* formed in the mind, he expreſsly reckons *cauſe* and *effect:* but in various articles of this work, it has been proved beyond the poſſibility of contradiction, that no *ſenſible* object is the *true metaphyſical cauſe* of any one event in nature; and indeed Kant himſelf is at much pains to ſhew that his *categories* or ideas *a priori* are not ideas of ſenſation. There muſt therefore, upon his own principles, be cauſes which are *not* the objects of *ſenſe* or *experience;* and by tracing theſe cauſes backward, if there be a ſucceſſion of them, we muſt arrive at one ſelf-exiſtent cauſe, by a demonſtration as complete as that by which Euclid proves the equality of the three angles of a plane triangle to two right angles. We have no other evidence for the truth of geometrical axioms than the laws of human thought, which compel us to perceive the impoſſibility of ſuch propoſitions being falſe. According to our philoſopher, we have the very ſame evidence for the reality of cauſes and effects which are not the objects of ſenſe. The conſequence is obvious.

28 His morality is extravagant.

Kant's *political* opinions are ſaid to be tolerably moderate, though he betrays, what we muſt think, an abſurd confidence in the *unlimited perfectibility* of the human mind. On his morality our valued correſpondent has beſtowed a much larger ſhare of his approbation than we can allow it of ours. Kant ſeems to contend, that the actions of men ſhould be directed to no end whatever; for he expreſsly condemns, as an end of action, the purſuit either of our own happineſs or of the happineſs of others, whether temporal or eternal; but actions performed for no purpoſe are ſurely indications of the very eſſence of folly. Such actions are indeed impoſſible to beings endowed with reaſon, paſſions, and appetites; for if there be that beauty in abſtract virtue, for which Kant and the Stoics contend, it cannot be but that the virtuous man muſt feel an internal pleaſure when he performs a virtuous action, or reflects upon his paſt conduct. He who makes his temporal intereſt the ſole rule of his conduct, has indeed no pretenſions to the character of a virtuous man; but as the morality of the goſpel has always appeared to us ſufficiently pure and diſintereſted, we think a man may, without deviating into vice, have reſpect unto "the recompence of future reward."

Pho-

PHOSPHORUS (See CHEMISTRY-*Index, Supplement.*) has lately been employed as a medicine by Alphonſus Leroi, profeſſor at the Medical School of Paris. Its effects, in a variety of caſes, are thus deſcribed in the *Bulletin de la Societé Philomatique,* 1798.

Phoſphorus.

1. Phoſphorus adminiſtered internally in conſumptive diſeaſes appears to give a certain degree of activity to life, and to revive the patients, without raiſing their pulſe in the ſame proportion. The author relates ſeveral inſtances that occurred to him in the courſe of his

practice; one of which is as follows: Being called to attend a woman, at the point of death, who was quite worn out by a conſumptive diſorder, with which ſhe had been afflicted for three years, in compliance with the earneſt deſire of her huſband, who requeſted him to give her ſome medicine, he compoſed one of a portion of ſyrup diluted with water, in which a few ſticks of phoſphorus had been kept. Next day the woman found herſelf much better. She was revived for a few days; and did not die till about a fortnight after.

2. He himſelf, as he acknowledges, was ſo imprudent as to take two or three grains of ſolid phoſphorus combined only with treacle, and experienced the moſt dreadful ſymptoms. At firſt he felt a burning heat in the whole region of the ſtomach. That organ ſeemed to be filled with gas which eſcaped by the mouth. Being dreadfully tormented, he tried to vomit, but in vain; and found relief only by drinking cold water from time to time. His uneaſy ſenſations were at length allayed; but next morning he ſeemed to be endowed with an aſtoniſhing muſcular force, and to be urged with an almoſt irreſiſtible impulſe to try its energy. The effect of this medicine at length ceaſed, adds the author, *à la ſuite d'un priapiſme violent*.

3. In many caſes the author employed, and ſtill employs, phoſphorus internally, with great benefit, to reſtore and revive young perſons exhauſted by exceſſes. He divides the phoſphorus into very ſmall particles, by ſhaking it in a glaſs filled with boiling water. He continues to ſhake the bottle, plunging it into cold water, and thus obtains a kind of precipitate of phoſphorus, exceedingly fine, which he bruiſes ſlowly with a little oil and ſugar, or afterwards employs as liquid electuary, by diluting the whole in the yolk of an egg. By means of this medicine he has effected aſtoniſhing cures, and reſtored the ſtrength of his patients in a very ſhort time.

4. In malignant fevers the uſe of phoſphorus internally, to check the progreſs of gangrene, has ſucceeded beyond expectation. The author relates ſeveral inſtances.

5. Pelletier told him, that having left, through negligence, ſome phoſphorus in a copper baſon, that metal was oxydated, and remained ſuſpended in the water. Having thoughtleſsly thrown out the water in a ſmall court in which ducks were kept, theſe animals drank of it, and all died. *Mais le male* (ſays the author) *couvrit toutes ſes femelles juſque au dernier inſtant de ſa vie.* An obſervation which accords with the effect experienced by the author.

6. The author relates a fact which proves the aſtoniſhing diviſibility of phoſphorus. Having adminiſtered to a patient ſome pills, in the compoſition of which there was not more than a quarter of a grain of phoſphorus, and having had occaſion afterwards to open the body, he found all the internal parts luminous; and even the hands of the perſon who had performed the operation, though waſhed and well dried, retained a phoſphoric ſplendor for a long time after.

7. The phoſphoric acid, employed as lemonade, has been ſerviceable to the author in the cure of a great number of diſeaſes.

8. Leroi aſſures us that he oxydated iron with phoſphorus, and obtained, by the common means, a white oxyd, almoſt irreducible, which he thinks may be employed with advantage in the arts, and particularly in painting with oil, and in enamel, inſtead of the white oxyd of lead. This white oxyd of iron occaſioned violent retchings to the author, who ventured to place a very ſmall particle of it on his tongue. He does not heſitate, therefore, to conſider this oxyd as a terrible poiſon. He was not able to reduce it but by fixed alkali and the glaſs of phoſphorus.

9. The author aſſerts that, by means of phoſphorus, he decompoſed and ſeparated from their baſes the ſulphuric, muriatic, and nitric acids; that by help of the phoſphoric acid he tranſmuted earths; and that with calcareous earth he can make, at pleaſure, conſiderable quantities of magneſia. He declares, that to his labours on phoſphorus he is indebted for proceſſes by which he effects the diſſipation (*opère la frite*) of rubies, the fuſion of emeralds, and the vitrification of mercury.

We agree with the editor of the reſpectable Miſcellany *, from which we have immediately taken this article, that Britiſh practitioners will do well to uſe their wonted caution in the application of ſo powerful a remedy. Indeed we conſider it as ſo very *hazardous* a remedy, that we had reſolved to make no mention of it, till we found it tranſcribed into various journals, both foreign and domeſtic, and thence began to ſuſpect that we might be accuſed of culpable negligence, were we to paſs unnoticed what had attracted the attention of ſo many of our fellow-labourers in the field of ſcience.

PHOSPHORUS, in aſtronomy, is the morning ſtar, or the planet Venus, when ſhe riſes before the ſun. The Latins call it *Lucifer*, the French *Etoile de berger*, and the Greeks *Phoſphorus*.

PHOTOMETER, an apparatus for meaſuring the intenſity of light, and likewiſe the tranſparency of the medium through which it paſſes. Inſtruments for this purpoſe have been invented by Count Rumford, M. de Sauſſure, that eminent mathematician and philoſopher Mr John Leſlie, and others. We ſhall content ourſelves with deſcribing in this place the photometer of Count Rumford, and the inſtrument to which Sauſſure gives the name of *diaphanometer*. Mr Leſlie's is indeed the ſimpleſt inſtrument of the kind of which we have anywhere met with a deſcription; but it meaſures only the momentary intenſities of light; and he who wiſhes to be informed of its conſtruction, will find that information in the third volume of Nicholſon's Philoſophical Journal.

Count Rumford, when making the experiments which we have noticed in the article LAMP (*Suppl.*), was led, ſtep by ſtep, to the conſtruction of a very accurate *photometer*, in which the ſhadows, inſtead of being thrown upon a paper ſpread out upon the wainſcot, or ſide of the room (See page 64 of this volume), are projected upon the inſide of the back part of a wooden box $7\frac{1}{4}$ inches wide, $10\frac{1}{2}$ inches long, and $3\frac{1}{4}$ inches deep, in the clear. The light is admitted into it through two horizontal tubes in the front, placed ſo as to form an angle of 60°; their axes meeting at the centre of the field of the inſtrument. In the middle of the front of the box, between theſe two tubes, is an opening thro' which is viewed the field of the photometer (See fig. 1.). This field is formed of a piece of white paper, which is not faſtened immediately upon the inſide of the back of the box, but is paſted upon a ſmall pane of very fine ground glaſs; and this glaſs, thus covered, is

Plate X

---

* Philoſophical Magazine, vol. ii.

P tome-er.

is let down into a groove, made to receive it, in the back of the box. The whole inſide of the box, except the field of the inſtrument, is painted of a deep black dead colour. To the under part of the box is fitted a ball and ſocket, by which it is attached to a ſtand which ſupports it; and the top or lid of it is fitted with hinges, in order that the box may be laid quite open, as often as it is neceſſary to alter any part of the machinery it contains.

The Count had found it very inconvenient to compare two ſhadows projected by the ſame cylinder, as theſe were either neceſſarily too far from each other to be compared with certainty, or, when they were nearer, were in part hid from the eye by the cylinder. To remedy this inconvenience, he now makes uſe of two cylinders, which are placed perpendicularly in the bottom of the box juſt deſcribed, in a line parallel to the back part of it, diſtant from this back $2\frac{2}{10}$ inches, and from each other 3 inches, meaſuring from the centres of the cylinders; when the two lights made uſe of in the experiment are properly placed, theſe two cylinders project four ſhadows upon the white paper upon the inſide of the back part of the box, or the *field* of the inſtrument; two of which ſhadows are in contact, preciſely in the middle of that field, and it is theſe two alone that are to be attended to. To prevent the attention being diſtracted by the preſence of unneceſſary objects, the two outſide ſhadows are made to diſappear; which is done by rendering the field of the inſtrument ſo narrow, that they fall without it, upon a blackened ſurface, upon which they are not viſible. If the cylinders be each $\frac{4}{10}$ of an inch in diameter, and $2\frac{2}{10}$ inches in height, it will be quite ſufficient that the field be $2\frac{7}{10}$ inches wide; and as an unneceſſary height of the field is not only uſeleſs, but diſadvantageous, as a large ſurface of white paper not covered by the ſhadows produces too ſtrong a glare of light, the field ought not to be more than $\frac{3}{10}$ of an inch higher than the tops of the cylinders. That its dimenſions, however, may be occaſionally augmented, the covered glaſs ſhould be made $5\frac{1}{2}$ inches long, and as wide as the box is deep, viz. $3\frac{1}{4}$ inches; ſince the field of the inſtrument can be reduced to its proper ſize by a ſcreen of black paſteboard, interpoſed before the anterior ſurface of this covered glaſs, and reſting immediately upon it. A hole in this paſteboard, in the form of an oblong ſquare, $1\frac{7}{10}$ inch wide, and two inches high, determines the dimenſions, and forms the boundaries of the field. This ſcreen ſhould be large enough to cover the whole inſide of the back of the box, and it may be fixed in its place by means of grooves in the ſides of the box, into which it may be made to enter. The poſition of the opening above-mentioned is determined by the height of the cylinders; the top of it being $\frac{3}{10}$ of an inch higher than the tops of the cylinders; and as the height of it is only two inches, while the height of the cylinders is $2\frac{2}{10}$ inches, it is evident that the ſhadows of the lower parts of the cylinders do not enter the field. No inconvenience ariſes from that circumſtance; on the contrary, ſeveral advantages are derived from that arrangement.

That the lights may be placed with facility and preciſion, a fine black line is drawn through the middle of the field, from the top to the bottom of it, and another (horizontal) line at right angles to it, at the height of the top of the cylinders. When the tops of the ſhadows touch this laſt mentioned line, the lights are at a proper height; and farther, when the two ſhadows are in contact with each other in the middle of the field, the lights are then in their proper directions.

Photometer.

We have ſaid that the cylinders, by which the ſhadows are projected, are placed perpendicularly in the bottom of the box; but as the diameters of the ſhadows of theſe cylinders vary in ſome degree, in proportion as the lights are broader or narrower, and as they are brought nearer to or removed farther from the photometer, in order to be able in all caſes to bring theſe ſhadows to be of the ſame diameter, which is very advantageous, in order to judge with greater facility and certainty when they are of the ſame denſity, the Count renders the cylinders moveable about their axes, and adds to each a vertical wing $\frac{11}{20}$ of an inch wide, $\frac{1}{10}$ of an inch thick, and of equal height with the cylinder itſelf, and firmly fixed to it from the top to the bottom. This wing commonly lies in the middle of the ſhadow of the cylinder, and as long as it remains in that ſituation it has no effect whatever; but when it is neceſſary that the diameter of one of the ſhadows be increaſed, the correſponding cylinder is moved about its axis, till the wing juſt deſcribed, emerging out of the ſhadow, and intercepting a portion of light, brings the ſhadow projected upon the field of the inſtrument to be of the width or diameter required. In this operation it is always neceſſary to turn the cylinder outwards, or in ſuch a manner that the augmentation of the width of the ſhadow may take place on that ſide of it which is oppoſite to the ſhadow correſponding to the other light. The neceſſity for that precaution will appear evident to any one who has a juſt idea of the inſtrument in queſtion, and of the manner of making uſe of it. They are turned likewiſe without opening the box, by taking hold of the ends of their axes, which project below its bottom.

As it is abſolutely neceſſary that the cylinders ſhould conſtantly remain preciſely perpendicular to the bottom of the box, or parallel to each other, it will be beſt to conſtruct them of braſs; and, inſtead of fixing them immediately to the bottom of the box (which, being of wood, may warp), to fix them to a ſtrong thick piece of well-hammered plate braſs; which plate of braſs may be afterwards faſtened to the bottom of the box by means of one ſtrong ſcrew. In this manner two of the Count's beſt inſtruments are conſtructed; and, in order to ſecure the cylinders ſtill more firmly in their vertical poſitions, they are furniſhed with broad flat rings, or projections, where they reſt upon the braſs plate; which rings are $\frac{1}{10}$ of an inch thick, and equal in diameter to the projection of the wing of the cylinder, to the bottom of which they afford a firm ſupport. Theſe cylinders are likewiſe forcibly puſhed, or rather pulled, againſt the braſs plate upon which they reſt, by means of compreſſed ſpiral ſprings placed between the under ſide of that plate and the lower ends of the cylinders. Of whatever material the cylinders be conſtructed, and whatever be their forms or dimenſions, it is abſolutely neceſſary that they, as well as every other part of the photometer, except the field, ſhould be well painted of a deep black dead colour.

In order to move the lights to and from the photometer with greater eaſe and preciſion, the obſerver ſhould provide two long and narrow, but very ſtrong and ſteady, tables; in the middle of each of which there

there is a ſtraight groove, in which a ſliding carriage, upon which the light is placed, is drawn along by means of a cord which is faſtened to it before and behind, and which, paſſing over pulleys at each end of the table, goes round a cylinder; which cylinder is furniſhed with a winch, and is ſo placed, near the end of the table adjoining the photometer, that the obſerver can turn it about, without taking his eye from the field of the inſtrument.

Many advantages are derived from this arrangement: Firſt, the obſerver can move the lights as he finds neceſſary, without the help of an aſſiſtant, and even without removing his eye from the ſhadows; ſecondly, each light is always preciſely in the line of direction in which it ought to be, in order that the ſhadows may be in contact in the middle of the vertical plane of the photometer; and, thirdly, the ſliding motion of the lights being perfectly ſoft and gentle, that motion produces little or no effect upon the lights themſelves, either to increaſe or diminiſh their brilliancy.

Theſe tables muſt be placed at an angle of 60 degrees from each other, and in ſuch a ſituation, with reſpect to the photometer, that lines drawn through their middles, in the direction of their lengths, meet in a point exactly under the middle of the vertical plane or field of the photometer, and from that point the diſtances of the lights are meaſured; the ſides of the tables being divided into Engliſh inches, and a vernier, ſhewing tenths of inches, being fixed to each of the ſliding carriages upon which the lights are placed, and which are ſo contrived that they may be raiſed or lowered at pleaſure; ſo that the lights may be always in a horizontal line with the tops of the cylinders of the photometer.

In order that the two long and narrow tables or platforms, juſt deſcribed, may remain immoveable in their proper poſitions, they are both firmly fixed to the ſtand which ſupports the photometer; and, in order that the motion of the carriages which carry the lights may be as ſoft and gentle as poſſible, they are made to ſlide upon parallel braſs wires, 9 inches aſunder, about $\frac{1}{10}$ of an inch in diameter, and well poliſhed, which are ſtretched out upon the tables from one end to the other.

The ſtructure of the apparatus will be clearly underſtood by a bare inſpection of Plate XLI. where fig. 1. is a plan of the inſide of the box, and the adjoining parts of the photometer. Fig. 2. Plan of the two tables belonging to the photometer. Fig. 3. The box of the photometer on its ſtand. Fig. 4. Elevation of the photometer, with one of the tables and carriages.

Having ſufficiently explained all the eſſential parts of this photometer, it remains for us to give ſome account of the precautions neceſſary to be obſerved in uſing it. And, firſt, with reſpect to the diſtance at which lights, whoſe intenſities are to be compared, ſhould be placed from the field of the inſtrument, the ingenious and accurate inventor found, that when the weakeſt of the lights in queſtion is about as ſtrong as a common wax-candle, that light may moſt advantageouſly be placed from 30 to 36 inches from the centre of the field; and when it is weaker or ſtronger, proportionally nearer or farther off. When the lights are too near, the ſhadows will not be well defined; and when they are too far off, they will be too weak.

It will greatly facilitate the calculations neceſſary in drawing concluſions from experiments of this kind, if ſome ſteady light, of a proper degree of ſtrength for that purpoſe, be aſſumed as a ſtandard by which all others may be compared. Our author found a good Argand's lamp much preferable for this purpoſe to any other lamp or candle whatever. As it appears, he ſays, from a number of experiments, that the quantity of light emitted by a lamp, which burns in the ſame manner with a clear flame, and *without ſmoke*, is in all caſes as the quantity of oil conſumed, there is much reaſon to ſuppoſe, that, if the Argand's lamp be ſo adjuſted as always to conſume a given quantity of oil in a given time, it may then be depended on as a juſt ſtandard of light.

In order to abridge the calculations neceſſary in theſe inquiries, it will always be advantageous to place the ſtandard-lamp at the diſtance of 100 inches from the photometer, and to aſſume the intenſity of its light at its ſource equal to unity; in this caſe (calling this ſtandard light A, the intenſity of the light at its ſource $= x = 1$, and the diſtance of the lamp from the field of the photometer $= m = 100$), the intenſity of the illumination at the field of the photometer ($= \frac{x}{m^2}$) (See Lamp, p. 67. of this volume) will be expreſſed by the fraction $\frac{1}{100^2} = \frac{1}{10000}$; and the relative intenſity of any other light which is compared with it, may be found by the following proportion: Calling this light B, putting $y =$ its intenſity at its ſource, and $n =$ its diſtance from the field of the photometer, expreſſed in Engliſh inches, as it is $\frac{y}{n^2} = \frac{x}{m^2}$, as was ſhewn in the article Lamp referred to; or, inſtead of $\frac{x}{m^2}$, writing its value $= \frac{1}{10000}$, it will be $\frac{y}{n^2} = \frac{1}{10000}$; and conſequently y is to 1 as n^2 is to 10000; or the intenſity of the light B at its ſource, is to the intenſity of the ſtandard light A at its ſource, as the ſquare of the diſtance of the light B from the middle of the field of the inſtrument, expreſſed in inches, is to 10000; and hence it is $y = \frac{n^2}{10000}$.

Or, if the light of the ſun, or that of the moon, be compared with the light of a given lamp or candle C, the reſult of ſuch compariſon may beſt be expreſſed in words, by ſaying, that the light of the celeſtial luminary in queſtion, *at the ſurface of the earth*, or, which is the ſame thing, at the field of the photometer, is equal to the light of the given lamp or candle, *at the diſtance found by the experiment*; or, putting $a =$ the intenſity of the light of this lamp C at its ſource, and $p =$ its diſtance, in inches, from the field, when the ſhadows correſponding to this light, and that correſponding to the celeſtial luminary in queſtion, are found to be of equal denſities, and putting $z =$ the intenſity of the rays of the luminary at the ſurface of the earth, the reſult of the experiment may be expreſſed thus, $z = \frac{a}{p^2}$; or the real value of a being determined by a particular experiment, made expreſsly for that purpoſe with the ſtandard lamp, that value may be written inſtead of it. When the ſtandard-lamp itſelf is made uſe of, inſtead of the lamp C, then the value of A will be 1.

The Count's firſt attempts with his photometer were to determine how far it might be poſſible to aſcertain, by direct experiments, the certainty of the aſſumed law of the diminution of the intenſity of the light emitted by luminous bodies; namely, that the intenſity of the light is everywhere as the ſquares of the diſtances from the luminous body inverſely. As it is obvious that this law can hold good only when the light is propagated through perfectly tranſparent ſpaces, ſo that its intenſity is weakened merely by the divergency of its rays, he inſtituted a ſet of experiments to aſcertain the tranſparency of the air and other mediums.

With this view, two equal wax candles, well trimmed, and which were found, by a previous experiment, to burn with exactly the ſame degree of brightneſs, were placed *together*, on one ſide, before the photometer, and their united light was counterbalanced by the light of an Argand's lamp, well trimmed, and burning very equally, placed on the other ſide over againſt them. The lamp was placed at the diſtance of 100 inches from the field of the photometer, and it was found that the two burning candles (which were placed as near together as poſſible, without their flames affecting each other by the currents of air they produced) were juſt able to counterbalance the light of the lamp at the field of the photometer, when they were placed at the diſtance of 60,8 inches from that field. One of the candles being now taken away and extinguiſhed, the other was brought nearer to the field of the inſtrument, till its light was found to be juſt able, ſingly, to counterbalance the light of the lamp; and this was found to happen when it had arrived at the diſtance of 43,4 inches. In this experiment, as the candles burnt with equal brightneſs, it is evident that the intenſities of their united and ſingle lights were as 2 to 1, and in that proportion ought, according to the aſſumed theory, the ſquares of the diſtances, 60,8 and 43,4, to be; and, in fact, $\overline{60{,}8}^2 = 3696{,}64$ is to $\overline{43{,}4}^2 = 1883{,}56$ as 2 is to 1 very nearly.

Again, in another experiment, the diſtances were,

With two candles = 54 inches. Square = 2916
With one candle = 38,6 - - = 1489,96

Upon another trial,

With two candles = 54,6 inches. Square = 2981,16
With one candle = 39,7 - - = 1576,09

And, in the fourth experiment,

With two candles = 58,4 inches. Square = 3410,56
With one candle = 42,2 - - = 1780,84

And, taking the mean of the reſults of theſe four experiments,

	Squares of the Diſtances		
	With two Candles.		With one Candle
In the Experiment Nº 1.	3696,64	—	1883,56
Nº 2.	2916	—	1489,96
Nº 3.	2981,16	—	1576,09
Nº 4.	3410,56	—	1780,84
	4) 13004,36		4) 6730,45
Means	3251,09	and	1682,61

which again are very nearly as 2 to 1.

With regard to theſe experiments, it may be obſerved, that were the reſiſtance of the air to light, or the diminution of the light from the imperfect tranſparency of air, ſenſible within the limits of the inconſiderable diſtances at which the candles were placed from the photometer, in that caſe the diſtance of the two equal lights united ought to be, to the diſtance of one of them ſingle, in a ratio leſs than that of the ſquare root of 2 to the ſquare root of 1. For if the intenſity of a light emitted by a luminous body, *in a ſpace void of all reſiſtance*, be diminiſhed in the proportion of the ſquares of the diſtances, it muſt of neceſſity be diminiſhed in a ſtill higher ratio when the light paſſes thro' a reſiſting medium, or one which is not perfectly tranſparent; and from the difference of thoſe ratios, namely, that of the ſquares of the diſtances, and that other higher ratio found by the experiment, the reſiſtance of the medium might be aſcertained. This he took much pains to do with reſpect to air, but did not ſucceed; the tranſparency of air being ſo great, that the diminution which light ſuffers in paſſing through a few inches, or even through ſeveral feet of it, is not ſenſible.

Photometer.

Having found, upon repeated trials, that the light of a lamp, properly trimmed, is incomparably more equal than that of a candle, whoſe wick, continually growing longer, renders its light extremely fluctuating, he ſubſtituted lamps to candles in theſe experiments, and made ſuch other variations in the manner of conducting them as he thought bid fair to lead to a diſcovery of the reſiſtance of the air to light, were it poſſible to render that reſiſtance ſenſible within the confined limits of his machinery. But the reſults of them, ſo far from affording means for aſcertaining the reſiſtance of the air to light, do not even indicate any reſiſtance at all; on the contrary, it might almoſt be inferred, from ſome of them, that the intenſity of the light emitted by a luminous body in air is diminiſhed in a ratio *leſs* than that of the ſquares of the diſtances; but as ſuch a concluſion would involve an evident abſurdity, namely, that light moving in air, its abſolute quantity, inſtead of being diminiſhed, actually goes on to *increaſe*, that concluſion can by no means be admitted.

Why not? Theories muſt give place to facts; and if this fact can be fairly aſcertained, inſtead of rejecting the concluſion, we ought certainly to rectify our notions of light, the nature of which we believe no man fully comprehends. Who can take it upon him to ſay, that the ſubſtance of light is not latent in the atmoſphere, as heat or caloric is now acknowledged to be latent, and that the agency of the former is not called forth by the paſſage of a ray through a portion of air, as the agency of the latter is known to be excited by the combination of oxygen with any combuſtible ſubſtance? See CHEMISTRY, nº 293, *Suppl.*

The ingenious author's experiments all conſpired to ſhew that the reſiſtance of the air to light is too inconſiderable to be perceptible, and that the aſſumed law of the diminution of the intenſity of light may be depended upon with ſafety. He admits, however, that means may be found for rendering the air's reſiſtance to light apparent; and he ſeems to have thought of the very means which occurred for this purpoſe to M. de Sauſſure.

That eminent philoſopher, wiſhing to aſcertain the tranſparency of the atmoſphere, by meaſuring the diſtances at which determined objects ceaſe to be viſible, perceived at once that his end would be attained, if he ſhould find objects of which the diſappearance might be accurately determined. Accordingly, after many trials, he found that the moment of diſappearance can be obſerved with much greater accuracy when a black object is placed on a white ground, than when a white object is placed on a black ground; that the accuracy was ſtill greater when the obſervation was made in the ſun than in the ſhade; and that even a ſtill greater degree of accuracy was obtained, when the white ſpace ſurrounding a black circle, was itſelf ſurrounded by a circle or ground of a dark colour. This laſt circumſtance was particularly remarkable, and an obſervation quite new.

If a circle totally black, of about two lines in diameter, be faſtened on the middle of a large ſheet of paper or paſteboard, and if this paper or paſteboard be placed in ſuch a manner as to be expoſed fully to the light of the ſun, if you then approach it at the diſtance of three or four feet, and afterwards gradually recede from it, keeping your eye conſtantly directed towards the black circle, it will appear always to decreaſe in ſize the farther you retire from it, and at the diſtance of 33 or 34 feet will have the appearance of a point. If you continue ſtill to recede, you will ſee it again enlarge itſelf; and it will ſeem to form a kind of cloud, the darkneſs of which decreaſes more and more according as the circumference becomes enlarged. The cloud will appear ſtill to increaſe in ſize the farther you remove from it; but at length it will totally diſappear. The moment of the diſappearance, however, cannot be accurately aſcertained; and the more experiments were repeated the more were the reſults different.

M. de Sauſſure, having reflected for a long time on the means of remedying this inconveniency, ſaw clearly, that, as long as this cloud took place, no accuracy could be obtained; and he diſcovered that it appeared in conſequence of the contraſt formed by the white parts which were at the greateſt diſtance from the black circle. He thence concluded, that if the ground was left white near this circle, and the parts of the paſteboard at the greateſt diſtance from it were covered with a dark colour, the cloud would no longer be viſible, or at leaſt almoſt totally diſappear.

This conjecture was confirmed by experiment. M. de Sauſſure left a white ſpace around the black circle equal in breadth to its diameter, by placing a circle of black paper a line in diameter on the middle of a white circle three lines in diameter, ſo that the black circle was only ſurrounded by a white ring a line in breadth. The whole was paſted upon a green ground. A green colour was choſen, becauſe it was dark enough to make the cloud diſappear, and the eaſieſt to be procured.

The black circle, ſurrounded in this manner with white on a green ground, diſappeared at a much leſs diſtance than when it was on a white ground of a large ſize.

If a perfectly black circle, a line in diameter, be paſted on the middle of a white ground expoſed to the open light, it may be obſerved at the diſtance of from 44 to 45 feet; but if this circle be ſurrounded by a white ring a line in breadth, while the reſt of the ground is green, all ſight of it is loſt at the diſtance of only 15½ feet.

According to theſe principles M. de Sauſſure delineated ſeveral black circles, the diameters of which increaſed in a geometrical progreſſion, the exponent of which was $\frac{3}{2}$. His ſmalleſt circle was $\frac{1}{5}$ or 0·2 of a line in diameter; the ſecond 0·3; the third, 0·45; and ſo on to the ſixteenth, which was 87·527, or about 7 inches 3½ lines. Each of theſe circles was ſurrounded by a white ring, the breadth of which was equal to the diameter of the circle, and the whole was paſted on a green ground.

M. de Sauſſure, for his experiments, ſelected a ſtraight road or plain of about 1200 or 1500 feet in circumference, which towards the north was bounded by trees or an aſcent. Thoſe who repeat them, however, muſt pay attention to the following remarks: When a perſon retires backwards, keeping his eye conſtantly fixed on the paſteboard, the eye becomes fatigued, and ſoon ceaſes to perceive the circle; as ſoon therefore as it ceaſes to be diſtinguiſhable, you muſt ſuffer your eyes to reſt; not, however, by ſhutting them, for they would when again opened be dazzled by the light, but by turning them gradually to ſome leſs illuminated object in the horizon. When you have done this for about half a minute, and again directed your eyes to the paſteboard, the circle will be again viſible, and you muſt continue to recede till it diſappear once more. You muſt then let your eyes reſt a ſecond time in order to look at the circle again, and continue in this manner till the circle becomes actually inviſible.

If you wiſh to find an accurate expreſſion for the want of tranſparency, you muſt employ a number of circles, the diameters of which increaſe according to a certain progreſſion; and a compariſon of the diſtances at which they diſappear will give the law according to which the tranſparency of the atmoſphere decreaſes at different diſtances. If you wiſh to compare the tranſparency of the atmoſphere on two days, or in two different places, two circles will be ſufficient for the experiment.

According to theſe principles, M. de Sauſſure cauſed to be prepared a piece of white linen cloth eight feet ſquare. In the middle of this ſquare he ſewed a perfect circle, two feet in diameter, of beautiful black wool; around this circle he left a white ring two feet in breadth, and the reſt of the ſquare was covered with pale green. In the like manner, and of the ſame materials, he prepared another ſquare; which was, however, equal to only $\frac{1}{12}$ of the ſize of the former, ſo that each ſide of it was 8 inches; the black circle in the middle was two inches in diameter, and the white ſpace around the circle was 2 inches alſo.

If two ſquares of this kind be ſuſpended vertically and parallel to each other, ſo that they may be both illuminated in an equal degree by the ſun; and if the atmoſphere, at the moment when the experiment is made, be perfectly tranſparent, the circle of the large ſquare, which is twelve times the ſize of the other, muſt be ſeen at twelve times the diſtance. In M. de Sauſſure's experiments the ſmall circle diſappeared at the diſtance of 314 feet, and the large one at the diſtance of 3588 feet, whereas it ſhould have diſappeared at the diſtance of 3768. The atmoſphere, therefore, was not perfectly tranſparent. This aroſe from the thin vapours which at that time were floating in it. M. de Sauſſure, as we have obſerved, calls his inſtrument a *diaphanometer*; but as it anſwers one of the purpoſes of a photometer, we truſt our readers will not conſider this account of it as a digreſſion.

To return to Count Rumford. From a number of experiments made with his *photometer*, he found that, by paſſing through a pane of fine, clear, well poliſhed glaſs, ſuch as is commonly made uſe of in the conſtruction of looking-glaſſes, light loſes ,1973 of its whole quantity,

ano
rte.

quantity, *i. e.* of the quantity which impinged on the glaſs; that when light is made to paſs through two panes of ſuch glaſs ſtanding parallel, but not touching each other, the loſs is ,3184 of the whole; and that in paſſing through a very thin, clear, colourleſs pane of window-glaſs, the loſs is only ,1263. Hence he infers, that this apparatus might be very uſefully employed by the optician, to determine the degree of tranſparency of glaſs, and direct his choice in the proviſion of that important article of his trade. The loſs of light when reflected from the very beſt plain glaſs mirror, the author aſcertained, by five experiments, to be $\frac{1}{3}$d of the whole which fell upon the mirror.

PIANO FORTE, otherwiſe called FORTE PIANO, a well-known muſical inſtrument, of which we need make no apology for conſidering the peculiarities with ſome attention. If we look on muſic from no higher point of view than as the *laborum dulce lenimen*, the innocent, the ſoothing, the chearing ſweetener of toil, we muſt acknowledge that it is far from being the meaneſt of thoſe enjoyments with which the Bountiful Father of Men has embelliſhed this ſcene of our exiſtence. But there is a *ſcience* in muſic, independent of that artificial half mathematical doctrine which we have contrived to unite with it, and which really enables us to improve pure muſical pleaſure. Hence in the Engliſh univerſities degrees are conferred in muſic.

The voice is the original muſical inſtrument, and all others are but imitations. The voice of man obeys the impulſe of the heart with wonderful promptitude, and ſtill more wonderful accuracy. A very coarſe ear is hurt by an error in its tone, amounting to what is called a *comma*. A very limited voice can execute melodies extending to 12 notes, or an octave and a fifth. The motion of the glottis between theſe extremes does not amount to $\frac{1}{11}$th of an inch. This muſt therefore be divided, by the moſt ordinary finger, into more than a thouſand parts; and this muſt be done in an inſtant, and repeated with rapidity, without ever miſtaking one of theſe diviſions; and this is done everywhere, and without any ſeeming effort or thought. The mechaniſm of the human organ for effecting this with eaſe and preciſion is very remarkable, and ſeems to prove that the Author of our Being meant to give us this pleaſure.

When, in the cultivation of this fruit of our own ſoil, the moderns diſcovered the beauties of harmony or conſonance, and inſtruments of fixed ſounds were employed, by means of which theſe beauties could be exhibited in their utmoſt richneſs and variety; and particularly when the organ, that "magic world of ſound," was invented, the immenſe advantages of the ingenious ſpeculations of the ancient Greeks about the diviſion of the monochord were now perceived, and muſic became a deep intellectual ſtudy. It fell into the hands of men of letters, and, for a long while, counterpoint occupied all their attention. Inſtruments of fixed ſounds were now made, not only with pipes, but with ſtrings, bells, rings, and every thing that could make a noiſe in tune.

But all theſe inſtruments were far inferior to the voice, the ſpontaneous gift of Nature, in promptitude, and in the power of obeying every call of ſentiment, every degree, as well as every kind of emotion, with which the heart was agitated. The pleaſures of harmony, though great, were monotonous, and could not expreſs the momentary variations of ſentiment, which are as fleeting as the light and ſhade of a proſpect while the dappled clouds ſail acroſs the ſky. The violin, and a ſmall number of the ſimple wind inſtruments, were found to be the only ones which could fully expreſs thoſe momentary gradations of ſentiment that give muſic its pathos, and enable it to thrill the very ſoul.

Piano
Forte.

Attempts were made to remove this defect of the harmonic inſtruments, and the SWELL was added to the organ. The effect was great, and encouraged the artiſts to attempt ſimilar improvements on other inſtruments of the ſame kind. This was firſt done in the ſame way as in the organ. The harpſichord was ſhut up, like the ſwell organ, and was opened by means of pedals when the performer wiſhed to enforce the ſound. But the effect was far inferior to that of the ſwell organ; for this was (at leaſt in all great organs) a real addition of another properly ſelected ſound. But the effect of the pedal on the harpſichord could not be miſtaken; it was juſt like opening the door of a room where muſic was performing. Other methods were tried with better effect. Uniſons were added to each note, which were brought on either by means of pedals or by another ſet of keys.

This method ſucceeded perfectly well, and the power of the harpſichord was greatly improved. But ſtill it was imperfect, becauſe it was only the more conſiderable changes of force which could be exhibited, and this only in one or two degrees. Other artiſts, therefore, attempted to conſtruct the inſtrument, ſo that the jacks (the moveable upright pieces which carry the quills) can be made to approach nearer to the wires, ſo that the quills ſhall give them a ſtronger twang. The mechaniſm was ſuch, that a very conſiderable motion of the pedal produced but a moſt minute motion of the quill; ſo that the performer was not reſtricted to the utmoſt preciſion in the degree of preſſure. Some of thoſe inſtruments, when freſh from the hand of the artiſt, gave full ſatisfaction. But, though made in the moſt accurate manner, at an enormous expence, they very ſoon become unfit for the purpoſe. The hundredth part of an inch, more or leſs, in the place of the quill, will make a great odds in the force of the ſound. Nor does the ſame change of diſtance produce an equal alteration of ſound on different quills. Other inſtrument makers have therefore tried baked or prepared leather (buffalo hide) in place of quills; and it is found much more uniform in the tone which it produces, and alſo remains longer in the ſame ſtate; but the tone is not ſo powerful, nor in general ſo much reliſhed.

But all theſe contrivances, both in the organ and harpſichord, were ſtill very deficient. Whatever change they could produce in the ſtrength of the ſound, was produced through the whole inſtrument, or at leaſt through two or three octaves. But the captivating expreſſion of muſic frequently reſults from the momentary ſwelling or ſoftening of a ſingle phraſe, or a ſingle note, in one of the parts. Hence ariſe the unrivalled powers of the harp, and the acknowledged ſuperiority of the theorbo, the lute, and even the guitar, over all keyed inſtruments, notwithſtanding their great limitations in harmony and in practicable melodies. Theſe inſtruments ſpeak, while the harpſichord only plays.

Many attempts have been made to enable the performer to produce, by the intervention of the key, all the gradations of ſtrength, and even the varieties of ſound,

ſound, which the ſinger can bring forth by the different manner of pinching, bruſhing, or, as it were, careſſing the ſtring; but we have no diſtinct account of any attempt that has ſucceeded. Such a thing would quickly ſpread over Europe. The compiler of the article LUTHIER, in the *Encyclopedie Methodique*, ſays a great deal about a harpſichord fitted with prepared buffalo leather inſtead of crow quills; and aſſerts expreſsly, that, by the mere preſſure on the key, without the aſſiſtance of pedals or ſtops of any kind, the leather is made to act with greater or leſs force on the ſtring. But he gives no account by which we can comprehend how this is brought about; and indeed he writes in terms which ſhew plainly that he has not ſeen the inſtrument, and is merely puffing ſomething that he does not underſtand.

The attempt has been made with more ſucceſs on keyed inſtruments, when the ſtrings are not pinched, but are rubbed by a wheel or band, in the manner of the vielle (hurdygurdy), or ſtruck with a plectrum, like the dulcimer. The CELESTINA (deſcribed by Merſennus by the name of ARCHIVIOLA) is of this kind. A fine band of horſe hair or ſilk, filled with roſin, is extended under the ſtrings, and drawn ſmoothly along by a wheel. By a particular mechaniſm of the keys, this band is made to preſs or rub on any ſtring tranſverſely, as the ſtrings of a violin are touched by the bow. The preſſure on the key regulates the ſtrength of the tone. This inſtrument is not without conſiderable beauties, and will execute ſoft *cantabile* muſic in eaſy modulation, with great expreſſion and juſtneſs. But the artiſts have not yet been able to give it either clearneſs or brilliancy of tone, nor ſufficient force for concert muſic, nor that promptitude of touch that is indiſpenſably neceſſary for figurative muſic or quick movements.

The ſame improvements have been made on the pulſatile inſtruments; and indeed they are here the moſt obvious and eaſy. When the key is employed merely as the means of cauſing a plectrum to give a blow to the ſtring, the performer will hardly fail to give that degree of force which he feels proper for his intended expreſſion. Accordingly, many inſtruments of this kind have been made in Germany, where the artiſts have long been eminent for mechanical knacks. But all their inſtruments of the dulcimer kind are feeble and ſpiritleſs, and none of them have been brought into general uſe, if we except the CLAVICHORD. This is indeed an inſtrument of feeble, and not the moſt pleaſing ſound; but is well fitted for giving every momentary gradation of ſtrength by the preſſure of the finger. Is is therefore a good inſtrument for forming the muſical taſte by chamber practice, and was much uſed by compoſitors in their ſtudies. It is alſo an ingenious, though ſeemingly an obvious and ſimple contrivance, and is capable of much more force, and even brilliancy of ſound, than has generally been given to it.

The conſtruction is ſhortly this. The inner end of the key is furniſhed with an upright piece, which terminates in an edge of braſs, ſomewhat like the end of a narrow blunt chiſel, whoſe line of direction is athwart the ſtrings. When the key is preſſed down, this edge ſtrikes the ſtring, and forces it out of the ſtraight line in which it is ſtretched between its pins. Thus the ſtring is ſhaken or jogged into vibration, in the ſame manner as we obſerve a tight rope ſet a vibrating by a ſudden jerk given to any part of it. The ſtring, thus agitated, gives a ſound, which will continue for ſome little time if the key be held down. As the tone depends on the length of the vibrating ſtring, as well as on its tenſion, it is of importance that the ſtroke be made on the preciſe point of the ſtring which terminates the proper length. The ſtring does not give the note correſponding to its whole length, but that which is produced by the part between the edge and the pin. And becauſe the parts of the ſtring on each ſide of the edge are equally thrown into vibration, the ſhorter portion of it muſt be wrapped up in a liſt of cloth, to prevent it from diſturbing the ear by its ſonorous vibrations. This, however, greatly diminiſhes the ſweetneſs of the ſound given by the other part.

The clavichord gives a fretful waſpiſh kind of ſound, not at all ſuited to tender expreſſion. If the bridge (for the end of the key is really a bridge during the ſound) were placed at an exact third of the length of the ſtring. and if both parts were free, and if the ſtroke be of a proper ſtrength, the ſtring would ſound its twelfth with great ſweetneſs, and with much more force and brilliancy than it does by the preſent conſtruction, and the clavichord would be a charming inſtrument for a leſſon and for private ſtudy. We ſay this from experience of the power of one conſtructed under the direction of the great mathematician Euler, who was alſo an excellent judge of muſic and muſical compoſition. The tones of the upper part of that inſtrument had a ſort of pipe or vocal ſound, and were ſuperior in clearneſs and ſweetneſs to any ſtringed inſtrument we ever heard. But as this conſtruction required every ſtring to be one half longer than a harpſichord wire of the ſame pitch, and as this would have made the inſtrument of a moſt inconvenient ſize, the baſſes were made ſhorter, by placing the bridge at one ſixth of the length, and loading the ſhorter portion of the ſtring with wire twiſted round it. But although this was executed by a moſt dexterous artiſt, the tones were far inferior to thoſe of the trebles, and the inſtrument was like the junction of a very fine one and a very bad one, and made but hobbling muſic. This was probably owing to the impoſſibility of connecting the metal wire and its covering with ſufficient cloſeneſs and ſolidity. An upright clavichord, where the length would be no inconvenience, would be indeed a capital inſtrument for muſical ſtudy. It is worthy of remark, that Mr Euler tried other diviſions of the ſtring by the bridge. When it is ſtruck preciſely in the middle, it ſhould ſound its octave; when it is ſtruck at one-fourth, it ſhould give the double octave, &c. But the maker found that theſe diviſions gave very indifferent, and even uncertain tones; ſometimes not ſounding at all, and ſometimes ſounding beautifully. Our readers will find this well explained in a future article of this *Supplement*, (TRUMPET, *Marine*). They may pleaſe to reflect on the very different tone of the violin as it is bowed on different parts of the ſtring, and on the very different tones of the fore and back uniſons, and particularly of the Cornet ſtop of the harpſichord. The harpſichords of Rucker are noted for the grand fulneſs of their tone; thoſe of Haſſe of Dreſden for their mellow ſweetneſs, and thoſe of Kirkmann of London for their unequalled brilliancy. Theſe makers differed greatly in the placing of their quills.

But the Engliſh PIANO FORTE, by its ſuperior force of tone, its adequate ſweetneſs, and the great variety of voice of which our artiſts have made it ſuſceptible, has with-

withdrawn all farther attention from the clavichord, ſo that it is no longer probable that the learned contribution of the great Euler to public amuſement will be followed up. The Piano forte correſponds to its name with great preciſion: For, without any other attention or effort than what ſentiment ſpontaneouſly dictates, and what we practiſe (without knowing it) on the harpſichord, where it is ineffectual, we make the Pianoforte give every gradation of ſtrength to the ſound of the ſtring, and give it every expreſſion that an inſtrument, purely pulſatile, is capable of. It is alſo ſuſceptible of a very conſiderable variety of tone by the clothing of the mallets, which may be acute or obtuſe, hard or ſoft. And we ſee, by the effect of what are called the grand Piano fortes, that they are fully equal to the harpſichord in fulneſs or body of tone. Nothing ſeems to be wanting to it but that ſliding, or (as the French call it) *careſſing* touch of the ſtring, by which a delicate finger, guided by fine taſte, cauſes the harp or lute to melt the heart, and excite its fineſt emotions. We truſt that the ingenuity of our Britiſh artiſts will accompliſh even this, and make this national inſtrument rival even the violin of Italy.

We call it a *national inſtrument*, not doubting but that this is a recommendation to a Britiſh heart, and becauſe we are very well aſſured that it is an Engliſh contrivance; the invention of a moſt excellent man and celebrated poet, Mr William Maſon. His Caractacus and Elfrida may convince any perſon who is a judge of muſic, that he had a mind exquiſitely ſenſible of all its charms; and we cannot be ſurpriſed that it was one of his chief delights. No man enjoyed the pleaſures of muſic with more rapture; and he uſed to ſay, that his ſpeedieſt recruit from the fatigue of a long walk was to ſit down for a few minutes to the harpſichord. He had ſeen ſeveral of the German attempts to make keyed dulcimers, which were, in ſome meaſure, ſuſceptible of the *forte* and *piano*: But they were all on one principle, and required a particular touch of the finger, of difficult acquiſition, and which ſpoiled it for harpſichord practice. We have alſo ſeen of thoſe inſtruments, ſome of very old date, and others of modern improvement. Some had very agreeable tones; but all were deficient in delicacy and juſtneſs. The performer was by no means certain of producing the very ſtrength of ſound that he intended. And, as Mr Maſon obſerved, they all required an artificial peculiarity of fingering; without which, either the intended ſtrength of tone was not brought out, or the tone was deſtroyed by repeated rattling of the mallet on the wire.

Mr Maſon removed all thoſe imperfections by detaching the mallet entirely from the key, and giving them a connection quite momentary. The ſketch in Plate XL. will give the reader a clear view of Mr Maſon's general principle by which the Engliſh piano forte is diſtinguiſhed from all others. The parts are repreſented in their ſtate of inaction. The key ABK turns, as uſual, on the round edge of the bar B, and a pin *b*, driven into the bar, keeps it in its place. The dot F repreſents a ſection of the ſtring. ED is the mallet, having a hinge of vellum, by which it is attached to the upper ſurface of the bar E. At the other end is the head D, of wood, covered with ſome folds of prepared leather. The mallet lies in the poſition repreſented in the figure, its lower end reſting on a cuſhion-bar K, which lies horizontally under the whole row of mallets. The key AR has a pin C, tipt with a bit of the ſofteſt cork or buckſkin. This reaches to within $\frac{1}{20}$th of an inch of the ſhank of the mallet, but muſt not touch it. The diſtance E *e* is about $\frac{1}{3}$d or $\frac{1}{4}$th of the length of the ſhank. When the end A of the key is preſſed down on the ſtuffing (two or three thickneſſes of the moſt elaſtic woollen liſt) it raiſes the mallet, by means of the pin C, to the horizontal poſition E *d*, within $\frac{1}{8}$th or $\frac{1}{10}$th of an inch of the wire F; but it cannot be ſo much preſſed down as to make the mallet touch the wire. At the ſame time that the key raiſes the mallet by means of the pin C, it alſo lifts off the damper G (a bit of ſpunge) from the wire. This damper is fixed on the end of a little wooden pin G *g*, connected with the lever *g* H, which has a vellum hinge at H. This motion of the damper is cauſed by the pin I, which is fixed into the key near to R. Theſe pieces are ſo adjuſted, that the firſt touch of the key lifts the damper, and, immediately after, the pin C acts on the ſhank of the mallet. As it acts ſo near to its centre of motion, it cauſes the head D to move briſkly through a conſiderable arch D *d*. Being made extremely moveable, and very light, it is thus *toſſed* beyond the horizontal poſition E *d*, and it ſtrikes the wire F, which is now at liberty to vibrate up and down, by the previous removal of the damper G. Having made its ſtroke, the mallet falls down again, and reſts on the ſoft ſubſtance on the pin C. It is of eſſential importance that this mallet be extremely light. Were it heavy, it would have ſo much force, after rebounding from the wire, that it would rebound again from the pin C, and again ſtrike the wire. For it will be recollected, that the key is, at this time, down, and the pin C raiſed as high as poſſible, ſo that there is very little room for this rebound. Leſſening the momentum of the mallet by making it very light, making the cuſhion on the top of the pin C very ſoft, and great preciſion in the ſhape and figure of all the parts, are the only ſecurities againſt the diſagreeable rattling which theſe rebounds would occaſion. In reſpect to the ſolidity and preciſion of workmanſhip, the Britiſh inſtruments are unrivalled, and vaſt numbers of them are ſent to all parts of the continent.

As the blow of ſo light a mallet cannot bring much ſound from a wire, it has always been found neceſſary to have two ſtrings for each note. Another circumſtance contributes to enfeeble the ſound. The mechaniſm neceſſary for producing it makes it almoſt impoſſible to give any conſiderable extent to the belly or ſound board of the inſtrument. There is ſeldom any more of it than what occupies the ſpace between the tuning pins and the bridge. This is the more to be regretted, becauſe the baſſes are commonly covered ſtrings, that they may be of a moderate length. The baſs notes are alſo of braſs, which has a conſiderably lower tone than a ſteel wire of the ſame diameter and tenſion. Yet even this ſubſtitution for ſteel in the baſs ſtrings is not enough. The higheſt of them are much too ſlack, and the loweſt ones muſt be loaded, to compenſate for want of length. This greatly diminiſhes the fulneſs, and ſtill more the mellowneſs and diſtinctneſs of the tone, and frequently makes the very loweſt notes hardly appreciable. This inequality of tone about the middle of the inſtrument is ſomewhat diminiſhed by conſtructing the inſtrument with two bridges; one for the ſteel, and the other for the braſs wires. But ſtill the baſs notes are very much inferior to the treble. It would ſurely be worth while to conſtruct ſome piano fortes, of full ſize, with naked baſſes. If theſe were made with all the other advantages of the grand piano forte, they would ſurpaſs all other inſtruments for the regulating power of their thorough baſs. We wiſh that the artiſts would alſo try to conſtruct them with the mechaniſm of mallets, &c. above the ſound board. This would allow to it the full extent of the inſtrument, and greatly improve the tone. It does not ſeem impoſſible, nor (we think) very difficult.

For directions how to tune this pleaſing inſtrument, ſee Temperament in this *Supplement.*

PIGMENTS, or Paints, are furniſhed by both the mineral and vegetable kingdoms. The former are the moſt durable, and are generally prepared from the Oxyds of metals (ſee Chemistry *Index* in this *Suppl.* and *Colour-Making*, Encycl.); but Fourcroy thinks that chemiſtry furniſhes a method of fixing vegetable colours completely. From a number of experiments, which we need not detail, as they will be noticed in the article *Vegetable Substances*, he draws the following concluſions:

1. That oxygen, when combined with vegetable ſubſtances, changes their colour.

2. That different proportions of this principle produce different ſhades in coloured vegetable matter.

3. That theſe ſhades paſs, by a ſort of degradation, from the darkeſt colours to the lighteſt; and that the extreme point of the latter may be conſidered as a complete deprivation of colour.

4. That in many vegetable ſubſtances this degradation does not take place, as M. Berthollet has obſerved.

5. That many red, violet, purple, cheſnut, and blue vegetable colours, are produced by different proportions of oxygen; but that none of theſe are completely ſaturated with this principle.

6. That the complete ſaturation here ſpoken of generally produces yellow colours, which are the leaſt changeable of all.

7. That vegetable ſubſtances coloured by oxygen, not only change their colour according to the proportion of oxygen they have imbibed, but that they alſo change their nature in the ſame proportion, and approach more to a reſinous ſtate as they become nearer to a yellow colour.

Laſtly, that the cauſe of the changeability of the red, brown, and violet colours, procured from vegetables, is ſuch as has been ſtated above; that there exiſts a method of fixing them, or rendering them permanent, by impregnating them with a certain quantity of oxygen, by means of the oxygenated muriatic acid; imitating, by this proceſs, the method purſued by nature, who never forms fixed and permanent colours, except in ſubſtances which have been long expoſed to the open air.

PITCH. See *Encycl.*—The beſt black pitch is made of the refuſe of roſin and turpentine, ſuch as will not paſs through the ſtraw filter, and the cuttings around the inciſion on the tree. Theſe materials are put into a boiler ſix or ſeven feet in circumference, and eight or ten high. Fuel is laid around the top, and the materials as they melt flow through a channel cut in the fire-place into a tub half filled with water. It is at that time very red, and almoſt liquid. To give this a proper conſiſtence, it is put in a cauldron placed in a furnace, and boiled down in the ſame manner as roſin, but it requires much leſs precaution and double the time. It is then poured into moulds of earth, and forms the beſt kind of black pitch. See Rosin and Turpentine in this *Suppl.*

Bastard PITCH, is a mixture of colophony, black pitch, and tar. They are boiled down together, and put into barrels of pine wood, forming, when the ingredients are mixed in equal portions, a ſubſtance of a very liquid conſiſtence, called in France *bray gras.* If, on the contrary, it is deſired of a thicker conſiſtence, a greater proportion of colophony is added, and it is caſt in moulds. It is then called *baſtard pitch.*

PLAGUE (ſee Medicine-*Index*, Encycl.), is a diſeaſe which has been lately aſſerted by Dr Moſeley to be not contagious. In ſupport of this opinion, he quotes many paſſages from medical writers, ancient and modern; but he ſeems to place the greateſt confidence (as is indeed natural) in his own obſervations on peſtilential fevers in the Weſt Indies, and on what is ſaid of the plague in Berthier's account of Buonaparte's expedition into Syria.

"At the time of our entry into Syria (ſays this Frenchman), all the towns were infected by the plague; a malady which ignorance and barbarity render ſo fatal in the Eaſt. Thoſe who are affected by it give themſelves up for dead: they are immediately abandoned by every body (A), and are left to die, when they might have been ſaved by medicine and attention.

"Citizen Degenettes, principal phyſician to the army, diſplayed a courage and character which entitle him to the national gratitude. When our ſoldiers were attacked by the leaſt fever, it was ſuppoſed that they had caught the plague, and theſe maladies were confounded. The fever hoſpitals were abandoned by the officers of health and their attendants. Citizen Degenettes repaired in perſon to the hoſpitals, viſited all the patients, felt the glandular ſwellings, dreſſed them, declared and maintained that the diſtemper was not the plague, but a malignant fever with glandular ſwellings, which might eaſily be cured by attention, and keeping the patient's mind eaſy."

Degenette's views in making this diſtinction were highly commendable; but certainly, ſays Dr Moſeley, this fever was the plague. The phyſician, however, carried his courage ſo far, as to make two inciſions, and to inoculate the ſuppurated matter from one of theſe buboes above his breaſt and under his arm-pits, but was not affected with the malady. He thus eaſed the minds of the ſoldiers, the firſt ſtep to a cure; and, by his aſſiduity and conſtant attendance in the hoſpitals, a number of men attacked with the plague were cured. His example was followed by other officers of health.

The lives of a number of men Citizen Degenettes was

(A) This can hardly be true. Every one knows that Mahometans are fataliſts in the ſtricteſt ſenſe of the word; and Mr Browne, whoſe knowledge of Syria and its inhabitants muſt be at leaſt equal to that of Berthier, aſſures us, that, far from abandoning his friend in the plague, "the Moſlem, awe-ſtruck, and reſigned to the unalterable decrees of fate, hangs over the couch of his expiring relative."

was thus inſtrumental of ſaving. He diſmiſſed thoſe who had been ill with the fever and buboes, without the leaſt contagion being communicated to the army.

"There are (ſays Dr Moſeley) annual or ſeaſonal diſorders, more or leſs ſevere, in all countries; but the plague, and other great depopulating epidemics, do not always obey the ſeaſons of the year. Like comets, their courſe is eccentric. They have their revolutions; but from whence they come, or whither they go after they have made their revolutions, no mortal can tell.

"To look for the cauſe of an epidemic in the preſent ſtate of the air, or weather, when it makes its appearance, is a very narrow contracted method of ſcrutiny. The cauſe of peſtilential epidemics cannnot be confined, and local. It muſt lie in the atmoſphere, which ſurrounds, and is in contact with every part of us; and in which we are immerſed, as bodies in fluids.

"Theſe diſeaſes not appearing in villages and thinly inhabited places, and generally attacking only great towns and cities, may be, that the atmoſphere, which I conceive to be the univerſal propagator of peſtilence, wants a commixture, or union, with ſome compounded and peculiar air, ſuch as is generated in populous communities, to releaſe its impriſoned virulence, and give it force. Like the divided ſeminal principles of many plants, concealed in winds and rains until they find ſuitable materials and ſoil to unite their ſeparated atoms, they then aſſume viſible forms in their own proper vegetation.

"Diſeaſes originating in the atmoſphere ſeize ſome, and paſs by others; and act excluſively on bodies graduated to receive their impreſſions; otherwiſe whole nations would be deſtroyed. In ſome conſtitutions of the body the acceſs is eaſy, in ſome difficult, and in others impoſſible.

"The air of confined places may be ſo vitiated as to be unfit for the purpoſes of the healthy exiſtence of any perſon. Hence gaol, hoſpital, and ſhip fevers. But as theſe diſtempers are the offspring of a local cauſe, that local cauſe, and not the diſtempered people, communicate the diſeaſe.

"Plagues and peſtilences, the produce of the great atmoſphere, are conveyed in the ſame manner, by the body being in contact with the cauſe; and not by its being in contact with the effect. If peſtilences were propagated by contagion, from infected perſons, the infection muſt iſſue from their breath or excrements, or from the exhalations of the bodies of the diſeaſed. The infection, if it were not in the atmoſphere, would be confined within very narrow limits; have a determinate ſphere of action; and none but phyſicians and attendants on the ſick would ſuffer; and theſe muſt ſuffer; and the cauſe and the effects would be palpable to our ſenſes. Upon this ground the precaution of quarantine would be rational. But who then would viſit and attend the ſick, or could live in hoſpitals, priſons, and lazarettos?"

From theſe reaſonings and facts, the author is convinced, that the bubo and carbuncle, of which we hear ſo much in Turkey, and read ſo much in our own hiſtory of plagues, ariſe from heating food and improper treatment; that they contain no infection; and conſequently that they are not the natural depoſit of the morbific virus ſeparated from the contagion.

He is equally confident that no peſtilential or pandemic fever was ever imported or exported; and hence he conſiders the fumigating of ſhip-letters, and ſhutting up the crews and paſſengers of veſſels, on their arrival from foreign places, ſeveral weeks, for fear they ſhould give diſeaſes to others which they have not themſelves, as an ignorant barbarous cuſtom. Whence was the importation of the plague at Naples in 1656; by which 20,000 people died in one day? Can any perſon, for a moment reflecting, believe, that the great plague of London in 1665, which imagination traced from the Levant to Holland, and from Holland to England, was cauſed by opening a bag of cotton in the city, or in Long Acre; or a package of hemp in St Giles's pariſh? Quarantine, always expenſive to commerce, and often ruinous to individuals, is a reflection on the good ſenſe of countries.

That Dr Moſeley is a man of learning, and a lively writer, is known to every one who has looked into his works, and is not himſelf a ſtranger to letters. On this account, and ſtill more on account of the opportunities which he has poſſeſſed of making accurate obſervations on various kinds of peſtilential diſeaſes, we have detailed at ſome length his notions of the plague; but as it does not appear that he ever *ſaw* the diſeaſe which is *known* by the name of *the plague*, juſtice requires that we give ſome account of it from a man who had the beſt poſſible opportunities of obtaining correct information on the ſubject.

"The facts that appear to be chiefly aſcertained relative to the plague (ſays Mr Browne), are, 1. That the infection is not received but by actual contact. In this particular, it would ſeem leſs formidable than ſeveral other diſorders. 2. That it is communicated by certain ſubſtances, by others not; as by a woollen cloth, or rope of hemp, but not by a piece of ivory, wood, or a rope made of the date tree; nor by any thing that has been completely immerſed in water. It would appear from the report of the Kahirines*, that no animal but man is affected with this diſorder; though, it is ſaid, a cat paſſing from an infected houſe has carried the contagion. 3. That perſons have often remained together in the ſame houſe, and entirely under the ſame circumſtances, of whom one has been attacked and died, and the others never felt the ſmalleſt inconvenience. 4. That a perſon may be affected any number of times. 5. That it is more fatal to the young than the old. 6. That no climate appears to be exempt from it; yet, 7. That the extremes of heat and cold both appear to be adverſe to it. In Conſtantinople it is often, but far from being always, terminated by the cold of winter, and in Kahira by the heat of ſummer; both circumſtances being, as may be conjectured, the effect of indiſpoſition for abſorption in the ſkin, unleſs it be ſuppoſed that in the latter caſe it may be attributed to the change the air undergoes from the increaſe of the Nile.

"The firſt ſymptoms are ſaid to be thirſt; 2. cephalalgia; 3. a ſtiff and uneaſy ſenſation, with redneſs and tumor about the eyes; 4. watering of the eyes; 5. White puſtules on the tongue. The more advanced ſymptoms of buboes, fœtor of the breath, &c. &c. are well known; and I have nothing authentic to add to them. Not uncommonly, all theſe have ſucceſſively ſhewn themſelves, yet the patient has recovered; in which caſe, where ſuppuration has had place, the ſkin always remains diſcoloured, commonly of a purple hue. Many who have been bleeded in an early ſtage of the

---

* The inhabitants of *Cairo*, which Mr Brown uniformly calls *Kahira*.

diſorder, have recovered without any fatal ſymptoms; but whether from that or any other cauſe, does not appear certain (B). The ſame operation is reported to have been commonly fatal in a late ſtage. It is ſaid that embrocating the buboes continually with oil has ſometimes wrought a cure; but this remedy is ſo difficult and dangerous for the operator, that it would appear experiments muſt yet be very defective."

They are not, perhaps, ſo defective as Mr Browne ſuppoſes. In the hoſpital of St Anthony at Smyrna, it has been the practice for many years paſt to rub over with warm olive oil the bodies of perſons infected by the plague; and that practice has been attended with wonderful ſucceſs. It was firſt ſuggeſted by Mr Baldwin the Engliſh conſul; and from him adopted by *P. Luigi di Pavia*, who for upwards of 27 years has expoſed himſelf to infection by his unremitting attendance on thoſe who are labouring under this dreadful diſtreſs. This excellent man, whoſe philanthropy equals that even of "Marſeilles' good biſhop," declares, that during the long period mentioned, he has found no remedy comparable to that of rubbing olive oil, with the ſtrongeſt friction, into the whole body of the infected perſon. When the body is thus rubbed, the pores being opened, imbibe the oil, and a profuſe perſpiration takes place, by which the poiſonous infection is again thrown out. This operation muſt be performed the firſt day of the infection; and if only a weak perſpiration enſues, it muſt be repeated till it is obſerved that every particle of infection is removed, and that the whole body of the patient is covered with a profuſe ſweat. Neither the patient's ſhirt nor bed-clothes muſt be changed till the perſpiration has entirely ceaſed. The operation muſt be performed in a very cloſe apartment; and at every ſeaſon of the year there muſt be kept in it a fire-pan, over which ſugar and juniper muſt be thrown from time to time, that the vapour which thence ariſes may promote the perſpiration. The whole body of the patient, the eyes alone excepted, muſt in this manner be anointed, or rather rubbed over with the greateſt care.

This practice of the pious monk is mentioned by Mr Howard in his work on Lazarettos; but a more ſatisfactory account of it is given by Count *Leopold von Berchtold*, who adds the following remarks by way of illuſtration: 1. The operation of rubbing in the oil muſt be performed by means of a ſponge, and ſo ſpeedily as not to laſt more than about three minutes. 2. The interval between the firſt and the ſecond rubbing, if a ſecond be neceſſary, muſt be determined by circumſtances, as the ſecond muſt not be performed till the firſt perſpiration is over, and this will depend on the conſtitution of the patient. If any ſweat remains upon the ſkin, it muſt be wiped off with a warm cloth before the ſecond rubbing takes place. This ſtrong friction with oil may be continued, for ſeveral days ſucceſſively, until a favourable change is remarked in the diſeaſe; after which the rubbing may be performed in a more gentle manner. The quantity of oil requiſite each time cannot be determined with accuracy; but, in general, a pound may be ſufficient. The pureſt and freſheſt oil is the beſt for this operation: it muſt not be hot, but only lukewarm. The breaſt and privities muſt be rubbed ſoftly. In a cold climate ſuch as ours, thoſe parts only into which the oil is rubbed muſt be expoſed naked. The other parts muſt be covered with warm clothing. In this manner each part of the body muſt be rubbed with oil in ſucceſſion, as quickly as poſſible, and be then inſtantly covered. If the patient has boils or buboes, they muſt be rubbed over gently with the oil till they can be brought to ſuppurate by means of emollient plaſters. The perſons who attend the patients to rub in the oil muſt take the precaution to rub themſelves over in the like manner, before they engage in the operation. They muſt, if poſſible, avoid the breath of the patient, and not be under any apprehenſions of catching the infection.

P. Luigi then ſays: "In order to prevent the patients from loſing their ſtrength, I preſcribed for them, during four or five days, ſoup made of vermicelli boiled in vinegar without ſalt. I gave them ſix or ſeven times a-day a ſmall ſpoonful of preſerved ſour cherries; preſerved not with honey, but with ſugar, as the former might have occaſioned a diarrhœa. When convinced that the patients were getting better, I uſually gave them the fifth morning a cup of good Mocha coffee, with a piece of toaſted biſcuit *(biſcotto)* prepared with ſugar; and I doubled the latter according to the ſtrength and improvement of my patients."

In the courſe of five years, during which friction with oil was employed in the hoſpital at Smyrna, of 250 perſons attacked by the plague the greater part were

---

(B) Dr Moſeley, we think, has aſſigned a very ſufficient reaſon why bleeding ſhould generally prove effectual, if recourſe be had to it at the commencement of the diſeaſe. "In the common order of peſtilential fevers (ſays he), they commence with coldneſs and ſhivering; ſimply demonſtrating, that ſomething unuſual has been in contact with the ſkin, agonizing cutaneous ſenſibility. Sickneſs at the ſtomach, and an immoveable preſſure about the præcordia, follow. Theſe demonſtrate, that the blood cannot pervade the extremities of the body, and that the quantity which ought to dilate through the whole machine is confined to the larger organs, and is crowding and diſtending the heart and central veſſels.

"The reſtraining power of the remoter blood-veſſels being deſtroyed, the thinner parts of the blood eſcape their boundaries; hence ariſes yellowneſs in the ſkin in ſome climates; in others, the extravaſated groſſer parts of the blood ſtagnate, forming black lodgements, bubo, anthrax, and exanthemata.

"The object in theſe fevers is, to decide the conteſt between the ſolids and the fluids; and this appears to me to be only practicable, when ſpontaneous ſweats do not happily appear, or cannot be raiſed by a cooling regimen; and by draining the vital parts, by bleeding and purging, before the fluids have burſt their confines, and diſſolved their bond of union with the ſolids. The next ſtep is to regain the loſt energy of the ſurface of the body, by exciting perſpiration; and then of the whole ſyſtem, by tonics.

"When theſe things are not done in the firſt hours of attack, in peſtilential fevers, and the conflict is not *extinguiſhed* at once attempting to extort ſweats from the body, by heating alexapharmics, will do miſchief; and bark, wine, ſtimulants, and cordials, may be called on, like undertakers, to perform an uſeleſs ceremony."

were cured; and this would have been the caſe with the reſt had they not neglected the operation, or had it not been employed too late after their nervous ſyſtem had been weakened by the diſeaſe ſo as to render them incurable. Immenſe numbers of people have been preſerved from the effects of this malady by the above means; and of all thoſe who have anointed themſelves with oil, and rubbed it well into their bodies, not one has been attacked by the plague, even though they approached perſons already infected, provided they abſtained from heavy and indigeſtible food.

Thus we ſee, if this account may be depended on, that oil rubbed into the ſkin acts as a preventative, as well as a cure. When the operation is performed to prevent infection, and it is ſucceſsfully performed with that view at Smyrna, as often as the plague makes its appearance in the city, as it is not done for the purpoſe of promoting perſpiration, it is not requiſite that it ſhould be performed with the ſame ſpeed as when for curing the diſorder; nor is it neceſſary to abſtain from fleſh and to uſe ſoups; but it will be proper to uſe only fowls or veal for ten or twelve days, boiled or roaſted, without any addition or ſeaſoning *(condimento)*. In the laſt place, it will be neceſſary to guard againſt fat and indigeſtible food, and ſuch liquors as might put in motion or inflame the maſs of the blood.

This important diſcovery deſerves the ſerious conſideration of all medical men; for if olive oil has been found efficacious in curing or preſerving againſt one ſpecies of infection, it is not abſurd to ſuppoſe that the ſame or other kinds of oil might be productive of much benefit in other malignant infectious diſeaſes. We hope ſoon to hear of ſome trial being made with it in this country. Would it be of any ſervice in the yellow fever, ſo prevalent in the weſtern world? See the *Philoſophical Magazine*, Vol. II.

PLANETARY hours, are twelfth parts of the artificial day and night; being each double in length to the hour uſed in civil computation in Europe. They are ſtill uſed by the Jews as they were among their forefathers; and hence are called *Jewiſh* hours. The reaſon of their being called *planetary* hours, is, that, according to the aſtrologers, a new planet comes to predominate every hour, and that the day takes its denomination from that which predominates the firſt hour of it; as Monday from the moon, &c.

PLANTS, organiſed bodies, of which a full account has been given in the *Encycl.* under the title BOTANY, PLANT, SEXES, *&c.* The eſtabliſhment of the ſexual ſyſtem in vegetables, and the acknowledged analogy between vegetable and animal bodies, has ſuggeſted a method of improving plants, as animals are confeſſedly improved, by what is called *croſſing the breed*. This thought occurred firſt, we believe, to Andrew Knight, Eſq; and in the Tranſactions of the Royal Society for 1799, we have an account of ſome very curious experiments made by him, with the view of aſcertaining whether the improvement which he had conceived be actually practicable. Thoſe were chiefly made on the garden pea, of which he had a kind growing in his yard; which having been long cultivated in the ſame ſoil, had ceaſed to be productive, and did not appear to recover the whole of its former vigour when removed to a ſoil of a ſomewhat different quality. On this his firſt experiment in 1787 was made. Having opened a dozen of its immature bloſſoms, he deſtroyed the male parts, taking great care not to injure the female ones; and a few days afterwards, when the bloſſoms appeared mature, he introduced the farina of a very large and luxuriant grey pea into one half of the bloſſoms, leaving the other half as they were. The pods of each grew equally well; but he ſoon perceived that of thoſe into whoſe bloſſoms the farina had not been introduced, the ſeed remained nearly as they were before the bloſſom expanded, and in that ſtate they withered. Thoſe in the other pods attained maturity, but were not in any ſenſible degree different from thoſe afforded by other plants of the ſame variety; owing, he imagines, to the external covering of the ſeed (as he had found in other plants) being furniſhed entirely by the female. In the ſucceeding ſpring, the difference, however, became extremely obvious; for the plants from them aroſe with exceſſive luxuriance, and the colour of their leaves and ſtems clearly indicated that they had all exchanged their whiteneſs for the colour of the male parent: the ſeeds produced in autumn were dark grey. By introducing the farina of another white variety (or in ſome inſtances by ſimple culture), he found this colour was eaſily diſcharged, and a numerous variety of new kinds produced; many of which were in ſize and every other reſpect much ſuperior to the original white kind, and grew with exceſſive luxuriance, ſome of them attaining the height of more than twelve feet.

The diſſimilarity he obſerved in the offspring, afforded by different kinds of farina in theſe experiments, pointed out to him an eaſy method of aſcertaining whether ſuperfœtation (the exiſtence of which has been admitted among animals) could alſo take place in the vegetable world. For as the offspring of a white pea is always white, unleſs the farina of a coloured kind be introduced into the bloſſom, and as the colour of the grey one is always transferred to its offspring, though the female be white, it readily occurred to Mr Knight, that if the farina of both were mingled or applied at the ſame moment, the offspring of each could be eaſily diſtinguiſhed.

His firſt experiment was not altogether ſucceſsful; for the offspring of five pods (the whole which eſcaped the birds) received their colour from the coloured male. There was, however, a ſtrong reſemblance to the other male in the growth and character of more than one of the plants; and the ſeeds of ſeveral in the autumn very cloſely reſembled it in every thing but colour. In this experiment he uſed the farina of a white pea, which poſſeſſed the remarkable property of ſhrivelling exceſſively when ripe; and in the ſecond year he obtained white ſeeds from the grey ones above mentioned, perfectly ſimilar to it. He is therefore ſtrongly diſpoſed to believe that the ſeeds were here of common parentage; but doth not conceive himſelf to be in poſſeſſion of facts ſufficient to enable him to ſpeak with deciſion on this queſtion. We have no right to form a decided opinion on this part of the ſubject, having paid to it very little attention; but at preſent we are inclined to think differently from the author. We admit, indeed, that if the female afford the firſt organized atom, and the male act only as a ſtimulus, it is by no means impoſſible that the exploſion of two veſicles of farina, at the ſame moment (taken from different plants), may afford ſeeds of common parentage; but whether the female or the male affords the firſt organized atom, is the queſtion which to us appears not yet decided.

Another ſpecies, however, of ſuperfœtation, in which one ſeed appears to have been the offspring of two males, has occurred to Mr Knight ſo often, as to remove, he ſays, all poſſibility of doubt as to its exiſtence. In 1797, the year after he had ſeen the reſult of the laſt mentioned experiment, having prepared a great many white bloſſoms, he introduced the farina of a white and that of a grey nearly at the ſame moment into each; and as in the laſt year the character of the coloured male had prevailed, he uſed its farina more ſparingly than that of the white one; and now almoſt every pod afforded plants of different colours. The majority, however, were white; but the characters of the two kinds were not ſufficiently diſtinct to allow him to judge with preciſion whether any of the ſeeds were produced of common parentage or not. In the year 1798 he was more fortunate; having prepared bloſſoms of the little early frame pea, he introduced its own farina, and immediately afterwards that of a very large and late grey kind, and ſowed the ſeeds thus obtained in the end of ſummer. Many of them retained the colour and character of the ſmall early pea, not in the ſlighteſt degree altered, and bloſſomed before they were eighteen inches high; whilſt others (taken from the ſame pods), whoſe colour was changed, grew to the height of more than four feet, and were killed by the froſt before any bloſſoms appeared.

It is evident, that in theſe inſtances ſuperfœtation took place; and it is equally evident that the ſeeds were not all of common parentage. Should ſubſequent experience evince, that a ſingle plant may be the offſpring of two males, the analogy between animal and vegetable nature may induce ſome curious conjectures relative to the proceſs of generation in the animal world.—It certainly may; but either we do not perfectly underſtand the author's meaning, or this experiment is not concluſive. There were here ſeeds of different colours produced by the farina of different males, operating on the ſame female plant; and there are well atteſted inſtances of twin children being born of different colours, in conſequence of the coition of different males, a negro and a white man, with the ſame woman. Had Mr Knight diſcovered, not that the ſame pod, but that the ſame individual *pea*, was the offspring of two males, his diſcovery would indeed have led to ſome curious conjectures reſpecting animal generation. But to proceed with his experiments:

By introducing the farina of the largeſt and moſt luxuriant kinds into the bloſſoms of the moſt diminutive, and by reverſing this proceſs, he found that the powers of the male and female, in their effects on the offspring, are exactly equal. The vigour of the growth, the ſize of the ſeeds produced, and the ſeaſon of maturity, were the ſame, though the one was a very early and the other a late variety. He had in this experiment a ſtriking inſtance of the ſtimulative effects of croſſing the breeds; for the ſmalleſt variety, whoſe height rarely exceeded two feet, was increaſed to ſix feet; whilſt the height of the large and luxuriant kind was very little diminiſhed. By this proceſs it is evident, that any number of new varieties may be obtained; and it is highly probable, that many of theſe will be found better calculated to correct the defects of different ſoils and ſituations than any we have at preſent.

The ſucceſs of Mr Knight's experiments on the pea induced him to make ſimilar experiments on wheat; but theſe did not anſwer his expectations. The varieties indeed which he obtained, eſcaped the blights of 1795 and 1796; but their qualities were not otherwiſe good, nor were they permanent. His experiments on the apple, the improvement of which was the firſt object of his attention, have, as far as he could judge from the cultivated appearance of trees which had not borne fruit when he wrote his memoir, been fully equal to his hopes. The plants which he obtained from his efforts to unite the good qualities of two kinds of apple, ſeem to poſſeſs the greateſt health and luxuriance of growth, as well as the moſt promiſing appearance in other reſpects. In ſome of theſe the character of the male appears to prevail; in others that of the female; and in others both appear blended, or neither is diſtinguiſhable. Theſe variations, which were often obſervable in the ſeeds taken from a ſingle apple, evidently ariſe from the want of permanence in the character of this fruit, when raiſed from ſeed. Many experiments of the ſame kind were tried on other plants; but it is ſufficient to ſay, that all tended to evince, that improved varieties of every fruit and of eſculent plants may be obtained by this proceſs, and that Nature intended that a ſexual intercourſe ſhould take place between neighbouring plants of the ſame ſpecies.

Plants, Nutrition of. This is a ſubject on which a variety of opinions has been entertained by modern chemiſts. Haſſenfratz conſiders carbon as the ſubſtance which nouriſhes vegetables. Ingenhouz, in his work on the nutrition of plants, publiſhed in 1797, endeavours to prove, that if carbon has any influence in this reſpect, it can be only in the ſtate of carbonic acid, as that acid is abſorbed and decompoſed by vegetables; while the ligneous carbon, furniſhed by Nature, produces no effect on the expanſion of plants. Mr A. Young has endeavoured to demonſtrate the ſame thing by experiments. M. Rafn, a Daniſh chemiſt, deſirous of diſcovering the truth amidſt theſe contradictory opinions, made, for three years, a ſeries of experiments; from which he concludes, by the expanſion, ſize, and colour of the plants employed, that carbon, either vegetable or animal, has a decided influence in the nouriſhment of vegetables. What is new, and particularly worthy of remark in theſe reſearches, is, that, according to M. Rafn, the carbonic acid produces exactly the ſame effect as charcoal of wood.

According to Mr Rafn, coal aſhes, on which the German and Engliſh farmers beſtow ſuch praiſe, deſtroy the plants if the ſoil contains an eighth part of that admixture. The leaves become faded, as if ſcorched, at the end of from fifteen to twenty days, and the plants themſelves die at the end of four or five weeks.

No ſeed germinates in oil. A ſingle grain of common ſalt, in 200 grains of water, is ſufficient to retard the vegetation of plants, and may even kill them if they are watered with that ſaline liquor.

Shavings of horn, next to infuſion animals, are the moſt favourable to vegetation: charcoal holds the third rank. For the truth of theſe opinions, ſee *Vegetable* SUBSTANCES in this *Suppl.*

PLATINUM, or PLATINA (See CHEMISTRY, *Suppl.* Part I. Chap. iii. Sect. 3.), is a metal, of which every chemiſt regrets the difficulty of making it malleable. Of the different proceſſes adopted to accompliſh this end, we have reaſon to believe that of Mr Richard Knight the moſt ſucceſsful; and, with the ſpirit

Pl ium, Po rds.

ſpirit of a true philoſopher, he wiſhes to make that proceſs as generally known as poſſible. We ſhall give it in his own words:

"To a given quantity of crude platinum, I add (ſays he) 15 times its weight of nitro-muriatic acid (compoſed of equal parts of nitric and muriatic acids) in a tubulated glaſs retort, with a tubulated receiver adapted to it. It is then boiled, by means of an Argand's lamp, till the acid has aſſumed a deep ſaffron colour: it is then poured off; and if any platina remains undiſſolved, more acid is added, and it is again boiled until the whole is taken up. The liquor, being ſuffered to reſt till quite clear, is again decanted: a ſolution of ſal-ammoniac is then added, by little and little, till it no longer gives a cloudineſs. By this means the platina is thrown down in the form of a lemon-coloured precipitate, which having ſubſided, the liquor is poured off, and the precipitate repeatedly waſhed with diſtilled water till it ceaſes to give an acid taſte (too much water is injurious, the precipitate being in a certain degree ſoluble in that liquid); the water is then poured off, and the precipitate evaporated to dryneſs."

Thus far our author's method, as he candidly obſerves himſelf, differs not from that which has been followed by many others; but the remainder of the proceſs is his own. "A ſtrong, hollow, inverted cone of crucible earth being procured, with a correſponding ſtopper to fit it, made of the ſame materials, the point of the latter is cut off about three-fourths from the baſe. The platina, now in the ſtate of a light yellow powder, is preſſed tight into the cone, and, a cover being fixed ſlightly on, it is placed in an air-furnace, and the fire raiſed gradually to a ſtrong white heat. (The furnace uſed by Mr Knight is portable, with a chamber for the fire only eight inches in diameter.) In the mean time the conical ſtopper, fixed in a pair of iron tongs ſuitable for the purpoſe, is brought to a red, or to a bright red, heat. The cover being then removed from the cone, the tongs with the heated ſtopper is introduced through a hole in the cover of the furnace, and preſſed at firſt gently on the platina, at this time in a ſtate nearly as ſoft as dough, till it at length acquires a more ſolid conſiſtence. It is then repeatedly ſtruck with the ſtopper, as hard as the nature of the materials will admit, till it appears to receive no farther impreſſion. The cone is then removed from the furnace; and being ſtruck lightly with a hammer, the platina falls out in a metallic button, from which ſtate it may be drawn, by repeatedly heating and gently hammering, into a bar fit for flatting, drawing into wire, planiſhing, &c.

"Beſides the comparative facility of this proceſs, it has the farther advantage of rendering the platina much purer than when red-hot iron is obliged to be had recourſe to; for platina, when of a white heat, has a ſtrong affinity for iron, and, with whatever care it may have been previouſly ſeparated from that metal, will be found to have taken up a portion of it, when it is employed of a red heat, to ſerve to unite the particles of the platina."

PLATONIC Bodies, ſee *Regular Bodies*, *Suppl.*

PLUVIAMETER, a machine for meaſuring the quantity of rain that falls, otherwiſe called Ombrometer; which ſee, *Encycl.*

POLLARDS, the name of a coarſe kind of wheaten flour. When the flour of wheat is ſeparated into three degrees of fineneſs, the third is the pollards. There is nothing between it and the bran.

Porcelain, Poſition.

PORCELAIN, a kind of earthen or ſtone ware, of the manufacture of which a full account is given in the *Encyclopædia* from Groſier and Reaumur. It may be proper, however, to add here, from Sir George Staunton, that one of the principal ingredients in the Chineſe porcelain called *pe-tun-tſe*, is a ſpecies of fine granite, or compound of quartz, feldſpath, and mica, in which the quartz bears the largeſt proportion. "It appears (ſays Sir George) from ſeveral experiments, that *pe-tun-tſe* is the ſame as the growan-ſtone of the Corniſh miners. The micaceous part in ſome of this granite from both countries, often contains ſome particles of iron; in which caſe it will not anſwer the potter's purpoſe. This material can be calcined and ground much finer by the improved mills of England, than by the very imperfect machinery of the Chineſe, and at a cheaper rate, than the prepared *pe-tun-tſe* of their own country, notwithſtanding the cheapneſs of labour there. The *kao-lin*, or principal matter mixed with the *pe-tun-tſe*, is the growan clay alſo of the Corniſh miners. The *wha-ſhe* of the Chineſe is the Engliſh ſoap rock; and the *ſhe kan* is aſſerted to be gypſum.

"The manufacture of porcelain is ſaid to be precarious, from the want of ſome preciſe method of aſcertaining and regulating the heat within the furnaces, in conſequence of which, their whole contents are baked ſometimes into one ſolid and uſeleſs maſs." If this be ſo, Wedgewood's thermometer would be a preſent highly valuable to the Chineſe potter, if that arrogant and conceited people would condeſcend to be taught by a native of Europe.

POSITION, Centre of, is a point of any body, or ſyſtem of bodies, ſo ſelected, that we can eſtimate with propriety the ſituation and motion of the body or ſyſtem by the ſituation and motion of this point. It is very plain that, in all our attempts to accurate diſcuſſion of mechanical queſtions, eſpecially in the preſent extended ſenſe of the word *mechaniſm*, ſuch a ſelection is neceſſary. Even in common converſation, we frequently find it neceſſary to aſcertain the diſtance of objects with a certain preciſion, and we then perceive that we muſt make ſome ſuch ſelection. We conceive the diſtance to be mentioned, neither with reſpect to the neareſt nor the remoteſt point of the object, but as a ſort of average diſtance; and we conceive the point ſo aſcertained to be ſomewhere about the middle of the object. The more we reflect on this, we find it the more neceſſary to attend to many circumſtances which we had overlooked. Were it the queſtion, to decide in what preciſe part of a country pariſh the church ſhould be placed, we find that the geometrical middle is not always the moſt proper. We muſt conſider the populouſneſs of the different quarters of the pariſh, and ſelect a point ſuch, that the diſtances of the inhabitants on each ſide, in every direction, ſhall be as equally balanced as poſſible.

In mechanical diſcuſſions, the point by whoſe poſition and diſtance we eſtimate the poſition and diſtance of the whole, muſt be ſo ſelected, that its poſition and diſtance, eſtimated in any direction whatever, ſhall be the average of the poſitions and diſtances of every particle of the aſſemblage, eſtimated in that direction.

This will be the caſe, if the point be ſo ſelected that, when a plane is made to paſs through it *in any direc-*

tion whatever, and perpendiculars are drawn to this plane from every particle in the body or ſyſtem, the ſum of all the perpendiculars on one ſide of this plane is equal to the ſum of all the perpendiculars on the other ſide. If there be ſuch a point in a body, the poſition and motion of this point is the average of the poſitions and motions of all the particles.

Plate XL.

For if P (fig. 1.) be a point ſo ſituated, and if QR be a plane (perpendicular to the paper) at any diſtance from it, the diſtance Pp of the point from this plane is the average of the diſtances of all the particles from it. For let the plane APB be paſſed through P, parallel to QR. The diſtance CS of any particle C from the plane QR is equal to DS—DC, or to Pp—DC. And the diſtance GT of any particle G, lying on the other ſide of APB, is equal to HT+GH, or to Pp+GH. Let n be the number of particles on that ſide of AB which is neareſt to QR, and let o be the number of thoſe on the remote ſide of AB, and let m be the number of particles in the whole body, and therefore equal to $n+o$. It is evident that the ſum of the diſtances of all the particles, ſuch as C, is n times Pp, after deducting all the diſtances, ſuch as DC. Alſo the ſum of all the diſtances of the particles, ſuch as G, is o times Pp, together with the ſum of all the diſtances, ſuch as GH. Therefore the ſum of both ſets is $\overline{n+o}\times \mathrm{P}p$ + ſum of GH — ſum of DC, or $m\times \mathrm{P}p$ + ſum of GH — ſum of DC. But the ſum of GH, wanting the ſum of DC, is nothing, by the ſuppoſed property of the point P. Therefore $m\times \mathrm{P}p$ is the ſum of all the diſtances, and Pp is the mth part of this ſum, or the average diſtance.

Now ſuppoſe that the body has changed both its place and its poſition with reſpect to the plane QR, and that P (fig. 2.) is ſtill the ſame point of the body, and $\alpha \mathrm{P} \beta$ a plane parallel to QR. Make $p\pi$ equal to pP of fig. 1. It is plain that Pp is ſtill the average diſtance, and that $m\times \mathrm{P}p$ is the ſum of all the preſent diſtances of the particles from QR, and that $m\times \pi p$ is the ſum of all the former diſtances. Therefore $m\times \mathrm{P}\pi$ is the ſum of all the changes of diſtance, or the whole quantity of motion eſtimated in the direction πP. Pπ is the mth part of this ſum, and is therefore the average motion in this direction. The point P has therefore been properly ſelected; and its poſition, and diſtance, and motion, in reſpect of any plane, is a proper repreſentation of the ſituation and motion of the whole.

It follows from the preceding diſcuſſion, that if any particle C (fig. 1.) moves from C to N, in the line CS, the centre of the whole will be transferred from P to Q, ſo that PQ is the mth part of CN; for the ſum of all the diſtances has been diminiſhed by the quantity CN, and therefore the average diſtance muſt be diminiſhed by the mth part of CN, or PQ is $=\frac{\mathrm{CN}}{m}$.

But it may be doubted whether there is in every body a point, and but one point, ſuch that if a plane paſs through it, *in any direction whatever*, the ſum of all the diſtances of the particles on one ſide of this plane is equal to the ſum of all the diſtances on the other.

It is eaſy to ſhew that ſuch a point may be found, with reſpect to a plane parallel to QR. For if the ſum of all the diſtances DC exceed the ſum of all the diſtances GH, we have only to paſs the plane AB a little nearer to QR, but ſtill parallel to it. This will diminiſh the ſum of the lines DC, and increaſe the ſum of the lines GH. We may do this till the ſums are equal.

In like manner we can do this with reſpect to a plane LM (alſo perpendicular to the paper), perpendicular to the plane AB. The point wanted is ſomewhere in the plane AB, and ſomewhere in the plane LM. Therefore it is ſomewhere in the line in which theſe two planes interſect each other. This line paſſes through the point P of the paper where the two lines AB and LM cut each other. Theſe two lines repreſent planes, but are, in fact, only the interſection of thoſe planes with the plane of the paper. Part of the body muſt be conceived as being above the paper, and part of it behind or below the paper. The plane of the paper therefore divides the body into two parts. It may be ſo ſituated, therefore, that the ſum of all the diſtances from it to the particles lying above it ſhall be equal to the ſum of all the diſtances of thoſe which are below it. Therefore the ſituation of the point P is now determined, namely, at the common interſection of three planes perpendicular to each other. It is evident that this point alone can have the condition required in reſpect of theſe three planes.

But it ſtill remains to be determined whether the ſame condition will hold true for the point thus found, in reſpect to *any other* plane paſſing through it; that is, whether the ſum of all the perpendiculars on one ſide of *this fourth* plane is equal to the ſum of all the perpendiculars on the other ſide. Therefore

Let AGHB (fig. 3.), AXYB, and CDFE, be three planes interſecting each other perpendicularly in the point C; and let CIKL be any other plane, interſecting the firſt in the line CI, and the ſecond in the line CL. Let P be any particle of matter in the body or ſyſtem. Draw PM, PO, PR, perpendicular to the firſt three planes reſpectively, and let PR, when produced, meet the oblique plane in V; draw MN, ON, perpendicular to CB. They will meet in one point N. Then PMNO is a rectangular parallelogram. Alſo draw MQ perpendicular to CE, and therefore parallel to AB, and meeting CI in S. Draw SV; alſo draw ST perpendicular to VP. It is evident that SV is parallel to CL, and that STRQ and STPM are rectangles.

All the perpendiculars, ſuch as PR, on one ſide of the plane CDFE, being equal to all thoſe on the other ſide, they may be conſidered as compenſating each other; the one being conſidered as poſitive or additive quantities, the other are negative or ſubtractive. There is no difference between their ſums, and the ſum of both ſets may be called 0 or nothing. The ſame muſt be affirmed of all the perpendiculars PM, and of all the perpendiculars PO.

Every line, ſuch as RT, or its equal QS, is in a certain invariable ratio to its correſponding QC, or its equal PO. Therefore the poſitive lines RT are compenſated by the negative, and the ſum total is nothing.

Every line, ſuch as TV, is in a certain invariable ratio to its correſponding ST, or its equal PM, and therefore their ſum total is nothing.

Therefore the ſum of all the lines PV is nothing; but each is in an invariable ratio to a correſponding perpendicular from P on the oblique plane CIKL. Therefore the ſum of all the poſitive perpendiculars on this plane is equal to the ſum of all the negative perpendiculars, and the propoſition is demonſtrated, *viz.* that in every body, or ſyſtem of bodies, there is a point ſuch, that if a plane be paſſed through it *in any direction whatever*, the ſum of all the perpendiculars on one ſide of the plane is equal to the ſum of all the perpendiculars on the other ſide.

The point P, thus ſelected, may, with great propriety, be called the CENTRE OF POSITION of the body or ſyſtem.

If A and B (fig. 4.) be the centres of poſition of two bodies, whoſe quantities of matter (or numbers of equal particles) are a and b, the centre C lies in the ſtraight line joining A and B, and $AC : CB = b : a$, or its diſtance from the centres of each are inverſely as their quantities of matter. For let $\alpha C \beta$ be any plane paſſing through C. Draw $A\alpha$, $B\beta$, perpendicular to this plane. Then we have $a \times A\alpha = b \times B\beta$, and $A\alpha : B\beta = b : a$, and, by ſimilarity of triangles, $CA : CB = b : a$.

If a third body D, whoſe quantity of matter is d, be added, the common centre of poſition E of the three bodies is in the ſtraight line DC, joining the centre D of the third body with the centre C of the other two, and $DE : EC = a + b : d$. For, paſſing the plane $\delta E \kappa$ through E, and drawing the perpendiculars $D\delta$, $C\kappa$, the ſum of the perpendiculars from D is $d \times D\delta$; and the ſum of the perpendiculars from A and B is $\overline{a+b} \times C\kappa$, and we have $d \times D\delta = \overline{a+b} \times C\kappa$; and therefore $DE : EC = a + b : d$.

In like manner, if a fourth body be added, the common centre is in the line joining the fourth with the centre of the other three, and its diſtance from this centre and from the fourth is inverſely as the quantities of matter; and ſo on for any number of bodies.

If all the particles of any ſyſtem be moving uniformly, in ſtraight lines, in any directions, and with any velocities whatever, the centre of the ſyſtem is either moving uniformly in a ſtraight line, or is at reſt.

For, let m be the number of particles in the ſyſtem. Suppoſe any particle to move uniformly in any direction. It is evident from the reaſoning in a former paragraph, that the motion of the common centre is the mth part of this motion, and is in the ſame direction. The ſame muſt be ſaid of every particle. Therefore the motion of the centre is the motion which is compounded of the mth part of the motion of each particle. And becauſe each of theſe was ſuppoſed to be uniform and rectilineal, the motion compounded of them all is alſo uniform and rectilineal; or it may happen that they will ſo compenſate each other that there will be no diagonal, and the common centre will remain at reſt.

Cor. 1. If the centres of any number of bodies move uniformly in ſtraight lines, whatever may have been the motions of each particle of each body, by rotation or otherwiſe, the motion of the common centre will be uniform and rectilineal.

Cor. 2. The quantity of motion of ſuch a ſyſtem is the ſum of the quantities of motion of each body, reduced to the direction of the centre's motion. And it is had by multiplying the quantity of matter in the ſyſtem by the velocity of the centre.

The velocity of the centre is had by reducing the motion of each particle to the direction of the centre's motion and then dividing the ſum of thoſe reduced motions by the quantity of matter in the ſyſtem.

By the ſelection of this point, we render the inveſtigation of the motions and actions of bodies incomparably more ſimple and eaſy, freeing our diſcuſſions from numberleſs intricate complications of motion, which would frequently make our progreſs almoſt impoſſible.

POSITION, in arithmetic, called alſo *Falſe Poſition*, or *Suppoſition*, or *Rule of Falſe*, is a rule ſo called, becauſe it conſiſts in calculating by falſe numbers ſuppoſed or taken at random, according to the proceſs deſcribed in any queſtion or problem propoſed, as if they were the true numbers, and then from the reſults, compared with that given in the queſtion, the true numbers are found.

Thus, take or aſſume any number at pleaſure for the number ſought, and proceed with it as if it were the true number, that is, perform the ſame operations with it as, in the queſtion, are deſcribed to be performed with the number required: then if the reſult of thoſe operations be the ſame with that mentioned or given in the queſtion, the ſuppoſed number is the ſame as the true one that was required; but if it be not, make this proportion, *viz.* as your reſult is to that in the queſtion, ſo is your ſuppoſed falſe number to the true one required.

Example. What number is that, to which if we add $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, and $\frac{1}{6}$ of itſelf, the ſum will be 240?

Suppoſe 99

$$\begin{array}{r l}
49.5 & = \frac{1}{2} \\
33. & = \frac{1}{3} \\
24.75 & = \frac{1}{4} \\
16\ 5 & = \frac{1}{6} \\
\hline
222.75 & = \text{reſult}
\end{array}$$

Then, as $222.75 : 240 :: 99 : 106.\dot{6}$ = Anſwer.

$$\begin{array}{r l}
53.\dot{3} & = \frac{1}{2} \\
35.5 & = \frac{1}{3} \\
26.\dot{6} & = \frac{1}{4} \\
17.\dot{7} & = \frac{1}{6} \\
\hline
240. & = \text{proof.}
\end{array}$$

This is *ſingle* poſition.

Sometimes it is neceſſary to make two different ſuppoſitions or aſſumptions, when the ſame operations muſt be performed with each as in the ſingle rule. If neither of the ſuppoſed numbers ſolve the queſtion, find the differences between the reſults and the given number; multiply each of theſe differences into the other's poſition; and if the errors in both ſuppoſitions be of the ſame kind, *i. e.* if both ſuppoſitions be either leſs or greater than the given number, divide the differences of the products by the differences of the errors. If the errors be not of the ſame kind, *i. e.* if the one be greater and the other leſs than the given number, divide the ſum of the products by the ſum of the errors. The quotient, in either caſe, will be the anſwer.

Example. Three partners, A, B, and C, bought a ſugar-work which coſt them L. 2000; of which A paid a certain ſum unknown; B paid as much as A, and L. 50 over; C paid as much as them both, and L. 25 over: What ſum did each pay?

(1.) Suppoſe A paid L. 500
B —— 550
C —— 1075

2125
2000

125 = error of exceſs.

(2.) Sup-

Pottery.

```
      (2.) Suppoſe A paid L. 400
                     B ——    450
125   = exceſs.      C ——    875
                            ————
  400 = 2d poſition.        1725
——————                      2000
                            ————
50000
                             275   = error of defect.
                               500 = 1ſt poſition.
                            ——————
         1ſt error, 125     137500
         2d  ——     275      50000
                    ———     ——————
                    400    )187500
                            ——————
                  ⎧ 468.75 = ſum paid by A.
        Anſwers.  ⎨ 518.75 = ———— ———— B.
                  ⎩ 1012.5 = ————————— C.
                           ——————
                    2000. . . = proof.
```

This is called double poſition.

POTTERY is an art of very conſiderable importance; and in addition to what has been ſaid on it in the *Encyclopædia*, the following reflections, by that eminent chemiſt Vauquelin, will probably be acceptable to many of our readers.

Four things (ſays he) may occaſion difference in the qualities of earthen-ware: *1ſt*, The nature or compoſition of the matter; *2d*, The mode of preparation; *3d*, The dimenſions given to the veſſels; *4th*, The baking to which they are ſubjected. By compoſition of the matter, the author underſtands the nature and proportions of the elements of which it is formed. Theſe elements, in the greater part of earthen-ware, either valuable or common, are ſilex, argil, lime, and ſometimes a little oxyd of iron. Hence it is evident that it is not ſo much by the diverſity of the elements that good earthen-ware differs from bad, as by the proportion in which they are united. Silex or quartz makes always two-thirds at leaſt of earthen-ware; argil or pure clay, from a fifth to a third; lime, from 5 to 20 parts in the hundred; and iron, from 0 to 12 or 15 parts in the hundred. Silex gives hardneſs, infuſibility, and unalterability; argil makes the paſte pliable, and renders it fit to be kneaded, moulded, and turned at pleaſure. It poſſeſſes at the ſame time the property of being partially fuſed by the heat which unites its parts with thoſe of the ſilex; but it muſt not be too abundant, as it would render the earthen-ware too fuſible and too brittle to be uſed over the fire.

Hitherto it has not been proved by experience that lime is neceſſary in the compoſition of pottery: and if traces of it are conſtantly found in that ſubſtance, it is becauſe it is always mixed with the other earths, from which the waſhings and other manipulations have not been able to ſeparate it. When this earth, however, does not exceed five or ſix parts in a hundred, it appears that it is not hurtful to the quality of the pottery; but if more abundant, it renders it too fuſible.

The oxyd of iron, beſides the inconvenience of communicating a red or brown colour, according to the degree of baking, to the veſſels in which it forms a part, has the property of rendering them fuſible, and even in a greater degree than lime.

As ſome kinds of pottery are deſtined to melt very penetrating ſubſtances, ſuch as ſalts, metallic oxyds, glaſs, &c. they require a fine kind of paſte, which is obtained only by reducing the earths employed to very minute particles. Others deſtined for melting metals, and ſubſtances not very penetrating, and which muſt be able to ſupport, without breaking, a ſudden tranſition from great heat to great cold, require for their fabrication a mixture of calcined argil with raw argil. By theſe means you obtain pottery, the coarſe paſte of which reſembles *breche*, or ſmall-grained pudding-ſtone, and which can endure ſudden changes of temperature.

The baking of pottery is alſo an object of great importance. The heat muſt be capable of expelling humidity, and agglutinating the parts which enter into the compoſition of the paſte, but not ſtrong enough to produce fuſion; which, if too far advanced, gives to pottery a homogenuouſneſs that renders it brittle. The ſame effect takes place in regard to the fine pottery, becauſe the very minute diviſion given to the earths reduces them nearly to the ſame ſtate as if this matter had been fuſed. This is the reaſon why porcelain ſtrongly baked is more or leſs brittle, and cannot eaſily endure alternations of temperature. Hence coarſe porcelain, in the compoſition of which a certain quantity of calcined argil is employed, porcelain retorts, crucibles, tubes, and common pottery, the paſte of which is coarſe, are much leſs brittle than diſhes and ſaucers formed of the ſame ſubſtance, ground with more labour.

The general and reſpective dimenſions of the different parts of veſſels of earthen-ware have alſo conſiderable influence on their capability to ſtand the fire.

In ſome caſes the glazing or covering, eſpecially when too thick, and of a nature different from the body of the pottery, alſo renders them liable to break. Thus, in making ſome kinds of pottery, it is always eſſential, *1ſt*, To follow the beſt proportion in the principles; *2d*, To give to the particles of the paſte, by grinding, a minuteneſs ſuited to the purpoſe for which it is intended, and to all the parts the ſame dimenſions as far as poſſible; *3d*, To carry the baking to the higheſt degree that the matter can bear without being fuſed; *4th*, To apply the glazing in thin layers, the fuſibility of which ought to approach as near as poſſible to that of the matter, in order that it may be more intimately united.

C. Vauquelin, being perſuaded that the quality of good pottery depends chiefly on uſing proper proportions of the earthy matters, thought it might be of importance, to thoſe engaged in this branch of manufacture, to make known the analyſis of different natural clays employed for this purpoſe, and of pottery produced by ſome of them, in order that, when a new earth is diſcovered, it may be known by a ſimple analyſis whether it will be proper for the ſame object, and to what kind of pottery already known it bears the greateſt reſemblance.

	Heſſian Crucibles.	Argil of Dieux.	Porcelain Capſules.	Wedgewood's Pyrometers.
Silex	69	43·5	61	64·2
Argil	21·5	33·2	28	25
Lime	1	3·5	6	6
Oxyd of iron	8	1	0·5	0·2
Water		18		6·2

elain,
ules.

Raw kaolin 100 parts.—Silex 74, argil 16·5, lime 2, water 7. A hundred parts of this earth gave eight of alum, after being treated with the ſulphuric acid.

Waſhed kaolin 100 parts —Silex 55, argil 27, lime 2, iron 0·5, water 14. This kaolin, treated with the ſulphuric acid, gave about 45 or 50 *per cent.* of alum.

Petuntzé.—Silex 74, argil 14·5, lime 5·5, loſs 6. A hundred parts of this ſubſtance, treated with the ſulphuric acid, gave ſeven or eight parts of alum. But this quantity does not equal the loſs ſuſtained.

Porcelain of retorts.—Silex 64, argil 28·8, lime 4·55, iron 0·50, loſs 2·77. Treated with the ſulphuric acid, this porcelain gave no alum.

There is a kind of earthen veſſels, called *Alcarrezes*, uſed in Spain for cooling the water intended to be drunk. Theſe veſſels conſiſt of 60 parts of calcareous earth, mixed with alumina and a little oxyd of iron, and 36½ of ſiliceous earth, alſo mixed with alumina and the ſame oxyd. The quantity of iron may be eſtimated at almoſt one hundredth part of the whole. This earth is firſt kneaded into a tough paſte, being for that purpoſe previouſly diluted with water; formed into a cake of about ſix inches in thickneſs, and left in that ſtate till it begin to crack. It is then kneaded with the feet, the workman gradually adding to it a quantity of ſea-ſalt, in the proportion of ſeven pounds to a hundred and fifty; after which it is applied to the lath, and baked in any kind of furnace uſed by potters. The alcarrezes, however, are only about half as much baked as the better kinds of common earthen ware; and being exceedingly porous, water oozes through them on all ſides. Hence the air, which comes in contact with it by making it evaporate, carries off the caloric contained in the water in the veſſel, which is thus rendered remarkably cool.

POULES, or FOULQUES, one of the principal nations which inhabit the banks of the Senegal. They poſſeſs an extent of more than ſixty leagues along the river, and exact heavy cuſtoms from the Senegal traders with the interior of the country. They are not ſo black as the other negroes, but of a copper colour, much inclining to red. It is remarkable, however, that their children who are ſent to Senegal, and reſide there for ſome years, become much blacker. The females are very handſome, and the whites of Senegal generally take care to procure ſome of them. But they are of a bad diſpoſition, and utterly incapable of attachment. When a man has a miſtreſs of this nation, he muſt watch her conduct very narrowly, and even chaſtiſe her, that ſhe may not be guilty of infidelity to him whom ſhe honours with her favours. The dread of the baſtinado will, in ſuch caſe, effect what attention and complaiſance can never bring about.

Although the Poules inhabit one of the fineſt ſpots in Africa, they are nevertheleſs a wretched people; they are baſe, cruel, thieviſh, and fanatic in the extreme. They are commanded by a chief of their religion, which is a contemptible mixture of Mahometaniſm and idolatry. This chief is called the *Almamy;* he is always choſen from among the Tampſirs, who are twelve in number. The Tampſirs are the interpreters of the law, and are the moſt learned, or rather the moſt fanatical among them. The Almamy has the power of life and death over his ſubjects; yet he may be depoſed by an aſſembly of Tampſirs: it is therefore his intereſt to keep on good terms with them. The payment of cuſtoms is made to the Almamy, and is afterwards diſtributed among the Tampſirs; and although a part belongs to the former, he nevertheleſs requires a ſeparate preſent for himſelf.

Printing.

PRINTING. (See that article, *Encycl.* and TYPOGRAPHY in this *Supplement.*) We ſhall here only deſcribe a *PRINTING-Preſs*, for the invention of which a patent was granted, in 1790, to Mr William Nicholſon of New North-ſtreet, Red Lion Square, London. This machine, with ſome ſlight varieties, is adapted for printing on *paper*, *linen*, *cotton*, *woollen*, and other articles, in a more neat, cheap, and accurate method, the author thinks, than the printing preſſes now in uſe.

The invention conſiſts in three particulars, 1*ſt*, The manner of preparing and placing the types, engravings, or carvings, from which the impreſſion is to be made; 2*dly*, In applying the ink or colouring matter to types or engravings; and, 3*dly*, In taking off the impreſſion.

1*ſt*, Mr Nicholſon makes his moulds, punches, and matrices, for caſting letters, in the ſame manner, and with the ſame materials, as other letter-founders do, excepting that, inſtead of leaving a ſpace in the mould for the ſtem of one letter only, he leaves ſpaces for two, three, or more letters, to be caſt at one pouring of the metal; and at the lower extremity of each of thoſe ſpaces (which communicate by a common groove at top) he places a matrix, or piece of copper, with the letter punched upon its face in the uſual way. And moreover, he brings the ſtem of his letters to a due form and finiſh, not only by rubbing it upon a ſtone, and ſcraping it when arranged in the finiſhing-ſtick, but likewiſe by ſcraping it, on one or more ſides, in a finiſhing-ſtick whoſe hollowed part is leſs deep at the inner than the outer ſide. He calls that ſide of the groove which is neareſt the face of the diſpoſed letter, the outer ſide; and the purpoſe accompliſhed by this method of ſcraping is, that of rendering the tail of the letter gradually ſmaller the more remote it is, or farther from the face. Such letters may be firmly impoſed upon a cylindrical ſurface, in the ſame manner as common letters are impoſed upon a flat ſtone.

2*dly*, He applies the ink or colouring matter to the types, forms, or plates, by cauſing the ſurface of a cylinder, ſmeared or wetted with the colouring matter, to roll over the ſurfaces of the ſaid forms or plates, or by cauſing the forms or plates apply themſelves ſucceſſively to the ſurface of the cylinder. The ſurface of this colouring cylinder is covered with leather, or with woollen, linen, or cotton-cloth. When the colour to be uſed is thin, as in calico-printing, and in almoſt every caſe, the covering is ſupported by a firm elaſtic ſtuffing, conſiſting of hair, or wool, or woollen cloth wrapped one or more folds round the cylinder. When the covering conſiſts of woollen cloth, the ſtuffing muſt be defended by leather, or oilſkin, to prevent its imbibing too much colour, and by that means loſing its elaſticity. It is abſolutely neceſſary that the colouring matter be evenly diſtributed over the ſurface of the cylinder; and for this purpoſe, when the colour is thick and ſtiff, as in letter-preſs printing, he applies two, three, or more ſmall cylinders, called diſtributing-rollers, longitudinally againſt the colouring cylinders, ſo that they may be turned by the motion of the latter; and the effect of this application is, that every lump or maſs of colour which may be redundant, or irregularly placed upon the face of the colouring cylinder, will be preſſed, ſpread, and partly taken up, and carried by the ſmall rollers to the other parts of the colouring cylinder; ſo that this laſt will very ſpeedily acquire and preſerve an even face of colour. But if the colouring matter be thinner, he does not apply more than one or two of theſe diſtributing-rollers; and, if it be very thin, he applies an even blunt edge of metal, or wood, or a ſtraight bruſh, or both of theſe laſt, againſt the colouring cylinder, for the purpoſe of rendering its colour uniform. When he applies colour to an engraved plate, or cylinder, or through the interſtices of a perforated pattern, as in the manufacturing of ſome kinds of paper-hangings, he uſes a cylinder entirely covered with hair or briſtles in the manner of a bruſh.

3*dly*, He performs all his impreſſions, even in letter-preſs printing, by the action of a cylinder or cylindrical ſurface. The conſtruction of this machine, and the manner of uſing it, will be intelligible to every reader, who ſhall attentively conſider Plate XL; where fig. 1. repreſents a printing-preſs, more eſpecially applicable to the printing of books. A and E are two cylinders, running or turning in a ſtrong frame of wood, or metal, or both. The cylinder A is faced with woollen cloth, and is capable of being preſſed with more or leſs force upon HI, by means of the lever M. HI is a long table, which is capable of moving endwiſe, backwards and forwards, upon the rollers E and K. The roller A acts upon this table by means of a cog-wheel, or by ſtraps, ſo as to draw it backwards and forwards by the motion of its handle L. The table is kept in the ſame line by grooves on its ſides, which contain the cylinder A. D is a chaſe, containing letter ſet up and impoſed. B is a box, containing a colouring-roller, with its diſtributing-rollers CC; it is ſupported by the arm N. O is a cylinder faced with leather, and lying acroſs an ink-block; this cylinder is fixed by the middle to a bended lever moveable on the joint Q.

The action. When D, or the letter, is drawn beneath the cylinder B, it receives ink; and when it has paſſed into the poſition R, a workman places or turns down a tympan with paper upon it (this tympan differs in no reſpect from the uſual one, except that its hinge opens ſidewiſe); it then proceeds to paſs under the cylinder A, which preſſes it ſucceſſively through its whole ſurface. On the other ſide, at S, the workman takes off the paper, and leaves the tympan up. This motion cauſes the cylinder B to revolve continually, and conſequently renders its inked ſurface very uniform, by the action of its diſtributing-rollers CC; and, when the table has paſſed to its extreme diſtance in the direction now ſpoken of, the arm G touches the lever P, and raiſes the cylinder O off the ink block, by which means it dabs againſt one of the diſtributing-rollers, and gives it a ſmall quantity of ink. The returning motion of the table carries the letter again under the roller B, which again inks it, and the proceſs of printing another ſheet goes on as before.

Fig. 2. is another printing-preſs. In this, B is the inking-roller; A is a cylinder, having the letter impoſed upon its ſurface; and E is a cylinder, having its uniform ſurface covered with woollen cloth: theſe three cylinders are connected, either by cogs or ſtraps at the edges of each. The machine is uniformly turned in one direction by the handle L. The workman applies a ſheet of paper to the ſurface of E, where it is retained, either by points in the uſual manner, or by the apparatus to be deſcribed in treating of fig. 4. The paper paſſes between E and A, and receives an impreſſion; after which the workman takes it off, and applies another ſheet; and in the mean time the letter on the ſurface of A paſſes round againſt the ſurface of B, and receives ink during the rotation of B. The diſtributing-rollers CC do their office as in the machine fig. 1.; and once in every revolution the tail F, affixed to B, raiſes the inking-piece G, ſo as to cauſe it to touch one of the diſtributing-rollers, and ſupply it with ink. In this way therefore the repeated printing of ſheet after ſheet goes on.

Fig. 3. is a printing-preſs, more particularly adapted to print cottons, ſilks, paper-hangings, or other articles which run of a conſiderable length. A is a cylinder covered with woollen cloth, or other ſoft ſubſtance. The web or piece of cotton, or other goods, is paſſed round this cylinder, from the carrying-roller F to the receiving-rollers GH; which are connected by a piece of linen, woollen, or hair-cloth, in the manner of a jack-towel ſewed round them; the rotation of this towel carries away the printed ſtuff or goods, and depoſits them at I. KL is a moveable box, containing three rollers, which move againſt each other in rotation. The loweſt roller C revolves in a maſs of colour, contained in a trough or veſſel in the bottom part of the box KL; the ſurface of this colour is repreſented by the line MN. The next roller B is ſtuffed and covered as deſcribed in ſection 2. The preſſure of B againſt C prevents the cylinder B from receiving too much colour. D is a cut or carved cylinder, which receives colour, during the rotation, from the roller B, and impreſſes it upon the web as it paſſes round the cylinder A; in this way the conſtant and effectual action of the machine is ſufficiently obvious. It muſt be obſerved, that the cylinders ADB and G are connected together by cog-wheels, ſtraps, or other well-known equivalent contrivances; ſo that the handle P drives the whole, without their neceſſarily depending on any adheſion or friction at their ſurfaces. The preſſure of B againſt D is governed by an adjuſtment of the axis of D, whoſe ſockets are capable of a ſmall motion; and the preſſure of D againſt A is governed by the poſition of the whole box KL. When it is required to print more than one colour upon a piece, Mr Nicholſon cauſes it to paſs two or more times through the machine; or, in thoſe caſes where the materials are liable to change their dimenſions, he applies, at one and the ſame time, two or more ſuch boxes as KL, with their reſpective cylinders, ſo that the pattern cylinder of each may make its impreſſion upon the web or material to be printed on.

Fig. 4. is a printing-preſs, chiefly of uſe for books and papers. 1, 2, 3, 4, repreſents a long table, with ledges on each ſide; ſo that the two cylinders A and B can run backwards and forwards without any ſide ſhake. In one of theſe ledges is placed a ſtrip or plate of metal cut into teeth, which lock into correſpondent teeth in each cylinder; by which means the two cylinders roll along, without the poſſibility of changing the relative poſitions of their ſurfaces at any determinate part of the table. This may alſo be effected by ſtraps, and may indeed be accompliſhed, with tolerable accuracy, by the mere rolling of the cylinders on the ſmooth or flat ledges without any proviſion A is the printing-cylinder, covered with woollen cloth, and B is the inking-cylinder, with its diſtributing rollers. The table

may be divided into four compartments, marked with a thicker bounding line than the reſt, and numbered 1, 2, 3, 4. At 1 is placed a ſheet of paper; at 2 is the form or chaſe, containing letter ſet and impoſed; at 3 is an apparatus for receiving the printed ſheet; and 4 is employed in no other uſe than as a place of ſtanding for the carriage E, after it has paſſed through one operation, and when it takes ink at F. Its action is as follows: the carriage is thruſt forward by the workman, and as the roller A paſſes over the ſpace numbered 1, it takes up the ſheet of paper previouſly laid there, while the roller B runs over the form and inks the letter. The ſheet of paper, being wrapped round the cylinder A, is preſſed againſt the form as that cylinder proceeds, and conſequently it receives an impreſſion. When A arrives at the ſpace numbered 3, it lets go the ſheet of paper, while the prominent part of the carriage G ſtrikes the lever P, and raiſes the inking-piece, which applies itſelf againſt one of the diſtributing-rollers. In this manner therefore the cylinder A returns empty, and the cylinder B inked, and in the mean time the workman places another ſheet of paper ready in the ſpace numbered 1. Thus it is that the operation proceeds in the printing of one ſheet after another.

The preceding deſcription is not incumbered with an account of the apparatus by which the paper is taken up and laid down. This may be done in ſeveral ways: Fig. 9. and 10. repreſent one of the methods. DE is a lever, moving on the centre pin C, and having its end D preſſed upwards by the action of the ſpring G. The ſhoulder which contains the pin C is fixed in another piece F, which is inſerted in a groove in the ſurface of the cylinder A (fig. 4.), ſo that it is capable of moving in and out, in a direction parallel to the axis of that cylinder. As that cylinder proceeds, it meets a pin in the table; which (letter P, fig. 9.) acting on the inclined plane at the other end of the lever, throws the whole inwards, in the poſition repreſented in fig. 10.; in which caſe the extremity D ſhoots inwards, and applies itſelf againſt the ſide of the cylinder.

In fig. 11. is a repreſentation of part of the table; the dotted ſquare repreſents a ſheet of paper, and the four ſmall ſhaded ſquares denote holes in the board, with pins ſtanding beſide them. When the lever DE (fig. 10.) ſhoots forward, it is ſituated in one of theſe holes, and advances under the edge of the paper, which conſequently it preſſes and retains againſt the cylinder with its extremity D. Nothing more remains to be ſaid reſpecting the taking up, but that the cylinder is provided with two pair of theſe claſps or levers, which are ſo fixed as to correſpond with the four holes repreſented in fig. 11. It will be eaſy to underſtand how the paper is depoſited in the compartment n° 3. (fig. 4.) A pin P (fig. 10.) riſing out of the platform or table, acts againſt a pin E, projecting ſidewiſe out of the lever, and muſt of courſe draw the ſlider and its lever to the original poſition; the paper conſequently will be let go, and its diſengagement is rendered certain by an apparatus fixed in the compartment numbered 3. (fig. 4.) of exactly the ſame kind as that upon the cylinder, and which, by the action of a pin duly placed in the ſurface of the cylinder A, takes the paper from the cylinder in preciſely the ſame manner as that cylinder originally took it up in the compartment numbered 1 (fig. 4.)

Figs. 5, 6, and 7, repreſent a ſimpler apparatus for accompliſhing the ſame purpoſe. If A *a* B *b* (fig. 7.) be ſuppoſed to repreſent a thick plate of metal of a circular form, with two pins, A and B, proceeding ſidewiſe or perpendicularly out of its plane, and diametrically oppoſite to each other, and G another pin proceeding in the direction of that plane, then it is obvious that any force applied to the pin A, ſo as to preſs it into the poſition *a* (by turning the plate on its axis or centre X), will at the ſame time cauſe the pin G to acquire the poſition *g*; and, on the other hand, when B is at *b*, or the dotted repreſentation of the ſide-pin, if any preſſure be applied to reſtore its original poſition at B, the pin *g* will return back to G. Now the figures 5 and 6 exhibit an apparatus of this kind, applied to the cylinder A; and that cylinder, by rolling over the pins P and *p*, properly fixed in the table to re-act upon the apparatus, will cauſe its prominent part G either to apply to the cylinder and claſp the paper, or to riſe up and let it go. The compartment numbered 3 (fig. 4.) muſt of courſe have an apparatus of the ſame kind to be acted upon by pins from A, in order that it may take the paper from that cylinder.

There is one other circumſtance belonging to this machine which remains to be explained. When the carriage E (fig. 4.) goes out in the direction of the numbers 1, 2, 3, 4, both rollers, A and B, preſs the form of letter in their paſſage; but in their return back again the roller A, having no paper upon it, would itſelf become ſoiled, by taking a faint impreſſion from the letter, if it were not prevented from touching it: the manner of effecting this may be underſtood from fig. 12. The apparatus there repreſented is fixed upon the outſide of the carriage E, near the lower corner, in the vicinity of the roller A; the whole of this projects ſidewiſe beyond the ledge of the table, except the ſmall truck or wheel B. The irregularly-triangular piece, which is ſhaded by the ſtroke of the pen, carries this wheel, and alſo a catch moveable on the axis or pin E. The whole piece is moveable on the pin A, which connects it to the carriage. CD, or the part which is ſhaded by dotting, is a detent, which ſerves to hold the piece down in a certain poſition. It may be obſerved, that both the detent and the triangular piece are furniſhed each with a claw, which holds in one direction, but trips or yields in the other, like the jacks of a harpſichord, or reſembling certain pieces uſed in clock and watch making, as is clearly repreſented in the figure. Theſe claws overhang the ſide of the table, and their effect is as follows: There is a pin C (fig. 4.) between the compartments of the table numbered 2 and 3, but which is marked F in fig. 12. where GH repreſents the table. In the outward run of the carriage theſe claws ſtrike that pin, but with no other effect than that they yield for an inſtant, and as inſtantly reſume their original poſition by the action of their reſpective ſlender back-ſprings. When the carriage returns, the claw of the detent indeed ſtrikes the pin, but with as little effect as before, becauſe its derangement is inſtantly removed by the action of the back ſpring of the detent itſelf; but, when the claw of the triangular piece takes the pin, the whole piece is made to revolve on its axis or pin A, the wheel B is forced down, ſo as to lift that end of the carriage, and the detent, catching on the piece at C, prevents the former poſition from being recovered. The conſequence of this is, that the carriage runs upon the truck B (and its correſpondent truck on the oppoſite ſide) inſtead of the cylinder A, which is too much raiſed to take the letter, and ſoil itſelf; but as ſoon as the end of the carriage has paſſed clear of the letter, another pin R (fig. 4.) takes the claw of the detent, and draws it off the triangular piece; at which inſtant the cylinder A ſubſides to its uſual place, and performs its functions as before. This laſt pin R does not affect the claw of the triangular piece, becauſe it is placed too low; and the claw of the detent is made the longeſt, on purpoſe that it may ſtrike this pin.

Fig. 8. repreſents an inſtrument for printing floor-cloths, paper-hangings, and the like, with ſtiff paint and a bruſh. D is a copper or metallic cylinder fixed in a frame A, like a garden roller; its carved part is thin, and is cut through in various places, according to the deſired pattern. A ſtrong axis paſſes through the cylinder, and its extremities are firmly attached to the frame A. To this axis is fixed a veſſel or box of the ſame kind, and anſwering the ſame purpoſe as the box KL in fig. 3. It carries a cylinder P, which revolves in the colour; another cylinder E, which revolves in contact with P; and a third cylinder B, whoſe exterior ſurface is covered with hair, after the manner of a bruſh, and revolves in contact with E. This cylinder B is adjuſted by its axis, in ſuch a manner that its bruſh-part ſweeps in the perforated parts of the metallic cylinder D. The circle C repreſents a cog-wheel, fixed concentric to the cylinder D, and revolving with it; this wheel takes another wheel concentric to, and fixed to, B; hence the action is as follows: When the metallic cylinder is wheeled or rolled along any ſurface, its cog-wheel C drives the bruſh B in the contrary direction; and this bruſh-cylinder, being connected by cogs or otherwiſe with E and P, cauſes thoſe alſo to revolve and ſupply it with colour. As the ſucceſſive openings of the cylinder D, therefore, come in contact with the ground, the ſeveral parts of the bruſh will traverſe the uncovered part of that ground, and paint the pattern upon it. The wheel G, being kept lightly on the ground, ſerves to determine the line of contact, that it ſhall be the part oppoſite to B, and no other.

PRINTS (ſee *Encycl.*) are valuable on many accounts; but they are liable to be ſoiled by ſmoke, vapour, and the excrements of inſects. Different methods have, of courſe, been practiſed to clean them. Some have propoſed ſimple waſhing with clear water, or a ley made of the aſhes of reeds, and then expoſing the prints to the dew. Others have cleaned prints with *aqua fortis* (ſulphuric acid); but both theſe methods are attended with a degree of riſk at leſt equal to their advantages. The following method of cleaning prints is recommended in the ſecond volume of Nicholſon's Journal of Natural Philoſophy, &c. as at once ſafe and efficacious:

“ Provide a certain quantity of the common muriatic acid, for example three ounces, in a glaſs bottle, with a ground ſtopper, of ſuch a capacity that it may be only half full. Half an ounce of minium muſt then be added; immediately after which the ſtopper is to be put in, and the bottle ſet in a cold and dark place. The heat, which ſoon becomes perceptible, ſhews the beginning of the new combination. The minium abandons the greateſt part of its oxygen with which the fluid remains impregnated, at the ſame time that it acquires a fine golden yellow, and emits the deteſtable ſmell of oxygenated muriatic acid. It contains a ſmall portion of muriat of lead; but this is not at all noxious in the ſubſequent proceſs. It is alſo neceſſary to be obſerved, that the bottle muſt be ſtrong, and the ſtopper not too firmly fixed, otherwiſe the active elaſtic vapour might burſt it. The method of uſing this prepared acid is as follows:

“ Provide a ſufficiently large plate of glaſs, upon which one or more prints may be ſeparately ſpread out. Near the edges let there be raiſed a border of ſoft white wax half an inch high, adhering well to the glaſs and flat at top. In this kind of trough the print is to be placed in a bath of freſh urine, or water containing a ſmall quantity of ox-gall, and kept in this ſituation for three or four hours. The fluid is then to be decanted off, and pure warm water poured on, which muſt be changed every three or four hours until it paſſes limpid and clear. The impurities are ſometimes of a reſinous nature, and reſiſt the action of pure water. When this is the caſe, the waſhed print muſt be left to dry, and alcohol is then to be poured on and left for a time. After the print is thus cleaned, and all the moiſture drained off, the muriatic acid prepared with minium is to be poured on in ſufficient quantity to cover the print; immediately after which another plate of glaſs is to be laid in contact with the rim of wax, in order to prevent the inconvenient exhalation of the oxygenated acid. In this ſituation the yelloweſt print will be ſeen to recover its original whiteneſs in a very ſhort time. One or two hours are ſufficient to produce the deſired effect; but the print will receive no injury if it be left in the acid for a whole night. Nothing more is neceſſary to complete the work, than to decant off the remaining acid, and waſh away every trace of acidity by repeated affuſions of pure water. The print being then left to dry (in the ſun if poſſible) will be found white, clear, firm, and in no reſpect damaged either in the texture of the paper or the tone and appearance of the impreſſion.”

The judicious editor of the Journal ſubjoins the following note, to which collectors of prints will do well to pay attention: “ As I have not repeated this proceſs, I cannot eſtimate how far the preſence of the lead may weaken the corroſive action of the acid on the paper; but I ſhould be diſpoſed to recommend a previous dilution of the acid with water. Whoever uſes this proceſs will of courſe make himſelf maſter of the proportion of water required to dilute the acid, by making his firſt trials with an old print of no value.”

PRISM, in geometry, is a body or a ſolid, whoſe two ends are any plane figures which are parallel, equal, and ſimilar; and its ſides, connecting thoſe ends, are parallelograms. The definition of this figure in the *Encyclopædia* we muſt, in candour, acknowledge to be unaccountably indiſtinct, if not unintelligible.

PRISMOID, is a ſolid or body, ſomewhat reſembling a priſm, but that its ends are any diſſimilar parallel plane figures of the ſame number of ſides; the upright ſides being trapezoids.—If the ends of the priſmoid be bounded by diſſimilar curves, it is ſometimes called a *cylindroid*.

PRISON is ſaid, in the *Encyclopædia*, to be only a place of ſafe cuſtody, not a place of puniſhment. Such was,

POSITION PLATE XL.

Fig. 1.

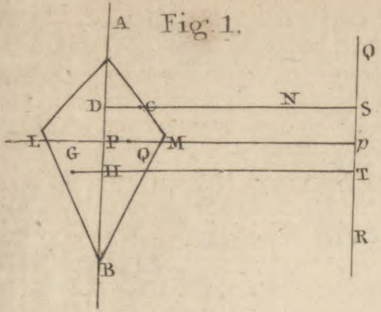


Fig. 2.

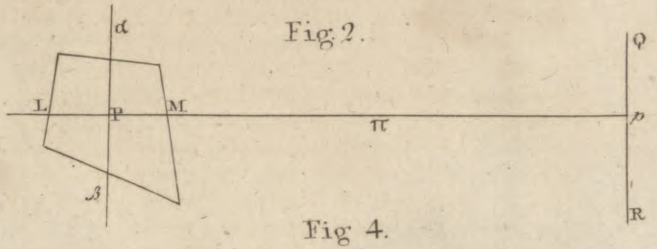


Fig. 3.

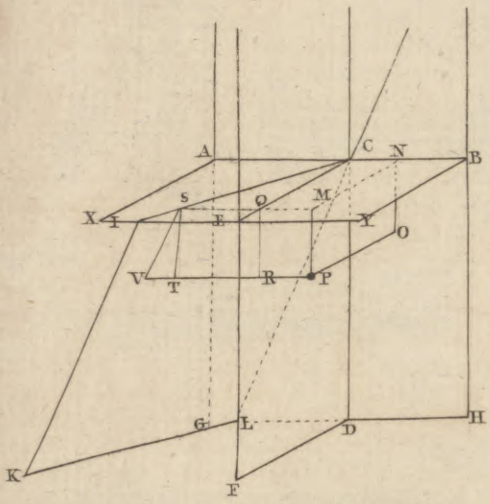
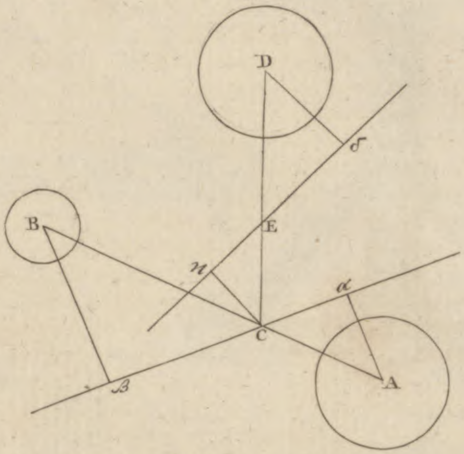
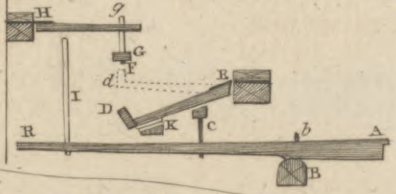


Fig 4.



KEY &c. of MASON'S PIANO FORTE.



PRINTING PRESS

Fig. 1.

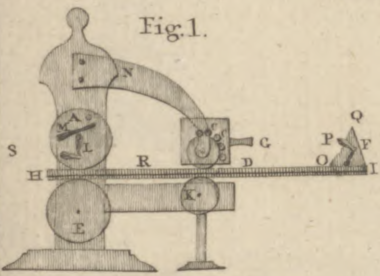


Fig. 2.

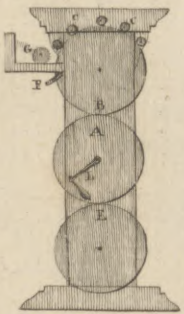


Fig. 3.

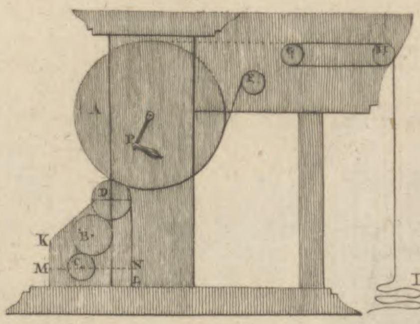


Fig. 9.

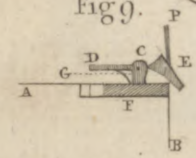


Fig. 10.

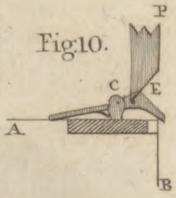


Fig. 5.

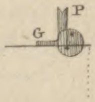


Fig. 6.

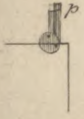


Fig. 7.

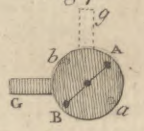


Fig. 8.

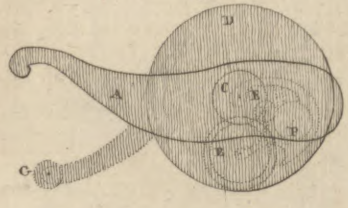


Fig. 4.

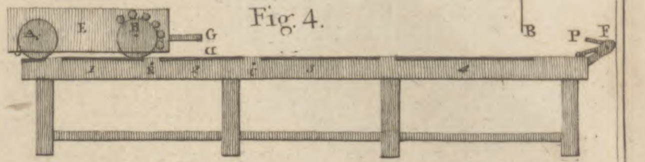


Fig. 11.

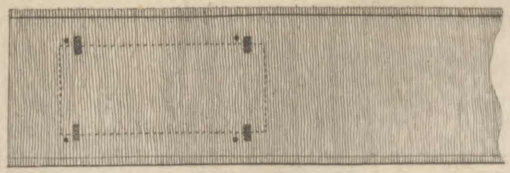
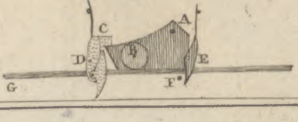
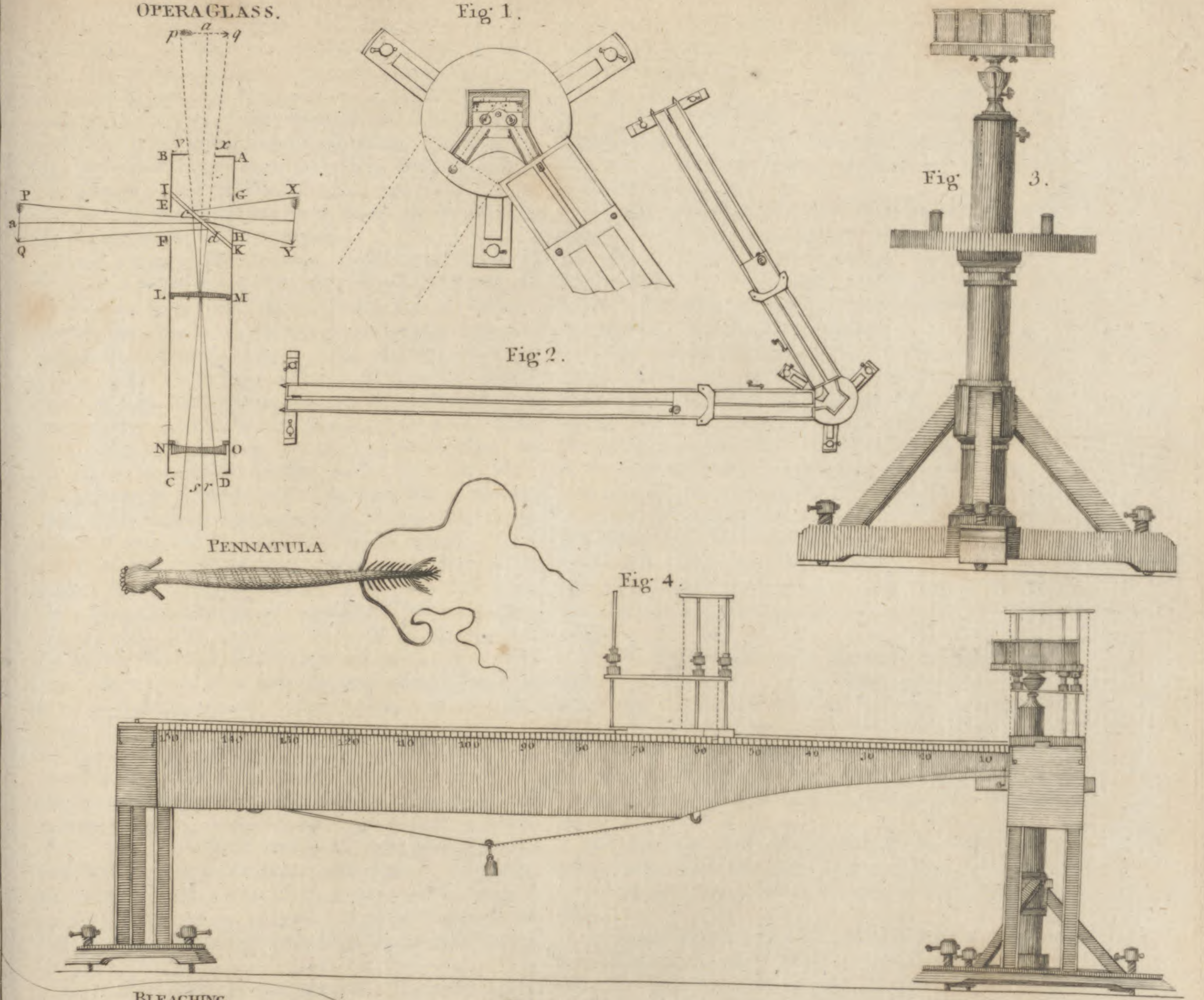


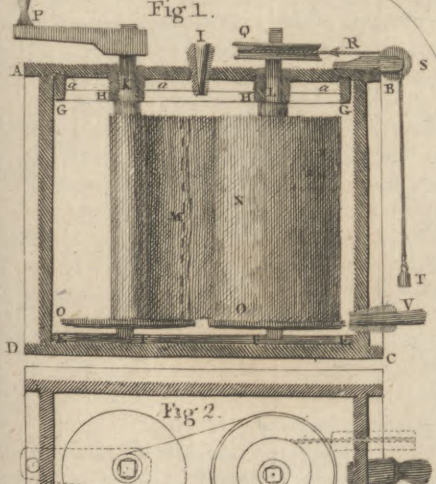
Fig. 12.



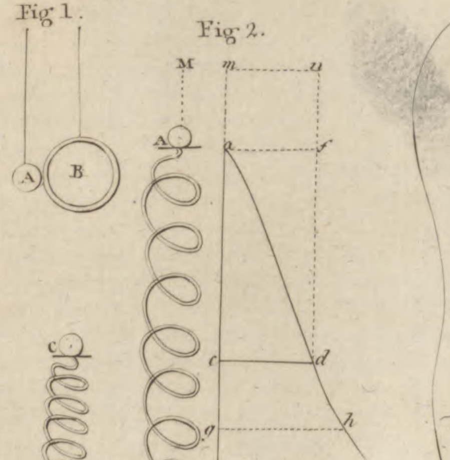
D.Lizars Sculp



BLEACHING



PERCUSSION



ORICOU

D.Lizars sculp.

was, no doubt, the original intention of Engliſh priſons; but now temporary confinement is, in England as well as elſewhere, inflicted as a puniſhment for certain crimes. Perhaps it would be expedient to ſubſtitute this puniſhment more frequently than is yet done in Great Britain, for tranſportation and death; proportioning the length of the confinement, as well as its cloſeneſs, to the heinouſneſs of the crime. In no country, we believe, is this more accurately done, or to better purpoſe, than in Pennſylvania; and ſurely in no country has impriſonment been more abuſed than in Venice under the old government.

By the laws of Pennſylvania, puniſhment by impriſonment is impoſed, not only as an expiation of paſt offences, and an example to the guilty part of ſociety, but alſo for another important purpoſe—the reformation of the criminal's morals. The regulations of the gaol are calculated to promote this effect as ſoon as poſſible; ſo that the building deſerves the name of a *penitentiary houſe* more than that of a *gaol* (ſee PHILADELPHIA, *Encycl.*) As ſoon as a criminal is committed to the priſon, he is made to waſh; his hair is ſhorn; and, if not decently clothed, he is furniſhed with clean apparel. He is then thrown into a ſolitary cell, about nine feet long and four wide, where he remains debarred from the ſight of every living being except his gaoler, whoſe duty is to attend to his bare neceſſities, but who is forbidden on any account to hold converſation with him. If a priſoner be at all refractory, or if the offence for which he is committed be of a very atrocious nature, he is then confined to a cell ſecluded even from the light of heaven. The treatment of each priſoner, during his confinement, is varied according to his crime and his ſubſequent repentance. Solitary confinement in a dark cell is looked upon as the ſevereſt uſage; next, ſolitary confinement in a cell with the admiſſion of light; next, ſolitary confinement in a cell, where the priſoner is allowed to do ſome ſort of work; and, laſtly, labour in company with others. The longeſt period of confinement is for a rape, which is not to be leſs than ten years, nor more than twenty-one; for high treaſon, it is not to exceed twelve, nor fall ſhort of ſix years.

The priſoners are obliged to bathe twice every week, proper conveniences for that purpoſe being provided within the walls of the priſon, and alſo to change their linen, with which they are regularly ſupplied. Thoſe in ſolitary confinement are kept upon bread and water; but thoſe who labour are allowed broth, porridge, puddings, and the like. Meat is diſpenſed only in ſmall quantities, twice in the week; and on no pretence whatever is any other beverage than water ſuffered to be brought into the priſon. Thoſe who labour are employed in the trade to which they have been accuſtomed; and for thoſe acquainted with no particular trade, ſome kind of work is deviſed which they can perform. One room is ſet apart for ſhoemakers, another for tailors, a third for carpenters, and ſo on. In the yards are ſtone cutters, ſmiths, nailers, &c. In a word, this priſon has all the advantages of the raſping houſe of Amſterdam, without any of its enormous defects. See CORRECTION-*Houſe* in this *Suppl.*

The priſon of Venice is of a very different deſcription, and is worthy of notice here only as a curioſity in the annals of tyranny, which has, we hope, paſſed away with the government which contrived it. Dr Moſeley, in conſequence of his being an Engliſh phyſician (a character then highly reſpected in Venice), was permitted, on the 16th of September 1787, to viſit the common priſon, but was abſolutely refuſed admittance into the *Sotto Piombi*, where the ſtate priſoners were kept. As the Doctor believes that no foreigner beſides himſelf ever witneſſed the ſcenes, even in the common priſon, which he relates, we ſhall give his relation in his own words.

"I was conducted (ſays he) through the priſon by one of its inferior dependants. We had a torch with us. We crept along narrow paſſages as dark as pitch. In ſome of them two people could ſcarcely paſs each other. The cells are made of maſſy marble; the architecture of the celebrated Sanſovini.

"The cells are not only dark, and black as ink, but being ſurrounded and confined with huge walls, the ſmalleſt breath of air can ſcarcely find circulation in them. They are about nine feet ſquare on the floor, arched at the top, and between ſix and ſeven feet high in the higheſt part. There is to each cell a round hole of eight inches diameter, through which the priſoner's daily allowance of twelve ounces of bread and a pot of water is delivered. There is a ſmall iron door to the cell. The furniture of the cell is a little ſtraw and a ſmall tub; nothing elſe. The ſtraw is renewed and the tub emptied through the iron door occaſionally.

"The diet is ingeniouſly contrived for the perduration of puniſhment. Animal food, or a cordial nutritious regimen, in ſuch a ſituation, would bring on diſeaſe, and defeat the end of this Venetian juſtice. Neither can the ſoul, if ſo inclined, ſteal away, wrapt up in ſlumbering deluſion, or ſink to reſt; from the admonition of her ſad exiſtence, by the gaoler's daily return.

"I ſaw one man who had been in a cell thirty years; two who had been twelve years; and ſeveral who had been eight and nine years in their reſpective cells.

"By my taper's light I could diſcover the priſoners horrid countenances. They were all naked The man who had been there thirty years, in face and body was covered with long hair. He had loſt the arrangement of words and order of language. When I ſpoke to him, he made an unintelligible noiſe, and expreſſed fear and ſurpriſe; and, like ſome wild animals in deſarts, which have ſuffered by the treachery of the human race, or have an inſtinctive abhorrence of it, he would have fled like lightning from me if he could.

"One whoſe faculties were not ſo obliterated; who ſtill recollected the difference between day and night; whoſe eyes and ears, though long cloſed with a ſilent blank, ſtill languiſhed to perform their natural functions—implored, in the moſt piercing manner, that I would prevail on the gaoler to murder him, or to give him ſome inſtrument to deſtroy himſelf. I told him I had no power to ſerve him in this requeſt. He then entreated I would uſe my endeavours with the inquiſitors to get him hanged, or drowned in the Canal' Orfano. But even in this I could not ſerve him: death was a favour I had not intereſt enough to procure for him.

"This kindneſs of death, however, was, during my ſtay in Venice, granted to one man, who had been ‘ from the cheerful ways of man cut off’ thirteen years.

“ Before he left his dungeon I had ſome converſation with him; this was ſix days previous to his execution. His tranſport at the proſpect of death was ſurpriſing. He longed for the happy moment. No ſaint ever exhibited more fervour in anticipating the joys of a future ſtate, than this man did at the thoughts of being releaſed from life, during the four days mockery of his trial.

“ It is in the Canal' Orfano where veſſels from Turkey and the Levant perform quarantine. This place is the watery grave of many who have committed political or perſonal offences againſt the ſtate or ſenate, and of many who have committed no offences at all. They are carried out of the city in the middle of the night, tied up in a ſack with a large ſtone faſtened to it, and thrown into the water. Fiſhermen are prohibited, on forfeiture of their lives, againſt fiſhing in this diſtrict. The pretence is the plague. This is the ſecret hiſtory of people being loſt in Venice.

“ The government, with age, grew feeble; was afraid of the diſcuſſion of legal proceſs and of public executions; and navigated this rotten Bucentaur of the Adriatic by ſpies, priſons, aſſaſſination, and the Canal' Orfano.”

This is indeed a frightful narrative, and, we doubt not, true as well as frightful; but when, from the ſtate of the Venetian priſons, the author inſinuates, that Howard was not actuated by genuine benevolence, and infers, or wiſhes his reader to infer, that the propoſal of that celebrated philanthropiſt for ſubſtituting ſolitary confinement, in many caſes, for capital puniſhment, muſt have reſulted from his not taking into conſideration the *mind* of the criminal—the inſinuation, to ſay the leaſt of it, is ungenerous, and the concluſion is at war with the premiſes. That there was ſomething romantic and ſuperfluous in Howard's wanderings, we readily admit; but it ſeems impoſſible to doubt of the reality of his benevolence; and though the horrid priſon of Venice, into which, as the Doctor aſſures us, Mr Howard never entered, was calculated to injure the body without improving the mind of the criminal, it does not follow but that ſolitary confinement, under ſuch regulations as at Philadelphia, is the beſt means that have yet been thought of for obtaining the object neareſt Howard's heart, the reformation of the morals of the criminal.

PROCYON, in aſtronomy, a fixed ſtar of the ſecond magnitude, in Canis Minor, or the Little Dog.

PROSTHAPHERESIS, in aſtronomy, the difference between the true and mean motion, or between the true and mean place, of a planet, or between the true and equated anomaly; called alſo *equation of the orbit*, or *equation of the centre*, or ſimply the *equation*; and it is equal to the angle formed at the planet, and ſubtended by the eccentricity of its orbit.

PROTRACTING, or PROTRACTION, in ſurveying, the act of plotting or laying down the dimenſions taken in the field, by means of a protractor, &c. Protracting makes one part of ſurveying.

PROTRACTING-Pin, a fine pointed pin or needle, fitted into a handle, uſed to prick off degrees and minutes from the limb of the protractor.

PRUNING. Under this title (*Encycl.*) it is obſerved, that when large branches of trees bearing ſtone-fruit are taken off, the trees are ſubject to gum and decay. For this a remedy has been invented by *Thomas Skip Dyot Bucknall*, Eſq; of Conduit-ſtreet, which, notwithſtanding many objections made to it at firſt, experience has proved to be ſucceſsful, and for the diſcovery of which the Society for the Encouragement of Arts, &c. voted the ſilver medal to the diſcoverer. It is as follows:

Cut every branch which ſhould be taken away cloſe to the place of its ſeparation from the trunk; ſmooth it well with a knife; and then with a painter's bruſh ſmear the wound over with what Mr Bucknall calls *medicated tar*. This medicated tar is compoſed of one quarter of an ounce of corroſive ſublimate, reduced to fine powder by beating with a wooden hammer, and then put into a three-pint earthen pipkin, with about a glaſs full of gin or other ſpirit, ſtirred well together, and the ſublimate thus diſſolved. The pipkin is then filled by degrees with vegetable or common tar, and conſtantly ſtirred, till the mixture be blended together as intimately as poſſible; and this quantity will at any time be ſufficient for two hundred trees. To prevent danger, let the corroſive ſublimate be mixed with the tar as quickly as poſſible after it is purchaſed; for, being of a very poiſonous nature to all animals, it ſhould not be ſuffered to lie about a houſe, for fear of miſchief to ſome part of the family.

By the application of this compoſition, Mr Bucknall can, without the ſmalleſt danger, uſe the pruning hook on all kinds of trees much more freely than we have recommended its uſe in the article referred to. “ I give no attention (ſays he) to fruit-branches, and wood-branches; but beg, once for all, that no branch ſhall ever be ſhortened, unleſs for the figure of the tree, and then conſtantly taken off cloſe to the ſeparation, by which means the wound ſoon heals. The more the range of the branches ſhoots circularly, a little inclining upwards, the more equally will the ſap be diſtributed, and the better will the tree bear; for, from that circumſtance, the ſap is more evenly impelled to every part. Do not let the ranges of branches be too near each other; for remember all the fruit and the leaves ſhould have their full ſhare of the ſun; and where it ſuits let the middle of the tree be free from wood, ſo that no branch ſhall ever croſs another, but all the extreme ends point outwards.”

PULO, the name of ſeveral iſlands of Aſia, in the Indian Ocean; the principal of which alone, according to Dr Brooke's, is inhabited. This is the iſland

PULO-Condore, which, being viſited by Lord Macartney as he ſailed to China, is thus deſcribed by Sir George Staunton. “ It has the advantage of convenient anchoring places in either monſoon. The ſquadron accordingly ſtopped on the 17th of May, in a ſpacious bay on the eaſtern ſide of the iſland; and came to anchor at the entrance of its ſouthern extremity, as the water ſhoaled there to five fathoms and a half, occaſioned by a bank which ſtretches acroſs two-thirds of the entrance. It was found afterwards, that beyond the bank there is a ſafe paſſage to the inner part of the bay, the north of which is ſheltered by a ſmall iſland lying to the eaſtward. The whole of the bay is formed by four ſmall iſlands, which approach ſo nearly to each other, as to appear, from ſeveral points, to join.

Pulo.

Pulo, Punctuation.

They all ſeem to be the rude fragments of primitive mountains, ſeparated from the great continent in the lapſe of time. The principal iſland is eleven or twelve miles in length, and about three in breadth. It is in the form of a creſcent, and conſiſts of a ridge of peaked hills. Its latitude, as calculated from a meridional obſervation, is 8° 40′ north from the equator; and its longitude, according to a good chronometer, is 105° 55′ eaſt from Greenwich.

"The Engliſh had a ſettlement on Condore until the beginning of the preſent century, when ſome Malay ſoldiers in their pay, in reſentment for ſome unjuſtifiable treatment, murdered their ſuperiors, with the exception of a very few who eſcaped off the iſland, where no Europeans have ſince reſided. At the bottom of the bay was a village ſituated cloſe to a fine ſandy beach, with a long range of cocoa-nut trees before it, and it was defended from the north-eaſt ſea by a reef of coral rocks, within which was good anchorage for ſmall veſſels, and an eaſy landing for boats. A party went on ſhore from Lord Macartney's ſquadron, with the precaution, however, of being armed, as large canoes were eſpied within the reef, which might have been Malay pirates. Several of the inhabitants came to the beach, and with the appearance of much urbanity of manners welcomed them on ſhore, and conducted them to the houſe of their chief. It was a neat bamboo cabin, larger than the reſt. The floor was elevated a few feet above the ground, and ſtrewed with mats, on which were aſſembled as many men as the place could hold. It was apparently on the occaſion of ſome feſtival, or pleaſurable meeting. There was in one of the apartments an altar decorated with images, and the partitions hung with figures of monſtrous deities; but the countenances and deportment of the people conveyed no idea of religious awe, and no perſon was ſeen in the poſture of prayer or adoration. A few ſpears ſtood againſt the wall with their points downwards, together with ſome matchlocks and a ſwivel gun. The dreſs of thoſe people was compoſed chiefly of blue cotton worn looſely about them; and their flat faces and little eyes denoted a Chineſe origin or relation. Several long ſlips of paper, hanging from the ceiling, were covered with columns of Chineſe writing. One of the miſſionaries, who was of the party, could not, however, in any degree, underſtand their converſation; but when the words were written, they inſtantly became intelligible to him. Though their colloquial language was altogether different from what is ſpoken in China, yet the characters were all Chineſe; and the fact was clearly aſcertained on this occaſion, that thoſe characters have an equal advantage with Arabic numbers, of which the figures convey the ſame meaning wherever known; whereas the letters of other languages denote not things, but elementary ſounds, which combined variouſly together, form words, or more complicated ſounds, conveying different ideas in different languages, though the form of their alphabet be the ſame.

"The inhabitants of Pulo Condore were, it ſeems, Cochin-Chineſe, with their deſcendants, who fled from their own country, in conſequence of their attachment to one of its ſovereigns, dethroned by ſeveral of his own ſubjects. It was propoſed to purchaſe proviſions here; and the people promiſed to have the ſpecified quantity ready, if poſſible, the next day, when it was intended, if the weather ſhould be favourable, to land the invalids. The next morning was fair in the beginning; and a party of pleaſure was made from the Hindoſtan to a ſmall iſland cloſe to Pulo Condore. They were ſcarcely arrived upon it when the weather began to lower; and the boat ſet off on its return, in order to reach the ſhip before the impending ſtorm ſhould begin.

"With difficulty it reached the ſhip; and as ſoon as the weather became fair, meſſengers were diſpatched on ſhore to receive and pay for the proviſions promiſed. When they arrived at the village, they were aſtoniſhed to find it abandoned. The houſes were left open, and none of the effects, except ſome arms, that had on the firſt viſit been perceived within them, or even of the poultry feeding about the doors, were taken away. In the principal cabin a paper was found, in the Chineſe language, of which the literal tranſlation purported, as nearly as it could be made, that 'the people of the iſland were few in number, and very poor, yet honeſt, and incapable of doing miſchief; but felt much terror at the arrival of ſuch great ſhips and powerful perſons, eſpecially as not being able to ſatisfy their wants in regard to the quantity of cattle and other proviſions, of which the poor inhabitants of Pulo Condore had ſcarcely any to ſupply, and conſequently could not give the expected ſatisfaction. They therefore, through dread and apprehenſion, reſolved to fly to preſerve their lives. That they ſupplicate the great people to have pity on them; that they left all they had behind them, and only requeſted that their cabins might not be burnt; and conclude by proſtrating themſelves to the great people a hundred times.'

"The writers of this letter had probably received ill treatment from other ſtrangers. It was determined that they ſhould not continue to think ill of all who came to viſit them. On their return they were perhaps as much ſurpriſed to find their houſes ſtill entire, as their viſitors had been who found they were deſerted. Nothing was diſturbed; and a ſmall preſent, likely to be acceptable to the chief, was left for him in the principal dwelling, with a Chineſe letter, ſignifying that 'the ſhips and people were Engliſh, who called merely for refreſhment, and on fair terms of purchaſe, without any ill intention; being a civilized nation, endowed with principles of humanity, which did not allow them to plunder or injure others who happened to be weaker or fewer than themſelves."

Pulo Lingen, another of this cluſter, is likewiſe a conſiderable iſland, remarkable for a mountain in its centre, terminating in a fork like Parnaſſus; but to which the unpoetical ſeamen beſtow the name of *aſſes ears*. Every day preſented new iſlands to the view, diſplaying a vaſt variety in form, ſize, and colour. Some iſolated, and ſome collected in cluſters. Many were clothed with verdure; ſome had tall trees growing on them; others were mere rocks, the reſort of innumerable birds, and whitened with their dung.

PUNCTUATION, in grammar, is an art with which we have ſaid, in the *Encyclopædia*, that the ancients were entirely unacquainted. Candour obliges us to confeſs that this was ſaid raſhly. A learned writer, in the Monthly Magazine for September 1798, who ſubſcribes J. WARBURTON, has proved, we think completely, that the art is not wholly modern; and we ſhall lay his proofs, in his own words, before our readers.

" Some ſpecies of pauſes and diviſions of ſentences in ſpeaking and writing muſt have been coeval with the knowledge of communicating ideas by ſound or by ſymbols. Suidas * ſays, that the *period* and the *colon* were diſcovered and explained by Thraſymacus, about 380 years before the Chriſtian æra. Cicero † ſays, that Thraſymacus was the firſt who ſtudied oratorical numbers, which entirely conſiſted in the artificial ſtructure of periods and colons. It appears from a paſſage in Ariſtotle ‡, that punctuation was known in his time. The learned Dr Edward Bernard § refers the knowledge of pointing to the time of that philoſopher, and ſays, that it conſiſted in the different poſitions of one ſingle point. At the bottom of a letter, thus, (A.) it was equivalent to a comma; in the middle (A·) it was equal to a colon; at the top (A˙) it denoted a period, or the concluſion of a ſentence.

" This mode was eaſily practiſed in Greek manuſcripts, while they were written in capitals. But when the ſmall letters were adopted, that is, about the 9th century, this diſtinction could not be obſerved; a change was therefore made in the ſcheme of punctuation. *Unciales literas hodierno uſu dicimus eas in vetuſtis codicibus, quæ priſcam formam ſervant, ac ſolutæ ſunt; nec mutuò colligantur. Hujus modi literæ unciales obſervantur in libris omnibus ad nonum uſque ſæculum*—Montf. Palæog. Recens. p. xii.

" According to Cicero, the ancient Romans, as well as the Greeks, made uſe of points. He mentions them under the appellation of *librariorum notæ*; and in ſeveral parts of his works he ſpeaks of '*interpunctæ clauſulæ in orationibus*,' of '*clauſulæ atque interpuncta verborum*,' of '*interpunctiones verborum*,' &c *.

" Seneca, who died A. D. 65, expreſsly ſays, that Latin writers, in his time, had been uſed to punctuation. '*Nos* †, *cum ſcribimus interpungere conſuevimus*.' Muretus and Lipſius imagined that theſe words alluded to the inſertion of a point after each word: but they certainly were miſtaken; for they muſt neceſſarily refer to marks of punctuation in the diviſion of ſentences, becauſe in the paſſage in which theſe words occur, Seneca is ſpeaking of one Q. Haterius, who made no pauſes in his orations.

" According to Suetonius, in his *Illuſt. Gram.* Valerius Probus procured copies of many old books, and employed himſelf in correcting, pointing, and illuſtrating them; devoting his time to this and no other part of grammar. *Multa exemplaria contracta emendare, ac diſtinguere et adnotare curavit; ſoli huic, nec ulli præterea, grammatices parti deditus.*

" It appears from hence, that in the time of Probus, or about the year 68, Latin manuſcripts had not been uſually pointed, and that grammarians made it their buſineſs to ſupply this deficiency.

" Quintilian, who wrote his celebrated treatiſe on Oratory, about the year 88, ſpeaks of commas, colons, and periods; but it muſt be obſerved, that by theſe terms he means clauſes, members, and complete ſentences, and not the marks of punctuation ‡.

" Ælius Donatus § publiſhed a treatiſe on Grammar in the 4th century, in which he explains the *diſtinctio*, the *media diſtinctio*, and the *ſubdiſtinctio*; that is, the uſe of a ſingle point in the various poſitions already mentioned.

" Jerom *, who had been the pupil of Donatus, in his Latin Verſion of the Scriptures, made uſe of certain diſtinctions or diviſions, which he calls *cola* and *commata*. It has, however, been thought probable, that theſe diviſions were not made by the addition of any points or ſtops; but were formed by writing, in one line, as many words as conſtituted a clauſe, equivalent to what we diſtinguiſh by a comma or a colon. Theſe diviſions were called στιχοι or ρηματα; and had the appearance of ſhort irregular verſes in poetry. There are ſome Greek manuſcripts ſtill extant, which are written in this manner †."

Mr Warburton ſays, that the beſt treatiſe upon punctuation that he has ſeen, was publiſhed ſome years ſince by an anonymous author, and dedicated to Sir Clifton Wintringham, Bart. With that treatiſe we are not acquainted; but we do not think that the art of punctuation can be taught by rules. The only way to acquire it is to obſerve attentively how the moſt perſpicuous writers diſpoſe of their periods, colons, ſemicolons, and commas. This will make us acquainted with the importance of each; and then every writer, who knows his own meaning, muſt be capable of pointing his own pages more correctly than any other man.

PYRAMIDOID, is ſometimes uſed for the parabolic ſpindle, or the ſolid formed by the rotation of a ſemiparabola about its baſe or greateſt ordinate. See Parabolic *Spindle*.

PYRITES. See Mineralogy in this *Suppl.*—In the third volume of Mr Nicholſon's Philoſophical Journal, we have a method of making artificial pyrites, which we ſhall give in the words of the author.

" I impregnated water (ſays he) very ſtrongly with carbonic acid, and introducing ſome iron filings, I continued the impregnation for a day or two, and afterwards allowed the water to ſtand in a well corked bottle for ſome days, till the acid had taken up as much iron as poſſible. I then poured it into an aerating apparatus; threw up the hepatic gas from ſulphuret of potaſh and ſulphuric acid; and after having agitated the water till it had got a good doſe of the gas, I poured the water into a large baſon: this was in the evening, and next morning when I looked at it I found it covered with a pretty thick film of a moſt beautiful variegated pyrites. I had ſo little of it, that the only proof I had of its being this ſubſtance was, that it was ignited on its being placed on a hot poker."

QUADRATURE,

---

* Qui primus periodum et colon monſtravit. *Suidas de Thraſymacho.*

† *Cicero Orat.* § 33.

‡ *Rhet.* Lib. iii. c 5.

§ *Bern. Orbis erud. Literat* tab 30. edit. 1689.

* *Cic. de Orat.* l. iii. § 20 ibid. 7. *Orat pro Muræna*, § 25.

† *Sen. Epiſt.* 40.

‡ *Quint.* l. ix. c. 4.

§ A. D. 34

* *Hieron. Præf in I ſaiam. Vi etiam. Præ in Joſuam,* &c tom.ii p. 26.

† *Vide Montf. Palæog. Græca,* lib. iii. c.

Q.

QUADRATURE, in geometry (ſee that article, and likewiſe **Fluxions**, *Encycl.*), has employed the time and ingenuity of ſome of the moſt eminent mathematicians both of ancient and of modern times. Dr Halley's method of computing the ratio of the diameter of the circle to its circumference, was conſidered by himſelf, and other learned mathematicians, as the eaſieſt the problem admits of. And although, in the courſe of a century, much eaſier methods have been diſcovered, ſtill a celebrated mathematician of our own times has expreſſed an opinion, that no other aliquot part of the circumference of a circle can be ſo eaſily computed by means of its tangent as that which was choſen by Dr Halley, viz. the arch of 30 degrees. Without taking upon him to determine whether this opinion be juſt or not, the Rev. John Hellins has ſhewn how the ſeries by which Dr Halley computed the ratio of the diameter to the circumference of the circle may be transformed into others of ſwifter convergency, and which, on account of the ſucceſſive powers of $\frac{1}{10}$ which occur in them, admit of an eaſy ſummation. We ſhall give the memoir in the author's own words.

"1. The propoſed transformation is obtained by means of different forms in which the fluents of ſome fluxions may be expreſſed; and to proceed with greater clearneſs, "I will here (ſays Mr Hellins) ſet down the fluxion in a general form, and its fluent, in the two ſeries which are uſed in the following particular inſtance, and may be applied with advantage in ſimilar caſes.

"2. The fluent of $\frac{x^{m-1}\dot{x}}{1-x^n}$ is $= \frac{x^m}{m} + \frac{x^{m+n}}{m+n} + \frac{x^{m+2n}}{m+2n} + \frac{x^{m+3n}}{m+3n}$, &c. which ſeries, being of the ſimpleſt form which the fluent ſeems to admit, was firſt diſcovered, and probably is the moſt generally uſeful. But it has alſo been found, that the fluent of the ſame fluxion may be expreſſed in ſeries of other forms, which, though leſs ſimple than that above written, yet have their particular advantages. Amongſt thoſe other forms of ſeries which the fluent admits of, that which ſuits my preſent purpoſe is $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2n.x^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3} - \frac{n.2n.3n.x^{m+3n}}{m.\overline{m+n}.\overline{m+2n}.\overline{m+3n}.\overline{1-x^n}|^4}$ + &c. which, to ſay nothing of other methods, may eaſily be inveſtigated by the rule given in p. 64. of the third edition of *Emerſon's Fluxions*; or its equality with the former ſeries may be proved by algebra.

"3. On account of the ſign — before x^n, in the laſt ſeries, it may be proper to remark, that its convergency, by a geometrical progreſſion, will not ceaſe till $\frac{x^n}{1-x^n}$ becomes $= 1$, or x becomes $= \sqrt[n]{\frac{1}{2}}$; and that when x is a ſmall quantity, and n a large number, this ſeries will converge almoſt as ſwiftly as the former. For inſtance, if x be $= \sqrt{\frac{1}{3}}$, and $n = 8$, which are the values in the following caſe, the former ſeries will converge by the quantity $x^n = \sqrt{\overline{\tfrac{1}{3}}}|^8 = \frac{1}{81}$, and this ſeries by the quantity $\frac{x^n}{1-x^n} = \frac{\frac{1}{81}}{1-\frac{1}{81}} = \frac{1}{80}$; where the difference in convergency will be but little, and the diviſions by 80 eaſier than thoſe by 81.

"4. With reſpect to the indices m and n, as they are here ſuppoſed to be affirmative whole numbers, and will be ſo in the uſe I am about to make of them, the reader need not be detained with any obſervations on the caſes in which theſe fluents will fail, when the indices have contrary ſigns.

"5. It may be proper further to remark, that by putting $\frac{x^n}{1-x^n} = z$, and calling the firſt, ſecond, third, &c. terms of the ſeries $\frac{x^m}{m.\overline{1-x^n}} - \frac{nx^{m+n}}{m.\overline{m+n}.\overline{1-x^n}|^2} + \frac{n.2nx^{m+2n}}{m.\overline{m+n}.\overline{m+2n}.\overline{1-x^n}|^3}$ + &c. A, B, C, &c. reſpectively, the ſeries will be expreſſed in the conciſe and elegant notation of Sir Iſaac Newton, viz. $\frac{x^m}{m.\overline{1-x^n}} - \frac{nzA}{m+n} + \frac{2nzB}{m+2n} - \frac{3nzC}{m+3n}$ + &c. which is well adapted to arithmetical calculation.

"6. I come now to the transformation propoſed, which will appear very eaſy, as ſoon as the common ſeries, expreſſing the length of an arch in terms of its tangent, is properly arranged.

"If the radius of a circle be 1, and the tangent of an arch of it be called t, it is well known that the length of that arch will be $= t - \frac{t^3}{3} + \frac{t^5}{5} - \frac{t^7}{7} + \frac{t^9}{9} - \frac{t^{11}}{11}$ + &c. Now, if the affirmative terms of this ſeries be written in one line, and the negative ones in another, the arch will be

$$= \begin{cases} t + \frac{t^5}{5} + \frac{t^9}{9} + \frac{t^{13}}{13} + \frac{t^{17}}{17} + \&c. \\ -\frac{t^3}{3} - \frac{t^7}{7} - \frac{t^{11}}{11} - \frac{t^{15}}{15} - \frac{t^{19}}{19} - \&c. \end{cases}$$

And if, again, the firſt, third, fifth, &c. term of each of theſe ſeries be written in one line, and the ſecond, fourth, ſixth, &c. in another, the ſame arch will be expreſſed thus:

$$= \begin{cases} + \begin{cases} t + \frac{t^9}{9} + \frac{t^{17}}{17} + \frac{t^{25}}{25} + \frac{t^{33}}{33} + \&c. \\ \frac{t^5}{5} + \frac{t^{13}}{13} + \frac{t^{21}}{21} + \frac{t^{29}}{29} + \frac{t^{37}}{37.} + \&c. \end{cases} \\ \hline - \begin{cases} \frac{t^3}{3} + \frac{t^{11}}{11} + \frac{t^{19}}{19} + \frac{t^{27}}{27} + \frac{t^{35}}{35} + \&c. \\ \frac{t^7}{7} + \frac{t^{15}}{15} + \frac{t^{23}}{23} + \frac{t^{31}}{31} + \frac{t^{39}}{39} + \&c. \end{cases} \end{cases}$$

All which ſeries are evidently of the firſt form in article 2. and therefore their values may be expreſſed in the ſecond form there given, or more neatly the Newtonian notation mentioned in art. 5. In each of theſe ſeries the value of n is 8:

$$\text{And the value of } m, \begin{cases} \text{in the firſt ſeries, is 1;} \\ \text{in the ſecond ſeries, is 5;} \\ \text{in the third ſeries, is 3;} \\ \text{in the fourth ſeries, is 7.} \end{cases}$$

"If now we take $t = \sqrt{\frac{1}{3}}$, the tangent of 30°, which was choſen by Dr Halley, we ſhall have the arch of 30°

$$=\left\{\begin{array}{l} +\left\{\begin{array}{l} \frac{1}{\sqrt{3}}\times:1+\frac{1}{9.81}+\frac{1}{17.81^2}+\frac{1}{25.81^3}+\frac{1}{33.81^4}, \text{\&c.} \\ \frac{1}{9\sqrt{3}}\times:\frac{1}{5}+\frac{1}{13.81}+\frac{1}{21.81^2}+\frac{1}{29.81^3}+\frac{1}{37.81^4}, \text{\&c.} \end{array}\right. \\ \hline -\left\{\begin{array}{l} \frac{1}{3\sqrt{3}}\times:\frac{1}{3}+\frac{1}{11.81}+\frac{1}{19.81^2}+\frac{1}{27.81^3}+\frac{1}{35.81^4}, \text{\&c.} \\ \frac{1}{27\sqrt{3}}\times:\frac{1}{7}+\frac{1}{15.81}+\frac{1}{23.81^2}+\frac{1}{31.81^3}+\frac{1}{39.81^4}, \text{\&c.} \end{array}\right. \end{array}\right.$$

Six timees this quantity will be = the ſemicircumference when radius is 1, and = the whole circumference when the diameter is 1. If therefore we multiply the laſt ſeries by 6, and write $\sqrt{12}$ for $\frac{6}{\sqrt{3}}$, and expreſs their value in the form given in art. 5. we ſhall have the circumference of a circle whoſe diameter is 1,

$$=\left\{\begin{array}{l} +\left\{\begin{array}{l} \frac{81\sqrt{12}}{80}-\frac{8A}{9.80}+\frac{16B}{17.80}-\frac{24C}{25.80}+\frac{32D}{33.80}, \text{\&c.} \\ \frac{81\sqrt{12}}{5.9.80}-\frac{8A}{13.80}+\frac{16B}{21.80}-\frac{24C}{29.80}+\frac{32D}{37.80}, \text{\&c.} \end{array}\right. \\ \hline -\left\{\begin{array}{l} \frac{81\sqrt{12}}{3.3.80}-\frac{8A}{11.80}+\frac{16B}{19.80}-\frac{24C}{27.80}+\frac{32D}{35.80}, \text{\&c.} \\ \frac{81\sqrt{12}}{7.27.80}-\frac{8A}{15.80}+\frac{16B}{23.80}-\frac{24C}{31.80}+\frac{32D}{39.80}, \text{\&c.} \end{array}\right. \end{array}\right.$$

"7. All theſe new ſeries, it is evident, converge ſomewhat ſwifter than by the powers of 80. For in the firſt ſeries, which has the ſloweſt convergency, the coefficients $\frac{8}{9}$, $\frac{16}{17}$, $\frac{24}{25}$, &c. are each of them leſs than 1; ſo that its convergency is ſomewhat ſwifter than by the powers of 80.

"8. But another advantage of theſe new ſeries is, that the numerator and denominator of every term except the firſt, in each of them, is diviſible by 8; in conſequence of which, the arithmetical operation by them is much facilitated, the diviſion by 80 being exchanged for a diviſion by 10, which is no more than removing the decimal point. Theſe ſeries, then, when the factors which are common to both numerators and denominators are expunged, will ſtand as below (each of which ſtill converging ſomewhat quicker than by the powers of 80), and we ſhall have the circumference of a circle whoſe diameter is 1,

$$=\left\{\begin{array}{l} +\left\{\begin{array}{l} \frac{81\sqrt{12}}{80}-\frac{A}{9.10}+\frac{2B}{17.10}-\frac{3C}{25.10}+\frac{4D}{33.10}, \text{\&c.} \\ \frac{9\sqrt{12}}{400}-\frac{A}{13.10}+\frac{2B}{21.10}-\frac{3C}{29.10}+\frac{4D}{37.10}, \text{\&c.} \end{array}\right. \\ \hline -\left\{\begin{array}{l} \frac{9\sqrt{12}}{80}-\frac{A}{11.10}+\frac{2B}{19.10}-\frac{3C}{27.10}+\frac{4D}{35.10}, \text{\&c.} \\ \frac{3\sqrt{12}}{7.80}-\frac{A}{15.10}+\frac{2B}{23.10}-\frac{3C}{31.10}+\frac{4D}{39.10}, \text{\&c.} \end{array}\right. \end{array}\right.$$

"By which ſeries the arithmetical computation will be much more eaſy than by the original ſeries."

Quadrature Lines, or *Lines of Quadrature*, are two lines often placed on Gunter's ſector. They are marked with the letter Q, and the figures 5, 6, 7, 8, 9, 10; of which Q denotes the ſide of a ſquare, and the figures denote the ſides of polygons of 5, 6, 7, &c. ſides. Alſo S denotes the ſemidiameter of a circle, and 90 a line equal to the quadrant or 90° in circumference.

QUADRIPARTITION, is the dividing by 4, or into four equal parts. Hence *quadripartite*, &c. the 4th part, or ſomething parted into four.

QUADRUPLE, is four-fold, or ſomething taken four times, or multiplied by 4; and ſo is the converſe of quadripartition.

QUART, a meaſure of capacity, being the quarter or 4th part of ſome other meaſure. The Engliſh quart is the 4th part of the gallon, and contains two pints. The Roman quart, or quartarius, was the 4th part of their congius. The French, beſides their quart or pot of two pints, have various other quarts, diſtinguiſhed by the whole of which they are quarters; as *quart de muid*, and *quart de boiſſeau*.

QUARTILE, an aſpect of the planets when they are at the diſtance of three ſigns or 90° from each other; and is denoted by the character □.

QUELPAERT, an iſland lying in the mouth of the channel of Japan, and ſubject to the king of COREA (See that article *Encycl.*) Till the laſt voyage of La Perouſe, this iſland was known to Europeans only by the wreck of the Dutch ſhip Sparrow-hawk in 1635. On the 21ſt of May 1787, the French Commodore made this iſland, and determined the ſouth point of it to be in Lat. 33° 14′ north, and in Lon. 124° 15′ eaſt from Paris. He ran along the whole ſouth eaſt ſide, at ſix leagues diſtance, and ſays that it is ſcarcely poſſible to find an iſland which affords a finer aſpect; a peak of about a thouſand toiſes, which is viſible at the diſtance of eighteen or twenty leagues, occupies the middle of the iſland, of which it is doubtleſs the reſervoir; the land gradually ſlopes towards the ſea, whence the habitations appear as an amphitheatre. The ſoil ſeemed to be cultivated to a very great height. By the aſſiſtance of glaſſes was perceived the diviſion of fields; they were very much parcelled out, which is the ſtrongeſt proof of a great population. The very varied gradation of colours, from the different ſtates of cultivation, rendered the view of this iſland ſtill more agreeable. Unfortunately, it belongs to a people who are prohibited from all communication with ſtrangers, and who detain in ſlavery thoſe who have the misfortune to be ſhipwrecked on theſe coaſts. Some of the Dutchmen of the ſhip Sparrow-hawk, after a captivity of eighteen years there, during which they received many baſtinadoes, found means to take away a bark, and to croſs to Japan, from which they arrived at Batavia, and afterwards at Amſterdam.

QUEUE D'ARONDE, or *Swallow's Tail*, in fortification, is a detached or outwork, whoſe ſides ſpread or open towards the campaign, or draw narrower and cloſer towards the gorge. Of this kind are either ſingle or double tenailles, and ſome horn-works, whoſe ſides are not parallel, but are narrow at the gorge, and open at the head, like the figure of a ſwallow's tail. On the contrary, when the ſides are leſs than the gorge, the work is called *contre queue d'aronde*.

Queue, Quintal

Queue d'aronde, in carpentry, a method of jointing, called alſo *dove-tailing*.

QUINTAL, the weight of a hundred pounds, in moſt countries: but in England it is the hundred weight, or 112 pounds. Quintal was alſo formerly uſed for a weight of lead, iron, or other common metal, uſually equal to a hundred pounds, at 6 ſcore to the hundred.

Quintile.

QUINTILE, in aſtronomy, an aſpect of the planets when they are diſtant the 5th part of the zodiac, or 72 degrees; and is marked thus, C, or O.

R.

Rachitis.

RACHITIS, Rickets (See Medicine-*Index*, *Encycl.*), is a diſeaſe ſo formidable to children, that we believe no parent will think the following abſtract of *Bonhomme*'s memoir on the nature and treatment of it too long even for this *Supplement*.

The change which the bones undergo in this diſorder, has long been attributed to the action of an acid on their ſubſtance; but this ſuppoſition was grounded on mere conjecture and remote analogy. Bonhomme holds the ſame opinion on better grounds; and the principal notions which conſtitute the baſis of his memoir are the following:

1. According to him, the nature of the rachitic diſorder ariſes, on the one hand, from the developement of an acid approaching in its properties to the vegetable acids, particularly the oxalic; and, on the other, from the defect of phoſphoric acid, of which the combination with the animal calcareous earth forms the natural baſis of the bones, and gives them their ſolidity. Whence it follows, that the indication reſulting from this propoſition, if once adopted, would be, that the treatment of rachitis muſt depend on two principal points, namely, to prevent the developement of the oxalic acid, and to re eſtabliſh the combination of the phoſphoric acid with the baſis of the bones to which they owe their ſolidity.

2. The author proves, by experiments and obſervations, in the firſt place, that alkaline lotions of the parts affected with rachitis contribute to their cure; next, that the calcareous phoſphate taken internally is really tranſmitted by the lymphatic paſſages, and contributes to oſſification; and, laſtly, that the internal uſe of calcareous phoſphate, whether alone or combined with the phoſphate of ſoda, powerfully contributes to reſtore the natural proportions in the ſubſtance of the bones, and accelerate the cure of rachitis.

With regard to the author's endeavours to prove that the calcareous acid is wanting in the bones of thoſe who are diſordered with rachitis, and that the developement of oxalic acid contributes to the diſeaſe, we muſt not conceal that his memoir contains views rather than abſolute proofs of theſe two poſitions. He declares, himſelf, he was not provided with the neceſſary means to eſtabliſh an exact and complete analyſis. He therefore preſents his ideas, in this reſpect, merely as conjectures approaching to the truth.

The effect of the action of acids upon bones was before known; that is to ſay, that when deprived of calcareous phoſphate, and reduced to the gelatinous parenchyma which forms one of their elements, they loſe their conſiſtence, and become flexible. Hence it was already conjectured by various phyſicians, that the rachitis was the effect of a peculiar acid.

Rachitis.

A diſpoſition to aceſcence in the firſt paſſages is obſervable in all infants. The odour which characterizes this aceſcence is often manifeſt in their breath, and even their perſpiration. The bile corrects this diſpoſition; but in general the bile is wanting in rachitic infants. It does not colour their excrements, and the acids accordingly are developed in a very decided manner. They diſturb the circulation, and attack and ſoften the bones. As it is by defect of animalization that theſe acids develope themſelves, it follows that their character is analogous to the fermenteſcible vegetable acids, and more or leſs to the oxalic acid; and that, on the contrary, the animal acid or phoſphoric acid ceaſes to be formed, and to unite with the animal calcareous earth; whence they are deprived of the principle of their ſolidity. This is the theory of Citizen Bonhomme.

In order to eſtabliſh this doctrine upon preciſe experiments, it was requiſite to analyſe rachitic bones comparatively with thoſe of healthy individuals of the ſame age; and as it is known that the urine of rachitic ſubjects depoſites a great quantity of a ſubſtance of ſparing ſolubility and earthy appearance, it would have been advantageous to have joined a complete analyſis of this urine and its ſediment. Citizen Bonhomme, not being provided with the means ſufficient to make theſe analyſes, and being beſides of opinion that ſuch rachitic bones as are deſtroyed by this malady exiſt in a progreſſive ſtate of change, which might render their analyſis ſcarcely ſuſceptible of compariſon, limited himſelf to a collection of ſome of the moſt remarkable phenomena of the urine, of the aged, the adult, and infants in the healthy ſtate, of infants in the rachitic ſtate, and of patients after the perfect cure of this diſorder. From theſe obſervations he has deduced ſeveral important reſults.

It is known, that when the urine contains diſengaged phoſphoric acid, as happens to aged individuals, and in ſome peculiar circumſtances of the ſyſtem, if lime water be poured in, there is a ſpeedy depoſition of calcareous phoſphate. It is alſo known, that when a ſolution of the nitrate of mercury is poured to the freſh urine of adults, a roſe-coloured precipitate is formed, which is a phoſphate of mercury produced by the decompoſition of the phoſphates contained in the urine. Theſe two proofs are therefore extremely proper to aſcertain the preſence of phoſphoric acid, whether free or combined, in a fluid which in its natural ſtate contains a remarkable proportion. Beſides this principle, the urine depoſits more or leſs of ſediment, either gelatinous or of an earthy appearance; and, laſtly, by evaporation, a ſaponaceous and ſaline extract, in greater or leſs abundance, is obtained by evaporation. By means of theſe four methods of examination, the author has aſcertained the following facts:

1. In the healthy ſtate, the ſediment naturally depoſited by urine is almoſt totally gelatinous in the infant and the adult, and in the aged individual it is ſurcharged with an abundant ſediment of an earthy appearance ſimilar to the earth of bones, which conſequently is calcareous phoſphate. 2. The quantity of brown ſaponaceous ſaline extract afforded by evaporation is greater in proportion to the age. 3. The preſence of diſengaged phoſphoric acid, as ſhewn by lime water, is none in the urine of infants, ſcarcely perceptible in that of adults, but very remarkable in that of old men. For two ounces of this laſt urine afforded by this means ten grains of phoſphate of lime. 4. The decompoſition of the phoſphates by nitrate of mercury is not ſeen in the urine of infants; an abundant precipitate of a light roſe-colour is produced in this way from the urine of adults; and in that of old men this precipitate is always of a grey colour, and very abundant. Hence Citizen Bonhomme concludes, that the phoſphoric acid, whether at liberty or combined, does exiſt in the urine of healthy individuals in proportion to the deſtruction of the ſolids by age, and that it increaſes with the age.

With regard to the urine of rachitic ſubjects, the moſt remarkable facts are, 1. The abundant and apparently earthy ſediment it depoſits (ſpontaneouſly) is different from that of old men, by its colour, which is grey, and does not reſemble phoſphate of lime, and alſo by its much greater quantity. For a pound of this urine let fall two gros, whereas the ſame quantity of the urine of old men depoſited only 45 grains. 2. The extract left by evaporation is likewiſe much more conſiderable than in other urine. It is one-third more in quantity than the extract afforded even by the urine of aged perſons.

From theſe two firſt obſervations it follows, that the ſolids in rachitic ſubjects are deſtroyed with much more rapidity than even in old men; and that they afford a much more abundant portion of waſte to the urine.

3. The light depoſition occaſioned by lime water in the urine of rachitic ſubjects is very ſmall in quantity, brown, gelatinous when freſh, and pulverulent when dry. It does not at all reſemble calcareous phoſphate. 4. The depoſition formed by the ſolution of mercurial nitrate is not abundant, neither of a roſe colour as in the urine of adults, nor grey like that of old men. It is always white, and conſequently has no external reſemblance to the phoſphate of mercury. The author affirms that it reſembles a mercurial oxalate. Laſtly, the urine of the ſame rachitic ſubjects when cured, exhibits again all the characters obſerved in the urine of healthy children. We ſhall not add to the reflections of the author. In effect, though theſe firſt obſervations are curious, they are incomplete. We offer them to phyſicians ſimply as the elements of an inveſtigation which it is of importance to continue and bring to perfection. We ſhall therefore proceed to the curative and experimental parts of the memoir.

One of the facts which it was of the utmoſt importance to eſtabliſh, was the tranſition of the calcareous phoſphate from the inteſtinal paſſages, into thoſe of circulation and ſecretion. Fourcroy had already well aſcertained that the ſerum of milk contains this ſalt naturally. Vauquelin had proved its exiſtence, as well as that of pure ſoda, in the ſeminal fluid; but was it poſſible that it could paſs unaltered from the ſtomach and inteſtines into the veſſels which contain the blood and lymph? Could it by this means apply itſelf to the bones? This was to be aſcertained by experiments; and the following are the experiments made by Bonhomme for that purpoſe. We give them in a tranſlation of his own words.

"I cauſed (ſays he) ſeveral young fowls of the ſame incubation to be fed in different manners. Some received the uſual food without any mixture; others received daily a certain quantity of calcareous phoſphate mixed in the ſame paſte as formed the ſupport of the others; and, laſtly, one of them was fed with variations in the uſe of the mixture: the calcareous phoſphate was ſometimes given and ſometimes ſuſpended. When theſe fowls, after two months, had acquired their ordinary growth, I examined and carefully compared the ſtate of their bones. The progreſs of the oſſification in the epiphyſes was various according to the nature of the food the animal had received. The bones of the laſt fowl, which had received the phoſphate only from time to time, were rather more advanced than the bones of thoſe which had been fed without mixture. The bones of thoſe fowls which had been habitually fed with the mixture were evidently more ſolid, and their epiphyſes were much leſs perceptible. Simple inſpection was ſufficient to ſhew theſe differences when the bones were mixed together.

"I had fed ſeveral young fowls of the ſame incubation according to another plan. Some were fed on a ſimple paſte, without mixture; for others it was mixed with pulveriſed madder-root; and a third compoſition was made of this laſt paſte and calcareous phoſphate. This was alſo given habitually to other fowls. When after two months I examined the progreſs of oſſification in the bones of theſe different animals, I eaſily perceived the red traces of the madder in the oſſified parts of all thoſe which had uſed it; but I obſerved, that the oſſification was not more advanced by the ſimple mixture of this root than by the ordinary food: on the contrary, the bones of thoſe fowls which had ſwallowed the phoſphate mixed with madder were much more ſolid than the others. The red colour ſerved admirably to diſtinguiſh the extremities of the long bones from their epiphyſes. After an exact compariſon, there could be no doubt of the efficacy of calcareous phoſphate in favour of the progreſs of oſſification. The virtue of the madder ſeemed confined to that of giving colour to the oſſified parts."

From theſe experiments, it was natural to make the trial of calcareous phoſphate in addition to the remedies made uſe of in the treatment of rachitic ſubjects. Here follows what the author himſelf ſays of two remarkable inſtances in which the calcareous phoſphate was adminiſtered with ſucceſs:

"The daughter of Mr Ranchon watch-maker, aged two years and a half, walked with a feeble and tottering pace, and the extremities of all her bones preſented epiphyſes very

Rachitis.

very prominent. In this ſituation ſhe exhibited the appearance of imperfect rachitis, or the firſt period of this diſorder. Alkaline lotions, which I immediately adviſed, were attended with a good effect. Her ſleep became more firm; and as the firſt paſſages were in a good ſtate, I gave, without internal preparation, one ſcruple of a mixture of equal parts of phoſphate of lime and phoſphate of ſoda twice a day. In the courſe of three weeks her legs were perfectly reſtored; and this amiable infant has ever ſince had the ſatisfaction to run with ſpirit and agility.

" A female infant, of the name of Boiard, aged four years had experienced from her birth the moſt decided ſymptoms of rachitis. The protuberance of the epiphyſes and tumefaction of the abdomen firſt indicated the diſeaſe. The impoſſibility of ſupporting herſelf and walking at the uſual age confirmed theſe unfortunate ſymptoms. By degrees the glands of the neck and of the meſentery became ſwelled; the teeth were blackened, became carious, and were not replaced. This ſituation became ſtill more afflicting by criſes almoſt periodical at an interval of three or four weeks. At theſe afflicting periods, a fever of conſiderable ſtrength, cardialgia, and even convulſions, particularly in the night, were obſerved. The termination of each paroxyſm was announced or aſcertained by abundant ſtools, and the evacuation of urine ſtrongly charged with an earthy ſediment. The imprudent exhibition of a purge at the beginning of one of theſe criſes had nearly deprived the patient of her life. In this ſtate it was that I beheld her for the firſt time in the month of January 1791. The alkaline lotion was the only remedy the mother adopted in the firſt inſtance, and it produced a remarkable effect. After eight days the infant was ſo much better as to be able to ſupport herſelf. The remedy was then laid aſide, and eight days aftewards the child was incapable of ſtanding without ſupport. The uſe of the alkaline ſolution being renewed, was attended with the ſame ſucceſs, and its diſcontinuance was again followed by the complete return of all the ſymptoms. In the firſt days of March, the other remedies I had adviſed were exhibited. The conſtipation which had always exiſted became leſs, and the following criſis was effected without pain. And at length the convulſions, the pains, and the criſes diſappeared; but the impoſſibility of walking ſtill remained. At this time, namely on the ſecond of May, I gave the child the phoſphate of ſoda and calcareous phoſphate mixed together, in the doſe of half a dram twice a-day. At the end of the month ſhe was able to ſtand upright, leaning againſt a chair, and the ſwellings began to diminiſh. She continued for a long time afterwards to take the mixture of the phoſphates. I likewiſe gave her occaſionally one grain of the extract of bile, prepared with ſpirit of wine; and at length in the month of July I had the pleaſure to ſee the patient run and play in the middle of the ſtreet with the other children of her own age, &c."

The author gives other inſtances of this medicine being adminiſtered with complete ſucceſs to rachitic children, and one in which it was attended with the beſt effects in a caſe of incurvated ſpine. Theſe it is needleſs to inſert, becauſe we truſt that none of our leſs learned readers will have recourſe to the medicine without the advice of a phyſician; and to him an enumeration of caſes could ſerve no purpoſe. It may be proper, however, as alkaline lotions and their beneficial effects are mentioned, to give here the author's account of the lotion which he uſed.

Rachitis, Raja.

" In ordinary caſes of rachitis, particularly at the commencement of the diſorder, it is of advantage to uſe a ſimple ſolution of pot-aſh to waſh the parts affected. This ſolution is made by diſſolving from half an ounce to an ounce of purified pot-aſh in a pound of diſtilled or very pure ſpring water. When it is to be uſed, the ſkin muſt firſt be rubbed with a dry cloth or a piece of fine flannel. After this precaution, the diſeaſed extremities are to be waſhed carefully with the warm ſolution, and at length wiped, ſo as to leave no trace of moiſture. This practice and waſhing muſt be repeated at leaſt twice a-day. I can affirm, from repeated trials, that it will ſoon be attended with ſucceſs."

In a note on this paſſage, M. Hallé, who analyſed the memoir at the deſire of the Society of Medicine at Paris, juſtly obſerves, that as pure potaſs, or the vegetable alkali, is a moſt powerful cauſtic, it cannot be uſed in theſe proportions; adding, that he found one-eighth part of the ſalt here indicated to form too ſtrong a lotion for the ſkin of an infant. M. Bonhomme, upon enquiry being made, informed him, that the potaſs which he uſed was that of the ſhops, which is very far from being pure; and Mr Nicholſon conjectures that it was the common ſalt of tartar of our ſhops. This, we think, extremely probable, eſpecially as M. Bonhomme aſſures us that even a lixium of wood-aſhes, ſuch as is uſed for waſhing fine linen, may anſwer the purpoſe extremely well.

For a fuller account of this intereſting memoir our readers are referred to the 17th volume of the *Annals de Chimie*, or to the firſt volume of *Nicholſon's Philoſophical Journal.*

RAJA, the *ray fiſh*. See *Encyclopædia*, where it is ſaid that the *oxyrinchus* or ſharp noſed ray, is ſuppoſed to be the *bos* of the ancients; but if there be any truth in the following narrative, which we confeſs has much the air of fiction, this is probably a miſtake. It is the narrative of Vaillant, and we ſhall give it in his own words.

" In the latitude 10° 15′ north, and longitude 355°, an enormous flat fiſh of the ray genus (ſays he), came and ſwam round our veſſel. It differed from the common ray, however, in the ſhape of its head, which, inſtead of being pointed, formed a creſcent, and from the extremities of the ſemicircle iſſued two arms as it were, which the ſailors called horns. They were two feet wide at the baſe, and only five inches at the extremity. This monſter they told me was called the *ſea-devil*.

" A few hours after, we ſaw two others with this, one of which was ſo extremely large, that it was computed by the crew to be *fifty* or *ſixty* feet wide. Each ſwam ſeparately, and was ſurrounded by thoſe ſmall fiſh which uſually precede the ſhark, and which are therefore called by ſeamen *pilot-fiſh*. Laſtly, all three carried on each of their horns a white fiſh, about the ſize of a man's arm, and half a yard long, which appeared to be ſtationed there on duty.

" You would have ſaid they were two ſentinels placed to keep watch for the ſafety of the animal, to inform him of any approaching danger, and to guide his movements. If he approached too near the veſſel, they quitted their poſts, and, ſwimming briſkly before, led him

him away. If he roſe too high above the water, they paſſed backward and forward over his back till he had deſcended deeper. If, on the contrary, he ſwam too low, they diſappeared, and we ſaw no more of them, becauſe, no doubt, they were paſſing underneath, as in the preceding inſtance they had paſſed above him. Accordingly we found him re-aſcend towards the ſurface, and then the two ſentinels reaſſumed their poſts, each on his horn."

Theſe manœuvres continued three days; and to give our author the better opportunity of obſerving them, the ſhip moſt fortunately was becalmed the whole time. He was naturally very deſirous of catching one of them that he might examine it at leiſure; and, by bribing the ſeamen with a dozen of bottles of wine, he accompliſhed his object. One of the fiſh was ſtruck with twelve or fifteen harpoons; ſeveral halſers were paſſed round his body, and he was hoiſted on board.

" This (ſays our author) was the leaſt of the three, being only *eight-and-twenty* feet in its extreme breadth, and *one-and-twenty* in length from the extremity of the horns to that of the tail. The tail, which was thick in proportion to the body, was *twenty-two inches* long. The mouth, placed exactly like that of the ray, was wide enough to ſwallow a man with eaſe. The ſkin was white under the belly, and brown on the back, like that of the ray. We reckoned the animal to weigh not leſs, certainly, than a ton."

We think it was fortunate that they chanced to ſtrike the ſmalleſt fiſh; for an addition of eight or ten ton weight, which the largeſt ray muſt have weighed, as certainly as the ſmalleſt weighed one ton, might have been very inconvenient on board a ſhip already loaded. We do not remember to have anywhere met with a deſcription of this ray before, and we think it ſhould be conſidered as a new ſpecies; but we ſhall not give it a name till its exiſtence be better aſcertained, when we ſubmit to the pupils of Linnæus, whether it may not be proper to give it the ancient name *bos*.

RAJAH. (See *Encyclopædia*.) We learn from Sir Charles Rouſe Boughton's *Diſſertation concerning the Landed Property of Bengal*, that this title is conferred upon Hindoos by the emperor, and frequently given out of courteſy to the greater zemindars. It would appear therefore that the Rajahs can never be independent of the Mogul but by a ſucceſsful rebellion.

RAYEI-UL-MULK, in the language of Bengal, the uſage of the country, the common law.

RATIO (See *Encyclopædia*) has been defined by Euclid, in the 5th book of his Elements, in terms to which many mathematicians have objected; and his definition of proportion, which is ſo ultimately connected with it, is ſtill more objectionable. The Rev. Abraham Robertſon of Oxford, in a ſmall tract publiſhed in 1789, demonſtrates the truth of the two definitions in queſtion in ſeven propoſitions, of which the ſubſtance is as follows. He firſt lays down theſe four definitions:

" 1. Ratio is the relation which one magnitude has to another, of the ſame kind, with reſpect to quantity.

" 2. If the firſt of four magnitudes be exactly as great when compared to the ſecond, as the third is when compared to the fourth, the firſt is ſaid to have to the ſecond the ſame ratio that the third has to the fourth.

" 3. If the firſt of four magnitudes be greater, when compared to the ſecond, than the third is when compared to the fourth, the firſt is ſaid to have to the ſecond a greater ratio than the third has to the fourth.

" 4. If the firſt of four magnitudes be leſs, when compared to the ſecond, than the third is when compared to the fourth, the firſt is ſaid to have to the ſecond a leſs ratio than the third has to the fourth."

He then demonſtrates, by reaſoning ſtrictly geometrical, the following propoſitions:

Prop. 1. If the firſt of four magnitudes have to the ſecond, the ſame ratio which the third has to the fourth; then, if the firſt be equal to the ſecond, the third is equal to the fourth; if greater, greater; if leſs, leſs.

Prop. 2. If the firſt of four magnitudes be to the ſecond as the third to the fourth, and if any equimultiples whatever of the firſt and third be taken, and alſo any equimultiples of the ſecond and fourth; the multiple of the firſt will be to the multiple of the ſecond as the multiple of the third to the multiple of the fourth.

Prop. 3. If the firſt of four magnitudes be to the ſecond as the third to the fourth, and if any like aliquot parts whatever be taken of the firſt and third, and any like aliquot parts whatever of the ſecond and fourth, the part of the firſt will be to the part of the ſecond as the part of the third to the part of the fourth.

Prop. 4. If the firſt of four magnitudes be to the ſecond as the third to the fourth, and if any equimultiples whatever be taken of the firſt and third, and any whatever of the ſecond and fourth; if the multiple of the firſt be equal to the multiple of the ſecond, the multiple of the third will be equal to the multiple of the fourth; if greater, greater; if leſs, leſs.

Prop. 5. If the firſt of four magnitudes be to the ſecond as the third is to a magnitude leſs than the fourth, then it is poſſible to take certain equimultiples of the firſt and third, and certain equimultiples of the ſecond and fourth, ſuch, that the multiple of the firſt ſhall be greater than the multiple of the ſecond, but the multiple of the third not greater than the multiple of the fourth.

Prop. 6. If the firſt of four magnitudes be to the ſecond as the third is to a magnitude greater than the fourth, then certain equimultiples can be taken of the firſt and third, and certain equimultiples of the ſecond and fourth, ſuch, that the multiple of the firſt ſhall be leſs than the multiple of the ſecond, but the multiple of the third not leſs than the multiple of the fourth.

Prop. 7. If any equimultiples whatever be taken of the firſt and third of four magnitudes, and any equimultiples whatever of the ſecond and fourth; and if when the multiple of the firſt is leſs than that of the ſecond, the multiple of the third is alſo leſs than that of the fourth; or if when the multiple of the firſt is equal to that of the ſecond, the multiple of the third is alſo equal to that of the fourth; or if when the multiple of the firſt is greater than that of the ſecond, the multiple of the third is alſo greater than that of the fourth: then, the firſt of the four magnitudes ſhall be to the ſecond as the third to the fourth.

RATIONAL, in arithmetic, &c. the quality of numbers, fractions, quantities, &c. when they can be expreſſed by common numbers; in contradiſtinction to irrational or ſurd ones, which cannot be expreſſed in common numbers.

RAYNAL (William Thomas), commonly called the Abbé Raynal, was educated among the Jeſuits, and had become one of the order. The learning of that Society is univerſally known, as well as the happy talents which its ſuperiors poſſeſſed, of aſſigning to each member his proper employment. Raynal, however, after having acquired among them a taſte for literature and ſcience, had probably become refractory, for he was expelled from the order; and the cauſe of his expulſion, according to the Abbé Barruel, was his impiety.

With the real cauſe of his expulſion M. Barruel is ſurely much better acquainted than we can pretend to be; but we have a ſtrong ſuſpicion that his impieties had not then reached farther than to call in queſtion the ſupreme authority of the church; for our author himſelf aſſures us, that he did not utter his atrocious declarations againſt Chriſtianity till he had ceaſed to be a member of the order of Jeſuits. He then aſſociated himſelf with Voltaire, D'Alembert, and Diderot, and was by them employed to furniſh the theological articles for the *Encyclopédie*. But though his religious opinions were certainly lax, and his moral principles very exceptionable, he could not even then be what, in a Proteſtant country, would be deemed a man remarkable for impiety; for he employed the Abbé Yvon, whom M. Barruel calls an odd metaphyſician, but an inoffenſive and upright man, to write the articles which he was engaged to furniſh. In the conducting of this tranſaction, he ſhewed, indeed, that he poſſeſſed not a proper ſenſe of honour; for he paid poor Yvon with twenty-five louis d'ors for writing theological articles, for which he received himſelf ſix times that ſum. This trick was diſcovered, Raynal was diſgraced, and compelled to pay up the balance to Abbé Yvon; but tho' he had thus ſhewn himſelf to be without honour, it is difficult to believe that he had yet proceeded ſo far as to blaſpheme Chriſt, ſince he had employed a Chriſtian divine to ſupply his place in the *Encyclopédie*.

His firſt work of eminence, and that indeed upon which his fame is chiefly built, is his "Political and Philoſophical Hiſtory of the European Settlements in the Eaſt and Weſt Indies." That this hiſtory is written in an animated ſtyle, and that it contains many juſt reflections, both political and philoſophical, is known to all Europe; for it has been tranſlated into every European language. Its beauties, however, are deformed by many ſentiments that are irreligious, and by ſome that are impure. It was followed, we think, in 1780, by a ſmall tract entitled "The Revolution of America;" in which the author pleads the cauſe of the revolted coloniſts with a degree of zeal, cenſures the conduct of the Britiſh government with a keenneſs of aſperity, and diſplays a knowledge of the principles and intrigues of the different factions which at that period divided the Engliſh nation, that ſurely was not natural to the impartial pen of a philoſophic foreigner. Hence he has been ſuppoſed to have been incited to the undertaking, and to have been furniſhed with part of his materials, by that deſperate faction which uniformly oppoſed the meaſures of Lord North, and ſecretly fomented the rebellion in America. Be this as it may, he propagated, both in this tract and in his hiſtory, a number of licentions opinions reſpecting government and religion, of which he lived to regret the conſequences.

A proſecution was inſtitnted againſt him by the French government on account of his hiſtory of the Eaſt and Weſt Indies; but it was conducted with ſo little ſeverity, that he had ſufficient time to retire to the dominions of the King of Pruſſia, who afforded him the protection he ſolicited, although his Majeſty's character was treated by the author in his book with no great degree of veneration. Raynal alſo experienced the kindneſs of the Empreſs of Ruſſia; and it is not a little remarkable of this ſingular perſonage, that, although he was always ſevere in diſcuſſing the characters of princes, yet the moſt deſpotic among theſe heaped upon him many marks of favour and generoſity. The Abbé alſo received a very unuſual mark of reſpect from a Britiſh Houſe of Commons. It was once intimated to the ſpeaker that Raynal was a ſpectator in the gallery. The buſineſs was immediately ſuſpended, and the ſtranger conducted to a more convenient and honourable ſituation. How different was the conduct of Dr Johnſon, who, when a friend advanced to him with our author, ſaying, "Will you give me leave, Doctor, to introduce to you the Abbé Raynal?" turned on his heel, and vociferated, "No, Sir!" We are far from wiſhing to vindicate the rudeneſs of the ſage; but it was perhaps as proper as the politeneſs of the Houſe of Commons.

The great trait of Raynal's character was a love of liberty, which, in his earlier writings, he did not properly define; but when he lived to ſee ſome of the conſequences of this, in the progreſs of the French Revolution, he made one glorious effort to retrieve his errors. In the month of May 1791, he addreſſed to the conſtituent aſſembly one of the moſt eloquent, argumentative, and impreſſive letters that ever was written on any ſubject; a letter which, if the majority of them had not been intoxicated with their newly acquired conſequence, muſt have given ſome check to their mad career. After complimenting them upon what they had done, he proceeds thus: "I have long dared to ſpeak to kings of their duty; ſuffer me now to ſpeak to the people of their errors, and to their repreſentatives of the dangers which threaten us. I am, I own to you, deeply afflicted at the crimes which plunge this empire into mourning. Is it true that I am to look back with horror at myſelf for being one of thoſe who, by feeling a noble indignation againſt arbitrary power, may perhaps have furniſhed arms to licentiouſneſs? Do then religion, the laws, the royal authority, and public order, demand back from philoſophy and reaſon the ties which united them to the grand ſociety of the French nation, as if, by expoſing abuſes, and teaching the rights of the people and the duties of princes, our criminal efforts had broken thoſe ties? But, no!—never have the bold conceptions of philoſophy been repreſented by us as the ſtrict rule for acts of legiſlation.

"You cannot juſtly attribute to us what could only be the reſult of a falſe interpretation of our principles. Alas! now that I ſtand on the brink of the grave; now that I am about to quit this immenſe family, whoſe happineſs I have ardently deſired, what do I ſee around me? Religious troubles, civil diſſenſions, conſternation on the one hand, tyranny and audacity on the other; a government the ſlave of popular tyranny; the ſanctuary of the laws ſurrounded by unruly men, who alternately dictate or deſpiſe thoſe laws; ſoldiers without diſcipline; leaders without authority; miniſters without means; a king, the firſt friend of his people, plunged into bitterneſs, inſulted, menaced, ſtripped of all authority; and the public power no longer exiſting but in clubs, in which ignorant and rude men dare to decide all political queſtions."

He then proceeds to prove, which he does very completely, that it was not the buſineſs of the aſſembly to aboliſh every ancient inſtitution; that the genius of the French people is ſuch, that they never can be happy or proſperous but under a well-regulated monarchical government; and that, if they wiſhed not the nation to fall under the worſt kind of deſpotiſm—the deſpotiſm of a low faction, they muſt increaſe the power of the king. "Alas! (continues he) what are my ſufferings, when in the heart of the capital, in the centre of knowledge, I ſee this miſguided people welcome, with a ferocious joy, the moſt criminal propoſitions, ſmile at the recital of murder, and celebrate their crimes as conqueſts!"

He had then ſeen comparatively but little; but he lived to ſee more—to ſee his countrymen celebrate, as virtues, crimes, compared with which the atrocities of 1790 appear almoſt as harmleſs. Being ſtripped of all his property, which was large, by the robbers of the revolution, he died in poverty in March 1796, and in the 84th year of his age.

Beſides the works which we have already mentioned, he wrote "A Hiſtory of the Parliament of England," and a "Hiſtory of the Stadholderate;" but theſe are both of them more remarkable for a ſpecious ſtyle and loftineſs of invention than for uſeful obſervation or ſolid argument. He wrote likewiſe "The Hiſtory of the Divorce of Catharine of Arragon by Henry the Eighth," which is not ſo much a recital of, and commentary upon, the fact from which he takes the title, as it is an able picture of univerſal Europe at that period, of the views, intereſts, and power, of all the different potentates. At the time of his death he was preparing a new edition of all his works, in which were to be made many alterations; and he is ſaid to have left among his manuſcripts a "Hiſtory of the Revocation of the Edict of Nantes," in four volumes; but it is alſo very certain, that, during the ſanguinary reign of Robeſpierre, he burnt a great part of his papers.

REAPING, the well known operation of cutting corn either by the ſickle or by the ſcythe. Reaping by the ſickle is by much the moſt common practice, and that which, we believe, prevails univerſally in Scotland; yet the other method, where it is practicable, is certainly the leaſt laborious, and by much the moſt expeditious. To the ſcythe, as an inſtrument of reaping, many objections are urged.

It is ſaid that it ſhakes the ear, ſo that many of the grains are loſt; that it lets the corn fall, after cutting it, in a confuſed and ſcattered ſtate, ſo that either much of it is loſt, or a great deal of time is conſumed in gathering it together; that it can only be made uſe of in land which is very even and free from ſtones; that it does not leave ſufficient length of ſtubble in the ground to lay the corn on when cut; that it mixes bad weeds with the corn, the ſeeds of which are ſown the next year; and, laſtly, that the uſe of the ſcythe is prejudicial to the health of the reaper.

Theſe objections, however, are either of no weight, or they are made by thoſe who are not acquainted with the ſcythes which have been adapted to this purpoſe, and with the proper manner of uſing them. With a good ſcythe, properly managed, the corn, after being cut, remains at firſt upright, and then falls very gently upon the rake fixed to the ſcythe, without any ſhake or jolt; or at leaſt with leſs than that which it receives when reaped with a ſickle. With reſpect to the loſs of grain, that proceeds chiefly from the corn being too dry; conſequently it ſhould be reaped only upon proper days, and proper times of the day, which is much more eaſily done with the ſcythe than with the ſickle, becauſe the work is ſo much ſhorter. The ſtalks, kept together by the rake, may be laid upon the ground, or rather againſt the corn not yet cut, in ſo regular and collected a ſtate, that thoſe who gather and tie the ſheaves, whether they are women or children, have nothing but their own negligence to accuſe if any thing is left behind. When land is properly ploughed and harrowed, it is ſufficiently even; and in ſuch as is ſtony, the only precaution neceſſary is to keep the ſcythe a little higher in uſing it, that it may not ſtrike againſt the ſtones. If the ſtubble left in the ground be ſhort, the ſtraw which is cut off will be the longer; and the latter is certainly of more value than the former, which only ſerves to incommode the cattle which afterwards go to feed in the field.

Theſe conſiderations, and others of a like nature, induced the patriotic ſociety of Milan to ſend, ſome years ago, to thoſe parts in which ſcythes are made uſe of for reaping; and having procured a model of a ſcythe from Sileſia, they cauſed one to be made of a proper ſize. It was firſt tried upon corn, and afterwards upon millet; and although the firſt ſcythe was not accurately made, and the reaper had never before made uſe of ſuch an inſtrument, yet it was found that nearly half the uſual time was ſaved, and that the labour and fatigue were much diminiſhed; the corn alſo was cut without receiving any ſhock that could be hurtful to it, and fell in an even and regular ſtate, ſo that it was afterwards eaſily bound up in compact ſheaves. They were afterwards preſented with a ſcythe ſomewhat different from the Sileſian, which is very generally uſed in Auſtria.

Plate XLII.

Theſe inſtruments are ſo ſimple, that the figure of one of them renders the deſcription of either almoſt unneceſſary. In fig. 1. is ſhewn the Sileſian ſcythe tried by the Society; the difference between that and the Auſtrian one we ſhall mention in our deſcription. The firſt, or Sileſian ſcythe, differs very little from the ſcythe we commonly uſe for mowing graſs, except that the blade is rather ſmaller; to it are added four teeth of wood, parallel to the blade, fixed and ſecured in a proper manner, and intended to keep the corn together after being cut, ſo that inſtead of its falling in a confuſed ſtate, the reaper may lay it down in a regular and compact one. The ſecond, or Auſtrian ſcythe, is ſimilar to the former, except that the blade is larger; conſequently the wooden teeth, of which there are five, are longer; the handle alſo is more flat, and rather crooked.

In the *firſt*, the handle *a b* (ſee fig. 1.) is two Milaneſe braſſes (A), and nine inches and a half in length; the

---

(A) One hundred Milaneſe *braſſes* are equal to fifty-eight Engliſh yards and a half.

the blade *b c* is one braſs three inches and a half; the piece of wood in which the teeth are fixed, one braſs one inch and a half. In the *ſecond*, the handle is two braſſes, and ſeven inches long; the blade, one braſs eleven inches; the piece in which the teeth are fixed, eleven inches and a quarter. The proportions of the other parts may be conceived from the figure.

The difference in the conſtruction of theſe two ſcythes makes it requiſite to uſe them in a different manner; but that will be better acquired in practice than by precept. Such of our countrymen as are accuſtomed to the uſe of the common ſcythe will very ſoon find out the moſt convenient and advantageous manner of uſing theſe new kinds of ſcythe, and of laying down the corn properly when cut.

It ſhould, however, be obſerved, that in mowing graſs the feet are kept almoſt parallel to each other, whereas in reaping corn they ſhould be kept upon a line, one behind the other, thruſting the right foot forward, and drawing the left towards it. This is neceſſary, becauſe when graſs is mowed it is left to fall juſt where it is cut; but when corn is cut, it is to be carried and laid in a proper manner againſt that which is not yet cut, and which is at the left hand of the reaper; and if the feet were kept parallel to each other, the reaper would be obliged to extend and turn his body in a very inconvenient manner.

After having made public theſe obſervations, the ſociety made farther experiments upon the ſubject; in which it was found, that when, on account of very wet weather, the ſtalks of the corn are bent down, the wooden teeth of the forementioned ſcythes are apt to lay hold of ſome ears, to the ſtalks of which the iron does not reach, and conſequently not being cut below, they are pulled ſo that the grain is ſcattered. This happens chiefly when the reapers, not being yet ſufficiently accuſtomed to that kind of ſcythe, do not know how to adapt it to particular circumſtances.

To remedy this inconvenience, it occurred to an ingenious blackſmith to add to the common ſcythe a *gatherer* or *collector* made of cloth, as may be ſeen at fig. 2. where *a b c* is a common ſcythe; *c d m l o f n e* is the gatherer; which at *c d e* is compoſed of a thin plate of iron, having at its extremity a hollow for receiving the point of the blade. At *e d* are holes for ſewing in the cloth, which is coarſe, light, and of low price; it is alſo fixed to two thick iron wires, of which the upper one is continued to *f*, where it terminates in a hole in the handle; the other is fixed to the back of the blade. The manner of fixing this gatherer to the blade of the ſcythe will be better underſtood by referring to fig. 3. which repreſents one of the irons which, by means of a ſcrew, are faſtened to the back of the ſcythe. Theſe irons proceed from, and make part of, the upright irons *m n*, *l o*, which ſerve to keep the gatherer extended.

This is a very ſimple and cheap contrivance; but an attempt was made to render it ſtill more ſimple, by ſubſtituting for the gatherer two iron hoops, which are ſhown in fig. 2. by the dotted lines *h g*, *k i*, with a croſs piece *p* which connects them. Experience, however, has ſhewn, that the gatherer is in general preferable to theſe hoops, as it does not leave an ear of corn behind.

RECTIFICATION of ether, a proceſs for depriving ether of its ſulphureous acid (See CHEMISTRY, *Index* in this *Suppl.*) It has been uſual to add an alkali for this purpoſe; but Dizé has found it much more advantageous to add a ſubſtance which might afford the requiſite quantity of oxygen to convert the ſulphureous into the ſulphuric acid; in which ſtate it is not diſpoſed to riſe and come over. Various metallic oxyds were tried, among which the black oxyd of manganeſe proved the beſt and the cheapeſt. His proceſs is as follows:

The ſulphureous acid contained in unrectified ether being neutralized with oxyd of manganeſe, the fluid is decanted into a pewter veſſel of the capacity of fifty ounces, which is placed on a water bath. To this veſſel a head and worm are adapted, the latter of which paſſes through a refrigeratory conſtantly ſupplied with water in a ſtream from below, which cauſes the heated water to flow off above. The diſtillation is then performed by raiſing the bath to a temperature of 36° (113° Fahrenheit, if the decimal thermometer be here meant). The rectification by this treatment uſually requires a day to complete it. The flavour of the ether is of the beſt kind, and the product about one-ſixth more than in the uſual method with retort and receiver. Dizé has practiſed this method with ſucceſs for three years.—*Journal de Phyſique, April*, 1798.

RECTIFICATION, in geometry, is the finding of a right line equal to a curve. The rectification of curves is a branch of the higher geometry, a branch in which the uſe of the inverſe method of fluxions is eſpecially uſeful.

TURKEY-RED, *Levant-Red*, and *Adrianople-Red*, the names indifferently given to that beautiful red dye which diſtinguiſhes the cotton manufactured in the Ottoman empire, and at *Aſtracan* in the dominions of Ruſſia. We have two accounts of the proceſs of communicating this dye to the ſtuffs; one by Profeſſor Pallas as he ſaw it practiſed at Aſtracan; the other in the 92d number of the *Annales de Chimie* by Citizen Felix. As every thing relating to uſeful manufactures is of general importance, we ſhall give pretty copious extracts from both papers.

According to Dr Pallas, the dye-ſtuffs employed at Aſtracan are, madder, ſumach, gall-nuts, alum, an inferior kind of ſoda, and fiſh-oil. The proceſs of dyeing is as follows:

The roots of the madder, when freſh gathered, are placed above each other in a ſtove, or in a pit dug in viſcous earth which has been ſtrongly heated. Earth is then thrown over the madder, and it muſt ſweat until the ſtove or pit becomes cold; when the roots, the ſecond or third day, are taken from it, and either ſpread out or hung up to dry. When it is thoroughly dried in the ſun, the madder is ground to a very fine powder, as are likewiſe the round leaves of the ſumach (*rhus cotinus*). The fiſh oil is boiled from the entrails of the ſturgeon and other large fiſhes; and the proof of its being proper for dyeing is, that when mixed with a lixivium of ſoda, it muſt immediately aſſume a milky appearance. Should that not be the caſe, it cannot be uſed by the dyers.

The cotton to be dyed red is firſt waſhed exceedingly clean in running water; and when the weather is clear, hung up on poles to dry. If it does not dry before the evening, it is taken into the houſe, on account

Turkey-Red.

of the ſaline dews ſo remarkable in the country around Aſtracan, and again expoſed to the air next morning. When it is thoroughly dry it is laid in a tub, and fiſh-oil is poured over it till it is entirely covered. In this ſtate it muſt ſtand all night; but in the morning it is hung up on poles, and left there the whole day; and this proceſs is repeated for a week, ſo that the cotton lies ſeven nights in oil, and is expoſed ſeven days to the atmoſphere, that it may imbibe the oil, and free itſelf from all air. The yarn is then again carried to a ſtream, cleaned as much as poſſible, and hung up on poles to dry.

After this preparation a mordant is made of three materials, which muſt give the grounds of the red colour. The pulveriſed leaves of the ſumach are firſt boiled in copper kettles; and when their colouring matter has been ſufficiently extracted, ſome powdered galls are added, with which the liquor muſt be again boiled; and by theſe means it acquires a dark dirty colour. After it has been ſufficiently boiled the fire is taken from under the kettle, and alum put into the ſtill hot liquor, where it is ſoon diſſolved. The proportion of theſe three ingredients cannot be aſcertained, as the dyers vary that proportion at pleaſure. The powder of the ſumach leaves is meaſured into the kettle with ladles; the water is poured in according to a gauge, on which marks are made to ſhew how high the water muſt ſtand in the kettle to ſoak ſix, eight, ten, &c. puds of cotton yarn. The galls and alum are added in the quantity of five pounds to each pud of cotton. In a word, the whole mordant muſt be ſufficiently yellow, ſtrong, and of an aſtringent taſte.

As ſoon as the alum is diſſolved, no time muſt be loſt in order that the mordant may not be ſuffered to cool. The yarn is then put into hollow blocks of wood ſhaped like a mortar, into each of which ſuch a quantity of the mordant has been poured as may be ſufficient to moiſten the yarn without any of it being left. As ſoon as the workman throws the mordant into the mortar, he puts a quantity of the yarn into it, and preſſes it down with his hand till it becomes uniformly moiſtened, and the whole cotton yarn has ſtruck. By this it acquires only a pale yellow colour, which, however, is durable. It is then hung up on poles in the ſun to dry; again waſhed in the ſtream, and afterwards dried once more.

The next part of the proceſs is to prepare the madder dye. The madder, ground to a fine powder, is ſpread out in large troughs, and into each trough is poured a large cupful of ſheep's blood, which is the kind that can be procured with the greateſt facility by the dyers. The madder muſt be ſtrongly mixed in it by means of the hand, and then ſtand ſome hours in order to be thoroughly ſoaked by it The liquor then aſſumes a dark red appearance, and the madder in boiling yields more dye.

After this proceſs water is made hot in large kettles, fixed in brickwork; and as ſoon as it is warm, the prepared red dye is put into it, in the proportion of a pound to every pound of cotton. The dye is then ſuffered to boil ſtrongly; and when it is enough, which may be tried on cotton threads, the fire is removed from under the kettle, and the prepared cotton is depoſited near it. The dyer places himſelf on the edge of the brickwork that incloſes the kettle; dips the cotton yarn, piece by piece, into the dye; turns it round backwards and forwards; preſſes it a little with his hands; and lays each piece, one after the other, in pails ſtanding ready for the purpoſe. As ſoon as all the cotton has received the firſt tint, it is hung up to dry; as the red, however, is ſtill too dull, the yarn, which has been already dyed once, and become dry, is put once more into the dyeing-kettle, and muſt be left there to ſeethe for three hours over a ſtrong fire; by which it acquires that beautiful dark red colour which is ſo much eſteemed in the Turkey yarn. The yarn is now taken from the dye with ſticks; the ſuperfluous dye which adheres to it is ſhaken off; the hanks are put in order, and hung up, one after another, to dry. When it is thoroughly dry, it is waſhed in the pure ſtream, and again dried.

Turkey-Red.

In the laſt place, the above-mentioned ſoda is diſſolved with boiling water in tubs deſtined for that purpoſe, and it is uſual at Aſtracan to allow 20 pounds of ſoda to 40 pounds of cotton, or half the weight. Large earthen jars, which are made in Perſia of very ſtrong clay, a yard and a half in height, almoſt five ſpans wide in the belly, and ending in a neck a ſpan and a half in diameter, incloſed by means of cement in brickwork over a fire-place, in ſuch a manner that the necks only appear, are filled with the dyed cotton yarn. The ley of diſſolved ſoda, which is blackiſh and very ſharp, is then poured over it till the jars be filled; and ſome clean rags are preſſed into their mouths, that the uppermoſt ſkains of yarn may not lie uncovered. A fire is then made in the fire place below, and continued for 24 hours; and in the mean time the ſteam which ariſes from the jars is ſeen collected among the rags in red drops. By this boiling the dye is ſtill more heightened, and is made to ſtrike completely; every thing ſuperfluous is removed, and all the fat matter which ſtill adheres to the yarn is waſhed out. Nothing more is then neceſſary for completing the dye of the yarn but to rinſe it well ſeveral times in running water, and then to dry it.

Cotton cloth is dyed with madder at Aſtracan in the ſame manner; but many purſue a fraudulent proceſs, by dyeing with red wood, and then ſell their cloth as that which has been dyed in the proper manner.

The proceſſes followed in the Grecian manufactories in the Levant, as deſcribed by M. Felix, varies in ſome particulars from this. The firſt proceſs is that of cleaning the cotton: for which purpoſe three leys are employed; one of ſoda, another of aſhes, and a third of lime. The cotton is thrown into a tub, and moiſtened with the liquor of the three leys in equal quantities: it is then boiled in pure water, and waſhed in running water.

The ſecond bath given to the cotton is compoſed of ſoda and ſheep's dung diſſolved in water. To facilitate the ſolution, the ſoda and dung are pounded in a mortar. The proportions of theſe ingredients employed, are one occa of dung, ſix of ſoda, and forty of water; each occa being equal to about fifty ounces. When the ingredients are well mixed, the liquor expreſſed from them is ſtrained; and being poured into a tub, ſix occas of olive oil are added to it, and the whole is well ſtirred till it becomes of a whitiſh colour like milk. The cotton is then beſprinkled with this water; and when the ſkains are thoroughly moiſtened, they are wrung,

wrung, preſſed, and expoſed to dry. The ſame bath muſt be repeated three or four times, becauſe it is this liquor which renders the cotton more or leſs fit for receiving the dye. Each bath is given with the ſame liquor, and ought to continue five or ſix hours. It is to be obſerved that the cotton, after each bath, muſt be dried without being waſhed, as it ought not to be rinſed till after the laſt bath. The cotton is then as white as if it had been bleached in the fields.

It may be ſuppoſed that the dung is of no utility for fixing the colours: but this ſuppoſition would be raſh; for, as M. Felix obſerves, it is well known that this ſubſtance contains a great quantity of volatile alkali in a diſengaged ſtate, which has the property of giving a roſy hue to the red. It is therefore probable that it is to this ingredient that the red dyes of the Levant are indebted for their ſplendour and vivacity. This much, at any rate, is certain, that the Morocco leather of the Levant is prepared with dog's dung; becauſe it has been found that this dung is proper for heightening the colour of the lack.

The proceſs of galling, which follows the bath of dung, is performed by immerſing the cotton in a bath of warm water, in which five occas of pulveriſed gall-nuts have been boiled. This operation renders the cotton more fit for being ſaturated with the colour, and gives to the dye more body and ſtrength. After the galling comes aluming, which is performed twice, with an interval of two days, and which conſiſts in dipping the cotton into a bath of water in which five occas of alum have been infuſed, mixed with five occas of water alkaliſed by a ley of ſoda. The aluming muſt be performed with care, as it is this operation which makes the colouring particles combine beſt with the cotton, and which ſecures them in part from the deſtructive action of the air. When the ſecond aluming is finiſhed, the cotton is wrung; it is then preſſed, and put to ſoak in running water, after being incloſed in a bag of thin cloth.

The workmen then proceed to the dyeing. To compoſe the colours, they put in a kettle five occas of water, and 35 occas of a root which the Greeks call *ali-zari*, or painting colour, and which in Europe is known under the name of *madder*. The madder, after being pulveriſed, is moiſtened with one occa of ox or ſheep's blood. The blood ſtrengthens the colour, and the doſe is increaſed or leſſened according to the ſhade of colour required. An equal heat is maintained below the kettle, but not too violent; and when the liquor ferments, and begins to grow warm, the ſkains are then gradually immerſed before the liquor becomes too hot. They are then tied with packthread to ſmall rods placed croſſwiſe above the kettle for that purpoſe; and when the liquor boils well, and in an uniform manner, the rods from which the ſkains were ſuſpended are removed, and the cotton is ſuffered to fall into the kettle, where it muſt remain till two-thirds of the water is evaporated. When one third only of the liquor remains, the cotton is taken out and waſhed in pure water.

The dye is afterwards brought to perfection by means of a bath alkaliſed with ſoda. This manipulation is the moſt difficult and the moſt delicate of the whole, becauſe it is that which gives the colour its tone. The cotton is thrown into this new bath, and made to boil over a ſteady fire till the colour aſſumes the required tint. The whole art conſiſts in catching the proper degree: a careful workman, therefore, muſt watch with the utmoſt attention for the moment when it is neceſſary to take out the cotton; and he will rather burn his hand than miſs that opportunity.

It appears that this bath, which the Greeks think of ſo much importance, might be ſupplied by a ley of ſoap; and it is probable that ſaponaceous water would give the colour more brightneſs and purity.

M. Felix ſeems doubtful whether the ali-zari of the Greeks be the ſame plant with the European madder. If it be, its ſuperiority muſt ariſe from the mode in which it is cultivated, and the method employed to dry it. The ali-zari is not collected till the fifth or ſixth year of its growth, when it has acquired its full ſtrength; and as it is the woody part of the roots which affords the greateſt quantity of colouring particles, this muſt give it an obvious ſuperiority over madder, which is collected before it has arrived at maturity. The mode of deſiccation contributes alſo, in the opinion of our author, to improve the quality of the ali-zari. The Levantines dry it in the open air; and this operation is eaſy in a country where great dryneſs prevails in the atmoſphere, while in our damp climates we are obliged to dry the madder by ſtoves. Hence it happens that the ſmoke, which mixes itſelf with the cold air, and penetrates the roots, impregnates them with fuliginous particles, which alter the colouring ſubſtance; an accident which does not take place when the madder is dried without the aſſiſtance of fire.

For the philoſophical principles of theſe proceſſes of dyeing, ſee *Animal and Vegetable* SUBSTANCES in this *Supplement*.

REDINTEGRATION, is the taking or finding the integral or fluent again from the fluxion. See FLUXIONS, *Encycl.*

REFLECTOR FOR A LIGHT-HOUSE, is compoſed of a number of ſquare plane glaſs mirrors, ſimilar to thoſe with which Archimedes is ſaid to have ſet fire to the Roman fleet at the ſiege of Syracuſe (See BURNING, *Encycl.*) Each of theſe mirrors is about an inch ſquare; and they are all diſpoſed cloſe to each other in the concave of a parabolic ſegment, formed of ſtucco or any other proper bed. Stucco has been found to anſwer the purpoſe beſt; and is accordingly employed in all the reflectors of the light-houſes erected by Mr Thomas Smith tinplate worker, Edinburgh, at the expence, and by the authority, of government. This ingenious and modeſt man ſeems to have conceived the idea of illuminating light-houſes by means of lamps and reflectors inſtead of coal-fires, without knowing that ſomething of the ſame kind had been long uſed in France; he has therefore all the merit of an inventor, and what he invented he has carried to a high degree of perfection.

His parabolic moulds are from three to five or ſix feet in diameter; and in the centre or apex of each is placed a long ſhallow lamp of tin-plate, filled with whale oil. In each lamp are ſix cotton wicks, almoſt contiguous to each other, which are ſo diſpoſed as to burn without trimming for about ſix hours. The light of theſe is reflected from each mirror ſpread over the concave ſurface, and is thus multiplied, as it were, by the number of mirrors. The ſtucco moulding is covered on the back with tin-plate, from which a tube, immediately over the lamp, proceeds to the roof of the

Reflector, Reflexity.

light room, and ſerves as a funnel, through which the ſmoke eſcapes without ſullying the faces of the mirrors. The light-room is a cupola or lantern of from eight to twelve ſides, compoſed entirely of glaſs, fixed in caſt-iron frames or ſaſhes, and roofed with copper. On circular benches paſſing round the inſide of this lantern, at about eighteen inches from the glaſs frames, are placed the reflectors with their lamps, ſo as that the concave ſurfaces of two or three of the reflectors front every point of the compaſs, and throw a blaze of light in all directions. In the roof immediately over the centre of the room is a hole, through which paſs all the funnels already mentioned, and which ſerves likewiſe to admit freſh air to the lamps. This light-room is firmly fixed on the top of a round tower ſo as to be immoveable by the weather; and the number of the reflectors, and the height of the tower, are leſs or greater according as it is the intention that the light ſhould be ſeen at a leſs or a greater diſtance.

A man judging from mere theory would be very apt to condemn light-houſes of this kind; becauſe the firmeſt building ſhakes in a violent ſtorm, and becauſe ſuch ſhaking, he might think, would ſometimes throw the whole rays of light into the air, and thus miſlead the bewildered ſeaman. This opinion, we know, was actually entertained of them by one of the profoundeſt philoſophers and moſt ſcientific mechanicians of the age. Experience, however, has convinced him, as well as the public at large, that ſuch apprehenſions are groundleſs, and that light-houſes with lamps and reflectors are, in every point of view, preferable to thoſe with fires burning in the open air. They are ſupported at much leſs expence; their light is more brilliant, and ſeen at a greater diſtance, whilſt it can never be obſcured by ſmoke, or beaten down on the lee-ſide by a violent guſt of wind; and what is perhaps of ſtill greater importance, the reflectors with their lamps may be ſo variouſly placed, that, as Mr Smith obſerves, one light-houſe cannot be miſtaken for another. If we add to all this, that the lamps do not ſtand in need of trimming ſo often as open fires require fuel, and that the light man is never expoſed either to cold or to wet by attending to his duty, we muſt be convinced that light-houſes with reflectors are much leſs liable to be neglected in ſtormy weather than thoſe with open fires, and that this circumſtance alone would be enough to give the former a preference, almoſt incalculable, over the latter.

It has been propoſed to make the concave ſurface of the parabola one ſpeculum of metal, inſtead of covering it over with a multitude of plain glaſs mirrors; or to diminiſh the ſize of each mirror, if they are to be retained in preference to the metallic ſpeculum. To every man who has but dipped into the ſcience of optics, it muſt be obvious, that either of theſe alterations would be wrong. The brighteſt metal does not reflect ſuch a quantity of light as well foliated clear glaſs; and were the ſize of the mirrors to be diminiſhed, the number of joinings would be increaſed, in each of which ſome light is loſt, not merely in the ſeam, but from its being almoſt impoſſible to foliate glaſs perfectly at its edge.

REFLEXITY, a word employed by Mr Brougham to denote a property of light which cauſes the different rays to be acted upon by bodies, and to begin to be refracted, reflected, inflected, and deflected, at different diſtances. This property follows the ſame law that the other optical properties of light follow: the red ray having moſt reflexity, and the violet leaſt (See *Philoſophical Tranſactions*, 1797, p. 360.) Mr Brougham has denoted this property by the three words, *refrangity*, *reflexity*, and *flexity*; but as the power is the ſame, there is no occaſion for different names. Some philoſophers have refuſed to admit this as a new property; we have not verified it by experiment.

Refraction

REFRACTION OF ALTITUDE, is the arc or portion of a vertical circle, by which the altitude of a ſtar is increaſed by the refraction of light.

REFRACTION of Aſcenſion and Deſcenſion, is an arc of the equator, by which the aſcenſion and deſcenſion of a ſtar, whether right or oblique, is increaſed or diminiſhed by the refraction.

REFRACTION of Declination, is an arc of a circle of declination, by which the declination of a ſtar is increaſed or diminiſhed by refraction.

REFRACTION of Latitude, is an arc of a circle of latitude, by which the latitude of a ſtar is increaſed or diminiſhed by the refraction.

REFRACTION of Longitude, is an arc of the ecliptic, by which the longitude of a ſtar is increaſed or diminiſhed by means of the refraction.

Terreſtrial REFRACTION, is that by which terreſtrial objects appear to be raiſed higher than they really are, in obſerving their altitudes. The quantity of this refraction is eſtimated by Dr Maſkelyne at one tenth; by Le Gendre at one-fourteenth; by De Lambre at one-eleventh; and by others at a twelfth of the diſtance of the object obſerved, expreſſed in degrees of a great circle. But it is obvious that there can be no fixed quantity of this refraction, ſince it depends upon the ſtate of the atmoſphere, which is extremely variable. Hence ſome very ſingular effects of it are related, of which the following is worthy of notice. It is taken from the Philoſophical Tranſactions of London 1798; being an extract of a letter, dated Haſtings, Auguſt 1. 1797.

"On Wedneſday, July 26, about five o'clock in the afternoon, while I was ſitting in my dining room at this place, which is ſituated upon the Parade, cloſe to the ſea ſhore, nearly fronting the ſouth, my attention was excited by a number of people running down to the ſea-ſide. Upon enquiring the reaſon, I was informed that the coaſt of France was plainly to be diſtinguiſhed by the naked eye. I immediately went down to the ſhore, and was ſurpriſed to find that, even without the aſſiſtance of a teleſcope, I could very plainly ſee the cliffs on the oppoſite coaſt; which, at the neareſt part, are between 40 and 50 miles diſtant, and are not to be diſcerned, from that low ſituation, by the aid of the beſt glaſſes. They appeared to be only a few miles off, and ſeemed to extend for ſome leagues along the coaſt. I purſued my walk along the ſhore eaſtward, cloſe to the water's edge, converſing with the ſailors and fiſhermen upon the ſubject. They at firſt could not be perſuaded of the reality of the appearance; but they ſoon became ſo thoroughly convinced, by the cliffs gradually appearing more elevated, and approaching nearer, as it were, that they pointed out and named to me the different places they had been accuſtomed to viſit; ſuch as the Bay, the Old Head or Man, the Windmill, &c. at Boulogne; St Vallery, and other places on the coaſt of Picardy; which they aftewards confirmed when they viewed them through their teleſcopes. Their obſervations were, that the places appeared as near as if they were ſailing, at a ſmall diſtance, into the harbours."

The writer of this extract was W. Latham, Eſq; F. R. S. and A. S. who adds, that the day was extremely hot, that it was high water at Haſtings about two o'clock P. M. and that not a breath of wind was ſtirring the whole day.

REGIS (Peter Sylvain), a French philoſopher, and great propagator of Carteſianiſm, was born in Agenois 1632. He cultivated the languages and philoſophy under the Jeſuits at Cahors, and afterwards divinity in the univerſity of that town, being deſigned for the church. He made ſo uncommon a progreſs, that at the end of four years he was offered a doctor's degree without the uſual charges; but he did not think it became him to accept of it till he had ſtudied alſo in the Sorbonne at Paris. He went thither, but was ſoon diſguſted with theology; and as the philoſophy of Des Cartes began at that time to make a noiſe through the lectures of Rohault, he conceived a taſte for it, and gave himſelf up entirely to it. He frequented theſe lectures; and becoming an adept, went to Toulouſe in 1665, and read lectures in it himſelf. Having fine parts, a clear and fluent manner, and a happy way of making himſelf underſtood, he drew all ſorts of people; the magiſtrates, the learned, the eccleſiaſtics, and the very women, who now all affected to abjure the ancient philoſophy. In 1680 he returned to Paris; where the concourſe about him was ſuch, that the ſticklers for Peripateticiſm began to be alarmed. They applied to the archbiſhop of Paris, who thought it expedient, in the name of the king, to put a ſtop to the lectures; which accordingly were diſcontinued for ſeveral months. The whole life of Regis was ſpent in propagating the new philoſophy. In 1690 he publiſhed a formal ſyſtem of it, containing logic, metaphyſics, phyſics, and morals, in 3 vols 4to, and written in French. It was reprinted the year after at Amſterdam, with the addition of a diſcourſe upon ancient and modern philoſophy. He wrote afterwards ſeveral pieces in defence of his ſyſtem; in which he had diſputes with M. Huet, Du Hamel, Malebranche, and others. His works, though abounding with ingenuity and learning, have been diſregarded, in conſequence of the great diſcoveries and advancement in philoſophic knowledge that have been ſince made. He died in 1707. He had been choſen member of the academy of ſciences in 1699*.

REGULAR BODY, called alſo *Platonic Body*, is a body or ſolid comprehended by like, equal, and regular plane figures, and whoſe ſolid angles are all equal.

The plane figures by which the ſolid is contained are the faces of the ſolid; and the ſides of the plane figures are the edges, or linear ſides of the ſolid.

There are only five regular ſolids, viz.

The tetrahedron, or regular triangular pyramid, having four triangular faces;
The hexahedron, or cube, having ſix ſquare faces;
The octahedron, having eight triangular faces;
The dodecahedron, having twelve pentagonal faces;
The icoſahedron, having twenty triangular faces.

Beſides theſe five, there can be no other regular bodies in nature. See PLATONIC *Body*, Suppl.

REGULUS, in aſtronomy, a ſtar of the firſt magnitude, in the conſtellation Leo; called alſo, from its ſituation, *Cor Leonis*, or the *Lion's Heart*; by the Arabs, *Alhabor*; and by the Chaldeans, *Kalbeleced*, or *Karbeleceid*; from an opinion of its influencing the affairs of the heavens.

Reid.

REID (Thomas, D. D.), ſo well known to the public by his moral and metaphyſical writings, was the ſon of the Rev. Lewis Reid, miniſter of the pariſh of Strachan, in the county of Kincardine, North Britain. His mother was the daughter of David Gregory, Eſq; of Kinardie, of whom ſome account has been given in this *Supplement*, and ſiſter to David, James, and Charles Gregories, who were at the ſame time profeſſors of aſtronomy, or mathematics, in the univerſities of Oxford, Edinburgh, and St Andrews.

He was born at the parſonage-houſe of Strachan in April 1710, and received the rudiments of his education at the pariſh ſchool of Kincardine-oniel. At that period the parochial ſchools of Scotland were very ſuperior to what they are now; and young men went from them to the univerſity well furniſhed with philological learning. The progreſs of young Reid muſt have been rapid; for he was removed from ſchool to the Mariſchal College, Aberdeen, when not more than twelve years of age; and we have never heard that he was admitted into the univerſity before he was qualified to profit by the lectures of the profeſſors. On the contrary, he ſoon diſplayed the genius of his mother's family, and ſhone conſpicuous among the ſtudents of mathematics in a college where that ſcience has been at all times cultivated with ardour and ſucceſs.

After the uſual courſe of four years employed in the ſtudy of Latin, Greek, Mathematics, and Philoſophy, he probably took his degree of M. A. which at that period, and for a long time ſubſequent to it, was the univerſal practice in the univerſity of Aberdeen, and then commenced the ſtudy of theology. In due time he was licenſed to preach the goſpel according to the forms of the church of Scotland; but continued to reſide for ſome years in Aberdeen, cultivating his favourite ſcience, mathematics.

The mathematical chair in Mariſchal College was then filled by Mr John Stuart, a man of great eminence in his profeſſion; but who, like many other profound mathematicians, was not happy in his mode of communicating ſcience, at leaſt to the duller part of his pupils. Mr Reid occaſionally read lectures for the profeſſor; and a friend of our's, by no means dull, has often been heard to expreſs great ſatisfaction that Mr Stuart was kept a whole winter from the ſchools, when he was a ſtudent, and that the claſs was taught by Mr Reid. "Had it not been for this circumſtance (ſaid he) I ſhould never have underſtood more of mathematics than the firſt ſix books of Euclid's elements; but Mr Reid had the faculty of making every thing intelligible to the ſtudents which he clearly apprehended himſelf."

He could not, however, ſpend his life in the ſtudy of mathematics, and in reading barren lectures for other men. He had been educated for the church; and it was in the church only that he had the proſpect of gaining a livelihood. He was accordingly preſented, we know not in what year, to the church of *New-Machar* in Aberdeenſhire, at a time when the good people of Scotland were very far from being reconciled to the rights of patronage; and the conſequence was,

that

that his ſettlement met with much popular oppoſition. Even a little riot took place in the church at his ordination; but he ſoon gained the affections of his flock by his good ſenſe, his acknowledged worth, and his unwearied attention to all their wants, which he was ever ready to relieve to the utmoſt extent of his abilities. So deeply rooted indeed was their regard for him at laſt, that, though it is now almoſt half a century ſince his relation to the pariſh of New Machar ceaſed, his memory continues to be revered in that pariſh even at the preſent day; and the following anecdote evinces that it is not revered without reaſon.

A man who, from being in decent circumſtances, and a member of the kirk ſeſſion (See PRESBYTERIANS, *Encycl.*), when Dr Reid was miniſter, had become, in his old age, poor and infirm, obſerved to the then miniſter of the pariſh, that if he were able to go to Glaſgow, and make his caſe known to his old friend and paſtor, he was ſure that he would get ſomething done for him. This obſervation was reported to the Doctor, who inſtantly recollected the man, though, in all probability, he had not thought of him for thirty years; and he ſettled upon him an annual penſion of ten pounds, which was punctually paid as long as they both lived. The pride of ſcience had not from the mind of this great man eradicated the amiable ſympathies of humanity, nor had his philoſophic fame made him overlook the unaſpiring duties of the Chriſtian paſtor.

In the year 1751, about the beginning of the ſeſſion or annual term, one of the profeſſors of philoſophy in King's College, Aberdeen, died; and his death being unexpected, preſented to the other members of that learned body ſome difficulty in carrying on the uſual courſe of education for that year. At this our readers will not be ſurpriſed, when they reflect on the mode in which ſcience was taught in that univerſity; for he who could with propriety be placed in the vacant chair, muſt have been qualified, without much previous preparation, to read lectures on LOGIC, ONTOLOGY, PNEUMATICS, MORALS, POLITICS, MATHEMATICS, and NATURAL PHILOSOPHY (See GERARD, in this *Suppl.*). In ſuch a place as Aberdeen, it is hardly to be ſuppoſed that there was a ſingle man unemployed, ſo completely maſter of all theſe branches of ſcience, as to take up the claſs where it was dropt by the deceaſed profeſſor, and carry it ſucceſsfully through that ſcience, whatever it might be, in which, at his death, he chanced to be lecturing. It occurred, however, to the principal, and ſome of the profeſſors, that the miniſter of New Machar was fully equal to the taſk; and the late Dr John Gregory, then profeſſor of medicine, and the Rev. Dr Macleod, the preſent ſubprincipal of King's College, were deputed to viſit Mr Reid, and requeſt his immediate acceptance of the vacant profeſſorſhip. He yielded to the requeſt not without ſome heſitation, and was admitted profeſſor of philoſophy on the 22d of November.

He was now in the very ſituation for which Nature ſeemed to have intended him. He had not only an opportunity, but it was his duty to cultivate the ſcience to which his attachment was ſo ſtrong; and the duties of his office made him turn his attention more cloſely than he had hitherto done to another ſcience, in which he was deſtined to make a more conſpicuous figure than he ever made even in his favourite mathematics.

It was during his profeſſorſhip in the univerſity of Aberdeen that he wrote his "Eſſay on Quantity," which was publiſhed in the 45th volume of the Philoſophical Tranſactions, and is perhaps the fineſt ſpecimen of metaphyſical mathematics, if we may uſe ſuch an expreſſion, that is extant in our own or in any other language (See QUANTITY, *Encycl.*). It was during the ſame period that he publiſhed his "Inquiry into the Human Mind on the Principles of Common Senſe;" a work of unqueſtionable merit, which has contributed more than any other work whatever to give a rational turn to metaphyſical ſpeculations. It was about this period that the degree of D. D. was conferred upon him by his mother-college.

The well-earned fame of Dr Reid attracted the attention of the univerſity of Glaſgow to him as the fitteſt perſon to ſucceed the celebrated Dr Adam Smith; and he was admitted profeſſor of moral philoſophy in that univerſity on the 11th of June 1764. There his attention was not diſtracted by a multitude of ſciences, which it was his duty to teach; and he had leiſure to improve his metaphyſical ſyſtem, though he continued through life to amuſe himſelf occaſionally with mathematical ſpeculations.

In the year 1773 appeared, in Lord Kames's "Sketches of the Hiſtory of Man, a brief Account of Ariſtotle's Logic; with remarks by Dr Reid." It would ſeem that he had entered upon this taſk rather reluctantly, and merely in compliance with the ſolicitations of his friend, the author of the Sketches. "In attempting (ſays he) to give ſome account of the analytics, and of the topics of Ariſtotle, ingenuity requires me to confeſs, that though I have often purpoſed to read the whole with care, and to underſtand what is intelligible, yet my courage and patience always failed before I had done. Why ſhould I throw away ſo much time and painful attention upon a thing of ſo little uſe? If I had lived in thoſe ages when the knowledge of Ariſtotle's Organon intitled a man to the higheſt rank in philoſophy, ambition might have induced me to employ upon it ſome years of painful ſtudy; and leſs, I conceive, would not be ſufficient. Such reflections as theſe always got the better of my reſolution, when the firſt ardour began to cool. All I can ſay is, that I have read ſome parts of the different books with care, ſome ſlightly, and ſome perhaps not at all. I have glanced over the whole often; and when any thing attracted my attention, have dipped into it till my appetite was ſatisfied."

Notwithſtanding this modeſt acknowledgment, we are not ſure that any one of Dr Reid's publications does him greater honour than his very perſpicuous view of this ſtupendous ſyſtem. Having ourſelves occaſionally looked into the writings of Ariſtotle, we ſhould not heſitate to ſay, that it is by much the beſt analyſis of theſe writings that we have anywhere met with, even though we could not corroborate our own opinion by that of other men much more converſant than we are with the oracular language of the Stagyrite. But when it is known that the late Dr Doig of Stirling, to whom Greek was as familiar as his mother tongue, and an equally learned Doctor of Oxford, who has been reading Ariſtotle ever ſince he was fourteen years of age, agreed in opinion, that a more accurate view of his logic could not be given in the ſame compaſs than had been given by Dr Reid, we may ſurely affirm, with ſome degree of confidence, that this ſmall work adds much to the fame of our celebrated countryman.

Though Dr Reid's health continued good, and his mental faculties unimpaired, till a very ſhort time before his death, he ceaſed for ſome years to read lectures from his profeſſorial chair, employing that time in preparations for eternity, and in fitting his lectures for the preſs. Theſe were publiſhed in two volumes 4to: the the firſt in 1785, under the title of "Eſſays on the Intellectual Powers of Man," dedicated to his friends Dr Gregory and Profeſſor Stewart, both of the univerſity of Edinburgh; and the ſecond in 1788, under the title of "Eſſays on the Active Powers of Man," without any dedication or preface. He continued to enjoy the fame acquired by this work, as well as the affection of his friends and the reverence of the public, for eight years, dying at Glaſgow in the end of September, or the beginning of October 1796, in the 87th year of his age. He had been married, and he left behind him one daughter.

To do juſtice to the biography of ſuch a man as this, we ſhould here attempt to draw his intellectual character, and to appreciate the merits of his works; but to perform this taſk in a manner at all worthy of him, or we hope of ourſelves, would require more room than our limits permit us to allot to any article of the kind; and our readers will be pleaſed to learn, that they may confidently expect an account of his life, with a critique on his works, by a man better qualified to do juſtice to both, than the writer of this ſhort ſketch pretends to be. His works are in the hands of the ſpeculative public; and by that public will be duly valued, as long as ſound ſenſe ſhall be preferred to impious jargon. How long that may be, God only knows; but if any thing can guard the minds of our youth againſt that ſophiſtry of which the object is to attribute real agency to material fluids, and to repreſent the elective attractions of chemiſtry as perfectly ſimilar to human volitions, it will be the unbiaſſed ſtudy of Dr Reid's "Eſſays on the Intellectual and Active Powers of Man." They will there find metaphyſics diveſted of myſtery, and the profoundeſt ſpeculations rendered intelligible by the conſtant uſe of words in one determined ſenſe. We think, indeed, that in this conſiſts the Doctor's chief merit; for, except when treating of our notions of power, he ſeems not to have added much to what certainly *may be* found in the writings of Locke.

Let not our readers ſuppoſe, that by this obſervation we wiſh to detract in the ſmalleſt degree from our author's fame, or to leſſen him by compariſon with the Engliſh philoſopher. If on mere topics of ſpeculative ſcience, he appears to us to have thought as Locke thought, it is on the other hand certain, that the greater part of Locke's doctrines may be gleaned from the logical and metaphyſical writings of Bacon, Hobbes, and Des Cartes. Nor need this ſurpriſe any one; for he who reflects a moment on the ſubject, muſt perceive that ſuch a coincidence of thought in metaphyſical ſcience is among men of eminence almoſt inevitable. Of mind and its powers—the ſubject of that ſcience—we neither know, nor can know any thing, but by patiently attending to the operations of our own minds, when we ſee, hear, feel, think, reaſon, and will, &c.: and it is obvious, that every man who is capable of ſuch patient attention, and does not labour under the bias of ſome prejudice, muſt view theſe operations in the ſame way. The great ſuperiority of Dr Reid over his predeceſſors, in this department of ſcience, appears to have been this, that he apprehended the operations of his own mind with a clearneſs, which gave to his language a preciſion and perſpicuity which the language of Locke certainly does not poſſeſs.

In the Eſſay on the Human Underſtanding, the term *idea* ſometimes ſignifies a material ſubſtance, ſometimes the qualities of that ſubſtance, ſometimes the conception of theſe qualities, ſometimes the power or faculty of the mind by which we conceive a thing, ſometimes a perception of ſenſe, and ſometimes an intellectual notion. Hence the ambiguity of terms which runs thro' the whole of that immortal work, has furniſhed both the author's friends and his enemies with an opportunity of attributing to him pernicious doctrines, which we are perſuaded he did not maintain, and which, we think, a patient analyſis of the eſſay muſt *convince every man* that he did not maintain. From this ambiguity the writings of Dr Reid are perfectly free. His doctrines, whether well or ill-founded, can never be miſunderſtood by him who is deſirous to underſtand them; and he who knows how much perſpicuity of ſtyle depends upon accuracy of thinking, will not deem us enemies to his fame for having ſaid that his chief merit conſiſts in the preciſion of his language.

He has been much cenſured by ſome, and much applauded by others, for introducing the phraſe *common ſenſe* into ſpeculative philoſophy, as the proper name of that faculty of the mind by which we apprehend firſt truths; but he is on this account entitled neither to praiſe nor to cenſure. He adopted the phraſe from others; and has proved, by the moſt unexceptionable authorities, both ancient and modern, that it may with great propriety be uſed as he has uſed it. Whether the adopting of it into works of ſcience was neceſſary, is another queſtion, on which we have given our opinion elſewhere; it is ſufficient in this place to vindicate his uſe of it, eſpecially in his latter works, from ambiguity.

Candour obliges us to acknowledge, that he has advanced ſome doctrines which we cannot admit as true. Though not in general partial to Locke, he has adopted his notions reſpecting our power of abſtraction, with hardly any other variation than the ſubſtituting of the term *conceptions* for Locke's favourite phraſe *ideas*. He has likewiſe endeavoured to prove, that we may diſtinctly conceive what cannot poſſibly exiſt. Theſe miſtakes, for ſuch they appear to us, we have pointed out elſewhere (See METAPHYSICS, Part I. Chap. iii. and iv. *Encycl.*); but they are infinitely more than counterbalanced by his clear, accurate, and ſatisfactory diſquiſitions on our notions of active power. Had Dr Reid never written a ſentence but the eſſay which treats of this delicate and important ſubject, he would have been entitled to a place in the very firſt rank of uſeful metaphyſicians; for, previous to the appearance of his works, we had nothing written directly on *power* but contradictory and unintelligible jargon. We recommend the ſerious peruſal of this eſſay, the firſt in his ſecond volume, to ſuch of our readers as fancy that they diſtinctly conceive the powers of chemical agents, and that intelligence and volition may reſult from any mechanical organization, or any combination whatever of matter and motion.

REISKE (John James), a moſt profound ſcholar and ſagacious critic, was born in 1706 at a ſmall town of the duchy of Anhalt. After ſtruggling with ſome difficulties in his ſchool education, in which, however, he, by perſeverance, obtained conſiderable advantages, he went, in 1733, to Leipſic; where he continued, for the ſake of ſtudy, five years. Here he accompliſhed himſelf in Arabic, and tranſlated and publiſhed a book from that language. In order to proſecute his ſtudy of Arabic with greater effect, he travelled on foot, and with many difficulties, to Leyden. Here he was employed in arranging the Arabic manuſcripts, for which, however, he received a very ſcanty compenſation; and here alſo he tranſlated from the German and French, into Latin, various eſſays ſent him by Dorville, whom he had viſited in his journey, and who afterwards inſerted theſe papers in the *Miſcellanea Critica*. Dorville was ſo well pleaſed with his ſkill and diligence, that he employed him in more important concerns. At his deſire, Reiſke tranſlated the whole of the Chariton from the Greek, and the Geography of Abulfeda from the Arabic, into Latin. At Leyden he continued for the ſpace of eight years; where a ſtorm of jealouſy and calumny, excited againſt him by the younger Burman, finally induced him to change his reſidence. This was principally owing to the freedom he uſed with reſpect to the edition of Petronius, edited by the younger Burman at Leyden; however, before he quitted it, he took the degree of doctor of phyſic, which was given him in a manner which did him the higheſt honour. He then viſited different parts of Germany, till he at length ſettled at Leipſic a ſecond time. Here, for twelve years, notwithſtanding he was made profeſſor of Arabic, he experienced all the inconveniences of poverty, and was obliged to undergo a great deal of drudgery for bookſellers, and the editors of periodical publications, to procure a ſubſiſtence; at this period, in particular, the *Acta Eruditorum* were greatly indebted to him. Amidſt all theſe hardſhips, however, he found opportunity to write, and to publiſh, his *Animadverſiones in Auctores Græcos*, in five volumes; a work of extraordinary learning and merit. In 1758, by the death of Haltauſius, he obtained a ſituation at once honourable and lucrative, which placed him above want, and enabled him to follow his favourite purſuits at eaſe. He was made rector of the academy at Leipſic, in which office he continued till the time of his death. In 1764, he married Erneſtina Chriſtina Muller, a woman of wonderful attainments, whoſe knowledge was hardly inferior to his own, and particularly in Greek literature. She aſſiſted him in all his literary labours, and eſpecially in his immortal work of the "Edition of the Greek Orators." Thus, in the manner moſt grateful to himſelf, Reiſke conſumed the remainder of his life, which continued till 1774, when he died poſſeſſed of the higheſt reputation. The number of works which he ſuperintended and publiſhed is very great; but it will be ſufficient to name thoſe which are moſt ſought after and eſteemed. Theſe are, the "Remarks upon Greek Authors," before mentioned. An "Edition of the Greek Orators," in 12 vols 8vo, which was finiſhed by his widow. "Dionyſius Halicarnaſſenſis," in 7 vols. "Plutarch's Works," in 9 vols. "Theocritus, &c. &c." This John James Reiſke muſt not be confounded with *John Reiſke*, rector of the college of Wolfenbuttel, who was alſo a learned man, and publiſhed various works*.

REMONSTRANTS, in church hiſtory, a title given to the ARMINIANS (See that article, *Encycl.*) by reaſon of the remonſtrance which, in 1610, they made to the States of Holland, againſt the ſentence of the ſynod of Dort, which condemned them as heretics. Epiſcopius and Grotius were at the head of the *Remonſtrants*, whoſe principles were firſt openly patroniſed in England by Archbiſhop Laud. In Holland, the patrons of Calviniſm preſented an addreſs in oppoſition to the remonſtrance of the Arminians, and called it a counter-remonſtrance. Hence the Dutch Calviniſts were termed *Counter remonſtrants*. Much controverſy was carried on by theſe rival ſects, which, on the ſide of the Calviniſts, was extremely illiberal.

REMORA, or SUCKING FISH, a ſpecies of ECHENEIS (See *Encycl.*), M. Vaillant found, upon different parts of his enormous *ray* (See RAJA in this *Suppl.*) about twenty ſmall ſucking fiſh, or *remoras*, faſtened ſo firmly, that they did not drop off when he was hoiſted on board. Some naturaliſts have ſaid, that the head of the ſucking fiſh is viſcous on the lower part, and furniſhed with rough points ſimilar to the teeth of a file; and, according to them, it is by means of theſe two qualities, its roughneſs and viſcoſity, that it is enabled to adhere to other fiſh.

"Figure to yourſelf (ſays one of them) a row of nineteen ſharp-edged and dentated laminæ, placed croſſwiſe, and iſſuing immediately from the rim of the lower jaw, and you will have a juſt idea of the part with which the remora makes itſelf faſt."

This deſcription (ſays Vaillant) is exact as far as relates to the figure and number of the dentated laminæ; but it places them on the lower part of the head, whereas they are, in reality, on the upper. Accordingly, when the remora fixes itſelf, it is obliged to turn upon its back, with its belly upward.

If the two white fiſh, however, that poſted themſelves on the arms of the *ray*, and ſerved him as pilots, be of the remora ſpecies, as he is inclined to think, the laminæ by which that variety adheres to other fiſhes muſt be on the lower part of the body, ſince the two pilots continued in their natural poſition, and had no occaſion to turn over to fix themſelves at their poſt.

REPETEND, in arithmetic, denotes that part of an infinite decimal fraction, which is continually repeated *ad infinitum*. Thus in the numbers 2·13 13 13 &c. the figures 13 are the repetend, and marked thus $\dot{1}\dot{3}$.

REPUBLICANS, the name given by Vaillant, with ſome propriety, to a kind of birds which were obſerved in South Africa, both by him and Paterſon, to inhabit apparently the ſame enormous neſt. Cutting one of theſe neſts in pieces with a hatchet, he perceived that the principal and fundamental piece conſiſted of a maſs of ſtrong coarſe graſs (called by the Hottentots *Boſhmen's graſs*), without any mixture, but ſo compact and firmly knit together as to be impenetrable to the rain. This nucleus is the commencement of the ſtructure; and each bird builds and applies to it its particular neſt. But theſe cells are formed only beneath and around the maſs; the upper ſurface remains void, without, however, being uſeleſs; for, as it has a pro-

---

* *Biog. Dict.* new edit.

jecting rim, and is a little inclined, it ſerves to let the water run off, and preſerves each dwelling from the rain. Figure to yourſelf a huge irregular maſs, the ſummit forming a kind of roof, and all the other parts of the ſurface completely covered with cells ſqueezed one againſt another, and you will have a tolerably accurate idea of theſe ſingular edifices.

Each cell is three or four inches in diameter, which is ſufficient for the bird. But as they are all in contact with one another through the greater part of the ſurface of the maſs, they appear to the eye to form but one building, and are diſtinguiſhable from each other only by a little external aperture, which ſerves as an entrance to the neſt; and even this is ſometimes common to three different neſts, one of which is ſituated at the bottom, and the other two at the ſides.

The neſt which he examined contained 320 inhabited cells, which, ſuppoſing a male and female to each, announce a ſociety of 640 individuals. Such a calculation, however, would not be exact; for whenever our author fired at a flock of theſe birds, he always killed four times as many females as males. "For the reſt (ſays he), theſe birds have nothing very remarkable in their plumage. It is an uniform brown grey, diverſified by a few black ſpots on the ſides, and a large patch of the ſame colour on the throat. The male is a little larger than the female; in other reſpects they exactly reſemble each other."

RESIDUAL ANALYSIS, a calculus propoſed by the inventor, Mr Landen, as a ſubſtitute for the method of fluxions. The object of this ſubſtitution was to avoid introducing the idea of motion, and of quantities infinitely or indefinitely ſmall, into mathematical inveſtigation. The reſidual analyſis accordingly proceeds, by taking the difference of the ſame function of a variable quantity in two different ſtates of that quantity, and expreſſing the relation of this difference to the difference between the two ſtates of the ſaid variable quantity itſelf. This relation being firſt expreſſed generally, is then conſidered in the caſe when the difference of the two ſtates of the variable quantity is $= 0$; and by that means it is evident, that the ſame thing is done as when the fluxion of a function of a variable quantity is aſſigned by the ordinary methods.

The evolution of the functions, conſidered in this very general view, requires the aſſiſtance of a new theorem, diſcovered by Mr Landen, and remarkable for its ſimplicity, as well as its great extent. It is, that if x and v are any two variable quantities, $\frac{x^{\frac{m}{n}} - v^{\frac{m}{n}}}{x - v}$

$$= x^{\frac{m}{n} - 1} \times \frac{1 + \frac{v}{x} + \frac{v^2}{x^2} + \frac{v^3}{x^3} + \cdots (m)}{1 + \left(\frac{v}{x}\right)^{\frac{m}{n}} + \left(\frac{v}{x}\right)^{\frac{2m}{n}} + \left(\frac{v}{x}\right)^{\frac{3m}{n}} \cdots (n)}$$

where m and n are any integer numbers.

This theorem is the baſis of the calculus; and from the expreſſions $x^{\frac{m}{n}} - v^{\frac{m}{n}}$, and $x - v$ having the form of what algebraiſts call *reſiduals*, the ingenious inventor gave to his whole method the name of the *reſidual analyſis*.

The firſt account of this method was publiſhed by Mr Landen in 1758, under the title of a *Diſcourſe concerning the Reſidual Analyſis*. The firſt book of the Reſidual Analyſis itſelf was publiſhed in 1764; and contained an explanation of the principles of the new calculus, with its application to ſeveral of the moſt conſiderable problems belonging to the direct method of fluxions. The ſecond book was intended to give the ſolution of many of the moſt difficult problems that belong to the inverſe method of fluxions, or to the integral calculus; but it has never been publiſhed: a circumſtance which every one, who has taken the trouble to ſtudy the firſt part of the work, will very much regret.

If we eſtimate the value of the reſidual analyſis from the genius, profound knowledge, and extenſive views required to the diſcovery of it, it will rank high among works of invention: but if, on the other hand, we eſtimate its value by its real practical utility, as an inſtrument of inveſtigation, we muſt rate it much lower. When compared with the fluxionary calculus, which it was intended to ſuperſede, its principles, though in appearance more rigorous, are much leſs eaſily apprehended, much leſs luminous, and leſs direct in their application; and therefore, as a means of extending the bounds of mathematical ſcience, it muſt ever be regarded as vaſtly inferior to the latter (A).

RETICULA, or RETICULE, in aſtronomy, a contrivance for meaſuring very nicely the quantity of eclipſes, &c. This inſtrument, introduced ſome years ſince by the Paris Academy of Sciences, is a little frame, conſiſting of 13 fine ſilken threads, parallel to, and equidiſtant from, each other, placed in the focus of object-glaſſes of teleſcopes; that is, in the place where the image of the luminary is painted in its full extent. Conſequently the diameter of the ſun or moon is thus ſeen divided into 12 equal parts or digits: ſo that, to find the quantity of the eclipſe, there is nothing to do but to number the parts that are dark, or that are luminous. As a ſquare reticule is only proper for the diameter of the luminary, not for the circumference of it, it is ſometimes made circular, by drawing ſix concentric equidiſtant circles, which repreſents the phaſes of the eclipſe perfectly. But it is evident that the reticule, whether ſquare or circular, ought to be perfectly equal to the diameter or circumference of the ſun or ſtar, ſuch as it appears in the focus of the glaſs; otherwiſe the diviſion cannot be juſt. Now this is no eaſy matter to effect, becauſe the apparent diameter of the ſun and moon differs in each eclipſe; nay, that of the moon differs from itſelf in the progreſs of the ſame eclipſe. Another imperfection in the reticule is, that its magnitude is determined by that of the image in the focus; and of conſequence it will only fit one certain magnitude. See MICROMETER, *Encycl.*

REVETEMENT, in fortification, a ſtrong wall built on the outſide of the rampart and parapet, to ſupport the earth, and prevent its rolling into the ditch.

REVIVIFICATION, in phyſiology, the recalling

(A) For this view of the *Reſidual Analyſis*, we are obliged to Mr Playfair profeſſor of Mathematics in the Univerſity of Edinburgh.

to life of animals apparently dead. There are many kinds of inſects which may be revivified, after all the powers of animation have been ſuſpended for a conſiderable time. Common flies, ſmall beetles, ſpiders, moths, bugs, &c. after being drowned in ſpirit of wine, and continuing apparently dead for more than a quarter of an hour, have been reſtored to life merely by being thrown among wood-aſhes ſlightly warm.

While Dr Franklin reſided in France, he received from America a quantity of Madeira wine which had been bottled in Virginia. In ſome of the bottles he found a few dead flies, which he expoſed to the warm ſun, it being then the month of July; and in leſs than three hours theſe apparently dead animals recovered life which had been ſo long ſuſpended. At firſt they appeared as if convulſed; they then raiſed themſelves on their legs, waſhed their eyes with their fore feet, dreſſed their wings with thoſe behind, and began in a little time to fly about.

But the moſt extraordinary inſtance of revivification that we ever heard of, is the following: In the warmer parts of France there is an inſect very deſtructive to rye, which ſeems to begin its operations at the root of the plant, and gradually to proceed upwards to the ear. If the plant be completely dried while the inſect is in the root or ſtem, the animal is irrecoverably killed; but after it has reached the grain, the caſe is very different. There have been inſtances, which are noticed in the Academy of Sciences, of theſe inſects being brought to life in a quarter of an hour, by a little warm water, after the grains, in which they were lodged, had been kept dry for 30 years.

What is the metaphyſician to think of theſe phænomena, or what concluſion is he to draw from them with reſpect to the mind or ſentient principle? If he be a ſober man, he will draw no concluſion; and for this very good reaſon, that of the ſentient principle of inſects, and indeed of every animal but man, he knows nothing. He is conſcious that it is the ſame individual being, which, in himſelf, thinks, and wills, and feels; he knows, that part of his thought is not in one place and part of it in another; and therefore he rationally concludes that this thinking being is not matter, whilſt experience teaches him that it quits the material ſyſtem as ſoon as that ſyſtem becomes completely unfit to diſcharge its functions, and that when it has once taken its flight, it cannot be recalled. Experience teaches him, on the other hand, that the ſentient principle of theſe inſects does not quit the material ſyſtem as ſoon as that ſyſtem ſeems unfit for its functions; and hence he ought to infer, that the minds of men and of inſects (if we may uſe ſuch language), though probably both immaterial, are very different ſubſtances; and that the bond which unites the material and immaterial parts of an inſect, is certainly different from that which unites the mind and body of man. This is the only inference which can be legitimately drawn from theſe phenomena; and he who makes them the baſis of materialiſm, muſt have his judgment warped by ſome paſſion or prejudice.

216 Narrative continued

REVOLUTION OF FRANCE. We formerly preſented to our readers a conciſe ſtatement of the commencement and progreſs of this extraordinary event (See REVOLUTION *Encycl.*). The ſingularity of its nature, and the important place which it muſt hereafter occupy in the moral and political hiſtory of mankind, require that we ſhould now reſume and continue the detail of its wide-waſting career. We left the ſubject towards the commencement of the year 1795, at the cloſe of that wonderful campaign, during which the armies of the Republic had exerted themſelves with ſuch unparalleled ſucceſs in every direction. On the one ſide they had croſſed the Pyrennees, and ſhaken the Spaniſh monarchy to its centre; while on the other they had driven the united forces of Auſtria, Pruſſia, and Britain, from the walls of Landrecies acroſs the Rhine, at all points from Hageneau to the ſea, and had finally cloſed their efforts by the conqueſt of Holland. At that period, though a prolongation of hoſtilities was threatened, we ſcarcely expected that Europe was ſo ſoon to witneſs, or we to record, a ſucceſſion of military enterpriſes of a ſtill more romantic and extraordinary nature, the ſcene of which was even to extend into barbarous countries, where the opinions and the quarrels of the European nations had hitherto remained unknown.

217 Diminiſhed energy of the Convention,

The campaign of 1794, however, was not immediately followed by any important military exertions. The Britiſh troops were recalled home, Pruſſia had been gradually withdrawing from the coalition, and the Auſtrian armies remained upon the defenſive. Neither was the French government in a ſituation which could enable it to renew its enterpriſes with vigour, or to give much trouble to the allies. The Convention ſtill exiſted; but it was no longer that terrible aſſembly which, under Robeſpierre and his aſſociates, had, in the ſhort period of fifteen months, reduced two thirds of France under its dominion, and ſent forth armies which the combined ſtrength of the reſt of Europe ſeemed unable to reſiſt. While its authority remained almoſt concentrated in one man, and while the fear of foreign invaſion, and the new born enthuſiaſm for freedom, induced the people to ſubmit to every meaſure of government, however oppreſſive or arbitrary, the power of the Convention, and the number of its armies, were unbounded. The dreadful price, however, which they had paid for liberty, and the facility with which they ſaw it might be loſt, had now diminiſhed the political zeal of all claſſes of citizens. The removal of the foreign armies had diſpelled the dread of invaſion, and the death of Robeſpierre, by diſſolving the unity of its efforts, and ſuffering it to fall into contending factions, had greatly weakened the authority of the Convention, and diminiſhed its efficiency as a government.

218 And diſcredit of the Jacobins,

The fall of Robeſpierre had been accompliſhed by two ſeparate conſpiracies. At the head of one of theſe were, Barrere, Billaud Varennes, and Collot d'Herbois, who had been members of the Committee of public ſafety. The other conſpiracy conſiſted of members of the Convention who did not belong to the committees, and had no immediate ſhare in the adminiſtration. Among theſe, Tallien, Bourdon de l'Oiſe, and Lecointre of Verſailles, were conſpicuous. After the deſtruction of their mutual tyrant, a conteſt for power took place between theſe parties. The popularity of Robeſpierre had once been ſo conſiderable, and all men had ſubmitted ſo tamely to his dominion, that both parties accounted it neceſſary, in their ſpeeches and writings, to juſtify to the nation the ſhare they had taken in accompliſhing his ruin. It was eaſy to be eloquent upon ſuch a topic; but its diſcuſſion naturally operated to the diſcredit of the members of the committee, and of the

the more violent Jacobins, who had been the immediate inſtruments for carrying into effect his ſanguinary meaſures. They nevertheleſs retained poſſeſſion, for ſome time, of a conſiderable portion of power. The current of public opinion, however, ran ſo ſtrongly againſt them, and the reſtoration to their ſeats in the Convention of the ſeventy one impriſoned members of the Girondiſt party, added ſo much to the ſtrength of their antagoniſts, that they gradually loſt their influence, and were threatened to be brought to trial for their conduct.

As early as Auguſt 1794, Lecointre of Verſailles had denounced the members of the old committee of ſafety; but his accuſation at that time produced little effect. Towards the end of that year, however, their approaching fall became evident. On the 26th of December the Convention ordered, on the motion of Clauzel, that the committees ſhould immediately report upon the conduct of the repreſentatives denounced by Lecointre and all France. Accordingly, on the following day, Merlin of Douay reported, in the name of the committees, that there was no cauſe for inquiry into the conduct of Vouland, Amar, and David; but that there was room for examining the conduct of Barrere, Billaud Varennes, Collot d'Herbois, and Vadier.

219
hoſe
aders
ere accu-
d,

In conſequence of this report, a committee of twenty-one members was appointed to make the enquiry. On the 2d of March this year (1795), Saladin preſented the report of the commiſſion; in which theſe four deputies were accuſed of having participated, as members of the governing committee, in the tyranny and atrocious meaſures of Robeſpierre. Their trial commenced before the Convention on the 22d of March; but previous to that period, Vadier had made his eſcape. The others remained, and reſted their defence upon this ground, that although members of the committee of ſafety, they had no power to reſiſt Robeſpierre, and that they were not more culpable in having acquieſced in his tyranny than the other members of the Convention, who had all been overpowered for the time by the knowledge that inſtant deſtruction awaited every man who ſhould dare to oppoſe his meaſures. Except in the caſe of the cruelties committed by Collot d'Herbois at Lyons, this defence was probably by no means deſtitute of foundation. It had much weight with the nation at large; in whoſe eyes it tended, not to exculpate the three perſons now accuſed, but to criminate and degrade the character of the whole Convention.

Carnot, Lindet, Cambon, Duhem, and the other members of what was now called the *Jacobin party*, defended their leaders with conſiderable ability, and with much vehemence. Nor was the party leſs active without doors than within the hall of the Convention. For ſome time they had drawn their friends to the capital from all quarters of the country; and in the morning ſitting of the firſt of April, they commenced their operations by an open inſurrection. An immenſe multitude having aſſembled in the ſuburbs, proceeded to the hall of the Convention. A real or factitious ſcarcity exiſted at the time. Taking advantage of this circumſtance, they pretended they were going to petition for bread; and this pretence drew numbers along with them who had no ſhare in their deſigns.

220
nd de-
nded by
n inſurrec-
on;

Boiſſy d'Anglas, a conſpicuous member of the moderate party, was addreſſing the Convention upon the means of removing the preſent ſcarcity when the inſurgents arrived, drove the centinels from their poſts, and ſuddenly filled the hall. They tumultuouſly demanded "Bread, and the Conſtitution." The Jacobin party ſupported the inſurgents; and one of the multitude, in a vehement harangue, exclaimed, "We are men of the 14th of July, of the 10th of Auguſt, and of the 31ſt of May." He demanded, that the Convention ſhould change its late meaſures, that the people ſhould no longer be the victims of mercantile rapacity, and that the accuſed patriots ſhould not be ſacrificed to the paſſions of their antagoniſts. The Convention ordered the tocſin to be rung, and the people of Paris to be called to arms. General Pichegru was in Paris at the time; and, upon the motion of Barras, he was appointed to the command of the military force.

221
Which is quelled by Pichegru.

The citizens of Paris, who remembered with horror the domination of Robeſpierre and his adherents, and now ſaw themſelves menaced with its return, inſtantly called each other to arms, and aſſembled, by ſix in the evening, for the protection of the Convention, to the amount of 20,000 men. Till that time the aſſembly had remained under no ſmall diſquietude, ſurrounded by the inſurgents, and liſtening to the addreſſes of their orators, and the ſpeeches of the Jacobin minority in their favour. The majority was now reſcued from this ſtate of conſtraint; and, on the motion of Dumont, without proceeding farther in the trial, it was decreed that Barrere, Collot d'Herbois, and Billaud Varennes, ſhould immediately be tranſported to Guiana.

During the following day the inſurgents were completely ſubdued; and the majority of the Convention, taking advantage of their victory, decreed the arreſt and confinement, in the caſtle of Ham in Picardy, of ſeveral of the moſt obnoxious of their antagoniſts. Among theſe were Leonard Bourdon, Duhem, Chaſles, Choudieu, Ruamps, Fouſſedoire, Huguet, Bayle, Lecointre, Cambon, Thuriot Maignet, Heutz, Craſſous, and Levaſſeur. By departing from the puniſhment of death, and adopting that of baniſhment on this occaſion, the Convention expected to diminiſh the ferocity of the contending factions in the ſtate, by rendering the reſult of a political defeat leſs fatal than formerly. The deſign was good; but in attempting to accompliſh it, they eſtabliſhed the pernicious precedent of inflicting puniſhment without a trial, which could ſcarcely fail to prove highly dangerous, if not ultimately fatal, to all their proſpects of a free and juſt government.

222
Victory of the Convention.

223
Propoſal for a new conſtitution.

The Convention now followed up its victory with the popular meaſure of preparing for its own diſſolution, by endeavouring to frame a fixed conſtitution for the Republic. The conſtitution which had been decreed in 1793, under the auſpices of Robeſpierre, was conſidered as impracticable, and a committee was appointed to report upon the meaſures which ought now to be adopted. It conſiſted of Sieyes, Cambaceres, Merlin of Douay, Thibaudeau, Mathieu, Le Sage of Eure and Loire, and Latouche. On the 19th of April, Cambaceres reported, that it was the opinion of this committee that a commiſſion ſhould be appointed to frame an entirely new conſtitution. The Convention accordingly appointed the following perſons to this important office, Le Sage, Louvet, Boiſſy d'Anglas, Creuze, Latouche, Bertier, Daunow, Baudin, Durand, Maillane, Languinais, La Reveillere Lepaux, and Thibaudeau. All other citizens of every deſcription were at

French Revolution, 1795.

at the ſame time invited to communicate projects upon the ſubject, and the committee was required to order the beſt conceived of theſe to be printed.

The Convention farther gratified the feelings of the great majority of the nation, by bringing to trial Fouquier Jenville the preſident, and fifteen judges and jurors of the late revolutionary tribunal. They were convicted on the 8th of May, and executed on the following day, amidſt the execrations of a multitude of ſpectators.

224 New inſurrection of the Jacobins,

In the mean time, though defeated on the 1ſt and 2d of April, the Jacobins by no means conſidered themſelves as ſubdued. On the contrary, they were preparing a new and more extenſive inſurrection, which ſhould not, like the former, be confined to the capital. They fixed upon the 20th of May as the day of revolt. Thuriot, and Robeſpierre's financier Cambon, had found means to eſcape from the caſtle of Ham in Picardy, and to come to Paris. They concealed themſelves in the ſuburb St Antoine, and from thence gave counſel to their party, and urged them to action. The ſcarcity of bread had increaſed, and advantage was again taken of this circumſtance. For ſome days the walls were covered in various places of Paris with printed accuſations againſt the Convention of withholding bread from the people, and attempts were made to excite the troops in the city to join the diſaffected party. On the evening of the 19th, a paper was openly diſtributed in the different ſections, explaining the object of the approaching inſurrection. It declared inſurrection to be the moſt ſacred duty of the people, and called upon the citizens of Paris to proceed in a maſs to the Convention, to demand from it bread and the eſtabliſhment of Robeſpierre's conſtitution, together with a new election of national repreſentatives.

On the morning of the 20th, the tocſin was rung, and drums beat to arms in the ſuburb St Antoine, which had always been the quarter of the city in which the Jacobins poſſeſſed the greateſt ſtrength. Upon this alarm the Convention aſſembled; but although the intended inſurrection was no ſecret, and though the committee of public and general ſafety now made a report, in which they confeſſed their previous knowledge of it, yet it does not appear that any vigorous meaſures of precaution had been taken; for it was only at the inſtant when the inſurgents were actually approaching, that General Hoche was appointed to command the armed force, and was ſent forth to aſſemble the military and the citizens for the defence of the Convention. In the mean time, the multitude ſurrounded the hall. They ſoon overpowered the guards, and burſt into the midſt of the aſſembly. In all the turbulent days of the revolution, the women of Paris have never failed to act a conſpicuous part. On this occaſion they greatly augmented the crowd by their numbers, and the tumult by their cries of "Bread, and the conſtitution of 1793," which was the rallying exclamation of the party. After ſome fruitleſs efforts to reſtore tranquillity, Vernier the preſident, an old man, reſigned the chair to Boiſſy D'Anglas, who remained in it with much firmneſs during the day. The whole ſtrength of the inſurgents had not arrived at once; for the firſt party that approached, although they forced their way into the hall, were ſoon repulſed by the aid of a few ſoldiers and citizens, who came to the aſſiſtance of the Convention. A ſhort interval of tranquillity was thus obtained; but the attack was ſpeedily renewed with double fury by armed men, who ſubdued all oppoſition, and entered the hall with cockades, on which was written the inſcription, "Bread, and the conſtitution of 1793."

225 Who murder ſome the Convention, and drive from its hall.

While things were in this ſtate, a citizen of the party of the Convention raſhly tore off the hat of one of the inſurgents, and was immediately aſſaulted with ſwords by the multitude. He fled towards the preſident's chair, and was killed at the ſide of it by a muſket ſhot. Ferand, one of the members, having attempted to reſcue him, was alſo attacked. He eſcaped into one of the paſſages, where he was alſo killed, and his head was brought into the Convention upon a pike. The greater number of the members now gradually departed, and left the hall in poſſeſſion of the inſurgents, who acted with ſome regularity, and propoſed a variety of laws favourable to their party, which were inſtantly decreed. Duroi, Duqueſnoi, Bombotte, and Goujon, were the members who ſtood moſt openly forward on this occaſion, and appeared as chiefs of the inſurrection. But their triumph only laſted a few hours. Towards the evening a large body of citizens joined the military, and marched to the aid of the Convention. Having overcome the inſurgents, they entered the hall in great force, and reſtored the powers of the majority. The decrees that had been forced upon them were repealed as ſpeedily as they had been enacted, and the deputies who had propoſed or ſupported them were arreſted.

The citizens of Paris, and even the members of the Convention, appear now to have fancied their victory complete; for they adopted no adequate meaſures to prevent a new diſturbance. But the Jacobins did not ſo eaſily give up their own cauſe. On the following day they once more aſſembled in the ſuburbs, and in the afternoon they returned to the attack. They took poſſeſſion of the Carouſal without oppoſition, and pointed ſome pieces of cannon againſt the hall of the Convention. This aſſembly was now unprotected, and attempted not to ſubdue, but to flatter, the inſurgents.

226 Meanneſs of the Convention.

A deputation of the members was ſent forth to fraterniſe with them, and to carry forth two decrees paſſed at that inſtant, which ordained that bread ſhould abound, and that Robeſpierre's conſtitution of 1793 ſhould immediately be put in force. The inſurgents, in return, ſent a deputation to the Convention, to expreſs their ſatisfaction with the decrees, to demand the releaſe of the impriſoned patriots, and the puniſhment of thoſe who preferred money to aſſignats. The Convention pretended to agree to all their demands, and the preſident was ordered to give to the deputation the fraternal embrace.

The 22d, which was the third day of the inſurrection, appears to have been paſſed by both parties in a ſtrange degree of inaction. The Convention proceeded in its ordinary buſineſs; and the Jacobins, at their head quarters in the ſuburb St Antoine, were occupied in conſultations and preparations for new movements. But on the following day the citizens aſſembled at their ſections, and haſtened from thence to the Thuilleries to defend the Convention. Conſiderable bodies of the military were alſo collected, and the aſſembly at laſt reſolved to act upon the offenſive. A decree was paſſed, declaring, that if the ſuburb St Antoine did not inſtantly ſurrender its arms and cannon, together with

the

ench olution, 795.

227 ictory the Jacobins;

the murderer of Ferand, it ſhould be conſidered as in a ſtate of rebellion. The conventional generals were at the ſame time ordered to reduce it by force. The inſurgents now found themſelves unequal to the conteſt, and were compelled to ſurrender without conditions by the inhabitants of the ſuburb, who dreaded the deſtruction of their property by military operations. Several ſoldiers being found among the priſoners, were put to death: and ſix members of the Convention were tried and condemned on this occaſion by a military commiſſion. Three of theſe periſhed by ſelf ſlaughter, and three were executed. The majority of the Convention, elated by their victory, ordered back Collot D'Herbois, Billaud Varennes, and Barrere to take their trial; but the two former had ſailed before the arrival of the courier. Barrere only remained, and he was brought back and impriſoned.

In the mean time, the Jacobins in the ſouth were not leſs active than their brethren at Paris. On the 20th of May they formed a vigorous inſurrection at Toulon. They ſeized the gates, and mounted them with cannon; they liberated ſuch of their aſſociates as had been impriſoned, and detained the fleet, which was about to ſail. Having begun their operations in this ſucceſsful manner, they marched from Toulon towards Marſeilles. Their force amounted to three thouſand men and twelve pieces of cannon. They were encountered on their way, however, and defeated by Generals Charton and Pactod. Three hundred of them were carried priſoners to Marſeilles, and Toulon was ſpeedily retaken.

228 ho ſtill tain their irit;

The party of the *Mountain*, as it had been called, or of the violent Jacobins, who wiſhed to revive the reign of terror and the meaſures of Robeſpierre, was now reduced very low both in the Convention and out of it. Thoſe who adhered to it were even in many places, and more eſpecially in the ſouth, expoſed to very violent perſecution. Aſſociations were formed, called Companies of *Jeſus* and of the *Sun*, for the purpoſe of avenging the crimes committed by them during the period of their power. At Lyons ſeveral of them were maſſacred in priſon, and many of them in all places periſhed by aſſaſſination. On conſidering the mercileſs character of the government of Robeſpierre and his aſſociates, and the perſecution which was ſuffered under it, not merely by the nobles and the rich, but by every man who was diſtinguiſhed by integrity, talents, or literature, it may appear ſurpriſing that it ſhould have obtained admirers, or that any number of individuals ſhould have been found willing to hazard their lives to procure its reſtoration. Accordingly, from the period of the fall of its leader, the party had gradually been forſaken by its adherents; and the more cloſely its conduct was conſidered, it loſt ground the more rapidly in the eſtimation of the public. After the unſucceſsful inſurrections of the 20th of May, it was treated with the utmoſt contempt, and its unpopularity was extreme. Still, however, a party remained. It was ſmall, indeed, but its members compenſated the inferiority of their numbers by ſuperior enterpriſe and activity. They conſiſted of outrageous republicans, whoſe heated imaginations beheld royalty and ariſtocracy in every propoſal for ſober and regular government. In the conduct of Robeſpierre, they remembered only the energy of his meaſures, by which France was enabled to triumph over the combined efforts of the kings of Europe; and overlooked the atrocities by which he had brought diſgrace upon their cauſe, and rendered his party odious to their own countrymen, as well as to the neighbouring nations. Amidſt this univerſal odium, however, the Jacobins did not deſpair of riſing once more into power; and it is not a little ſingular, that we muſt date the revival of their ſtrength from the period of the unſucceſsful inſurrections which we have juſt recorded, and which ſeemed to have extinguiſhed their hopes for ever.

French Revolution, 1795.

The unpopularity under which the Jacobins laboured ſoon began to affect the Convention itſelf. The tame ſubmiſſion of that body to the government of Robeſpierre was now remembered. It was recollected, that the majority of its members had been the inſtruments of his power, and had applauded, or at leaſt acquieſced in, his crimes. As the preſs was now free, and the reins of government unſteadily held, their conduct was repreſented to the public in the moſt odious colours. A celebrated ſong, *Le Reveil du Peuple*, became extremely popular, as the means of marking diſlike both to the Convention and to the Jacobins; and their conduct was canvaſſed with the utmoſt bitterneſs in a great variety of publications, but more eſpecially in a journal that at this time attracted much notice, and which was conducted by Freron, who had himſelf been a Jacobin, but had now abandoned his party.

229 And terrify the Convention.

In this ſtate of things, the majority of the Convention ſpeedily began to repent of their late victory over the Jacobins. In the firſt efforts of their zeal, they had taken meaſures for the immediate formation and eſtabliſhment of a ſettled conſtitution to ſuperſede their own authority; but they now regretted their raſhneſs, when they perceived, from the temper the nation was in, that the men, the moſt avowedly hoſtile to their character and meaſures, would without doubt be elected as their ſucceſſors. They, and their friends, had ariſen to great diſtinction and wealth under the revolutionary government; and they now began to dread, not only the loſs of power, but alſo a ſevere inveſtigation of their conduct. Theſe conſiderations ſoon produced their natural effects. The decrees for forming and putting in force the conſtitution could not decently be recalled; but the majority of the Convention ſet about deviſing means for rendering them of little importance, ſo far as they themſelves were concerned.

230 New conſtitution, conſiſting of

On the 23d of June, Boiſſy D'Anglas preſented the report of the committee that had been appointed to prepare the plan of a conſtitution. It began, like the former conſtitutions, with a declaration of the rights of man; and in addition to this, conſiſted of fourteen chapters, upon the following ſubjects:—The extent of the territorial poſſeſſions of the Republic, the political ſtate of citizens, the primary aſſemblies, the electoral aſſemblies, the legiſlature, the executive power, the municipal bodies, the judicial authority, the public force, public inſtruction, the finances, foreign treaties, the mode of reviſing the conſtitution, and, laſtly, an enactment, that no rank or ſuperiority ſhould exiſt among citizens, excepting what might ariſe from the exerciſe of public functions.

The primary aſſemblies were to poſſeſs the right of electing the members of the electoral aſſemblies, and alſo the juſtices of the peace. The electoral aſſemblies were to nominate the judges and the legiſlators of the ſtate.

231 Two Councils and an

ſtate. The legiſlature was divided into two aſſemblies; the one of which conſiſted of 250 members, and was called the *Council of the Ancients*, as none but married men and widowers above 40 years of age could be members of it. The other aſſembly or council conſiſted of 500 members, and poſſeſſed the excluſive privilege of propoſing the laws; the Council of Ancients being only intitled to reject or approve, without power to alter the decrees preſented to it. To this rule there was one exception, which was afterwards employed as the means of overturning the whole fabric of the conſtitution; the Council of the Ancients might decree the removal of the legiſlature from its ordinary place of ſitting. To this decree the approbation of the Council of Five Hundred was not neceſſary; and when once enacted, it could not be reconſidered even by the Council of Ancients itſelf. One-third of the members of the two Councils was to be elected annually. A member might be once re-elected, but he could not be elected a third time till an interval of two years had elapſed.

232 Executive Directory.

The executive power was intruſted to five perſons of forty years of age at leaſt, to be ſtyled the *Executive Directory*. Its members were elected by the two Councils; the Council of Five Hundred electing ten times the number of candidates that might be neceſſary to fill up the vacancies, and the Council of Two Hundred and Fifty nominating the directors from this liſt of candidates. One member of the Directory was to go out annually; ſo that the whole might be changed every five years. The Executive Directory had no vote in the enactment of laws; but it ſuperintended their execution, regulated the coining of money, and diſpoſed of the armed force. Foreign treaties made by it were not binding till ratified by the legiſlative body, nor could it make war without the authority of a decree of the two aſſemblies. The public functionaries were to receive ſalaries, and to appear dreſſed in an appropriated habit.

Each article of this conſtitution was ſeparately diſcuſſed; and on the 23d of Auguſt the whole was declared to be complete, and ordained to be tranſmitted to the primary aſſemblies for their approbation. Previous to this reſolution, however (that is, on the 22d of the ſame month), the majority of the Convention had brought forward the grand meaſure by which they meant to provide for their own ſafety, and the ſafety of their friends and adherents, againſt the change which the public opinion had undergone concerning them They decreed, that at the approaching general election, the electoral bodies ſhould be bound to chooſe *two-thirds* of the new legiſlature from among the members of the preſent convention; and they afterwards decreed, that, in default of the election of two-thirds of the Convention, the Convention ſhould fill up the vacancies themſelves.

233 The Convention fetters the fredom of election.

Theſe decrees were tranſmitted, along with the Conſtitution, to the primary aſſemblies, to be accepted or rejected by them. Many of the primary aſſemblies underſtood, that they could not accept of the conſtitution without accepting along with it the law for the re-election of the *two-thirds*. The point had, in all probability, been purpoſely left under a certain degree of ambiguity; and as the people were now weary of this Convention, they acquieſced in any conditions that gave them the proſpect of one day getting quit of it. But at Paris, and in the neighbouring departments, where the ſubject was more accurately inveſtigated, the public diſapprobation of the Convention diſplayed itſelf with great vehemence.

234 Conſeque ces of thi conduct,

There was indeed ſomething extremely aukward in the decree about the re-election of two thirds of the Convention. That body might, if neceſſary, have continued its own exiſtence for ſome time longer, or it might have diſmiſſed one-third of its number by ballot or otherwiſe, and allowed a new election only to that extent; but a compulſory election was an abſurdity ſo new, and ſo obvious, that it gave their antagoniſts every advantage againſt them. Accordingly, at the meetings of the ſections of Paris, the laws for the re-election were rejected with contempt, and their abſurdity demonſtrated with much acrimony. In conſequence of the debates which took place at theſe meetings, the minds of men were gradually inflamed, and it became obvious that a political convulſion approached. On the one ſide, the Convention took care to publiſh daily the approbation of the decrees, along with the conſtitution, by the majority of the primary aſſemblies, by moſt of which the two had been confounded and accepted in the groſs. Its committees alſo called in the aid of the troops of the line for its protection. On the other hand, the language of the ſections became every day more violent. The whole Convention was repreſented as a band of tyrants and of murderers, the aſſociates of all the cruelty of Robeſpierre and the Mountain party. It was even propoſed to bring to trial every individual member of the aſſembly before a new revolutionary tribunal, and to puniſh him according to his demerits.

For ſome time much anxiety prevailed on both ſides. Numerous deputations were repeatedly ſent from the ſections to the Convention to remonſtrate againſt the obnoxious decrees. But the eagerneſs with which theſe remonſtrances were made, ſerved only to convince more ſtrongly the members of the Convention of the danger to themſelves as individuals which would attend a reſignation of their power, and confirmed the reſolution they had taken to retain it. The deputies of the ſections having obtained inſpection of the records of the convention, aſſerted, that the national majority, if rightly numbered, had rejected the decrees; as every aſſembly that voted in oppoſition to them was only numbered as one vote, however numerous its members might be; which enabled the primary aſſemblies of remote diſtricts to outvote the more populous ſections of Paris and other great towns. Whereas it was ſaid, that if the individual voters were counted, it would be found that the decrees were diſapproved of by a conſiderable majority. All this was diſregarded by the Convention, and the ſections prepared to decide the diſpute by arms. The firſt ſtep taken by them, however, was ill concerted. A notion was propagated, that as ſoon as the primary aſſemblies or ſections had choſen the electors who were to chooſe the members of the new legiſlature, the national ſovereignty became veſted in theſe electors, and that they had a right to aſſume the government in their various diſtricts. Accordingly, about 100 of the electors of Paris aſſembled in the hall of the French theatre in the ſuburb St Germain, previous to the day of meeting appointed by the Convention. Having choſen

De Nivernois (formerly the Duke de Nivernois) their preſident, they began their debates. The Convention was alarmed, and inſtantly ſent a body of the military to diſmiſs the meeting as illegal. This was eaſily accompliſhed, as the citizens had not been unanimous with regard to it, and no meaſures were taken for its protection.

435 Con- ion ts the bins.

Notwithſtanding this firſt advantage on the ſide of the Convention, the ſections regarded its power with contempt, and imagined themſelves ſecure of ultimate ſucceſs. In every political conteſt that had hitherto occurred ſince the commencement of the revolution, the immenſe population of the capital had given a deciſive ſuperiority to the faction whoſe ſide it eſpouſed. The citizens alſo regarded with indifference the armed force with which the Convention had ſurrounded itſelf, from a notion, which they fondly entertained, that the military would in no caſe be brought to act againſt the people. It would appear that the Convention itſelf entertained ſome jealouſy upon this head, and did not account itſelf entirely ſafe under the protection of the ſoldiers. On this occaſion, therefore, it had recourſe to a new ally, and beſought the aid of thoſe very Jacobins whom it had almoſt cruſhed on the 24th of May. The members of the Convention were odious to the ſections of Paris, on account of their participation in the revolutionary crimes and meaſures of Robeſpierre; but this very circumſtance endeared them to the Jacobins, whoſe character it was to imagine that they had never enough of war abroad or of revolution at home. It was eaſy therefore to bring about a reconciliation between the Convention and theſe men. Several hundreds of them were diſmiſſed from the priſons, where they had been confined ſince the two laſt inſurrections, and they were now put in requiſition to defend the legiſlative body.

When the ſections of Paris beheld the Convention ſurrounded by thoſe Jacobins who had been the unrelenting agents of the government of Robeſpierre, and who were now denominated *terroriſts* and *men of blood*, their ardour for action became unbounded. They aſſembled in arms at their different ſections on the 12th Vendemaire (October 4th); but they do not ſeem to have acted with much concert, or upon any well digeſted plan of operations. The general deſign of their leaders was to ſeize the members of the Convention, and impriſon them in the church of the Quatre Nations till they could be brought to trial. As this would occaſion a vacancy or interregnum in the government, it was reſolved that all affairs ſhould be conducted by committees of the ſections, till a new legiſlature could be elected. General Miranda, a Spaniard, a native of the Carraccas in South America, who had ſerved in the republican armies, was to be appointed to the chief command of the armed force after the overthrow of the Convention. This man, in his eagerneſs for preferment, had alternately courted all parties, and he now ſeems to have joined the Pariſians upon the ſuppoſition of their being the ſtrongeſt. As he entertained ſome doubts of their ſucceſs, however, he adopted the crooked and timid policy of avoiding the ſtorm by retiring from the city till the combat ſhould be finiſhed, reſolving to return immediately on its concluſion to ſhare the rewards and the triumph of victory.

The Convention, in the mean time, reſolved to ſtrike the firſt blow. For this purpoſe they ſent General Menou to the ſection of Le Pelletier to diſperſe the citizens, whoſe greateſt force was aſſembled there. But this officer, diſliking the ſervice which he was employed to perform, inſtead of proceeding to action, began to negociate with the leaders of the ſections, and ſpent the evening of this day in fruitleſs conferences. The ſections on their ſide appointed General Danican, who had diſtinguiſhed himſelf in the war againſt the Royaliſts in La Vendee to act as their military leader. It would appear, however, that this officer, from the moment that he aſſumed the command, began to deſpair of the cauſe of the ſections. He found them totally deſtitute of cannon, whereas the Convention was ſurrounded by regular troops and a numerous artillery. This inequality in point of weapons appears to have been conſidered by him as a ſufficient reaſon for avoiding an engagement. Occupied in viſiting and arranging the different poſts, he was unacquainted with the diſaffection of the conventional generals. He therefore thought he had done much when he had prevented bloodſhed for another day, and thus the favourable moment for attack was loſt. Whether the ſections would have been ſucceſsful had they been inſtantly led to battle on this important occaſion, cannot now be known. Though the ſuperior officers of the Convention were unfaithful, yet the ſubalterns and the troops in general might have ſtood firm, confirmed as they were by the perſuaſion of their Jacobin auxiliaries. Even in this caſe, however, the fate of a battle might have at leaſt been doubtful. The battalions of Paris were very numerous, their contempt of danger was great, and their ardour unbounded. The mere poſſeſſion of cannon might not in a conteſt againſt ſuch men have afforded ſecurity to the Convention. But the firſt moments of popular enthuſiaſm were ſuffered to paſs away, and that diſtruſt and diſſenſion, which delay never fails to introduce among great and irregular aſſemblages of men, ſoon began to render the conduct of the ſections undecided and weak.

The conventional committees, during the night of the 12th Vendemaire (October 4th), diſmiſſed Generals Menou, Raffet, and ſome others, from their ſtations, and gave the command of the troops to Barras. He immediately collected around him a variety of able officers, among whom we find the names of Generals Brune and Bonaparte. With their aſſiſtance he began to provide for a moſt vigorous defence. Troops with cannon were ſtationed in all the avenues leading to the Thuilleries. In caſe any of theſe poſts ſhould be forced, maſked batteries were planted in more retired ſituations. Nor was this all; meaſures were taken for conveying the public magazines of proviſions and military ſtores to St Cloud, whither the Convention prepared to retreat if they ſhould ſuffer a defeat at Paris.

On the 13th Vendemaire (October 5th) from which the inſurrection was afterwards named, both parties remained for many hours upon the defenſive. At laſt, about three o'clock in the afternoon, General Danican made advances to an accommodation by a letter to the committee of public ſafety; in which he ſtated, that the only cauſe on account of which the citizens had taken arms was the dread of a maſſacre being intended by the armed terroriſts who ſurrounded the Convention, and that if theſe men were removed, tranquillity would immediately be re-eſtabliſhed. A civil meſſage was returned;

236 Subdues the citizens of Paris.

turned; but the Jacobin party in the Convention, being now more confident of victory, and wiſhing to ſtrengthen themſelves by the defeat and puniſhment of their antagoniſts, it was reſolved that the diſpute ſhould be decided by arms. It is not correctly known how the conteſt commenced, but the armed Jacobins are moſt generally underſtood to have begun the attack. The citizens on the ſouthern ſide of the river attempted to reach the Convention by the Quay de Voltaire, but were ſpeedily repulſed by the conventional cannon; but on the northern ſide of the river, near the Convention, the combat was extremely obſtinate. The cannon were repeatedly ſeized by the citizens, and repeatedly retaken by the troops and the armed Jacobins. It was not till after a conteſt of four hours that the ſections were repulſed and driven to the poſt of St Roch. This poſt was alſo taken after great ſlaughter, and the ſections were driven to their head quarters at the ſection of Le Pelletier. After a ſhort interval they were purſued thither by the troops of the Convention, who by midnight were maſters of the whole city.

237 Mountain party, or the moſt violent Jacobins, again at the head of the ſtate.

This inſurrection was aſcribed by the victorious party to the exertions of the Royaliſts. It is no doubt true, that by this time Royalty was become leſs unpopular even among the rabble of France than the extreme of Republicaniſm, as it had appeared in the conduct of the Mountain party. It is alſo probable, that the Royaliſts mingled in a conteſt that had the overthrow of the preſent Convention for its object; but the inſurgents in general ſeem neither to have avowed nor entertained any farther view than the diſarming of the Jacobins, and the obtaining an immediate election of new repreſentatives. The failure of the attempt had the effect of placing the Mountain party once more at the head of the ſtate. This party at firſt thought of adjourning the new conſtitution, and of renewing all the terrors of the revolutionary government. This project, however, was oppoſed in the Convention with ſo much vehemence and ability by Thibaudeau, that it was renounced. Indeed it was become unneceſſary to the ſafety or aſcendency of the men who propoſed it, as the decrees for the re-election of two-thirds of the Convention enabled them to retain the full poſſeſſion of their power. A few members of the moderate party, ſuch as Boiſſy D'Anglas, Languinais, and Le Sage, were elected by almoſt every place in France, though they could only ſit for one place. Hence the Convention itſelf had the re-election of nearly two-thirds of its own members; and the Mountain party, which now commanded the majority, was thus enabled to fill the new legiſlature with its own leaders.

238 Firſt ſitting of the new legiſlature.

On the 27th of October the Convention terminated its ſittings, and was ſucceeded by the new legiſlature as appointed by the Conſtitution. By its laſt decrees, a general amneſty was granted for all revolutionary crimes and proceedings. From this amneſty, however, were excepted the emigrants, the tranſported prieſts, and all perſons concerned in the laſt inſurrection; ſo that in fact it was merely a pardon granted by the Mountain party to its own friends for all the exceſſes they had committed. The members of the Convention, who had been impriſoned in the caſtle of Ham ſince the Jacobin inſurrection in May, were now ſet at liberty. The members of the revolutionary committees, and other agents of Robeſpierre in Paris and the departments, were all diſmiſſed from their priſons, and advanced to the moſt important offices under the new government.

239 The Council of Five Hundred outwits the Council of Ancients.

As ſoon as the new legiſlature had divided itſelf into two councils, it proceeded to the election of an Executive Directory. Here the genius of the French nation for intrigue inſtantly diſplayed itſelf. The Council of Five Hundred was bound to preſent to the Council of Two Hundred and Fifty a liſt of ten times the number of candidates neceſſary for the office. It fulfilled this duty in the following manner. The majority of the Council of Five Hundred made out a liſt, conſiſting of the five following perſons, upon whom they wiſhed the election ultimately to fall: Sieyes, Barras, Rewbell, La Reveillere Lepaux, and Letourneur de la Manche. To complete the liſt, they added the names of 45 obſcure perſons, country juſtices, farmers, and even peaſants. Thus there was nothing left to the Council of Ancients but the mere form of an election; and from the want of other qualified candidates, they were under the neceſſity of nominating to the office of directors the five perſons at the head of the liſt preſented by the Council of Five Hundred. The crafty Sieyes, however, who had been the adviſer of all parties, but the oſtenſible agent of none, did not yet think fit to venture upon the poſſeſſion of power. He had diſapproved of the conſtitution which was now put in force, and had even framed one of his own in oppoſition to it, which, however, was rejected by the Convention. The moſt remarkable circumſtance in his plan of government was a national jury, upon which he propoſed to confer the power of diſmiſſing from their offices, without a cauſe being aſſigned, any of the public functionaries whom they might account dangerous to the ſtate. Sieyes having refuſed to accept the office of director, Carnot was elected in his ſtead. But on this occaſion the Council of Ancients was treated with a little, and but a little, more decency than formerly; as the name of Cambaceres, a man of conſiderable eminence, appeared along with that of Carnot in the liſt of candidates voted by the Council of Five Hundred.

240 New government not popular.

The republican government that was now attempted to be eſtabliſhed promiſed little tranquillity to the nation. This great misfortune attended it, that the chief offices in the ſtate were intruſted to men who were diſliked by the people. The members of the Executive Directory, with the exception of Reveillere Lepaux, had always belonged to the Mountain or moſt violent Jacobin party. As they now owed their power to that party, they employed its members in almoſt every official department. The goverment was therefore neceſſarily unpopular. Things might have been gradually altered, indeed, by ſucceſſive elections, which would in time bring other men into power: But, by the forms of the conſtitution, the executive power was more permanent than the legiſlative body, without poſſeſſing any influence over it. Hence it was to be feared that a conteſt for power might ſpeedily occur between a directory nominated by the Jacobin party and the new legiſlators appointed by the people, in which the Conſtitution might ſuffer ſhipwreck; an event which actually occurred.

While the poſſeſſion of power continued to fluctuate in the manner we have already ſtated, between the Moderate and the Jacobin or Mountain parties, the armies of the ſtate were ſuffered to languiſh; but upon the rench olution, 795.

4r atment e Republic by ign vers.

credit of its former military ſucceſs, the Republic was treated with reſpect by ſome of the neighbouring powers. On the 10th of April, a treaty of peace with Pruſſia, which had been negociated by the committees through the medium of Barthelemi the French reſident at Baſle, was preſented to the Convention for ratification. By this treaty, it was ſtipulated, that the French troops ſhould immediately evacuate the Pruſſian territory on the right bank of the Rhine, but ſhould retain the territory belonging to that power on the left bank till a general peace. Priſoners of war were to be mutually reſtored, and the commerce of the two countries was to be placed on its ancient footing. Meaſures were alſo to be taken to remove the theatre of war from the north of Germany by treaties between France and thoſe princes for whom the king of Pruſſia might interpoſe.

During the ſame month of April, the French Republic was acknowledged by the king of Sweden; and Baron Stael his ambaſſador was received at Paris with great ſolemnity. In the month of May a ſecond treaty with Pruſſia was concluded. It chiefly regarded the line of neutrality. It is worthy of remark, that theſe treaties contained ſecret articles which were to be revealed only to a ſelect committee. By authoriſing this mode of procedure, the Convention ſufficiently demonſtrated its reſolution, that no form of popular government to be adopted in France ſhould ſtand in the way of the national aggrandiſement. The Swiſs cantons now followed the example of Sweden, and acknowledged the French Republic. A treaty of peace with Spain was alſo concluded at Baſle on the 22d of July. France, on this occaſion, relinquiſhed all the conqueſts ſhe had made in the territory of that country, and reſtored the ancient frontier. She received in return all the Spaniſh part of the iſland of St Domingo. The Dutch Republic was included in this treaty; and France agreed to accept of the king of Spain's mediation in favour of Portugal and the Italian princes.

242 ath of uisXVII.

On the 9th of June, the Dauphin, ſon of the unfortunate Louis XVI. died in the priſon of the Temple, where he had been confined, along with his ſiſter, ſince the executions of his father, mother, and aunt. His death, which was probably produced by diſeaſes ariſing from long confinement, if not by more unjuſtifiable means, excited in the French nation ſuch a degree of intereſt in favour of his family, that the Convention found it neceſſary to liberate his ſiſter from impriſonment. The committee of public ſafety propoſed to the Emperor to exchange this princeſs for the members of the Convention whom Dumourier had delivered up to Auſtria, along with two ambaſſadors, Semonville and Maret, who had been ſeized on their way to Turkey. This propoſal was accepted, and the exchange took place at Baſle in Switzerland.

243 val ſupe. rity of tain.

On the ſide of Britain the war maintained its former character. The Britiſh retained their ſuperiority by ſea, and were unfortunate in their efforts on the continent. On the 14th of March the Britiſh fleet in the Mediterranean, under Admiral Hotham, engaged the French fleet, and took two ſail of the line, the Ca-Ira and the Cenſeur; but as the French fleet, four days before the engagement, had captured the Berwick, a Britiſh ſhip of the line, when detached from the fleet, and as the Illuſtrious, another Britiſh ſhip of the line, was ſo ſeverely injured in the action that ſhe run aſhore and was loſt at Avenza, the ſubſtantial loſs on both ſides was nearly equal. On the 23d of June another Britiſh fleet under Lord Bridport attacked the French off Port L'Orient, and took three ſhips of the line, the reſt of the fleet eſcaping into that port.

French Revolution, 1795.

This evident ſuperiority of the Britiſh fleet in every conteſt, induced the government to take advantage of the command which it had of the ſea, to give aſſiſtance to the French Royaliſts in the weſtern departments. Theſe Royaliſts, hitherto unaſſiſted by foreign powers, had, by repeated defeats, been reduced very low. The Convention had at laſt offered them a treaty, which was accepted and ſigned at Nantes on the 3d of March, on the one ſide by deputies from the Convention, and on the other by Charette, Sapineau, and other chiefs of the inſurgents of La Vendée, and by Cormartin, as repreſenting the party called *Chouans* or Night Owls. Stofflet, another chief, held out for ſome weeks longer; but at laſt, on the 20th of April, he too was under the neceſſity of ſubmitting by treaty to the Republic.

244 Expedition to Quiberon Bay.

In a ſhort time, however, the hopes of the Royaliſts were revived by the countenance of the Britiſh government, and theſe treaties were ill obſerved. In the beginning of June the Britiſh expedition was ready to ſail for the French coaſt. The troops to be employed conſiſted of emigrants in the pay of Great Britain, and many of them had been priſoners of war, who now agreed to join the royal cauſe. The command during the voyage, and the ſelection of the place of landing, were intruſted to the Count D'Hervilly. The command on ſhore was given to Puiſaye, who had been employed under the Girondiſts in the military ſervice of the Republic, but had now become a royaliſt. The Count de Sombreuil was afterwards ſent to join them with a ſmall reinforcement.

On the 25th of June the expedition arrived in the Bay of Quiberon, and on the 27th 2500 emigrants made good their landing, after diſperſing a ſmall party of republican troops. The emigrant army ſoon after diſtributed itſelf into cantonments along the ſhore, and gave arms to the inhabitants of the country, who appeared to receive them with joy. It was ſoon found, however, that the Chouans, though well qualified for a deſultory warfare, could not be of much uſe to regular troops. They had little ſubordination. They were eaſily diſperſed, and never fought unleſs every advantage was on their ſide. When it was found that their unſteady aid could not be depended on, a reſolution was taken to withdraw the emigrant army within the peninſula of Quiberon. The fort of that name was taken on the 3d of July. Its garriſon conſiſted of five or ſix hundred men, and it was now occupied by the emigrants. A republican army, in the mean time, under General Hoche, advanced, and attacked all the poſts that had been left without the peninſula. Theſe were ſpeedily taken. The emigrants and Chouans eſcaped into the boats of the Britiſh fleet, or fled under the cannon of the fort of Quiberon. The republicans then began to conſtruct formidable works on the heights of St Barbe, at the entrance of the peninſula. To prevent their operations, a ſally was made from the fort on the 7th of July; but without ſucceſs. On the 15th, another ſally was attempted in greater force. The whole troops in the peninſula amounted to about 12,000, including Chouans. Out of theſe a detachment of 5000 was ſent to attack the heights of St Barbe. The republicans were entrenched in three camps. The two firſt of theſe were eaſily taken, and the detachment preſſed eagerly forward to attack the third. But here a maſked battery opened upon them with grape ſhot. A dreadful carnage enſued; and very few of the detachment could have eſcaped, had not the fire of the Britiſh ſhips ſoon compelled the republicans to deſiſt from the purſuit.

245 Its failure.

It now became obvious that the expedition muſt ultimately fail. Deſertion became extremely common among the emigrants. Thoſe men in particular who had been priſoners of war, and received their liberty on condition of joining the expedition, ſeized every opportunity of going over to their countrymen; and a correſpondence ſeems even to have been eſtabliſhed between the republicans and the diſcontented troops in the fort of Quiberon. On the evening of the 20th of July, the weather was extremely tempeſtuous, which produced a fatal ſecurity in the emigrant army. Suſpicious patroles were remarked; but as they repeated the watchword for the night, they were allowed to paſs. The republican troops were conducted in ſilence along an unguarded quarter of the ſhore, till they were enabled to ſurpriſe one of the poſts of the garriſon, where they found the artillery men faſt aſleep. Their matches were ſeized, and the lanthorn intended to give the alarm to the Britiſh fleet was extinguiſhed. The fort was ſpeedily in confuſion. Some regiments threw away their arms, and went over to the republicans; others even maſſacred their own officers. A conſiderable number, however, maintained a violent conflict for ſome time before they ſurrendered. Puiſaye eſcaped on board the fleet. The Count de Sombreuil was taken; and this accompliſhed young man was ſoon after put to death, along with the other emigrant officers and all the Chouans that were found in the fort. The biſhop of Dol was alſo put to death, with his clergy who accompanied him; but many of the private ſoldiers of the emigrant army made their peace with the republicans, by pretending they had been compelled to engage in the expedition.

The Britiſh fleet, with tranſports and troops, ſtill hovered upon the French coaſt, and made an unſucceſsful attempt upon the iſland of Noirmontier. In conſequence of the ſeaſon of the year, however, it returned home in December, after evacuating a ſmall iſland called *L'Iſle Dieu*, which the troops had for ſome time occupied.

246 Succeſſes of the French in Germany.

On the ſide of Germany the fortreſs of Luxembourg ſurrendered on the 7th of June, after having been in a ſtate of blockade ſince the preceding campaign. The French were now in poſſeſſion of the whole left bank of the Rhine excepting the city of Mentz, which they attacked in vain, becauſe the Auſtrians could at all times throw ſuccours into it from Fort Caſſel on the oppoſite bank of the river. Finding the capture of Mentz impoſſible in theſe circumſtances, the French reſolved to croſs the Rhine, to inveſt the city on all ſides. The enterpriſe, however, was delayed for ſome time, till the reſult of the Britiſh expedition to Quiberon ſhould appear. In the month of Auguſt, General Jourdan forced the paſſage of the Rhine at Duſſeldorf, at the head of what was called the army of the Sambre and Meuſe. After driving before him three Auſtrian poſts upon the Lahn, he croſſed the Mein, and completely inveſted Mentz and Caſſel. Pichegru, in the mean time, croſſed the river, with the army of the Rhine and Moſelle, near Manheim, of which city he immediately took poſſeſſion.

247 They receive a check.

But the French generals ſoon found their forces inadequate to the undertaking in which they were engaged. A conſiderable detachment of Pichegru's army, after driving the Auſtrians under General Wurmſer from a poſt of ſome importance, began to plunder, and went into confuſion. The Auſtrians being informed of this circumſtance, returned to the charge, and defeated the French. General Clairfait alſo, having violated the line of neutrality, came upon the rear of Jourdan's army, and took a conſiderable part of his artillery. Both the French generals now retreated. Jourdan was rapidly purſued by Clairfait till he returned to Duſſeldorf, where he maintained his ground. Pichegru recroſſed the Rhine near Manheim, leaving a garriſon of 8000 men in that city. The Auſtrians advanced in all directions. Manheim was taken after a vigorous ſiege. The French were driven from the neighbourhood of Mentz. The Palatinate became the theatre of war, and the Auſtrians ſeized the country called the *Hundſruck*, ſouth of the Rhine as far as Landau and Treves. After various engagements, in which little more ground was loſt or won, the two parties entered into an armiſtice for three months.

248 Treaties with German princes.

On the 28th of Auguſt a treaty of peace was concluded between the French Republic and the Landgrave of Heſſe Caſſel, on condition that he ſhould lend no more troops to Great Britain for the proſecution of the war. It is not a little ſingular, that peace was concluded with the Elector of Hanover, at this period upon ſimilar terms. The Duke of Wirtemberg, and ſome other princes of the empire, alſo began to treat; but the negociations were broken off in conſequence of the reverſe of fortune now experienced by the French.

1796.

The Directory, however, reſolved to continue the war with vigour, and vaſt preparations for the approaching campaign were made during the winter. The Mountain party being once more poſſeſſed of power, its members exerted themſelves with their uſual energy. Such, however, was the turbulent character of theſe men, that they could not long ſubmit peaceably to any government, and ſoon became weary of that Directory whom they themſelves had eſtabliſhed. They held clubs in all quarters, and were continually diſturbing the public tranquillity. For ſome time the government ſupported them. The Pariſians, after the 5th October, no longer dared to avow openly their diſlike to the Jacobins; but they were underſtood to expreſs this ſentiment by wearing green ſilk cravats, and by applauding with much vehemence at the public ſpectacles the air called *Le Reveil du Peuple*.

249 Ridicul conduct the Direc tory.

The Directory now prohibited, by an edict, as tokens of royaliſm, the wearing of green cravats, or the performing at any of the theatres the air now mentioned, though the ſentiments it contained were entirely republican. The Directory alſo ordered in its ſtead, that the Marſeillois hymn, and other popular ſongs, ſhould be performed every evening at all the theatres. The Pariſians ſhewed their diſapprobation of the Directory by maintaining a profound ſilence during the performance of theſe ſongs.

ſongs, which had never failed till that period to excite burſts of applauſe. The Directory ſoon became aſhamed of this ridiculous conteſt, and in a few weeks recalled their edict. Indeed they found it impoſſible to give countenance for any long period to the reſtleſs and innovating ſpirit of the Jacobins, who continually wiſhed and attempted to return to revolutionary, that is, to violent meaſures againſt their antagoniſts. In the ſouth, in particular, the preſent ſupremacy of the Jacobins produced very pernicious effects. Freron, who had deſerted them after the death of Robeſpierre, and became one of their moſt violent adverſaries, thought fit to return to their party before the 5th October, and was ſent to Toulon with full powers of adminiſtration. Here he diſmiſſed the municipality that had been elected by the people, reſtored the Jacobin clubs, and proceeded to impriſon all ſuſpected perſons as in the days of Robeſpierre. Theſe meaſures produced a violent reaction on the part of the enemies of the Jacobins. Aſſaſſinations became frequent, and many perſons began to leave the country. The Directory was alarmed by the many complaints againſt the Jacobins or terroriſts that came from all quarters, and reſolved to aim at popularity by deſerting a ſet of men who could not be prevailed upon to act with moderation. Freron was recalled from Toulon, and more manageable men were ſought out to replace the more violent Jacobins, who were in general diſmiſſed from the ſervice of government.

250 leaſures ken a- inſt the cobins.

The Directory proceeded farther, and acknowledged, by a public reſolution, that its confidence had been abuſed. The miniſter of police was ordered to remove from Paris the members of former revolutionary tribunals, and others who now acted as leaders of the Jacobins, or *anarchiſts* as they were called. A body of troops, amounting to 10,000 men, called the *legion of police*, that had acted againſt the Pariſians on the 5th October, and was now devoted to the Jacobins, was ordered by the Directory, with the authority of the legiſlature, to join the armies on the frontiers. Theſe men refuſed to obey the order; but they were reduced to ſubmiſſion by ſome troops that had been brought to the neighbourhood to provide againſt ſuch an event. The more violent Jacobins were enraged, but not intimidated, by theſe meaſures, and began to organize a plot for the overthrow of the Directory and of the majority of the councils, who had now deſerted them. They were not prepared for action, however, before the month of May, and by that time their deſigns were diſcovered and counteracted. On the 10th of that month the guards were increaſed, and bodies of cavalry ſtationed around the Luxembourg and the Thuilleries. The Directory at the ſame time informed the Council of Five Hundred, by a meſſage, that a dreadful conſpiracy was prepared to burſt forth on the following morning. At the ſound of the morning bell, which is every day rung, the conſpirators were to proceed in ſmall parties of three or four men to the houſes of ſuch perſons as they had marked out for deſtruction. After aſſaſſinating thoſe perſons, the whole parties were to unite, and to act againſt the Directory, whoſe guard they apprehended they could eaſily overpower. The conſpirators had appointed a new Directory and a new legiſlature, to conſiſt of the moſt violent of their own party. Among the leaders of this conſpiracy, who were now arreſted by order of the Directory, was Drouet the poſtmaſter of Varennes, whom we formerly mentioned as having arreſted the unfortunate Louis XVI. when attempting to eſcape to the frontiers. Along with him were Babeuf, Antonelle, Pelletier, Gaudet, Julien, General Roſſignol, Germain, D'Arthe, Laignelot, and Amar, who had been a member of the committee of general ſafety along with Robeſpierre. Vadier and Robert Lindet were alſo engaged in the conſpiracy, but they made their eſcape. Drouet alſo eſcaped by the connivance of the Directory, as was generally underſtood; but the reſt of the conſpirators were removed for trial to the high national court at Vendome, where they were condemned. At the period of their removal thither, a new attempt was made by their party for their reſcue. About 600 men entered the camp at Grenelle near Paris, and endeavoured to prevail with the ſoldiers to join them in an inſurrection. This attempt was altogether unſucceſsful. A few of the inſurgents were killed, and the reſt fled.

251 Moderate party.

Theſe defeats of the Jacobins, and the diſcredit under which they were again brought, encouraged the moderate party in the two legiſlative councils to attempt to repeal the laſt decrees of the Convention, which had at once granted them an amneſty, and confirmed all the laws which, by confiſcating the property of emigrants, excluded their relations from the ſucceſſion. The diſcuſſion laſted many days; but the reſult was, that the law with regard to emigrants remained on the former footing; and the only point which the moderate party were yet able to carry was a modification of the decree to this extent, that thoſe terroriſts were declared incapable of holding public offices who owed their ſafety to the amneſty.

252 Diſtreſſed ſtate of the finances.

The ſtate of the finances now began to occupy the French government in a very ſerious manner. During the government of Robeſpierre, while the credit of the aſſignats was preſerved by the influence of terror, or by the ſale of the church lands, and the property of emigrants, little attention was beſtowed upon this ſubject. When money was wanted, more aſſignats were fabricated; and as few or no taxes were demanded from the people, no enquiry was made about the public expenditure. But when the boundleſs extravagance of the agents of government had loaded the circulation with aſſignats till they became of little or no value, it became a very difficult queſtion how the public ſervice was hereafter to be ſupported. A new paper currency, called *reſcripts*, was firſt adopted. Theſe were orders on the treaſury for caſh, payable at certain periods. But their credit ſoon paſſed away, as the treaſury had no means of fulfilling its engagements. The Directory complained very bitterly, in a meſſage to the Councils, of its diſtreſſes, and of the want of funds to carry on the approaching campaign. In conſequence of this meſſage, a law was paſſed, on the 25th of March, authoriſing the ſale of the remainder of the national domains for the price that had been fixed upon them at an early period of the revolution, amounting to about twenty-two years purchaſe. A new paper currency, called *mandats*, was to be received in payment. But the credit of government was now gone. The mandats inſtantly loſt in all private tranſactions one-fourth of their value, and they ſoon fell ſtill lower. This, however, produced a great demand for national property, which was thus about to be ſold far below its value. To prevent this effect, the legiſlature broke its engagements, and decreed, that one-fourth of every purchaſe ſhould be paid, not in mandats, but in caſh. This decree put a ſtop both to the ſale of national property and to the circulation of mandats.

253 Reaſons of the flouriſhing ſtate of agriculture.

Recourſe was next had to taxation; but this was attended with much difficulty. By the war, and the violent government of Robeſpierre, the French commerce had been in a great meaſure ruined. Induſtrious men, who poſſeſſed any capital, had therefore turned their attention to the cultivation of land. Many circumſtances led to this. By the emigration of the nobles, and the confiſcation of the church lands, the farmers were left with no landlord but the government; which, being ſupported by aſſignats, paid little attention to any other ſource of revenue. Hence they paid no rent, and ſpeedily roſe into opulence. The revolutionary government, which kept the inhabitants of the towns under dreadful bondage, was ſcarcely felt by the inhabitants of the country, who thus enjoyed the advantage of exciting no ſuſpicion in the rulers, and of paying neither rent nor taxes. The law which declared aſſignats to be a legal tender of payment, was a great ſource of profit to the cultivators of the ſoil. They contrived to ſell the produce of their farms only to ſuch as offered them ready ſpecie; while, at the ſame time, they paid their rents, where the landlord had not emigrated, in aſſignats, which they obtained at a trifling price. Hence it uſually happened, that while the tenant enjoyed affluence, his miſerable landlord was reduced to the neceſſity of ſelling his moveables to buy a portion of the grain that grew upon his own eſtate, or was tempted to ſell the eſtate itſelf, at an undervalue, to obtain the means of emigration. By theſe and other circumſtances, the whole induſtry of the French nation came to be directed towards agriculture. Their country was accordingly well cultivated; but as the riches of agricultural nations are not eaſily ſubjected to taxation, the French Directory now found it impoſſible to carry on the ſchemes of ambition and of conqueſt, which they had already formed, without relying for reſources upon the plunder of the neighbouring ſtates, which ſpeedily rendered their armies odious in all thoſe quarters of Europe to which they penetrated.

254 National Inſtitute.

Amidſt their preparations for the approaching campaign, the Directory attempted to increaſe their own reputation at home, by eſtabliſhing what is called the *National Inſtitute*; which is a ſociety of men of letters, under the protection of the government*. Into this body were collected the moſt celebrated literary characters in the nation that had eſcaped the fury of the Mountain Party. Among theſe were La Place, Lalande, Fourcroy, Bertholet, Volney, Dolomieu, and others, well known throughout Europe. The firſt public meeting of the Inſtitute was held, with great ſplendour, on the 4th of April, in the hall of the Louvre, called the *Hall of Antiques*. The ambaſſadors of Spain, Pruſſia, Sweden, Denmark, Holland, America, Tuſcany, Genoa, and Geneva, were preſent. The members of the Directory attended in their robes, and their preſident made a ſpeech of inſtallation, declaring the determination of the executive power to protect and encourage literature and the arts. Duſaulx, the preſident of the Inſtitute, replied, in a ſpeech in which he declared the reſolution of the members to labour to give luſtre to the republican government by their talents and productions. Fifteen hundred ſpectators applauded the ſpeeches with enthuſiaſm, and vainly imagined that all the evils of the revolution were terminated, and that their country was now entering upon a career of unexampled glory and proſperity.

255 Overtures of the Britiſh government.

At this period the Britiſh government made an approach towards a negociation with France. On the 8th of March Mr Wickham, the miniſter plenipotentiary to the Swiſs Cantons, tranſmitted to Barthelemy, ambaſſador from the French Republic to the Helvetic body, a note containing three queſtions. Whether France would be diſpoſed to ſend miniſters to a congreſs to negociate peace with his Britannic Majeſty and his allies? Whether France would be diſpoſed to communicate the general grounds on which ſhe would be willing to conclude peace, that his Majeſty and his allies might conſider them in concert? and, laſtly, Whether France would deſire to communicate any other mode of accompliſhing a peace? The note concluded with a promiſe to tranſmit to the Britiſh court whatever anſwer ſhould be returned; but declared, that Mr Wickham was not authoriſed to enter into any diſcuſſion upon theſe ſubjects.

256 Inſolently rejected by the Directory.

On the 26th of the ſame month Barthelemy returned an anſwer in name of the French Directory. This anſwer began by complaining of inſincerity in the propoſal made by the Britiſh court, ſeeing its ambaſſador was not authoriſed to negociate, and that a congreſs was propoſed, which muſt render negociation endleſs. It proceeded to ſtate the ardent deſire of the Directory for peace; but aſſerted, that it could liſten to no propoſal for giving up any territory that had been declared by the conſtitutional act to form a part of the Republic (alluding to the Auſtrian Netherlands); declaring, however, that other countries occupied by the French armies, and political or commercial intereſts, might become the ſubject of negociation. Upon theſe points the Directory declared its readineſs to receive reaſonable propoſals.

To this anſwer no reply was ſent; but the Britiſh court publiſhed a note, of which copies were preſented to the foreign miniſters reſiding at London; and in it the ſpirit of the Directors anſwer was complained of, and alſo the refuſal even to negociate about the retention of foreign territory, under pretence of an internal regulation. It was added, with truth, that while ſuch diſpoſitions were perſiſted in, nothing was left but to proſecute a war equally juſt and neceſſary; but that, when more pacific ſentiments ſhould be manifeſted, his Majeſty would be ready to concur with his allies in taking meaſures for eſtabliſhing a juſt, honourable, and permanent peace.

257 French armies.

The French Directory had ſucceeded, during the winter, in reducing the weſtern departments into ſubjection. The emigrant expedition from England had induced the royaliſts once more to try the fortune of war; but, after various defeats, their leaders, Charette and Stofflet, were taken, and put to death on the 29th of March, and the inſurgents were ſuppreſſed in all quarters. The French government being thus left without an enemy at home, was enabled to make great efforts on the frontiers. The military force of the Republic was divided into three armies. On the Lower Rhine, the army of the Sambre and Meuſe was chiefly ſtationed about Duſſel-

---

* See INSTITUTE, *Suppl.*

ench olution, 796.

Duſſeldorf and Coblentz, and was commanded by Jourdan. Moreau commanded the army of the Rhine and Moſelle, in the room of General Pichegru, who had been diſmiſſed from his command. This army was ſtationed on the Upper Rhine, and from Landau to Treves. The third and laſt army was ſtationed on the coaſt of Italy, from Nice towards Genoa, and now received Bonaparte as its commander. The name and the actions of this man muſt hereafter fill ſo large a ſpace in the detail of this eventful period, that it is neceſſary to pay ſome attention to his perſonal hiſtory.

58 aparte

A Corſican gentleman, a lawyer by profeſſion, but who had appeared in arms under the celebrated Paoli in defence of the independence of his native iſland, was the father of Napolone Bonaparte. Napolone was born at Ajaccio in 1767; and by the intereſt of M. de Marboeuf, the French governor of the iſland, he was placed for his education at the celebrated military academy of France (*Ecole Militaire*), which has produced ſo many accompliſhed men. At a very early period of life he preſented himſelf as candidate for a commiſſion in the artillery, and was ſucceſsful, being the 12th on the liſt out of 36 victorious candidates. In conſequence of this event he ſerved two or three years in the French army as a lieutenant in the regiment of La Fere. Bonaparte having riſen to the rank of captain of artillery, returned to Corſica after the revolution, and was there elected lieutenant-colonel of a corps of Corſican national guards. Here he formed a connection, which had nearly proved fatal to him, with General Paoli, the friend of his father. He reſented the treatment which Paoli received from Robeſpierre's government, and entered ſo far into his intereſts as to write the remonſtrance, which was tranſmitted by the municipality to the Convention, againſt the decree which declared the general an enemy to the Republic. In conſequence of this, a warrant was at one time iſſued for his arreſt by the commiſſioners of the Convention. He made his peace, however, on this occaſion; and reſolved to adhere to the intereſts of France, in oppoſition to Great Britain, which at this period formed the deſign of taking poſſeſſion of Corſica. He embarked with the other members of his family for France, and arrived there at the time when Lord Hood was in poſſeſſion of Toulon. Salicetti, a deputy from Corſica to the Convention, introduced him to Barras, who was now ſuperintending the ſiege of Toulon. Here Bonaparte was advanced to the rank of general of artillery; and, under Dugommier, directed the attack of the various fortified poſts around the city. He was afterwards employed for a ſhort time againſt the royaliſts in the weſt of France; and we have already mentioned, that he was at the capital, and aſſiſted Barras in the conteſt between the Convention and the Pariſians on the 5th October. Hence he was regarded with diſlike by the moderate party, and repreſented as an unprincipled adventurer, brought forward to ſupport the terroriſt faction. He had many enemies, therefore, at the commencement of his career, and his character was treated with much freedom. The ſcandal of the times went ſo far as to aſſert, that he owed his preſent preferment, not ſo much to any talents he had yet had an opportunity to diſplay, as to his marriage with Madame Beaucharnois, a beautiful French woman whom Barras had taken under his protection.

French Revolution, 1796.

259 Takes the command of the army of Italy.

The French army of Italy amounted at this time to 56,000 men. Bonaparte at his arrival found it ill equipped, and the troops mutinous for want of pay and neceſſaries. He addreſſed them, however, in the true ſtyle of military enterpriſe, "If we are to be vanquiſhed, we have already too much; and if we conquer, we ſhall want nothing;" and ordered them to prepare for immediate action. His opponents, however, anticipated him in the attack. The Auſtrians employed in the defence of Italy, under General Beaulieu, are ſaid to have more than equalled the French in numbers. To theſe were united the King of Sardinia's army, under Count Colli, of 60,000 regular troops, beſides the militia of the country, which was now embodied, and a ſmall body of Neapolitan cavalry, amounting to about 2500 men. General Beaulieu began the campaign, on the 9th of April, by attacking a poſt called Voltri, which the French poſſeſſed, within ſix leagues of Genoa. They defended themſelves till the evening, and then retreated to Savona. Next morning Beaulieu, at the head of 15,000 men, preſſing upon the centre of the French army, was completely ſucceſsful till one o'clock afternoon, when he reached a redoubt at Montenotte, which was the laſt of their entrenchments. This redoubt contained 1500 French. Their commander, Rampon, prevailed with them, in a moment of enthuſiaſm, to ſwear that they would not ſurrender; and the conſequence was, that they arreſted the progreſs of Beaulieu for the remainder of the day. During the night, Bonaparte ſtationed his right wing under La Harpe, a Swiſs exile, in the rear of the redoubt of Montenotte, which ſtill held out, while he himſelf, with Maſſena, Berthier, and Salicetti, advanced by Altara, to take the Auſtrians on their flank and rear. Beaulieu, in the mean time, had received powerful reinforcements, and on the morning of the 11th renewed the attack on the French under La Harpe; but Maſſena ſoon advancing upon the flank of the Auſtrians and Sardinians, they gave way on all ſides. Two of their generals, Roccavina and Argentau, were wounded. They loſt 2500 priſoners, and were purſued beyond Cairo, of which the French took poſſeſſion on the following day.

260 His ſucceſſes.

On the 13th at day-break, the defiles of Milleſimo were forced by the French General Augereau; and, by a ſudden movement, General Provera, a knight of the order of Maria Thereſa, at the head of 1500 Auſtrian grenadiers, was ſurrounded; a circumſtance which proved not a little embarraſſing to the French army. For this reſolute officer, inſtead of ſurrendering, inſtantly withdrew to a ruined caſtle on the top of the mountain, and there entrenched himſelf. Augereau brought up his artillery, and ſpent many hours in attempting to diſlodge him. At laſt he divided his troops into four columns, and endeavoured to carry Provera's entrenchments by ſtorm. The French loſt two generals, Banel and Quenin, and Joubert was wounded in this attempt, which proved unſucceſsful. Provera paſſed the night in the midſt of the French army, which had been prevented by his obſtinate reſiſtance from coming to battle. On the 14th the hoſtile armies faced each other, but a diviſion of the French troops was ſtill occupied in blockading General Provera. The Auſtrians attempted to force the centre of the French, but without ſucceſs. Maſſena, in the mean time, turned the left flank of their left wing near the village

village of Dego; while La Harpe, with his diviſion in three cloſe columns, turned the right flank of the ſame wing. One column kept in awe the centre of the Auſtrians, a ſecond attacked the flank of their left wing, while the third column gained its rear. Thus was the left wing of the combined army completely ſurrounded and thrown into confuſion. Eight thouſand men were, on this occaſion, taken priſoners, and General Provera at laſt alſo ſurrendered.

Theſe victories were not gained over a timid or an inactive adverſary. On the morning after his fatal defeat at Milleſimo, Beaulieu made one of thoſe ſpirited efforts which often retrieve and alter the fortune of war At the head of 7000 choſen Auſtrian troops he attacked, at day-break, the village of Dego, where the French repoſed in ſecurity after their ſucceſs. He took the village; but the French having rallied under General Maſſena, ſpent the greater part of the day in attempting to retake it. They were thrice repulſed, and one of their generals, Cauſſe, was killed. Towards evening, however, Bonaparte in perſon having brought up reinforcements, the poſt was retaken, and the Auſtrians retired with the loſs of 1400 made priſoners.

Bonaparte had now thrown himſelf between the Auſtrian and Sardinian armies. By the poſſeſſion of the ſtrong poſt of Dego, his right was ſecured againſt the efforts of Beaulieu, while he was enabled to act with the maſs of his force againſt the Piedmonteſe troops. His enterpriſes in this quarter were facilitated by the exertions of Augereau, who had opened a communication with the valley of the Tanaro, where Serrurier's diviſion was approaching the town of Ceva, near which the Piedmonteſe had an entrenched camp defended by 8000 men.

On the 16th Augereau attacked the redoubts which covered this camp, and took moſt of them; which induced the Piedmonteſe to evacuate it during the night, and on the 17th Ceva was entered by Serrurier. Count Colli now retreated to cover Turin; making choice, however, of the ſtrongeſt poſts, and fighting in them all. He was able, on the 20th, to repulſe Serrurier; but on the 22d Bonaparte, ſtill preſſing on the Piedmonteſe general, defeated him near Mondovi, and entered that place. The retreating army next endeavoured to make a ſtand, with its head quarters at Foſſano, and its wings at Coni and Cheraſco. On the 25th Maſſena advanced againſt Cheraſco, which was ſpeedily evacuated. Foſſano ſurrendered to Serrurier, and Alba to Augereau.

261 Armiſtice with Sardinia ſucceeded by

Previous to theſe laſt movements, however, Count Colli, on the 23d of April, had written to Bonaparte, requeſting an armiſtice, to allow the King of Sardinia an opportunity of negociating a peace. The French army was now within 26 miles of Turin; and that prince ſaw himſelf ſuddenly reduced to the neceſſity of ſtanding a ſiege in his capital, or of accepting ſuch terms as the conqueror might think fit to impoſe. Bonaparte granted an armiſtice, on condition that the three fortreſſes of Coni, Ceva, and Tortona, ſhould be delivered up to him, with their artillery and magazines, and that he ſhould be allowed to croſs the Po at Valentia. 262 A formal treaty. The armiſtice was ſigned on the 29th, and it was followed by a formal treaty with the French Republic, which was concluded at Paris on the 17th of May. The conditions impoſed by this treaty upon the King of Sardinia were humiliating and ſevere. He gave up to France for ever the duchy of Savoy, and the counties of Nice, Jenda, and Bretneil. He gave an amneſty to all his ſubjects that were proſecuted for political opinions. He agreed that the French troops ſhould have free acceſs to Italy through his territory; and, in addition to the fortreſſes ſurrendered by the armiſtice, he gave up thoſe of Exiles, Suſa, Brunette, Aſſiette, Chateau Dauphin, and Alexandria, to be poſſeſſed by the French during the war; and they were authoriſed to levy military contributions in the territory occupied by them. He agreed to erect no fortreſſes on the ſide of France, to demoliſh the fortreſſes of Brunette and Suſa, and to diſavow his diſreſpectful conduct towards the laſt French ambaſſador.

In the mean time the French army advanced towards the Po. Beaulieu was deceived by the article in the armiſtice; which ſtipulated, that the French ſhould be allowed to croſs that river at Valentia, and made all his preparations for reſiſtance in that quarter. Bonaparte laboured, by ſeveral evolutions, to confirm this error; and while the Auſtrian general waited for him near Valentia, in various well fortified poſitions, he advanced haſtily into Lombardy, and had proceeded ſixty miles down the river to Placentia, where he arrived on the 7th of May, before the direction of his march was diſcovered. He immediately ſeized whatever boats or other craft he could find, and effected his paſſage without difficulty, there being only a ſmall party of Auſtrian cavalry accidentally on the oppoſite bank, and they fled at his approach. Beaulieu in the meanwhile had ſent, when too late, a body of 6000 infantry and 2000 cavalry, to prevent if poſſible the French from paſſing the river; but Bonaparte, now on the ſame ſide of the river with themſelves, met and defeated them on the 8th at the village of Fombio. Another body of 5000 Imperialiſts, advancing to the aſſiſtance of thoſe at Fombio, was met at Codogno, and repulſed by General La Harpe; but this officer was killed on the occaſion. 263 Armiſtice with the Duke of Parma. On the 9th Bonaparte granted an armiſtice to the Duke of Parma, on condition of his paying a contribution of 2,000,000 of French money, and delivering 10,000 quintals of wheat, 5,000 quintals of oats, and 2,000 oxen, for the uſe of the army. This prince alſo agreed to deliver up 20 of his beſt paintings, to be choſen by the French. This laſt ſtipulation was no ſooner known in France, than many men of letters and artiſts remonſtrated againſt it as both impolitic and uſeleſs. They contended, that it would render the French Republic odious to all Italy, without producing any advantage to compenſate this evil, as the progreſs of the arts could not be promoted by removing their beſt productions from the ſcenes in which they originated. But the Directory was too much occupied by views of national aggrandiſement to liſten to conſiderations of this kind, and ſimilar ſtipulations were ordered to be inſerted in every future treaty; by which means the moſt valuable curioſities of Italy were gradually transferred to the French capital.

Beaulieu, now driven from the Po, croſſed the Adda at Lodi, Pizzighitone, and Cremona. He left ſome troops, however, to defend the approaches to Lodi. The advanced guard of the French attacked theſe on the 10th, and drove them into the town; which was entered in ſuch cloſe purſuit, that the Imperialiſts, on leaving ench R olution, 796. 64 V ory at L i.

ving it, had not leiſure to break down the bridge over the Adda. At the other end of the bridge the Imperial army was drawn up, and thirty pieces of cannon defended the paſſage. The French generals, after a conſultation, agreed that it could not be forced. But Bonaparte having demanded of his grenadiers if they were willing to make the attempt, they applauded the propoſal, and he formed them into a cloſe column. Taking advantage of a cloud of ſmoke which iſſued from the hoſtile artillery, they ruſhed along the bridge, which was about 100 yards in length, and were at the middle of it before they were diſcovered. Here a general diſcharge from the Auſtrians deſtroyed 700 men. The French column heſitated, and the carnage became terrible; but Maſſena, Berthier, Dallemagne, Cervoni, Laſneſs, Dupat, and other officers, flying to the head of the column, urged on the ſoldiers, and preſſing forward, broke into the ranks of the Imperial army, which immediately gave way, and fled in all directions. This exploit has been much celebrated. The intrepidity of the troops by whom it was accompliſhed is unqueſtionable; but how far the leader who urged them to ſuch an enterpriſe is entitled to approbation may well be doubted. He had paſſed the Po with ſcarcely the loſs of a man. The Adda is a very inferior ſtream, which has fords both above and below the town of Lodi. The river was actually croſſed at one of theſe by Augereau with the cavalry, during the attack upon the bridge. With the delay of one day therefore the paſſage might have been effected without difficulty by the whole army, and there was no adequate motive to juſtify the laviſh expenditure of blood which was here made; for the French army no longer preſſed forward in purſuit of Beaulieu, but, after the ſurrender of Pizzighitone and Cremona on the 12th, returned upon Pavia and Milan on its left (A). Theſe places opened their gates without reſiſtance, though the citadel of Milan held out for a ſhort time.

265 conſe- ences.

It would ſeem that, in the original plan of Bonaparte's campaign, the utmoſt expected from his efforts was to gain ſuch an aſcendancy in Italy as might induce the princes and ſtates of that country to deſert the coalition againſt France, which all of them aſſiſted with money and proviſions, if not with troops. To accompliſh this object, though he ſent Maſſena in purſuit of Beaulieu as far as Verona, yet he himſelf now turned aſide into Modena and the territories of the Pope. He took Ferrara, Bologna, and Urbino; and at laſt granted an armiſtice to his holineſs and the Duke of Modena, on the uſual conditions of large contributions of money, paintings, and curioſities. From the Pope he farther exacted the ceſſion of the legations of Bologna and Ferrara, and poſſeſſion of the citadel of Ancona. His march into the Roman territory ſo alarmed the Neapolitan cabinet, that it now ſolicited peace; and Bonaparte granted an armiſtice, without attempting to add to it the humiliating conditions to which the other Italian ſtates were ſubjected. From the territories of the Pope, Bonaparte haſtily advanced with a body of troops to Leghorn, in the neutral ſtate of Tuſcany, under pretence of driving out the Engliſh, whoſe property there he confiſcated. By theſe meaſures the taſk aſſigned to Bonaparte was completed by the time the campaign upon the Rhine was begun. Mantua was ſtill indeed in the hands of the Imperialiſts, but it was blockaded, and all Italy was now ſubmiſſive to France.

French Revolution, 1796.

266 Succeſſes of the French in Germany.

To diminiſh, if poſſible, the efforts of the French on the ſide of Italy, the Imperialiſts thought it neceſſary to renew the conteſt in Germany. An intimation was therefore ſent to General Jourdan, that the armiſtice would terminate and hoſtilities commence on the 31ſt of May. At this time General Wartenſleben oppoſed Jourdan; and the Archduke Charles commanded the army in the Hundſruck, which covered Mentz and Manheim, and was ſtationed againſt Moreau on the Upper Rhine. The French began their operations with a very artful ſtratagem, intended to draw the whole Auſtrian force to the Lower Rhine, that Moreau might have an opportunity of ſuddenly penetrating into Swabia, and conſequently of carrying the war towards the hereditary territories of Auſtria. For this purpoſe Moreau remained quiet, while Jourdan began to act vigorouſly. On the 31ſt of May his left wing, under Kleber, iſſued from the lines of Duſſeldorf, on the right bank of the Rhine, and, advancing towards the Sieg, defeated the Imperialiſts. Thereafter they were driven ſucceſſively from the ſtrong poſitions of Ukareth and Altenkirchen, and retreated acroſs the Lahn. Jourdan, in the mean time, having advanced with his centre and right wing, forced the Auſtrian poſts on the Nahe, croſſed the Rhine, formed the blockade of the fortreſs of Ehrenbreitſtein, and haſtened forward as if about to form the blockade or ſiege of Mentz. By theſe movements the Archduke found himſelf in the hazardous ſituation of having Moreau in his front, while Jourdan, with a victorious army, commanded his rear. He therefore haſtily croſſed the river, leaving the fortreſſes of Mentz and Manheim to keep Moreau in check. Having joined the retreating army, he encountered Jourdan's advanced guard, which he compelled to retire after an obſtinate conflict. Jourdan did not hazard a general engagement, but withdrew to his former poſitions, the Archduke preſſing hard upon him, till he raiſed the blockade of Ehrenbreitſtein, and croſſed the Rhine in its neighbourhood, till Kleber, on the 20th of June, entered the lines of Duſſeldorf, from which he had ſet out.

Theſe movements were foreſeen. For the inſtant that the Archduke withdrew from the Palatinate to drive Jourdan down the Rhine, Moreau aſcended rapidly towards Straſburg; ſo that theſe hoſtile armies ſeemed to be flying from each other with all poſſible ſpeed. On the 24th of June, Moreau effected the paſſage of the river oppoſite to fort Kehl. This was an enterpriſe of conſiderable difficulty; for a ſudden ſwell, by covering a part of the iſlands with which the river abounds, had prevented the Auſtrians from being taken by ſurpriſe, as was originally intended. The entrenchments on ſuch iſlands as were occupied by troops were ſpeedily carried by the bayonet, and 2600 French landed on the oppoſite ſhore, but without cavalry or artillery. Here they were expoſed to the attacks of the Auſtrian

---

(A) We think this conduct cannot be accounted for, but by the ſuppoſition of a very improper correſpondence between Bonaparte and the Auſtrian officers.

Auſtrian horſe from the camp of Wilſtedt, and to the fire of the cannon of the fort. They maintained their ground, however, and even acted on the offenſive, till the boats, which had been ſent back, returned with a reinforcement. The whole redoubts and the fort were then inſtantly taken by ſtorm, or with the aſſiſtance of ſuch cannon as had been found in the firſt redoubts at which the French arrived, and the Imperialiſts fled towards Offenburgh.

The departure of the Archduke to the Lower Rhine in purſuit of Jourdan, and the large detachments which had recently been ſent towards Italy to oppoſe Bonaparte, now enabled Moreau to enter Swabia with a great ſuperiority of force. The ſtrong military poſitions, however, which the country affords, preſented to him conſiderable difficulties. On the 26th of June he drove the Auſtrians from their camp of Wilſtedt; and on the 27th he advanced with his army, in three columns, againſt another camp of 15,000 men in front of Offenburg. General Wurmſer ſent a ſtrong reinforcement from Manheim to the aſſiſtance of theſe troops; but having encountered two of the French columns on its way, the reinforcement was defeated, and the camp at Offenburg was evacuated during the night. The Auſtrians made an obſtinate ſtand at Renchen, near Philipſburg, on the 29th, but were at laſt compelled to retire with the loſs of 1200 men taken priſoners, and ſeveral pieces of cannon. On the 2d of July a diviſion of the French army, under General Laroche, ſucceeded in ſeizing the mountain Knubis, which is the higheſt point of the ridge of mountains called the Black Foreſt. On the 3d, after an obſtinate conflict, the Auſtrians were driven from the paſs of Friedenſtadt; in conſequence of which they loſt all communication with the emigrant troops under the Prince of Condé, and other Imperial troops ſtationed on the Rhine towards Switzerland. On the 6th, the left wing of the French, under Deſaix, encountered the Imperialiſts at Raſtadt, where the Auſtrians, who had received ſome reinforcements from the Lower Rhine, made a very determined reſiſtance; but were at laſt compelled to give way, and to retire to Ettingen.

The Archduke Charles now arrived in perſon with his army from the Lower Rhine, where he had left Wartenſleben, but with inferior force, to oppoſe Jourdan. The French, under this general, had inſtantly reſumed the offenſive upon the departure of the Archduke. Kleber advanced from the lines of Duſſeldorf, as formerly; while the centre and right wing croſſed the Rhine near Coblentz. The poſts of Ukareth and Altenkirchen were forced, and on the 9th of July the whole of Jourdan's army croſſed the Lahn. On the 10th, Wartenſleben was defeated near this river, after great ſlaughter on both ſides, with the loſs of 500 priſoners; and the French on the 12th entered Franckfort. The ſituation of the hoſtile armies was now become extremely important. The two Imperial armies were at no great diſtance from each other, and were placed in the centre between the armies of Moreau and Jourdan. Could the Archduke, who was commander in chief, have reſiſted one of theſe armies for a ſhort time, at any ſtrong poſition, by a detachment of his troops, while he precipitated himſelf with the maſs of his force upon the other, it is probable that any farther invaſion of Germany might have been prevented. But the activity of the French generals, whoſe progreſs could nowhere be reſiſted by partial efforts, prevented the poſſibility of executing ſuch a plan. He was therefore under the neceſſity of making his final exertion for the preſent ſafety of Germany againſt Moreau at Ettingen, on the 9th of July, without having formed any junction with Wartenſleben. The battle was moſt obſtinately fought. The French were four times repulſed in their attempts to force the heights of Rollenſolhe; and it was not till they had experienced a dreadful ſlaughter that they at laſt carried the field by the bayonet.

The loſs of the battle of Ettingen compelled the two Imperial armies to retire eaſtward. After placing ſtrong garriſons in Mentz, Manheim, and Philipſburg, the Archduke retreated through Swabia towards Ulm, where his magazines were placed. At every ſtrong poſition, however, he made an obſtinate ſtand; thus endeavouring to render the progreſs of the French under Moreau as tardy as poſſible. Wartenſleben, with the other Imperial army, retired through Franconia, reſiſting Jourdan in the ſame manner. Many bloody battles were fought, of which it is here unneceſſary to give a minute deſcription. It is ſufficient to remark, that the French were long ſucceſsful in them all. They gradually preſſed forward till Moreau's army compelled the Archduke to croſs the Neckar, and afterwards the Danube, leaving the whole circle of Swabia in the rear of the French. Wartenſleben was in like manner driven through Aſchaffenburg, Wurtzburg, Schweinfurt, and found it neceſſary to croſs the Rednitz, on the 6th of Auguſt, at Bamberg, to avoid the preſſure of Jourdan's army in his rear. This army continued to advance till its right wing, under Bernadotte, was poſted at Neumarck, with his advanced poſts at Teining, while the body of the army had driven Wartenſleben beyond the Nab, and had reached Amberg on the 22d of Auguſt.

267 Alarm throughou Germany.

Excepting a part of the mountains of Tyrol, three French armies, under Jourdan, Moreau, and Bonaparte, now occupied the whole country reaching from the frontiers of Bohemia to the Adriatic Sea. The alarm throughout Germany was extreme. The Duke of Wirtemberg obtained peace from the French on condition of paying 4,000,000 of French money. The circle of Swabia did the ſame, on engaging to pay 12,000,000 of livres, and to deliver 8,400 horſes, 5,000 oxen, 100,000 quintals of wheat, 50,000 quintals of rye, 100,000 ſacks of oats, 100,000 pairs of ſhoes, and a large quantity of hay. The Margrave of Baden obtained peace on ſimilar terms. The elector of Bavaria and the circle of Franconia negociated, and offered large payments; and even the diet of Ratiſbon ſent a deputation to treat with the French generals for neutrality. The King of Pruſſia now entered into a new treaty with the French; the conditions of which were concealed, but its nature appeared in the advantage which he took of the progreſs of their arms to take poſſeſſion of certain territories in Germany, and particularly of the ſuburbs of Nuremberg, under pretence of ſome antiquated title. Spain alſo entered into a treaty offenſive and defenſive with France, which was afterwards followed up by a declaration of war againſt Britain.

268 Danger the houſ of Auſtri

The danger of the houſe of Auſtria was now very great; and had Bonaparte, inſtead of being detained in Italy, by events of which we ſhall immediately take notice, ench Re lution, 796.

tice, been able to croſs the Tyrol by Inſpruck, and to reach the banks of the Danube, there is little doubt that the Emperor muſt have ſubmitted to ſuch conditions as the French thought fit to impoſe. Deſerted in all quarters by the members of the coalition, he ſtill, however, retained an ally in Great Britain, whoſe riches, liberally beſtowed in the form of a loan, extricated him from the preſent difficulties. Having the command of abundance of money, he was enabled to ſend one army after another to oppoſe Bonaparte in Italy, while he recruited his armies in Germany by extenſive levies, and by taking into his pay the troops of thoſe ſtates that made peace with France.

69 erly uct of Arch- d.

The Archduke, having received powerful reinforcements, reſolved to make a ſtand, on the 11th of Auguſt, againſt Moreau at Umenheim. A ſevere battle was fought during ſeventeen hours, and one of the wings of the Auſtrian army, under General Rieſe, even ſucceeded in occupying four leagues of territory in the rear of the French army; but the Archduke having received intelligence, in the mean time, that Wartenſleben could not maintain his ground againſt Jourdan, he thought it neceſſary to continue his retreat, and to adopt new meaſures. On the 17th of Auguſt he left General La Tour, with a part of his numerous army, to oppoſe Moreau, and having croſſed the Danube at Neuburg and Ingolſtadt, he marched to Wartenſleben's aſſiſtance to fall upon Jourdan with united forces. On the 23d he attacked Bernadotte at Teining, and forced him to retire towards Nuremberg. The Archduke was thus upon the right of Jourdan, while Wartenſleben was ſtationed on his front. The French general, finding his poſition dangerous, began to retreat on the 24th. From the ſtate of the finances, the French armies, at the commencement of this campaign, had been extremely ill equipped and ill paid. Hence the two armies of Moreau and Jourdan plundered, without decency or mercy, every place into which they entered. In Jourdan's army, more eſpecially, the want of diſcipline was extreme (A). Hence, when they began to retreat, loaded as they were with ſpoil, they ſuffered not leſs from the enraged inhabitants of the countries through which they paſſed, than from the military efforts of the hoſtile army. The Archduke having joined Wartenſleben, was enabled to ſend off Nauendorf with reinforcements to La Tour, who oppoſed Moreau, and, in the mean time, he continued in perſon to purſue Jourdan towards Wurtzburg. Here the French made a ſtand, on the 3d of September, and a general engagement took place. Both parties ſuffered great loſs, but more eſpecially the French, who retreated during the night. Jourdan now fled by Fuldaw to Wetzlaer. Having croſſed the Lahn, where he made ſome reſiſtance, he deſcended along the banks of the Rhine, till his army, on the 17th, reached Coblentz and Duſſeldorf, from which it had originally departed.

French Revolution, 1796.

270 Critical ſituation of Moreau.

The ſituation of Moreau's army was now uncommonly dangerous. He maintained his poſition, however, till the 17th of September; but he was undecided in his movements, and was obviouſly at a loſs how he ought to proceed. He attempted, without ſucceſs, to withdraw the Archduke from the purſuit of Jourdan, by detaching a part of his troops towards Nuremberg. Many attacks were made upon him, but all of them without ſucceſs; and the Imperial generals at laſt gave way to him wherever he turned. Finding at laſt that Jourdan's defeat was irretrievable, and that Bonaparte did not arrive from Italy, he reſolved to retreat. He had recroſſed the Lech, to prepare for this event; but now ſuddenly paſſing it again, as if determined to advance farther into Auſtria, he drove back General La Tour as far as Landſperg. Having thus obtained freedom for his future movements, he ſet out in full retreat, proceeding between the Danube at Ulm and the lake of Conſtance. La Tour, however, ſoon preſſed upon his rear. He found the paſſes of the Black Foreſt occupied by large bodies of Auſtrians and armed peaſants, while Generals Nauendorf and Petrarſch haraſſed his right flank with 24,000 men. Once more therefore he turned upon La Tour, at Biberach, on the 3d of October, with great impetuoſity, and having defeated him, took no leſs than 5000 priſoners; whom he was able to carry to France. He now continued his retreat; his right wing, under General Deſaix, keeping Nauendorf and Petrarſch in check, while the reſt of the army cleared the paſſages in front till he arrived at what is called the Valley of Hell (*Val d'Enfer*), a narrow defile, running for ſome leagues between lofty mountains, and in ſome places only a few fathoms in breadth. The centre of his army, advancing in a maſs, forced this paſſage, while the wings reſiſted the Imperial troops under La Tour and Nauendorf. After this deſperate effort he reached Fribourg on the 13th of October, and was ſoon compelled by the Archduke Charles, who had now arrived from the purſuit of Jourdan, to evacuate all his poſitions on the Swabian ſide of the Rhine, with the exception of Kehl, and a temporary fortification erected at Huningen, called a

271 His ſkilful retreat.

(A) It would be improper to interrupt our military detail with the following information reſpecting the morals of Jourdan's army at this time; which, however, it is of importance for our readers to know. We have it from a German Count, who ſaw with his own eyes a conſiderable extent of the march and countermarch of the French through Franconia.

Almoſt every officer in Jourdan's army had a miſtreſs; and ſuch of them as by plunder could ſupport the expence, gave balls, acted plays, and exhibited every ſpecies of gaiety when the army was not in actual motion. In all this there was nothing wonderful. The ladies, however, were not unfrequently pregnant; and as nurſing would keep them from theſe aſſemblies, where their company could not be diſpenſed with by the ſoldiers of liberty, they drowned their new-born infants—*they drowned them publicly!* Our correſpondent (the Count) ſaw two of the little victims, and he heard, from unqueſtionable authority, of ſeveral more. At a place within ſix miles of Nuremberg, a Pruſſian pariſh-miniſter, who was alſo a ſort of juſtice, endeavoured to ſave one innocent, and was thrown into the river and fired at by the French, when his pariſhioners endeavoured to ſave him. He had the happineſs, however, to ſave the child, and was allowed to keep it, the mother never enquiring after it!

bridge-head (*tete de pont*), though there was no bridge at that place.

The Imperial troops, in the mean time, had taken advantage of the defenceleſs ſtate of the French frontier to croſs the Rhine at Manheim, and to advance in various detachments to Weiſſemburg, Seltz, Hagenau, and almoſt to the gates of Straſburg, levying contributions and taking hoſtages wherever they came. Theſe detachments being now recalled, the Archduke reſolved to terminate the campaign by the capture of Kehl, and of the fortification at Huningen. But this proved no eaſy taſk. As the communication with the French ſide of the river was open at both places, the diviſions of Moreau's army did duty at them by turns. A great part of the winter was ſpent in fruitleſs attempts, on the part of the Auſtrians, ſometimes to take them by ſtorm, and ſometimes to reduce them by the forms of regular ſiege. Different ſallies were made by the French, and immenſe numbers of men were loſt on both ſides by the ſword, and by the ſeverity of the ſeaſon. It was not till the 10th of January that the French agreed to evacuate Kehl, and the fortification at Huningen was not given up till the ſucceeding month.

272
Reflections on the different orders of battle.

273
The order adopted by Bonaparte.

274
His pompous proclamation.

During the invaſion of Germany that has been now mentioned, and the reverſes that were ſuffered by the French armies there, Bonaparte ſtill continued to gain victories in Italy. The ſucceſs and the wonderful fortune of this man, require that we ſhould give ſome account of the arts by which he was enabled, ſo unexpectedly, to triumph over the moſt experienced military commanders of the age in which he lived. In the military art three orders of battle, or forms of drawing up an army, have been chiefly adopted by thoſe nations whoſe force has principally conſiſted of foot ſoldiers. The firſt form or mode conſiſts of arranging the troops in a deep line; that is, with from 16 to 30 men placed cloſe behind each other. This is the moſt ancient and the ſimpleſt order of battle. It was carried to perfection by the Greeks, under the name of the *Phalanx*; and, when the ſoldiers were armed with the long ſpear, it was extremely formidable. It left little to the ſkill of the general, except the choice of the ground where he was to fight, and made all to depend upon the ſteadineſs of the troops. It was attended with theſe diſadvantages, however, that an army thus drawn up commanded very little territory, and that if its ranks happened to be broken by unequal ground, or an uncommon effort of the enemy at a particular quarter, its parts could not eaſily be re-united, and it infallibly went into confuſion. In modern times, this order of battle cannot be adopted with ſucceſs on account of the facility with which it is broken by artillery, and the ſlaughter to which it expoſes the troops from every kind of fire arms. The ſecond, or modern order of battle, conſiſts in forming a front of an immenſe extent, with only two or three men in depth, and uſually ſupporting theſe by another, and perhaps a third equally ſlender line, at a conſiderable diſtance in the rear. Troops thus drawn up derive the greateſt poſſible benefit from their own fire arms, and ſuffer the leaſt loſs from thoſe of the enemy. They provide for their own ſubſiſtence by covering an immenſe track of country. Their battles are not ſanguinary, as they are ſeldom very cloſely engaged; and in caſe of a defeat, little loſs is ſuffered, becauſe they can ſcatter themſelves over a wide ſpace, as the rear protects the advanced body; and as the troops in a long line can ſeldom all be engaged at once, they are ſupported by each other in a retreat. This order of battle, however, is eaſily broken; and the moment the flank of an army is turned, it is under the neceſſity of retreating, as troops cannot ſpeedily be brought from other quarters to face the enemy there. The laſt order of battle conſiſts of dividing an army into columns of a narrow front and very great depth, and of ſtationing the columns at ſome diſtance from each other, with a ſecond ſet of columns oppoſite to the intervals between the firſt. This arrangement is ſuperior to the phalanx, in this reſpect, that it does not expoſe an army to diſorder by inequalities of ground, by the turning of its flank, or even by the defeat of one of its parts. The celebrated Epaminondas won the battles of Leuctra and Mantinea, by forming a part of his troops, on each of theſe occaſions, into a ſtrong column, which, by its great depth, and the mechanical weight of its ſhock, broke through the Spartan phalanx. The Romans are known to have owed their military ſucceſs, in a great meaſure, to the arrangement of their legion. It was drawn up upon the principle now mentioned; and tho' the columns were only 16 men in depth, it was confeſſedly ſuperior to the phalanx. In modern times, however, this order of battle is attended with great difficulties. It muſt reduce an army to embarraſſment with regard to proviſions from the ſmallneſs of territory which is thus occupied, and it expoſes the troops in an engagement to dreadful deſtruction from the powerful miſſile weapons which are now employed. In every enterpriſe they muſt inſtantly carry their point or be undone, as the fire of a few guns from a ſingle battery or redoubt would exterminate them by thouſands. With all its imperfections, however, this laſt order of battle has at times been employed by enterpriſing men. It was the favourite arrangement of Guſtavus Adolphus; and his troops were drawn up according to it at the battle of Lutzen, where he himſelf was killed, while his army was victorious. The celebrated Marquis of Montroſe alſo uſed it on more than one occaſion, and it was now adopted in all important caſes by Bonaparte. Truſting to its ſucceſs, he puſhed his columns into the midſt of the Auſtrian army at Milleſimo, and fairly captured one of its wings. He ventured farther to throw himſelf into the centre, between the Auſtrian and Sardinian armies, and to vanquiſh the one, by acting againſt it with his whole troops while ſeparated from the other. Being careleſs about the ſhedding of blood, he never heſitated to expoſe his whole army to utter ruin in caſe of a failure. The ſucceſs of his battles, by enabling him to lay almoſt all Italy under contribution, gave him the means of maintaining the moſt ſteady and ſevere diſcipline over a well paid army. Filled with high notions of military glory, which he is ſaid to have derived from the writings of Plutarch, he laboured to inflame, with the ſame ſpirit, the minds of his ſoldiers by proclamations, expreſſed in a very different ſtyle from the formal and more modeſt language of modern times. "Soldiers (ſaid he, when he firſt entered Lombardy), you have ruſhed like a torrent from the ſummit of the Appenines, you have driven back and diſperſed all who oppoſed your march. Your fathers, your mothers, your wives, your ſiſters, your ſweethearts, rejoice in your ſucceſs, and boaſt with pride of being related to you.

But

But remains there nothing more for you to effect? Shall poſterity reproach us with having found a Capua in Lombardy? But I already ſee you ruſhing to arms; an unmanly repoſe fatigues you, and the days loſt to glory are loſt to your felicity. But let the people be tranquil; we are the friends of all nations, and more particularly of the deſcendants of the Brutuſes, the Scipios, and the illuſtrious perſonages whom we have choſen as models. To reſtore the Capitol, to replace with honour the ſtatues of the heroes who rendered it renowned, and to rouſe the Roman people, become torpid by ſo many ages of ſlavery, ſuch will be the fruit of your victories; they will form an epoch to poſterity, and you will have the immortal glory of renovating the faireſt portion of Europe. The French nation, free and reſpected by all the world, will give to Europe a glorious peace. You will then return to your homes and your fellow-citizens; who, when pointing to you, will ſay, *He was of the army of Italy*."

275 rſhal urmſer cked.

At the commencement of the French invaſion of Germany, Marſhal Wurmſer was ſent into Italy to replace Beaulieu, who was removed from his command. On his arrival, he collected the wrecks of the Auſtrian army, and prepared, till he ſhould receive re-inforcements, to confine the French within as narrow limits as poſſible, by lines drawn from the lake of Garda to the river Adige. At the end of June, however, theſe lines were attacked and carried by Maſſena's diviſion, which induced Wurmſer to avoid farther exertion till he ſhould receive an increaſe of force. In the mean time Bonaparte was not a little diſturbed by partial inſurrections of the Italians. Soon after his arrival in Lombardy, the inhabitants of Milan and of Pavia had riſen in concert againſt his troops; but they were reduced to ſubjection with little bloodſhed. In the beginning of July, farther inſurrections broke out in the Romagna. The inſurgents eſtabliſhed their head quarters at Lugo, and repulſed a party of French cavalry that was ſent againſt them. It was not till Augereau had overcome them, on the 6th, in a battle in which he loſt 200 men, that they could be ſubdued. The ſlaughter of theſe unhappy people was very great. Their town was given up to pillage, and all found in arms were deſtroyed.

276 antua ſieged.

The firſt part of the month of July was ſpent by Bonaparte in commencing the ſiege of Mantua in regular form; and towards the cloſe of that month he expected its capture. In this, however, he had ill calculated the immenſe military efforts which Auſtria, aided by the money of Britain, was capable of making. Twenty thouſand troops had been ſent from the Rhine, and other reinforcements were marching towards Italy from all quarters; ſo that Bonaparte, inſtead of being able to take Mantua, had ſpeedily to defend himſelf againſt the force of a ſuperior army to his own, that approached to raiſe the ſiege, and even threatened to drive him out of Italy.

277 rtial ſuc- ſſes of urmſer.

Wurmſer's army deſcended from the Tyrol in two diviſions. One half of it proceeded along the eaſt ſide of the lake of Garda, and the other came by the weſt to cut off the retreat of the French, who were thus encloſed by the Auſtrians. On the 29th of July, at three o'clock in the morning, Maſſena was driven from the ſtrong poſt of La Corona, on the eaſt of the lake, while, at the ſame time, 15,000 Auſtrians drove the French from Salo, and afterwards took Breſcia, with all the magazines and hoſpitals of Bonaparte's army. There was a fatal error, however, in the general plan of operations that had been formed by the Imperialiſts. Their army united was an overmatch for the French; but they had voluntarily divided it into two parts, placing Bonaparte between them. The error was inſtantly diſcerned, and taken advantage of by their antagoniſt. On the night of the 30th, he ſuddenly raiſed the ſiege of Mantua, and leaving a ſmall body of troops to keep in check the Imperialiſts on that ſide, he marched rapidly weſtward, and on the firſt of Auguſt retook Breſcia, with the magazines and hoſpitals. Having the maſs of his army united, Bonaparte ſurpaſſed his antagoniſts in numbers wherever he encountered them. He prepared to attack the Imperialiſts on the 3d at Salo, Lonado, and Caſtiglione, but was anticipated by them. Having formed a large body of his troops into cloſe columns, the Auſtrians, who were not yet aware of the nature of his mode of fighting, extended their line to ſurround them; a movement which enabled the columns to penetrate the Imperial army in all directions, and throw it into compleat diſorder.

278 He is defeated.

The French took 4000 priſoners, and 20 pieces of cannon. The Imperial troops were here ſo completely defeated, that a conſiderable diviſion of them having in vain attempted to retreat by Salo, which they found occupied by the French, wandered about in ſearch of a road by which to eſcape; and having next day come to Lonado, they ſummoned it to ſurrender, upon the ſuppoſition that the greater part of the French army had gone eaſtward to encounter Wurmſer. This was actually the caſe; but it ſo happened, that Bonaparte was in perſon at Lonado with only 1200 men. He was ſufficiently perplexed by this accident; but having ordered the meſſenger to be brought into his preſence, he threatened to deſtroy the whole diviſion for having dared to inſult the French army, by ſummoning its commander in chief to ſurrender. The ſtratagem was ſucceſsful. The Imperial officers imagined that the whole army was in the place, and immediately, with their troops, laid down their arms, to the number of 4000 men.

Such is the account of this tranſaction, which we have from the partial pen of the panegyriſt of Bonaparte, who writes the hiſtory of his campaigns in Italy; but we believe that the General has himſelf aſſigned the true reaſon of his ſucceſs on this occaſion, and others, where ſucceſs could not be reaſonably expected. In one of his intercepted letters, Bonaparte informs his correſpondent, that the Auſtrian armies in Italy coſt him more money than his own; and indeed it is not within the compaſs of ſuppoſition, that a body of veteran ſoldiers could have been intimidated to lay down their arms by ſo vain-glorious a threat as this, had not their officers been corrupted by French gold and French principles. The ſtratagem might have its effect upon the common ſoldiers, but it could not poſſibly impoſe upon their leaders, or upon the meſſenger who ſummoned Lonado to ſurrender.

279 Again defeated.

On the 5th and 6th, Bonaparte attacked Marſhal Wurmſer, and drove him from Peſchiera and the river Mincio. On the 7th, the Auſtrians were compelled to quit Verona, and to retire once more to the mountains of Tyrol. This conteſt, which had laſted more than ſix days, coſt the Imperialiſts more than 20,000 men, upwards of 15,000 of whom were made priſoners. A part of the Emperor's troops had been levied in Gallicia,

licia, the part of Poland which, in the partition of that country, had been allotted to Auſtria. Theſe men ſeized the moment of defeat to quit a ſervice which they diſliked, and to go over to the French; a circumſtance which greatly ſwelled the liſt of priſoners.

It was now neceſſary for the French to commence the ſiege of Mantua anew. The garriſon in their abſence had deſtroyed their works, and carried into the place 140 pieces of heavy cannon which they had left behind them, and procured a conſiderable quantity of proviſions. The blockade was renewed; but the French, by the loſs of their artillery, were unable to proceed to a regular ſiege; and by the beginning of the month of September, Marſhal Wurmſer, having received new reinforcements, was again enabled to attempt the relief of the place. Bonaparte having information of his intended approach, left ſufficient troops to keep up the blockade, while he advanced northward with his army; and on the 4th of September drove the Auſtrians from the paſſes of St Marco and the city of Roveredo to the paſs of Calliano, where they made their principal ſtand.

280 His maſterly conduct after a third defeat.

Here a battle enſued, in which the French took no leſs than 6000 priſoners, and entered Trent as conquerors. Upon ſuffering this defeat, Marſhal Wurmſer adopted a meaſure which cannot be ſufficiently approved of. Inſtead of retiring before the conqueror, who might have driven him to Inſpruck, and arrived at a critical moment at the Danube, where Moreau, after much heſitation, had only commenced his retreat, he ſuddenly threw himſelf with his vanquiſhed army into Baſſano, upon the flank and rear of Bonaparte, and then advanced by haſty marches towards Mantua. He attempted to make a ſtand at Baſſano on the 8th, but was defeated, and 5000 of his men were taken priſoners. He had ſtill a conſiderable body of troops however. With theſe he puſhed forward; and having fought different ſcattered diviſions of the French at Cerea, Caſtellano,

280 He enters Mantua.

and Due Caſtello, he effected the paſſage of the Adige at Porto Legnano, entered Mantua with the wreck of his army, amounting to about 4000 infantry and 4500 cavalry. In this enterpriſe the Imperialiſts loſt altogether 20,000 men; but the effect of it was, that it fixed Bonaparte in Italy, where he was obliged to remain watching and keeping under blockade the numerous garriſon of Mantua. He hoped that its numbers would ſoon reduce it by famine to the neceſſity of a capitulation; but in this he was deceived, as the fleſh of the horſes, carried into it by Wurmſer, afforded ſubſiſtence to the troops during a very long period.

281 Corſica revolts from Britain, and unites with France.

In the mean time, the fame which their countryman Bonaparte gained by theſe victories, produced in the Corſicans a deſire to change the Britiſh government for that of France. They accordingly diſplayed ſo mutinous a ſpirit, that the Britiſh Viceroy thought fit to evacute the iſland, which was no longer of any value to his government after all Italy had, in a great meaſure, ſubmitted to the French. The Imperial ſubjects in Italy alſo, along with the inhabitants of Bologna, Ferrara, and Modena, who were completely corrupted by the falſe philoſophy of the age, began now to republicaniſe themſelves under the patronage of the French general. They ſent deputies to a convention, levied troops, and aboliſhed all orders of nobility.

The Emperor ſoon ſent into the field a new army to attempt the relief of Mantua. In the beginning of November this army advanced under the command of Field Marſhal Alvinzi, who advanced towards Vizenza on the eaſt, ſeconded by General Davidovich, who deſcended with another diviſion from Tyrol. Alvinzi had already croſſed the Piava, when he was met by the French, and compelled to repaſs that river.

282 Partial ſucceſſes of the Auſtrians.

But Davidovich, in the mean time, after ſeveral engagements, having ſucceeded in driving the French down the Adige towards Verona, Bonaparte was under the neceſſity of concentrating his forces. He now adopted his uſual expedient of keeping one diviſion of the hoſtile army in check, while he contended with the maſs of his forces againſt the other. He left Vaubois with ſome troops to detain Davidovich, while he advanced in perſon againſt Alvinzi, who was now haſtening towards Verona. He was met, on his way, by the Auſtrians at the village of Arcole. To ſeize this village, which could not be ſpeedily turned on account of a canal, the French were under the neceſſity of paſſing a narrow bridge in the face of the fire of the Auſtrians. They made the attempt without ſucceſs. Their officers ruſhed to the head of the column, and in vain attempted to rally the troops. Generals Verdier, Bon, Verne, and Laſnes, were carried off the field. Augereau advanced with a ſtandard to the extremity of the bridge, but nobody followed him. At laſt Bonaparte, who in the mean time had ſent Guieux with 2000 men to turn the village at two miles diſtance, haſtened to the bridge of Arcole. Seizing a ſtandard, he advanced at the head of the grenadiers, crying, "Follow your general." They accordingly followed him to within 30 yards of the bridge, when they were intimidated by the terrible fire of the Auſtrians, and their leader found it neceſſary to retire. Attempting to mount his horſe to rally the column, leſt the Auſtrians ſhould advance to the purſuit, he was thrown into a moraſs, while ſtill under the fire of the troops in the village; but here he again eſcaped, as the Auſtrians did not attempt to follow up their advantage.

The village of Arcole was taken towards the evening by Guieux, and afterwards evacuated by the French. On the following day (the 16th of November) an obſtinate conflict enſued in its neighbourhood, in which nothing deciſive was accompliſhed.

283 They are defeated.

On the 17th the Auſtrians, having preſſed impetuouſly forward upon the centre of the French army, were taken by ſurpriſe upon their flank by the left wing of the French, which had been ſtationed for that purpoſe in ambuſcade. Their left wing, however, maintained its ground till Bonaparte ſent round a party of horſe with twenty-five trumpeters to their rear, who, by the noiſe they made, induced the Auſtrians to believe themſelves ſurrounded, and to fly on all ſides in confuſion.

Here again appear evidences of treachery among the Auſtrian officers, though the battle of Arcole was the moſt ſevere which the French had yet fought in Italy, and extremely fatal to their officers, as well as to a multitude of their troops. During its continuance, Davidovich had ſucceeded in defeating Vaubois, who was oppoſed to him and Rivoli, and the blockade of Mantua was actually uncovered for a time. But Bonaparte now returned, after having driven Alvinzi acroſs the Brenta, and the poſitions of Rivoli and La Corona were retaken, and Davidovich repulſed into Tyrol. General Wurmſer, however, ſtill held out in Mantua during 'rench volution, 1796.

during the remaining part of the year; and the only fruit hitherto derived from ſo many victories was, that the French nation was led to look towards Bonaparte as its only invincible commander, upon whom all its hopes of conqueſt were to depend.

284 gocia- i be- een Bri- n and ance.

During theſe military tranſactions, Great Britain had entered into a negociation with France. In conſequence of paſſports obtained from the Directory, Lord Malmeſbury arrived in Paris, and began the negociation with De la Croix the miniſter for foreign affairs. Tho' the Directory could not decently refuſe to negociate, yet they were unwilling ſeriouſly to conclude a peace with Britain. On the other hand, the Britiſh miniſtry have ſince declared that, as individuals, they actually diſapproved of a peace at this time, but that they thought it neceſſary both to negociate, and even to conclude a treaty, if proper terms could be obtained. In judging thus, they were certainly right; for the country at large, not ſeeing the danger of peace, was very deſirous of it, whilſt a deſperate faction was conſtantly aſcribing the continuance of the war to the criminal obſtinacy of the Britiſh government. The negociation which was now ſet on foot opened the eyes of all but thoſe who wiſhed to ſell their country to French regicides. Lord Malmeſbury propoſed, that the principle of mutual reſtitutions ſhould be agreed upon as the baſis of the treaty. After much uſeleſs altercation, and many notes had paſſed upon this ſubject, and alſo upon the queſtion, how far Lord Malmeſbury could negociate for the allies of Great Britain, from whom he had received no official powers, the Directory at laſt agreed to the general principle of mutual reſtitutions, and required that the objects of theſe ſhould be ſpecified. Accordingly, the Britiſh ambaſſador propoſed, in two memorials, that France ſhould relinquiſh the Auſtrian Netherlands, and offered to give up the French foreign ſettlements in return. An offer was alſo made to reſtore a great part of the Dutch foreign poſſeſſions, on condition that the Stadtholder's ancient authority ſhould be acknowledged in that country. The Directory now required Lord Malmeſbury to preſent the ultimatum of his conditions within twenty-four hours. On his complaining of this demand, he was informed, on the 19th of December, that the Directory would agree to no conditions contrary to the French conſtitution; and it was added, that his farther reſidence at Paris was unneceſſary!

285 uddenly roke off y the Di- ectory.

286 Cape of Good Hope, with a Dutch squadron, aken by he Briti*ſh*.

During this year, Great Britain retained her uſual ſuperiority by ſea. A Britiſh ſquadron, under Admiral Elphinſton, had taken poſſeſſion of the Dutch ſettlement at the Cape of Good Hope, on the 16th of September 1795. This ſettlement the Dutch wiſhed eagerly to recover; and for this purpoſe they advanced money to enable the French to fit out a ſquadron to co-operate with them in an attack upon it. The French government took the money, but the ſquadron was never equipped. The Dutch themſelves this year ſent a ſquadron of ſeven ſhips of war, under Admiral Lucas, to attempt to reconquer the Cape; but being no match for the Britiſh ſquadron, and being likewiſe caught between two fires, without the poſſibility of eſcaping, the Dutch fleet, without firing a gun, was delivered up to the Britiſh admiral.

Notwithſtanding the ſuperiority of Great Britain by ſea, the French, towards the cloſe of this year, attempted an invaſion of Ireland; but the plan was ill concerted, and, of courſe, unſucceſsful. The whole conduct of it was intruſted to one man, General Hoche, and no ſecond was prepared to occupy his place in caſe of any accident. The diſaffected faction with whom the French meant to co-operate was not warned of their approach, and the fleet was ſent towards a quarter of the country where the people were little diſpoſed, or, at leaſt, by no means prepared to receive them. Eighteen ſhips of the line, thirteen frigates, twelve ſloops, and ſome tranſports, having 25,000 land forces on board, were employed in this expedition. When about to ſail, it was detained for ſome time by a mutiny which aroſe in conſequence of the enliſtment of about 1,200 galley ſlaves. The fleet ſailed on the 10th of December; but a ſhip of the line was loſt in going out of Breſt, and ſome of the reſt were damaged. The frigate in which the commander in chief had embarked was ſeparated from the fleet in a gale of wind; and the conſequence was, that when the greater part of the fleet arrived at Bantry Bay, on the weſt coaſt of Ireland, nobody had inſtructions how to proceed. The troops and their officers wiſhed to land, but the admiral, Bouvet, refuſed to comply with their requeſt. Having remained ſeveral days upon the coaſt, he ſailed for France, and arrived at Breſt with a part of the fleet on the 31ſt of December. General Hoche did not reach Bantry Bay till it was too late. and therefore could not land. The fleet ſuffered great loſſes in its return. One ſhip of the line and two frigates foundered at ſea, a frigate was taken by the Britiſh, and a ſhip of the line, after an engagement with two Britiſh ſhips, was run aſhore to prevent her being captured.

French Revolution, 1796.

287 Unſucceſsful attempt by the French on Ireland.

1797.

At the commencement of the year 1797, the Archduke Charles was ſtill occupied in the reduction of Kehl, and of the French fortifications oppoſite to Huningen. Moreau ſtill commanded the army that oppoſed the Archduke; but General Hoche, after his return from the expedition to Ireland, was appointed to ſucceed Jourdan on the Lower Rhine. Bonaparte was ſtill engaged in the blockade of Mantua, while the Auſtrian government was making vaſt efforts to recruit the army of Alvinzi after its defeat at Arcole, and to enable that General to make a laſt and deſperate effort for the relief of Mantua. The young men of Vienna were urged to give their aſſiſtance on this important occaſion, and 6000 of them marched into Italy as volunteers. Alvinzi's army amounted now to nearly 50,000 men; and he commenced his operations on the 8th of January, by ſkirmiſhing along the whole of the French line from below Porto Legnago upwards, to La Corona near the Lake Garda. He continued for ſome days to alarm the French at all points, and thus to conceal the plan of his future efforts. On the 10th Bonaparte was ſtill at Bologna, on the other ſide of Mantua, taking precautions againſt the eſcape of Wurmſer by that quarter, which, from an intercepted letter, he had learned was in contemplation. Being now informed of the approach of the Auſtrian army, he haſtened to Mantua, and from thence to Verona, which was the centre of the line of his army that oppoſed Alvinzi. He arrived at Verona on the morning of the 12th; but as the Auſtrians continued to make their attacks upon all quarters at once, he was unable to penetrate the deſign of their leader. At laſt, on the 13th, the

288 Succeſſes of the Auſtrians.

the efforts of the Auſtrians began to aſſume a more formidable aſpect on the lower part of his line near Porto Legnago; but on the evening of the ſame day he received intelligence, that the upper extremity of his line, where Joubert commanded, had been attacked by ſuch an immenſe ſuperiority of numbers, that there could be no doubt that the greateſt number of the Imperial troops was concentrated there. The poſt of La Corona had even been forced, and Joubert compelled to withdraw to Rivoli, which he alſo abandoned.

298 They divide their army; The Auſtrians ſtill perſiſted in their unfortunate plan of dividing their army, that they might have two chances of ſucceſs. Ten thouſand choſen troops, among whom were the Vienna volunteers, were deſtined under General Provera to penetrate to Mantua by Porto Legnago, at the lower extremity of the French line; while Alvinzi in perſon advanced with the maſs of the army againſt Joubert at its other extremity. On the 13th all went well; Joubert was compelled to retreat; and he was ſo ſituated, that the eaſy capture of his whole diviſion on the following day appeared a very probable event.

Bonaparte, in the mean time, having learned the ſtate of affairs, left Verona in the evening of the 13th, having firſt ordered the whole centre of his army under Maſſena to follow him to the neighbourhood of Rivoli with all poſſible ſpeed. Here he ſpent the night with his officers in arranging the order of battle for next day, and in occupying proper poſitions. At day-break of the 14th the attack was begun by Joubert's diviſion, to the no ſmall ſurpriſe of the Imperialiſts, who were not aware of the arrival of Bonaparte with reinforcements. The battle, however, was long and obſtinate. The ſuperiority of numbers on the ſide of the Auſtrians enabled them to defeat all the efforts of the French to turn their diviſions. They at laſt ſucceeded in driving back upon the centre the two wings of the French army in conſiderable diſorder. Alvinzi now attacked the centre, which ſcarcely maintained its poſition; and the Auſtrian wings advancing on both ſides, completely ſurrounded the French army. The victory ſeemed already won; and it is ſaid that Alvinzi diſpatched a courier to Vienna to announce the approaching capture of Bonaparte and his army. Bonaparte indeed conſidered his own ſituation as very alarming; and is ſaid to have meditated his eſcape acroſs the Auſtrian right wing. From the nature of his order of battle, his troops had rather been concentrated than ſcattered by the repulſe they had received, and it was therefore ſtill in his power to make a deſperate effort. Having formed three ſtrong columns, he ſent them againſt the Auſtrian right wing. They ſucceeded in penetrating it at different points; and it fled in ſuch confuſion, that having encountered a party of French that had not arrived in time to join the body of the army, 4000 Auſtrians laid down their arms in a panic, and ſurrendered themſelves priſoners of war. 290 And are defeated. Night put an end to any farther conteſt; but Bonaparte conſidering this quarter of his line as no longer in danger, departed to oppoſe General Provera, leaving Joubert to proſecute the victory now gained. This ſervice he performed with great ſucceſs. A detachment under General Murat having marched all the night of the 14th after the battle, ſeized Montebaldo in the rear of the poſition at Corona, to which a conſiderable diviſion of the Auſtrians had retreated, while Joubert, next morning, attacked them in front. Finding themſelves ſurrounded, they ſoon fell into confuſion. Six thouſand men were made priſoners, many were drowned in attempting to croſs the Adige, and the remainder fled to Tyrol.

During this ſanguinary conteſt on the upper part of the Adige, General Provera had forced his paſſage acroſs the lower part of that river at Angiara near Porto Legnago, and compelled the French General Guieux to retire to Ronco. Augereau collected all the troops in the neighbourhood, and marched to attack Provera; but as he haſtened towards Mantua, Augereau could only come up with his rear; of which, after an engagement, he took 2000 priſoners. On the 15th, however, General Provera arrived in the vicinity of Mantua. The city, which ſtands in a lake, was blockaded at the two points, by which it has acceſs to the main-land called *St George* and *La Favorite*. Alvinzi was to have formed his junction with Provera at the poſt of St George. Receiving no intelligence of him, General Provera ſummoned the French commander here to ſurrender; and on his refuſal, endeavoured to carry the poſition by aſſault. 291 Mantua ſurrenders. Having failed in this attempt, he turned his attention towards the poſt of La Favorite, which he attacked on the morning of the 16th; while Wurmſer, who had perceived his arrival, advanced with the troops of the garriſon againſt the ſame point. But by this time Bonaparte had arrived with reinforcements. General Wurmſer was repulſed (B); and Provera being completely ſurrounded by the French, was under the neceſſity of ſurrendering himſelf with his troops priſoners of war. The reſult of all theſe battles at Rivoli and Mantua was the capture of 23,000 priſoners and 60 pieces of cannon; and thus four Imperial armies had periſhed in Italy in the attempt to preſerve Mantua. The capture of this city, however, was now inevitable, in conſequence of famine. It ſurrendered by capitulation on the 2d of February. Bonaparte on this occaſion endeavoured to acquire the reputation of humanity. To allow the French emigrants in the garriſon to eſcape, he conſented to an article in the capitulation that General Wurmſer ſhould be allowed to ſelect and carry out of the garriſon 700 men, who were not to be examined

---

(B) Marſhal Wurmſer had before this time begun to ſuſpect that his plans were betrayed to the enemy. When he reſolved to make his laſt ſally to co-operate with Alvinzi, he kept his plan to himſelf; and in the morning of that day on which the army was to march out, he gave to each of the generals commanding the diviſions (which we think were ſeven) his orders in a ſealed packet. The troops marched at the hour fixed on, in ſo many diviſions; and they were inſtantly attacked at all points by the enemy. Upon this, the old General ſaid to a Britiſh officer of high rank, who was with him in the fortreſs, We are betrayed, make your eſcape by any means that you can. This anecdote was communicated to us through a channel which leaves no doubt of its truth in our own minds; but not being authoriſed to give the *names* of our informers, we thought it not right to inſert it in the text. Its truth or falſehood may be eaſily aſcertained.

mined nor conſidered as priſoners; and the General himſelf was allowed to depart unconditionally.

29?
e Pope
ſeveres
oſti-
es;

In the meanwhile, the Pope, who of all the European princes had the beſt reaſon for diſliking the French cauſe, uncautiouſly perſevered in hoſtility, in the hope that ſome one of the Imperial armies might ſucceed in driving Bonaparte from Italy. Having recovered from the panic which induced him to ſolicit an armiſtice when the French firſt entered Lombardy, he had avoided concluding a treaty of peace, and attempted to enter into a cloſe alliance with the court of Vienna. He procured officers to be ſent from thence to take the command of his troops, and flattered himſelf with the vain hope of being able to make an important diverſion in favour of the Imperial troops.

As the Emperor and the French were both preparing with all poſſible ſpeed to renew their bloody conteſt on the frontiers of Germany, it was of importance to Bonaparte to leave all Italy in peace on his rear. On the 1ſt of February he ſent a diviſion of his troops under General Victor, along with what was called the *Lombard Legion*, conſiſting of Italians, to enter the territory of the Pope; and upon the ſurrender of Mantua Bonaparte followed in perſon. The troops of his Holineſs made feeble reſiſtance. The new raiſed Lombard legion was made to try its valour againſt them on the river Senis on the 2d. After ſtorming their entrenchments, it took their cannon and 1000 of themſelves priſoners. Urbino, Ancona, and Loretto, ſucceſſively fell an eaſy prey to the French. From the chapel at Loretto the papal General Colli had carried moſt of the treaſure; but the French ſtill found gold and ſilver articles worth 1,000,000 of livres, and the image of the virgin was conveyed as a curioſity to Paris. Bonaparte now proceeded through Macerata to Tolentino. He was here met by a meſſenger from the Pope with offers of peace, and concluded a treaty with his Holineſs on the 19th. By this treaty the conditions of the armiſtice were confirmed; and in addition to the payments then ſtipulated, the Pope promiſed to pay 15,000,000 of livres, and to deliver 800 cavalry horſes, with as many draught horſes and oxen. He alſo engaged to pay 300,000 livres to the family of the French envoy Baſſeville, who had been murdered at Rome, and to apologiſe by his miniſter at Paris for that event.

293
it is con-
ered.

294
onaparte
inforced.

The French had been ſo unſucceſsful in their late irruption into Germany, through Swabia and Franconia, that they now reſolved to make their principal effort from Italy under Bonaparte. For this purpoſe, the Directory detached great bodies of the veteran troops that had fought under Moreau as ſecretly as poſſible through Savoy into Italy. The court of Vienna, however, was aware of the approaching danger, and gave the command on the ſide of Italy to the Archduke Charles, who of all their military leaders had alone of late been ſucceſsful againſt the French. He brought along with him his beſt troops from the Rhine, and numerous levies were endeavoured to be made in all the hereditary ſtates for his farther ſupport. The war was now about to be carried into new territories, on which the houſe of Auſtria had ſcarcely hitherto beheld a foe. It was neceſſary that Bonaparte ſhould once more attempt to ſcale the ſummit of the Alps. This immenſe chain of mountains, which takes its riſe in the vicinity of Toulon, at firſt ſtretches northward under the names of *Piedmont* and *Savoy*. It then runs towards the eaſt, forming the countries of Switzerland, Tyrol, Carinthia, and Carniola. The three laſt of theſe, paſſing along the head of the Adriatic, form the frontier in this quarter of the hereditary ſtates of Auſtria. Between the mountains and the ſea lies the level and fertile tract of territory which belonged to Venice. It is croſſed by many large ſtreams, which are fed by the melting ſnows of the Alps, and whoſe nature is this, that they are greateſt in ſummer, and that their waters diminiſh during the froſts of winter.

295
Blunder of
the Court
of Vienna.

The council of war at Vienna now committed an important error in the plan of defence which it adopted. Inſtead of making a ſtand in the defiles of the mountains, the Archduke was ſent down into the plain to defend the paſſages of the rivers. War is eſſentially an offenſive art. Whatever the general purpoſe of hoſtility may be, it is always conducted with moſt ſucceſs when the detail of its operations is ſo managed as to aſſume the form of enterpriſe and of vigorous attack. This ariſes not from any thing in the nature of the art of war, but from the immutable conſtitution of the human character. The ſtrength of men who are fixed without motion in a particular ſpot, is ſubdued by the depreſſing paſſion of fear, and by the deſpair of accompliſhing any important object; whereas, when urged to action and to enterpriſe, their energy is increaſed by hope, and by that preſumption of their own ſuperiority which all men readily entertain. Hence we have ſo few inſtances in hiſtory of nations ſucceſsfully defended by rivers or extenſive fortified lines; whereas mountainous countries have uſually ſet bounds to the progreſs of armies. In ſuch ſituations, the defending party can always act upon the offenſive. He finds his adverſaries divided, by their ſituation, into ſmall parties. He hopes to vanquiſh them in detail, and he acquires ſtrength and courage from the proſpect of ſucceſs.

While Bonaparte was advancing into the territory of the Pope, the Auſtrian army was arranging itſelf along the eaſtern bank of the Piava. The French were on the oppoſite bank, and Bonaparte haſtened to join them after he had concluded his treaty with the Pope. The beginning of March was ſpent in preparations; but at laſt the troops advanced, that the point of reſiſtance might be diſcovered. Having croſſed the Piava on the 12th of March, the Auſtrians retired, ſkirmiſhing for ſome days till they had croſſed the Tagliamento, where they made a ſtand with their whole force. Early on the 17th the French army arrived at Valvaſone, on the oppoſite bank; and after ſome heſitation, reſolved to force the paſſage of the river. To have accompliſhed this object very ſpeedily would have been difficult, had not a recent froſt diminiſhed the ſtream, by which means the French were enabled to croſs it in the face of the enemy in columns at various points. The army of Bonaparte was now in three diviſions. Joubert, with the left wing, advanced along the courſe of the Adige into Tyrol, and was ordered to croſs over from thence, and to deſcend along the valley of the river Drave, which is beyond the higheſt chain of what the Romans called the *Noric Alps*. Maſſena, with the centre, after croſſing the Tagliamento, advanced into the defiles of theſe mountains; while the right diviſion, which was attended by Bonaparte in perſon, proceeded along the coaſt of the Adriatic.

296
Progreſs of
the French
army.

After forcing the paſſage of the Tagliamento on the 17th, the French had eaſily defeated the Auſtrians on the oppoſite bank, and compelled them everywhere to retreat. The other rivers were eaſily paſſed; and on the 19th, the town of Gradiſca, on the river Liſonzo, ſurrendered to the right wing of the army, and its garriſon, amounting to 3000 men, were made priſoners of war. On the 21ſt Goritz was entered by the ſame diviſion, who found there the principal Auſtrian magazines and hoſpitals. Trieſte was entered on the 23d; and the French ſent off in waggons, from the quickſilver mines of Ydria, materials worth 2,000,000 of livres. In the mean time, the Auſtrians, in their haſty retreat, entangled themſelves and their baggage among the mountains. On the 24th, a large body of them was hemmed in between Maſſena, who had reached Tarvis, and a part of the French right wing under Guieux. 297 The Auſtrians defeated. Reinforcements, however, having found means to reach them from the Archduke's head quarters at Clagenfurt, they hazarded an enagement on the following day, but were defeated, with the loſs of 5000 taken priſoners, and 400 waggons loaded with baggage. The French left wing under Joubert, Baraguay D'Hilliers, and Delmas, was equally ſucceſsful. On the banks of the Lavis, after an obſtinate engagement, 4000 Auſtrians were taken; and thereafter at Clauzen they were again defeated, with the loſs of 1500 taken priſoners. Having entered Brixen, this diviſion turned eaſtward, and deſcended the valley of the Drave towards Clagenfurt. the capital of Carinthia, where it was met by General Maſſena; the Archduke, after a ſlight conteſt, having evacuated the place, and advanced farther towards the capital of the empire, which was now ſeriouſly menaced, and in which great conſternation prevailed. 298 Wonderful ſucceſs of Bonaparte. In 15 days Bonaparte had taken 20,000 priſoners, and croſſed the Alps; and though the country ſtill preſented ſome difficulties, there was no fortified place capable of reſiſting his progreſs towards Vienna. He did not, however, conſider his own ſituation as deſtitute of hazard, and ſeized the preſent moment of unbounded ſucceſs to make propoſals of peace. On the 31ſt of March he ſent a letter to the Archduke, in which he deprecated the uſeleſs prolongation of the war, and intreated him to interpoſe his good offices to put a ſtop to its farther ravages. But this prince, who ſeems to have doubted his own influence at the court of Vienna, returned a cold anſwer, ſtating, that it belonged not to him to inveſtigate the principles on which the war was carried on, and that he had no powers to negociate.

299 Partial ſucceſſes of the Auſtrians. The Auſtrian chiefs made a laſt effort, by raiſing the peaſants of the Tyrol in a maſs to embarraſs the rear of the French. They accordingly gained ſome ſucceſſes under General Laudohn, and drove out the French troops that had been left at Botzen and Brixen. The inhabitants of the Venetian ſtates alſo roſe againſt the troops that remained in their country; and being joined by ten regiments of Sclavonians, which had been in the pay of the government of Venice, they put the French to death wherever they were found, without excepting the ſick in the hoſpitals, of whom 500 were maſſacred at Verona. A party of Imperialiſts alſo drove the French garriſon out of Trieſte, and thus attempted to ſurround the invading army. Bonaparte, however, knew that the court of Vienna muſt be at leaſt as much embarraſſed as himſelf. His army amounted to 95,000 men. It had hitherto proved irreſiſtible; and the Auſtrians knew, that to ſurround was not to conquer it. He therefore perſiſted in advancing. On the 2d of April he ſucceeded in forcing the ſtrong defiles between Freiſach and Newmark, after a bloody battle, in which he took 600 priſoners. On the 4th, his advanced guard reached Hunſmark, where the Auſtrians were again defeated; and his army occupied Kintenfeld, Murau, and Judenbourg. 300 The Auſtrian cabinet treats for peace. Theſe advantages compelled the Auſtrian cabinet to treat for peace, as there was no longer any point at which the Archduke's army could hope to make a ſtand till it came to the mountains in the vicinity of Vienna. Meaſures were taken for removing the public treaſure and effects into Hungary, while Generals Bellegarde and Morveld were ſent to requeſt from Bonaparte a ſuſpenſion of hoſtilities. On being ſuffered to take poſſeſſion of Gratz and Leoben, within little more than 50 miles of Vienna, he conſented, on the 7th of April, to an armiſtice, which was only to endure till the night of the 13th, but was afterwards renewed for a longer period. It was followed on the 19th by a preliminary treaty, ſigned at Leoben; by which it was agreed that the Auſtrian Netherlands ſhould belong to France, and that the new republic in Lombardy ſhould continue under the name of the *Ciſalpine Republic*, and ſhould include the Milaneſe, the duchy of Mantua, and the territories of Modena, Ferrara, and Bologna. There is reaſon to ſuſpect that ſomething hoſtile to the independence of Venice was here alſo ſtipulated. 301 Unjuſt and cruel conduct of Bonaparte. Bonaparte agreed to withdraw without delay into Italy, on receiving ſubſiſtence for his army during its march; and it was reſolved, that all farther diſputes ſhould be afterwards ſettled by a definitive treaty of peace. On his return he accuſed the Venetian government of connivance at the inſurrection which had taken place againſt the French in his abſence; and having ſeized their city and whole territory, he diſſolved that ancient and ſingular, but now feeble, ariſtocracy.

While Bonaparte was advancing towards Vienna, the French armies on the Rhine had begun to preſs upon the Auſtrians, to prevent farther reinforcements from being ſent againſt him from that quarter. The Auſtrians offered an armiſtice; but as the French demanded the fortreſs of Ehrenbreitſtein as the price of it, both parties prepared for action. The left wing of the army of General Hoche advanced rapidly from Duſſeldorf, while the centre and right wing croſſed the Rhine near Coblentz. 302 Succeſſes of the French on the Rhine. The Auſtrians under General Wernecht retreated to the Lahn, where they waited the arrival of the French. Here a violent conteſt enſued on the 18th of April, in which 4000 Auſtrians were taken priſoners. The French took poſſeſſion of Wetzlaer, and drove their antagoniſts to the gates of Francfort. In the mean time, General Moreau, on the Upper Rhine, forced the paſſage of the river near Straſburg, and attacked the village of Dierſheim, of which he at laſt retained poſſeſſion, after having been more than once driven out, and the village nearly deſtroyed. The following day, however, the Auſtrians renewed the attack, and forced the French for ſome time to give way; but powerful reinforcements having croſſed the river, 03 e con- ed.

river, the French were at laſt enabled to renew the battle with ſuch vigour, that they took Fort Kehl, together with 5000 priſoners. The Imperialiſts in this quarter were now purſued towards the Danube; when all military operations were ſuddenly arreſted by meſſengers ſent through Germany by the Archduke Charles and Bonaparte, announcing that peace was concluded. Theſe meſſengers found the army of Hoche violently attacking Francfort on the Maine, which General Wernecht was endeavouring to defend. The news was diffuſed in an inſtant through both armies; and the contending troops, throwing aſide their weapons, congratulated each other upon the event.

04 ver of ce at period.

France now held a very elevated rank, and a formidable character, among the nations of Europe. Spain, Italy, and Holland, were held in dependence; while her victorious armies had compelled the laſt continental member of the coalition to accept of peace from an army that approached his capital. Had the Auſtrian officers been faithful, and the court of Vienna leſs ſelfiſh, ſubſequent events have indeed ſhewn that the affairs of the Emperor were not yet deſperate, and that Bonaparte was not that invincible hero which his rapid ſucceſſes gave ſome reaſon to ſuppoſe him. After the peruſal of his letters from Egypt, his victories loſe much of their brilliancy; nor does any action, or all the actions of his life, diſplay ſuch military ſkill, as the retreat of Moreau through Swabia, when preſſed on the rear by a victorious army, and ſurrounded on all hands by an incenſed populace. But Bonaparte had been ſucceſsful; the Archduke knew not whom to truſt: there is reaſon to believe that his plans were continually thwarted by a corrupt council at home; and the court of Vienna was bribed to make a peace. Of all the enemies of the French revolution, Britain alone remained in hoſtility. From her command of the ocean ſhe was enabled indeed to retain the feeble ſtate of Portugal, attached to her cauſe; but on land, ſuch was the terrible energy of France, that, with this exception, which ſeemed only to exiſt by tolerance, the Britiſh trading veſſels were excluded, by her influence, from all approach to the continent, from the Elbe to the Adriatic; and the Britiſh government was once more induced, in theſe circumſtances, to try the effect of a new negociation. All theſe external advantages, however, were ſpeedily loſt by the French nation; and it ſeemed the unhappy deſtiny of this people to be conſtantly deprived of the fruits of all their ſufferings, and their courage, by the turbulence of their domeſtic factions, and the profligacy and unprincipled conduct of their rulers.

05 tain con- es the r.

306 nteſt be- een the rectory l Coun-

A ſerious conteſt between the executive power and the legiſlature was now approaching. We already remarked, that the Directory was originally ſelected by thoſe men who had been the aſſociates of Robeſpierre; and though deſerted of late by ſome of the more violent ſpirits, who were termed *Anarchiſts*, it was ſtill conſidered as the head of the Mountain party. By the victory obtained over the ſections of Paris on the 5th of October, all oppoſition had been ſet at defiance for a time; but the nation at large had never been reconciled to theſe men. The period now arrived when a third of the legiſlative body was to be changed. On the 19th of May, Letourneur went out of the directory by lot. On the 20th, the new third took their ſeats in the Councils, a third of their predeceſſors having evacuated their ſeats by lot; and on the following day, Barthelemi, the ambaſſador to Switzerland, was choſen to ſucceed Letourneur in the Directory. The election of the members of the new third had almoſt entirely fallen upon men who were underſtood to be hoſtile to the Directory. Many Generals out of employment were choſen; ſuch as Pichegru, Jourdan, and Willot, and many repreſentatives of the families of the ancient nobility who had not emigrated (among whom was the prince of Conti) were now elected into the legiſlature. The moderate or oppoſition party in the two Councils now poſſeſſed a complete majority. Carnot and Barthelemi were underſtood to be favourable to them in the Directory; the former having made his peace with them, and the latter being eſtabliſhed by themſelves. The effect of this change in the ſtate of the Councils ſpeedily appeared in their adopting every meaſure that could embarraſs the Directory, or caſt odium upon the Mountain party, and alter the ſtate of things which it had eſtabliſhed.

307 Mild meaſures of the Councils.

On the 14th of June, Gilbert Deſmolieres brought forward a report from a committee upon the ſtate of the finances; in which he exhibited and reprobated in the ſtrongeſt terms the prodigality of the Directory, and the profuſion and rapacity of its agents. On the 18th the ſame committee propoſed a new plan of finance, the object of which was to deprive the Directory of any ſhare in the adminiſtration of the public money. In the mean time, on the 17th of the ſame month, Camille Jourdan had preſented a long report on the ſubject of religion; in which he endeavoured to demonſtrate the impropriety of prohibiting the public diſplay of its ceremonies, and the injuſtice of the perſecution which its miniſters had undergone for refuſing to take oaths preſcribed by the legiſlature. This report was afterwards, on the 15th of July, followed up in the Council of Five Hundred, by a decree, repealing all the laws againſt refractory prieſts, or which aſſimilated them to emigrants. On the following day, another decree, requiring from them a declaration of fidelity to the conſtitution, could only be carried by a majority of 210 againſt 204. A propoſal was now brought forward in the Council of Five Hundred by Emery, a new member, to repeal the laws which confiſcated the property of emigrants, and to allow their relations to ſucceed to them as if they had died at the period of their emigration. Thoſe who had fled into foreign countries from Toulon and other places, during the reign of terror, were alſo encouraged to return, and allowed to expect that their names would be crazed from the liſt of emigrants. The conduct of the Directory towards foreign powers was attacked on different occaſions; and Dumoullard propoſed the appointment of a committee to enquire into the external relations of the republic. This was a delicate ſubject; as it involved the character of the armies and their leaders, and as it might ſubvert the intereſts of the Directory with ſome of their friends of the Mountain party. The Venetian republic, though a neutral ſtate, had been overturned by Bonaparte on account of a popular inſurrection, for which the government apologiſed. Little account had been given of the immenſe ſums of money that had been levied in Italy. The armies in the preceding year had entered Germany in the character of plunderers;

plunderers; which had diſguſted all thoſe in that country who had once been friendly to their cauſe, and longed for their arrival. The Directory, at the ſame time, inſtead of encouraging the progreſs of revolution, which the Jacobins eagerly deſired, had ſuddenly made peace with the German princes, upon receiving pecuniary contributions, which were left to be exacted according to the ancient laws of the different ſtates (which exempt the nobles and the clergy), and thus fell heavieſt upon thoſe very perſons who had cheriſhed the new republican principles.

The diſcuſſion of theſe ſubjects brought the majority of the Directory and of the Councils into a ſtate of complete hoſtility. Both parties reſolved to violate the conſtitution, under the pretence of preſerving it. The one wiſhed to change the Directory before the time preſcribed by law, and the other to deprive of their ſeats a great number of the new legiſlators elected by the people. Barras was the moſt obnoxious of the directors; and an attempt was made to deprive him of his office, upon the footing that he was leſs than 40 years of age. But his colleagues aſſerted that he was born in the year 1755; and as no proof to the contrary could be brought, this abortive attempt ſerved only ſtill farther to irritate the contending parties, and they began to prepare for more effectual meaſures. Had not force been ſpeedily uſed on the ſide of the Directory, the Councils muſt naturally have prevailed. 308 Their popularity. The majority of the people confided in them. The national purſe was in their hands; and they hoped to ſubdue the Directory, as the conſtituent aſſembly had done the king, by avoiding to vote the neceſſary ſupplies. They could enact what laws they pleaſed. They had not indeed the command of the armies; but to remedy their weakneſs in this reſpect, General Pichegru, on the 20th of July, preſented a plan for reorganiſing the national guard, and placing it more at the diſpoſal of the Councils, by depriving the Directory of the nomination of the officers.

In the mean time the Directory was by no means deſtitute of adherents. The reſolutions of the Councils in favour of the prieſts, and the relations of emigrants, looked ſo like a deſertion of former maxims, that many perſons expected an immediate counter-revolution. The royaliſts gained courage, and a multitude of journals or newſpapers, favourable to their cauſe, began to be publiſhed. Emigrants obtained paſſports, and haſtened to Paris in the hope of being ſtruck off the liſt, upon alleging that they fled to avoid proſcription during the power of the Jacobins. The effect of all this was, that the purchaſers of national property, and thoſe who had become rich by the revolution, were alarmed. The whole Mountain party, and all thoſe who had been active in oppoſition to royalty, rallied round the Directory. The armies, whoſe chiefs found themſelves involved in ſome of the accuſations brought againſt that body, ſent addreſſes, in which they declared their reſolution to ſupport its power. The Councils declared theſe addreſſes, which the Directory had received from armed bodies, unconſtitutional, and procured counter addreſſes from different departments. At laſt the partizans of the two contending powers began to diſtinguiſh themſelves in Paris by their dreſs, and every thing preſaged an approaching appeal to force. On the 20th of July the Councils received intelligence that a diviſion of the army of General Hoche had advanced within a few leagues of Paris; whereas, by the conſtitution, the Directory incurred the penalty of ten years impriſonment if it authoriſed troops to approach nearer to the reſidence of the legiſlative body than twelve leagues, without its own conſent. An explanation of this event was immediately demanded. The Directory denied that they had ordered the march, and aſcribed it to a miſtake of the officer by whom it was conducted. Their explanation was treated with contempt, and much angry debate took place in the Councils concerning it; the Directory all the while conducting themſelves with much ſeeming moderation, and even ſubmiſſiveneſs. In the mean time their antagoniſts acted a very undecided part. 309 The Directory victorious. They long hoped to gain Lareveillere Lepaux to their ſide; in which caſe they would have had a majority in the Directory. This vain expectation rendered their conduct indeciſive. At length the majority of the Directory procured an addreſs of adherence from the ſuburb St Antoine, which in all the tempeſtuous days of the revolution had been the rallying point of the Mountain party. Encouraged by this addreſs they proceeded to immediate action. General Augereau had been ſent from Italy under pretence of preſenting ſome Auſtrian ſtandards to the Directory, and he was employed as their tool upon this occaſion. They commanded the garriſon of Paris, and they had managed to bring over to their party the ſoldiers compoſing the guard of the two councils. Before day-break on the morning of the 4th, Augereau ſurrounded the Thuilleries with a diviſion of the troops. The guard of the Councils refuſed to reſiſt, and their commander, Ramel, was taken priſoner. Having entered the hall, he found Pichegru and other twelve of the chiefs of the oppoſite party ſitting in conſultation, and immediately ſent them priſoners to the Temple. Some other obnoxious members of the Councils were alſo put under arreſt. The director Carnot had made his eſcape on the preceding evening, but Barthelemi remained, and was impriſoned.

All this was accompliſhed without noiſe, and in an inſtant. Many members of the Councils, when they came to the hall at the uſual hour, were ſurpriſed to find that ſeals were put upon the doors, and that they could not obtain admittance. They were invited, however, to go to the Surgeons Hall and the theatre of the Odeon, where they were told the Directory had appointed the Councils to aſſemble. At theſe places, about forty of the Council of Ancients, and double that number of the other Council, aſſembled about noon, and ſent to demand from the Directory an account of the proceedings of the morning. They received an anſwer, declaring, that what had been done was neceſſary to the ſalvation of the Republic, and congratulating the Councils *on their eſcape* from the machinations of royaliſts. 310 Pretended conſpiracy. Being ſtill at a loſs how to act, the Council of Five Hundred appointed a committee of four members (of whom Sieyes was one) to report upon the meaſures to be adopted. On the following day Boullay de la Meurth preſented a report from this committee, in which he announced, that a vaſt royaliſt conſpiracy, whoſe centre was in the boſom of the Councils, had been formed to overturn the conſtitution, but that it had been baffled by the wiſdom and activity of the Directory. The report concluded, by propoſing the immediate tranſportation of the conſpirators without a trial.

rench
olution,
797.

French
Revolution,
1797.

trial. Accordingly, theſe degraded repreſentative bodies proceeded, after ſome debate, on hearing the names of the accuſed perſons read over, to vote the tranſportation to Guiana in South America, of fifty-three of their own members, and twelve other perſons, among whom were the directors Carnot and Barthelemi. They annulled the elections in forty-nine departments, repealed the laws lately enacted in favour of the diſaffected clergy and the relations of emigrants; and even ſo far aboliſhed the liberty of the preſs, as to put all periodical publications under the inſpection of the police for one year. New taxes were voted without heſitation, Francis de Neufchateau and Merlin were elected to fill the vacancies in the Directory, and affairs were endeavoured to be conducted in their ordinary train.

311
ployed
the Di-
tory to
ify their
duct.

All this while the city of Paris remained tranquil. That turbulent capital, which had made ſo many ſanguinary efforts in favour of what it accounted the cauſe of freedom, had been ſo completely ſubdued ſince its unfortunate ſtruggle on the 5th of October, that it now permitted the national repreſentation to be violated, and the moſt obvious rules of practical liberty to be infringed, without an effort in their defence. The Directory, in the mean time, attempted to juſtify their conduct to the nation at large, by publiſhing various documents intended to prove the exiſtence of a royaliſt conſpiracy. The moſt remarkable of theſe was a paper, ſaid to be written by M. d'Antraigues, and found by Bonaparte at Venice; in which a detail was given of a correſpondence between General Pichegru and the Prince of Condé in the year 1795. The correſpondence itſelf was alſo, at the ſame time, ſaid to be found by General Moreau among papers taken by him at the late paſſage of the Rhine. It ſtated, that Pichegru had offered to the Prince of Condé to croſs the Rhine with his army, and having joined the Auſtrians under General Wurmſer, and the emigrants under the Prince of Condé, to return with the united armies and march to Paris, where they were to re-eſtabliſh royalty. The Prince is ſaid to have refuſed to accept of the offer, from jealouſy of the participation of the Auſtrians in the honour of the tranſaction. He therefore inſiſted that it ſhould be conducted without their aid; but Pichegru thought the attempt too hazardous in this form, and, being ſoon after removed from his command, the project failed. At the time of its publication, the genuineneſs of this correſpondence, and alſo of the paper found by Bonaparte, was denied; and nothing has appeared ſince to induce an unprejudiced man to think otherwiſe at preſent. Moreau, who was certainly involved in this conſpiracy, if real, has been intruſted ſince that period with the command of the armies of the republic; and though defeated by Marſhal Suwarrow, he is ſo far from being now conſidered as a royaliſt, that the revolutionary government ſeems inclined to intruſt to his military ſkill and fidelity its laſt efforts for the continuance of its exiſtence.

312
e Direc-
y all
werful.

From the violation of the repreſentative government that has been now ſtated, it became obvious to ſurrounding nations, that France had paſſed under the dominion of a ſmall faction at variance with the majority of the people. The Directory was all powerful. Its members, however, ſeem very ſoon to have become giddy by the elevated nature of their ſituation, and to have adopted a notion that there was no project of ambition or rapacity in which they might not venture to engage. During their conteſt with the Councils, they had protracted the negociations with Lord Malmeſbury at Liſle, and had ſuffered thoſe to relax which had been entered into between Bonaparte and the Imperial ambaſſadors at Campo Formio near Udine. Great Britain had offered to conſent to peace, on condition of being allowed to retain the Dutch ſettlements of the Cape of Good Hope, and the Spaniſh iſland of Trinidad, which had been taken in the month of February this year. The Directory now recalled their former negociators Letourneur and Maret, and ſent two others, Treilhard and Bonnier, in their ſtead; who immediately demanded whether Lord Malmeſbury had full power to reſtore all the ſettlements taken from France and her allies during the war? Upon his Lordſhip's declining to anſwer ſuch a queſtion, becauſe it implied an enquiry, not into his powers, which were in the uſual form, but into his inſtructions, which would preclude all negociation, he was required to return home to procure more ample powers. The negociations with the Emperor, however, were now ſpeedily brought to a concluſion. On the 17th of October, a definitive treaty was ſigned at Campo Formio. By it the Emperor gave up the Netherlands to France, the Milaneſe to the Ciſalpine republic, and his territories in the Briſgaw to the Duke of Modena, as an indemnification for the loſs of his duchy in Italy. The Emperor alſo conſented that the French ſhould poſſeſs the Venetian iſlands in the Levant of Corfu, Zante, Cephalonia, Santa Maura, Cerigo, and others. On the other hand, the French Republic conſented that the Emperor ſhould poſſeſs in full ſovereignty the city of Venice, and its whole other territory, from the extremity of Dalmatia round the Adriatic as far as the Adige and the lake Garda. The Ciſalpine Republic was to poſſeſs the remaining territory of Venice in this quarter, along with the city and duchy of Mantua, and the eccleſiaſtical ſtates of Ferrara and Bologna.

312
Treaty of
Campo
Formio.

Upon whatever principles the war might have hitherto been conducted, the terms of this treaty ſufficiently demonſtrated to all Europe, that its leſſer ſtates had no better reaſon to expect ſecurity from the houſe of Auſtria than from that of the new republic. This truth would have been ſtill more evident, had the articles of a convention, which was ſigned by theſe parties at the ſame period at Campo Formio, been publiſhed to the world. Fearing, however, to alarm too much the Germanic body, theſe articles were kept ſecret, and the parties agreed to prevail with the German princes, at a congreſs to be opened at Raſtadt, to conſent, in conſequence of an apparently fair negociation, to what France and Auſtria had determined ſhould take place. By the ſecret convention or treaty now alluded to, it was ſtipulated, that the Rhine, including the fortreſs of Mentz, ſhould be the boundary of the French Republic; that the princes, whoſe territories were alienated by this agreement, ſhould be indemnified by the ſecularization of church lands in Germany; that the Stadtholder of Holland ſhould be indemnified for the loſs of his eſtates in that country, by receiving German territory; that the Emperor ſhould receive the Archbiſhopric of Saltzburg, and the part of the circle of Bavaria ſituated between that archbiſhopric, the rivers Inn and Salzt, and the Tyrol; that the Imperial troops ſhould immediately withdraw to the confines of the hereditary ſtates beyond Ulm; and if the Germanic body ſhould refuſe peace on the above terms, it was ſtipulated, that the Emperor ſhould ſupply to it no more troops than his contingent as a co-eſtate amounted to, and that even theſe ſhould not be employed in any fortified place

313 Violent meaſures of the Directory.

Theſe treaties were immediately begun to be put in execution. The Auſtrians left the Rhine, which enabled the French to ſurround the fortreſſes of Mentz and Ehrenbreitſtein. Of the former, they ſpeedily obtained poſſeſſion; but the latter coſt them a very tedious blockade, before the garriſon, conſiſting of troops of the Palatinate, would agree to ſurrender. The Imperial troops, at the ſame time, entered Venice; the French having evacuated that city after carrying off or deſtroying its whole navy. The Ciſalpine Republic was eſtabliſhed, and Bonaparte left Italy; leaving, however, an army of 25,000 men to garriſon Mantua, Breſcia, Milan, and other places, and to retain this new republic in dependence upon France. Genoa was, at the ſame time, brought under a ſimilar dependence by means of popular commotions, inſtigated by the French, and a revolution in its government which took place at this period. And thus the French Directory, without the excuſe of hoſtility, as in the caſes of Holland and Spain, began a ſyſtem of interference in the affairs of weaker neighbouring ſtates, which was ſpeedily carried to an height that once more alarmed all Europe These men even attempted, at this time, to compel the ſtates of North America to purchaſe with money their forbearance from war. This was done through a circuitous channel, and in the form of an intrigue, by private perſons, who were inſtructed to inform the American miniſters at Paris, that a large loan on the part of America would be the beſt means of ſecuring peace; and it was hinted, that it would be rendered more acceptable if accompanied with a private preſent of L. 50,000 ſterling to the members of the Directory. This laſt propoſal was indeed denied by the French miniſter Tallyrand, who had given his countenance to this crooked negociation: but the general impreſſion produced by the tranſaction could not be removed; and its effect was to injure very deeply the character of the French government in the opinion of thoſe diſtant nations that were otherwiſe diſpoſed to regard it in the moſt favourable light. Nor was its reſpectability increaſed by a law which the two Councils, at the deſire of the Directory, thought fit to enact, declaring the ſhips of all neutral ſtates bound for Britain, or returning from thence, liable to capture. This law was not leſs impolitic than unjuſt. It placed the whole carrying trade of the weſtern world in the hands of the Britiſh, and thus enriched the very people whom it was intended to injure.

314 Invaſion of Wales.

For at this period Britain had acquired over the ocean a degree of uncontrouled dominion that was altogether unexampled in former times. During the whole year the French fleet lay blockaded in its own ports, and no enterpriſe was attempted by ſea, excepting in one ſolitary but ſingular inſtance. We have already mentioned that a number of galley ſlaves were ſent as ſoldiers with Hoche in his attempt upon Ireland. On the failure of that expedition, the Directory were at a loſs how to diſpoſe of theſe men. They could not now with propriety be ſent back to puniſhment, the troops would not ſerve along with them in the army; and as the new laws of France allow no remiſſion of crimes, they could not receive a pardon, nor was it ſafe to let looſe upon the country 1400 criminals. In this dilemma, the Directory reſolved to throw them into England. Accordingly, they were ſent in two frigates and ſome ſmall veſſels to the coaſt of Wales, and there landed with muſkets and ammunition, but without artillery. In the evening of the very day on which they landed, the 23d of February, they ſurrendered themſelves priſoners of war to a party of militia, yeomanry, cavalry, colliers and others, under the command of Lord Cawdor. The Directory boaſted that, by this enterpriſe, they had demonſtrated the poſſibility of landing troops on the Britiſh coaſt in ſpite of the vigilance of the navy; but this aſſertion was ill ſupported by the fate of the two frigates accompanying the expedition; both were captured in attempting to return to Breſt.

315 Brilliar victory Sir Joh Jervis the Spa fleet,

Though the French navy remained in port, and conſequently ſafe during the reſt of the year, their allies, the Spaniards and Dutch, ſuffered ſeverely. On the 14th of February, a Britiſh fleet of 15 ſail of the line, under the command of Sir John Jervis, engaged the Spaniſh fleet, amounting to 27 ſail of the line, off Cape St Vincent. In this action, the Spaniſh force, if it be eſtimated by the number of men, the number of guns, and the weight of metal, was more than double that of the Britiſh; but by the ſkilful manœuvres of its heroic commander, the Britiſh fleet twice croſſed through the line of the Spaniards, and ſucceeded in cutting off a part of their fleet from the reſt. Four ſhips of the line were taken, and the Spaniſh admiral's own ſhip eſcaped with difficulty. The fleet had been on its way to Breſt to join the French fleet there; but in conſequence of this action, it returned to Cadiz, where it was blockaded by the Britiſh.

For his gallant conduct in this engagement, which, when every circumſtance is taken into conſideration, is perhaps unparalleled in the annals of naval war, Sir John Jervis was immediately created Earl St Vincent, and received the thanks of both houſes of the Britiſh Parliament.

316 And of miral can ov the D

The Dutch were ſtill more unfortunate. The Texel, within which their fleet lay, was blockaded during the whole ſummer by Admiral Duncan. The French intended, by means of the Dutch fleet, to make another attempt upon Ireland. Troops were accordingly embarked, under the command of General Daendels; but a reſolution having at laſt been adopted of hazarding an engagement with the Britiſh, the Dutch admiral De Winter, in oppoſition to his own remonſtrances, was ordered to put to ſea. The Britiſh admiral had by this time left his ſtation near the Texel, and gone to Yarmouth to refit. On receiving intelligence, however, that the Dutch had ſailed, he inſtantly proceeded in queſt of them. On the 11th of October the Britiſh fleet, amounting to 16 ſail of the line, and 3 frigates, came in ſight of the Dutch fleet, which in force was nearly equal, within about nine miles of Camperdown in Holland. Admiral Duncan immediately run his fleet through the Dutch line, and, though on a lee ſhore, began the engagement between them and their own coaſt. A moſt bloody and obſtinate conflict enſued, which laſted nearly three hours. By that time, it is ſaid that almoſt the whole Dutch fleet had ſtruck. The ſhips could not all be approached and ſeized, however,

ench
olution
798.

ever, on account of the ſhallowneſs of the water upon the coaſt, to which the fleets were now very near. Eight ſhips of the line, with two of 56 guns, and one of 44, were taken, beſides a frigate, which was afterwards loſt near the Britiſh coaſt, and one of the ſhips of 56 guns foundered at ſea. Admiral de Winter was taken with his ſhip, and alſo the Vice-admiral Rentjies.

Similar honours were conferred upon Admiral Duncan as upon Sir John Jervis, and both admirals had each a penſion of L. 2000 *per annum* conferred upon him for life, with the full approbation, we may venture to ſay, of every well affected man in the kingdom.

1798.

317
cline of
lic ſpi-
in
ance.

The internal hiſtory of France now ceaſed to be very intereſting. Political freedom could not be ſaid to exiſt after ſo many of the repreſentatives choſen by the people had been driven from the legiſlature, and the departments reduced to the neceſſity of electing men more acceptable to their preſent rulers. Public ſpirit therefore rapidly declined. The high notions of the freedom and felicity it was about to enjoy, which had once been ſo eagerly cheriſhed by a great part of the nation, now gave way to a growing indifference about political queſtions, and the future deſtiny of the republic; for the people at large found themſelves little intereſted in a government which exiſted independent of their will, which conſiſted of a narrow circle of perſons, and whoſe conduct was ſurely not leſs crooked, intriguing, and unprincipled, than that of the ancient royalty, and its attending court, from which they had eſcaped; whilſt its ferocious cruelty, and total diſregard even of the forms of juſtice, were infinitely greater. But though the Directory was all-powerful, yet its power was limited by the preſent ſtate of things, which denied it the poſſeſſion of an abundant revenue. It had not yet been found poſſible to re-eſtabliſh a ſyſtem of productive taxation. The legiſlative councils, indeed, who now complied with every wiſh of the Directory, voted abundance of taxes: but theſe were ſcantily paid; partly on account of the total loſs of the national commerce, and partly becauſe the people were not diſpoſed to make great exertions in this way for the ſupport of government. By the conſtitution, they ſtill poſſeſſed the election of the judges and other magiſtrates; the country was filled with veteran ſoldiers, who at different times had returned from the armies after the lapſe of

318
Meaſure of
the Direc-
tory.

the uſual period of ſervice. The Directory, kept in awe by theſe circumſtances, turned its attention abroad, and found means to eſtabliſh an extenſive patronage, by dividing among its adherents the plunder of neighbouring ſtates, in whoſe welfare the people of France were little intereſted. The Girondiſt party had formerly propoſed to propagate their principles by eſtabliſhing a number of petty republics in the vicinity of France. The Directory now adopted the ſame project; that, under the pretence of diffuſing liberty, they might obtain new ſources of revenue and of power, by the dominion which they meant to exerciſe over theſe new governments. Holland and the Ciſalpine republic were already placed in dependence upon them; and Rome and Switzerland readily afforded them opportunities for extending their plan.

319
Embaſſy to
Rome.

After the treaty with the Emperor had been concluded at Campo Formio, Joſeph Bonaparte, brother of the General, had entered Rome as ambaſſador from the French Republic. The Pope, now deprived of all hope of foreign aid, and accuſtomed to humiliations, had ſubmitted to every demand made by him for reducing the number of his troops, and ſetting at liberty perſons impriſoned on account of political opinions. But an event

French
Revolution,
1798.

320
Inſurrec-
tion in that
city.

ſoon occurred to afford the Directory a pretence for accompliſhing the ruin of this decayed government. On the 26th of December 1797, three perſons had waited upon the French ambaſſador, and ſolicited the protection of his government to a revolution which a party at Rome meant to accompliſh. He rejected their propoſals, and diſſuaded them from the attempt; but did not, as was certainly his duty, communicate theſe propoſals to the papal government, to which he was ſent on a friendly embaſſy. On the following day, however, a tumult took place, in which the French cockade was worn by about 100 inſurgents. They were ſpeedily diſperſed, but two of the Pope's dragoons were killed. The ambaſſador, who probably knew the diſpoſition of the Directory towards the Pope, ſeems to have reſolved that his own perſonal conduct ſhould be blameleſs on the occaſion. He therefore went on the 28th of December to the ſecretary of ſtate, and preſented a liſt of the perſons under his protection who were entitled to wear the French cockade, conſenting that all others adopting it ſhould be puniſhed. He alſo agreed to ſurrender ſix of the inſurgents who had taken refuge in his palace. Towards the evening of this day, however, the popular tumult became more ſerious, particularly in the courts and neighbourhood of the French miniſter's palace. The Pope appears to have been perſonally unacquainted with the ſtate of affairs; but the governor of the city ſent parties of cavalry and infantry to diſperſe the inſurgents. About twenty perſons, having a Frenchman at their head, had, in the mean time, ruſhed into the palace, and demanded aid towards accompliſhing a revolution. A number of French officers, and others who were with the ambaſſador, propoſed to drive the whole inſurgents by force from the juriſdiction of the palace. This was certainly a ſalutary advice, and ſuch as could not have been rejected by the ambaſſador, had not his deſigns been hoſtile to the eſtabliſhed government. Rejected, however, it was; for, pretending to believe that his authority would be ſufficient to accompliſh the object in a peaceable manner, he went out into the court to addreſs the multitude. He was prevented from doing ſo by a diſcharge of muſquetry from the military, who were firing within the juriſdiction of the palace. He interpoſed with his friends between the military and the inſurgents; and while a part of the French officers in his train drove back the inſurgents with their ſabres, the ambaſſador advanced towards the ſoldiers, and demanded why they preſumed to violate his juriſdiction? as if the juriſdiction of a foreign ambaſſador were a legal aſylum for men in open rebellion againſt the government of the ſtate. It is not, therefore, ſurpriſing, that no attention was paid to this arrogant and abſurd demand; and the nature of the ground being ſuch, that the troops could fire over his head upon the multitude in the rear, they made a ſecond diſcharge, which killed ſeveral of the inſurgents. Upon this the ambaſſador advanced cloſe upon the ſoldiers, to prevail with them to depart; but they remained in a menacing attitude, and prepared for another diſcharge. Eager to prevent this, the French General Duphot, who was with the ambaſ-

321 A French general killed.

ambaſſador, and was next day to have married his ſiſter, ruſhed into the ranks of the military, intreating them to deſiſt. Here a petty officer of the Pope's troops diſcharged his muſket into the body of Duphot. Upon this, the ambaſſador and his other friends found it neceſſary to make their eſcape through a bye-way into the palace. The Spaniſh miniſter hearing of this event, ſent to the ſecretary of ſtate to proteſt againſt this violation of the privileges of ambaſſadors. But the government, equally alarmed and perplexed by the fear of a revolution, and of French vengeance, remained during many hours totally inactive. All this while the palace of the French ambaſſador remained cloſely beſet by the military, who occupied the whole of its juriſdiction, and all its courts and paſſages. He at laſt ſent to demand paſſports, to enable him to leave the territories of the Pope. They were granted; but with many proteſtations of the innocence of the government, and its regret on account of this unfortunate occurrence.

322 The papal government overturned.

Joſeph Bonaparte retired to Florence, and from thence to Paris. The Pope ſolicited the protection of the courts of Vienna, Naples, Tuſcany, and Spain; but they all ſtood aloof from his misfortunes: and this government, which had once poſſeſſed the moſt uncontrouled dominion over the minds of men, now fell without a ſtruggle. General Berthier, at the head of a body of French and Ciſalpine troops, encountered no oppoſition in his march to Rome, where he overturned the government of the Pope, and proclaimed the ſovereignty of the Roman people, with circumſtances of wanton inſult; which convey a ſtriking example of French humanity and French delicacy.

“ That the head of the church might be made to feel with more poignancy his humiliating ſituation, the day choſen for planting the tree of liberty on the Capitol was the anniverſary of his election to the ſovereignty. Whilſt he was, according to cuſtom, in the Siſtine chapel celebrating his acceſſion to the papal chair, and receiving the congratulations of the cardinals, Citizen Haller, the commiſſary general, and Cervoni, who then commanded the French troops within the city, gratified themſelves in a peculiar triumph over this unfortunate potentate. During that ceremony they both entered the chapel, and Haller announced to the ſovereign Pontiff on his throne, that his reign was at an end.

323 Cruel treatment of th Pope.

“ The poor old man ſeemed ſhocked at the abruptneſs of this unexpected notice, but ſoon recovered himſelf with becoming fortitude; and when General Cervoni, adding ridicule to oppreſſion, preſented him the national cockade, he rejected it with a dignity that ſhewed he was ſtill ſuperior to his misfortunes. At the ſame time that his Holineſs received this notice of the diſſolution of his power, his Swiſs guards were diſmiſſed, and republican ſoldiers put in their place.”

He was himſelf removed to the territory of Tuſcany, where he reſided in much obſcurity, till his enemies, driven from Rome in their turn, thought fit to carry him ſtill farther from his capital, to end his days beyond the Alps.

324 Roman re- public.

In the mean time, the Roman ſtates were converted into a republic after the French model; excepting that the ancient appellations of *conſuls*, *ſenators*, and *tribunes*, were adopted, inſtead of the new names of a *Directory* and *two Councils* (D). But this oſtentatious grant of freedom was rendered completely illuſory, by a condition

---

(D) The character of a nation, like that of an individual, will not perhaps admit of a ſudden and total change. This remark is exemplified in the French; who, even when they affect to aſſume the ſtern manners of Republicans, cannot diveſt themſelves of their frivolous and fantaſtical turn, and of that fondneſs for pomp and ſhow by which they were always diſtinguiſhed. The following account of the re-eſtabliſhment of the Roman Republic, by an author of reſpectability, who witneſſed the ſolemn farce, will amply confirm the truth of our aſſertion.

“ That the regenerated Roman people might be conſtitutionally confirmed in their newly-acquired rights, a day was ſet apart ſolemnly to renounce their old government, and ſwear fidelity to the new. For the celebration of this ſolemnity, which took place on the 20th of March, an altar was erected, in the middle of the piazza of St Peter's, with three ſtatues upon it, repreſenting the French, Ciſalpine, and Roman Republics. Behind the altar was a large tent, covered and decorated with ſilk of the Roman colours, ſurmounted with a red cap, to receive the deputies from the departments who had been ſummoned to aſſiſt. Before the altar was placed an open orcheſtra, filled with the ſame band that had before been employed to celebrate the funeral honours of Duphot. At the foot of the bridge of St Angelo, in the piazza di Ponte, was erected a triumphal arch, upon the general deſign of that of Conſtantine, in the Campo Vacino, on the top of which was alſo placed three coloſſal figures, repreſenting the three republics. As a ſubſtitute for baſs-reliefs, it was painted in compartments in *chiara ſcura*, repreſenting the moſt diſtinguiſhed actions of Bonaparte in Italy. Before this arch was another orcheſtra.

“ The ceremony in the piazza began by the marching in of the Roman legion, which was drawn up cloſe to the colonnade, forming a ſemicircular line; then came French infantry, and then cavalry, one regiment after another alternately, drawn up in ſeparate detachments round the piazza. When all was thus in order, the conſuls made their entrance, on foot, from the Vatican palace, where they had robed themſelves, preceded by a company of national troops and a band of muſic; and if the weather had permitted, a proceſſion of citizens, ſelected and dreſſed in *gala* for the occaſion, from the age of five years to fifty, were to have walked two and two carrying olive branches; but an exceſſively heavy rain prevented this part of the ceremony.

“ Before the high altar, on which were placed the ſtatues, there was another ſmaller one with fire upon it. Over this fire the conſuls, ſtretching out their hands, ſwore eternal hatred to monarchies, and fidelity to the republic; and at the concluſion, one of them committed to the flames a ſcroll of paper he held in his hand, containing a repreſentation of all the inſignia of royalty, as a crown, a ſceptre, a tiara, &c.; after which the French troops fired a round of muſketry; and, at a ſignal given, the Roman legion raiſed their hats in the air upon the points of their bayonets, as a demonſtration of attachment to the new government: but there was no ſhouting—no ench lution, 798.

tion annexed to it, that for ten years the French General ſhould poſſeſs a negative upon all laws and public acts. At firſt, however, the conquerors took care to place the government in the hands of the moſt reſpectable perſons in the ſtate favourable to democracy. But theſe men finding that they were merely to be employed as tools to plunder their fellow-citizens, for the emolument of their northern maſters, ſoon renounced their odious dignities, and were ſucceeded by men of more compliant characters, and leſs ſcrupulous integrity. The whole public property was ſeized by the invaders, and contributions were levied without end. The property of the cardinals and others who fled was confiſcated, and thoſe members of the ſacred college who remained were thrown into priſons, from which they could only eſcape by purchaſing their freedom at a high price.

325 erſeded military potiſm.

When this was done, and Generals and Commiſſaries had glutted themſelves with wealth, quarrelled about a *juſt* diviſion of the ſpoil, mutinied, and diſperſed, other unpaid, unclothed, unproviſioned armies from the north, with new appointments, ſucceeded; and when at length, even by theſe *conſtitutional* means, nothing more was to be obtained, and artifice had exhauſted every reſource, the maſk was put under the feet that had been long held in the hand; liberty was declared dangerous to the ſafety of the republic, the conſtituted authorities incapable of managing the affairs of the ſtate, and military law the only rational expedient to ſupply their place. Thus at once the mockery of conſular dignity was put an end to, the ſenators ſent home to take care of their families, and the tribunes to blend with the people whom they before repreſented. This new and preferable ſyſtem began its operations with nothing leſs important for the general welfare, than ſeizing the whole annual revenue of every eſtate productive of more than ten thouſand crowns; two-thirds of every eſtate that produced more than five, but leſs than ten; and one half of every inferior annual income.

Even the degenerated Romans could not have ſubmitted to all this, or at leaſt would not have aſſiſted in forging their own chains, had not the ſame means been employed to eradicate from their minds every moral and religious principle, which had been formerly employed for the ſame purpoſe in Paris. In order that the ſpirit of equality might be more extenſively diffuſed, a conſtitutional democratic club was inſtituted, and held in the hall of the Duke d'Altemp's palace. Here the new-born ſons of freedom harangued each other on the bleſſings of emancipation; talked loudly and boldly againſt all conſtituted authority; and even their own conſuls, when hardly inveſted with their robes, became the ſubjects of cenſure and abuſe. The Engliſh were held as particularly odious, and a conſtant theme of imprecation; and this farce was ſo ridiculouſly carried on, that a twopenny ſubſcription was ſet on foot to reduce what they were pleaſed to call the proud Carthage of the North.

French Revolution, 1798.

326 Methods employed to corrupt the Roman youth.

If this fooliſh ſociety had had no other object in view than ſpouting for each other's amuſement, bowing to and kiſſing a buſt of Brutus which was placed before the roſtrum (a ceremony conſtantly practiſed before the evening's debate), it would have been of little conſequence to any but the idle, who preferred that mode of ſpending their time; but it had other objects of a very different tendency, more baneful, and more deſtructive to the peace and morals of ſociety—that of intoxicating young minds with heterogeneous principles they could not underſtand, in order to ſuperſede the firſt laws of nature in all the ſocial duties; for there were not wanting men who knew how to direct the folly and enthuſiaſm of thoſe who did not know how to direct themſelves. Here they were taught, that their duty to the Republic ought ever to be paramount to every other obligation; that the illuſtrious Brutus, whoſe buſt they had before them, and whoſe patriotic virtue and juſtice ought never to be loſt ſight of, furniſhed them with the ſtrongeſt and moſt heroic example of the ſubordination of the deareſt ties of humanity to the public good; and that, however dear parental affection might be, yet, when put in competition with the general welfare of ſociety, there ought not to be a moment's heſitation which was to be preferred.

This ſort of reaſoning might perhaps have done no harm to the ſpeculative cloſet metaphyſician, who might have had neither father, nor mother, nor brother, nor ſiſter, nor a chance of ever being thrown in the way to reduce his theory to practice; but with a people who knew of no other ties but ſuch as depended on their religion and their natural feelings, without having been previouſly educated to diſcriminate, how far their reaſon might be deluded by ſophiſtry, or upon what cauſes

---

no voluntary ſigns of approbation; nor do I believe that there ever was a ſhow, in which the people were intended to act ſo principal a part, where ſo decided a tacit diſapprobation was given as on this occaſion.

"After the ceremony was concluded, the French officers, with the conſuls and deputies from the departments, dined together in the papal palace on Monte Cavallo, and in the evening gave a magnificent ball to the exnobles and others, their partizans, which was numerouſly attended, yet with an exception to the houſes Borgheſe, Santacroce, Altemp, and Ceſarini: I believe not one diſtinguiſhed family was preſent from deſire or inclination: but it was now no longer time to accumulate additional cauſes for oppreſſion; and he who hoped to ſave a remnant of his property, avoided giving occaſion for perſonal reſentment. At night the dome of St Peter's was illuminated, with the ſame ſplendour as was cuſtomary on the anniverſary of St Peter's day. This was the ſecond time of its illumination ſince the arrival of the French, having been before diſplayed on the evening of the ſolemn fete to honour the manes of Duphot, which, though not quite ſo opportune, was done to gratify the officers that were to leave Rome on the morrow.

"The day after this federation, the French publiſhed the Roman conſtitution in form, which was only a repetition of the one given to the unfortunate Venetians, conſiſting of 372 articles, and which I think unneceſſary to tranſcribe, as it would only be giving what we have already had from time to time in tranſlations made from their own."—*Duppa's Journal of the moſt remarkable Occurrences that took place in Rome,* upon the Subverſion of **the Eccleſiaſtical Government in 1798.**

cauſes the permanent good of ſociety depended, it had the moſt direct tendency to generate the worſt paſſions, and to annihilate the beſt.

Young men were thus initiated to loſe all reſpect for their parents and relations, and even encouraged to lodge information againſt them, with the hopeful proſpect of being conſidered as deſerving well, of what they were pleaſed to denominate, the republic; and by thus weakening or deſtroying the bonds of affection, the way was made ſmooth and eaſy to the deſtruction of every thing like what, in a ſtate of civilization, is called character; doubtleſs, in order to prepare them the better to become the faithful agents of thoſe whom they were thus educated to ſerve.

327 Monuments of ancient art expoſed to ſale.

The moſt remarkable curioſities of this celebrated city had already been conveyed to Paris; and as national vanity had now given place to avarice in the minds of the Directory, the remaining monuments of ancient or of modern art, with which Rome abounded, were ſold by public auction. Advertiſements (E) were ſent through Europe, offering paſſports to the natives of countries at war with France, if they ſhould wiſh to become purchaſers; and thus the wealthier inhabitants of the Roman territory not only ſaw themſelves ſubjected to ſevere exactions, but they beheld with cruel mortification thoſe objects now given up as a prey to vulgar ſpeculation, and diſperſed over the world, which had ſo long rendered their city the reſort of all nations.

Such was the progreſſive conduct of the *Great Nation* towards an injured and oppreſſed people, whoſe happineſs and deareſt intereſts were its firſt care, and to whom *freedom* and *liberty* had been reſtored, that they might know how to appreciate the virtue of their benefactors, and the ineſtimable bleſſings of independence.

328 French ingratitude to Switzerland.

More ſanguinary ſcenes were, in the meanwhile, taking place in Switzerland. That country had remained neutral during the conteſt in which France had lately been engaged; and had thus protected the weakeſt portion of her frontier, while the reſt of it was aſſailed by the combined forces of Europe. The merit of this ſervice was now forgotten, and the Directory reſolved to render Switzerland one of their tributary ſtates. Ambitious nations have in all ages found it an eaſy matter to deviſe apologies for invading the territory of their neighbours. The wealthier branches of the Swiſs confederacy were in general governed by hereditary ariſtocracies. Some of the cantons had no government within themſelves, but were the ſubjects of neighbouring cantons. In conſequence of this circumſtance, and of the contending privileges of different orders of men, popular inſurrections were more frequent in Switzerland than in any country in Europe, though none was more equitably governed. When an inſurrection took place in one canton, its government was frequently under the neceſſity of ſoliciting the aid of the government of an adjoining canton, or even of the neighbouring monarchs of France or Sardinia, to enable it to ſubdue its own rebellious ſubjects. A dangerous precedent was thus eſtabliſhed; and as the French kings had formerly interfered in favour of the rulers, the republican Directory now interfered in favour of the ſubjects. The canton of Berne was ſovereign of the territory called the *Pays de Vaud*. In this diſtrict diſcontents had always exiſted; and an inſurrection, under the countenance of the French Directory, broke out towards the end of the year 1797. The government of Berne ſaw the dangerous nature of its own ſituation; and on the 5th of January iſſued a proclamation, commanding the inhabitants of the Pays de Vaud to aſſemble in arms, to renew their oath of allegiance, and to reform every abuſe that might appear to exiſt in their government. A commiſſion was at the ſame time appointed by the Senate or Sovereign Council at Berne to examine all complaints, and to redreſs all grievances. The proceedings of this commiſſion, however, did not keep pace with the popular impatience; and the inſurgents began to ſeize the ſtrong places in their country. The government of Berne now reſolved to reduce them by force, and ſent troops againſt them; but their commander Weiſs appears to have acted with much heſitation, if not with treachery. In the mean time, a body of French approached under General Menard. He ſent an aide de camp with two huſſars, with a meſſage to General Weiſs. On the return of the meſſengers, an accidental affray took place, in which one of the huſſars was killed. This was magnified into an atrocious breach of the law of nations. The French advanced; and by the end of January obtained poſſeſſion of the whole Pays de Vaud. Still, however, the government of Berne attempted to preſerve peace, while it endeavoured to prepare for war. The ſoldiers who had killed the French huſſar were delivered up, negociations were begun, and a truce entered into with General Brune, who ſucceeded Menard in the command of the French troops in the Pays de Vaud. As internal commotions were breaking out in all quarters, an attempt was made to quiet the minds of the people, that they might be induced to unite againſt the threatened invaſion.

329 Undecided conduct of the magiſtrates of Berne.

Fifty-two deputies from the different diſtricts were allowed to ſit in the Supreme Council of Berne, and a ſimilar meaſure was adopted by the cantons of Zurich, Lucerne, Fribourg, Soleure, and Schaffhauſen. An army of 20,000 men was at the ſame time aſſembled, and intruſted to the command of M. d'Erlach, formerly field-marſhal in the French ſervice. But diſaffection greatly prevailed in this army, and the people could not be brought to any tolerable degree of union. The French knew all this, and demanded a total change of government. M. d'Erlach, dreading the increaſing tendency to deſertion among his troops, requeſted leave to diſſolve the armiſtice. It was granted by the government, and immediately recalled. But the French now refuſed to negociate; and on the 2d of March, General Schawenberg, at the head of 13,000 men, entered Soleure.

(E) A copy of an advertiſement, iſſued on this occaſion by what was called *The Adminiſtration of Finances and Contributions of the French Republic in Italy*, is to be found in *Nicholſon's Journal of Philoſophy, Chemiſtry, and the Arts, for May* 1798. The advertiſement is dated at Rome, 28th Feb. 1798. A copy of it was ſent by Hubert, the agent of the French adminiſtrators, to Mr Trevor the Britiſh miniſter at Turin, and by him was tranſmitted to England.

rench volution, 1798.

330 nſterna- n of the vern- nt, and itulation Berne.

Soleure. Friburg was afterwards reduced by Brune, and the Swiſs army retreated. The government of Berne was in conſternation, and decreed what was called the *landſthurm*, or riſing of the people; which, in caſes of emergency, was authoriſed by their ancient cuſtoms. The people accordingly aſſembled; and their firſt act was to diſſolve the government, and to offer to diſmiſs the army, on condition that the French troops ſhould proceed no farther. This offer was refuſed, unleſs a French garriſon ſhould be received into Berne, and the invaders continued to advance. The regular troops under M. d'Erlach were reduced by deſertion to 14,000. The riſing of the people had indeed ſupplied him with numbers, but there was no time for arranging them. On the 5th of March he was attacked, and driven from the poſts of Newenbeg and Favenbrun. He rallied his troops, however, at Uteren, where they made a ſtand for ſome time. They renewed the conteſt at Grauholtz without ſucceſs, and were driven from thence about four miles farther to the gates of their capital. Here the Swiſs army made a laſt and bloody effort. Being completely routed, they murdered many of their officers in deſpair, and among others their commander M. d'Erlach. The ſlaughter on both ſides is ſaid to have been nearly equal; but the French ſucceeded in obtaining poſſeſſion of Berne by capitulation on the evening of the day on which theſe battles were fought. Upon the capture of this city, the other more wealthy and populous ſtates ſubmitted to the French; but the poorer cantons, who had leaſt to loſe, made a terrible effort in defence of their ſmall poſſeſſions, and the independence of their country. They even at firſt compelled Schawenberg to retire with the loſs of 3000 men; but were at laſt overpowered by the ſuperior numbers and military ſkill of the French army. Switzerland was treated as a conquered country. Its public magazines were ſeized by the French, heavy contributions were levied, and a new conſtitution, in imitation of that of France, was impoſed.

331 itzer- d treat- as a con- ered intry.

332 ie Direc- y vio- es the nſtitu- n.

While the Directory continued to encroach upon the independence of other nations, they were not likely to reſpect the freedom of their countrymen at home. In the month of April, a third of the legiſlature was changed. Francis de Neufchateau went out of the Directory by ballot, and Treilhard was choſen in his ſtead. The Directory had made great efforts to influence the elections in favour of their friends, but with little ſucceſs. They prepared therefore to preſerve the legiſlature in ſubjection to them by a new violation of the conſtitution. On the 2d of May they complained to the Council of Five Hundred of the plots of anarchiſts and royaliſts; by which they alleged that the elections had in many places been made to fall on men hoſtile to the Republic. On the 7th a committee made a report upon this meſſage, and propoſed that the proceedings of many electoral aſſemblies ſhould be totally or partially annulled, according to the characters of the perſons they had choſen. General Jourdan, and ſome others, ventured to oppoſe this plan as utterly inconſiſtent with the freedom of election, and as proceeding upon alleged intrigues of conſpirators againſt the Republic, while no conſpiracy had been proved to exiſt. But the majority agreed to the propoſal of the committee, and arbitrarily annulled the whole elections in ſix or ſeven departments, beſides the particular elections of a great number of individuals.

French Revolution, 1798.

333 Plans an expedition to Egypt and India.

The Directory now carried into effect the moſt fatal of all their projects, that of ſending a powerful army to the eaſt to ſeize upon Egypt, and from thence to attack the empire which Britain has acquired in India. The treaty with Auſtria had no ſooner been ſigned at Campo Formio, than the Directory excited the expectation of France and of all Europe, by loudly proclaiming their determination to invade Great Britain. They ſent troops into their own weſtern departments, called them the *Army of England*, and appointed Bonaparte their commander in chief. This officer, in the mean time, had reſided during the winter at Paris. Here he ſeems to have endeavoured to guard againſt the jealouſy of government, and the envy of individuals, by paſſing his time in retirement, and aſſuming the character of a man of letters. He procured himſelf to be elected a member of the National Inſtitute; but ſo ſeldom did he appear abroad, that when he attended ſome of its public ſittings his perſon was altogether unknown to the ſpectators. Greedy of renown, but aware that it ultimately depends upon the labours and the approbation of the learned, he never failed, when called into military ſervice, to remind this order of men of his alliance with them, by adding to his name at all proclamations and diſpatches the deſignation of *Member of the National Inſtitute.*

Whether the expedition to Egypt was now ſuggeſted by Bonaparte himſelf, or whether it was not a ſnare by which the preſent rulers of France impoſed upon the vanity of an enterpriſing young man, to enable them to get quit of him and his veteran army, is not known. It is very poſſible, however, that Bonaparte might neither be the deviſer nor the unconſcious victim of this plan; but that he might account himſelf more ſafe abroad, upon the moſt hazardous expedition, than expoſed at home to the malice of a government that had become jealous of his reputation, and was by no means ſcrupulous in its conduct.

334 Preparations for it conducted with ſecrecy.

The projected invaſion of Egypt was conducted with much ſecrecy. The world was amuſed with tales of monſtrous rafts to be conſtructed to convey the army of England over into Britain. To favour the deception, Bonaparte made a journey to the weſtern coaſt. In the mean time, the fleet was preparing at Toulon, and troops aſſembling in its neighbourhood. When all was in readineſs, Bonaparte embarked with 40,000 of the troops that had fought in Italy. On the 9th of June he arrived at the iſland of Malta, and contrived to quarrel with the Grandmaſter, becauſe he refuſed to admit ſo large a fleet all at once into his ports to water. The French General immediately landed his troops in different quarters, and endeavoured to reduce the iſland. The knights were divided into factions. Many of them, as is now well known, were of the order of ILLUMINATI, and of courſe prepared to act the part of traitors. After making a very feeble reſiſtance, the Grandmaſter propoſed a capitulation; and thus was treacherouſly ſurrendered, in a few days, a fortreſs which, if defended by faithful troops, might have held out for as many weeks againſt all the forces of the French Republic. Bonaparte, after leaving a garriſon of 4000 men in the iſland, ſailed on the 21ſt of June for Alexandria.

335 Conqueſt of Malta.

336 Admiral Nelſon ſails in queſt of Bonaparte.

In the mean time, Rear-admiral Nelſon, who, in the ſtation of Commodore, had ſignalized himſelf in a very high degree under Lord St Vincent, had been diſpatched in queſt of him from the Britiſh fleet, which ſtill blockaded Cadiz. Not knowing the object of the French expedition, the Britiſh Admiral ſailed firſt to Naples; and having there been informed of the attack upon Malta, he directed his courſe to that iſland. By the time he arrived there, however, Bonaparte had departed. Conjecturing now that Alexandria might be the deſtination of the French troops, he ſailed thither; but they had not been ſeen in that quarter, and he therefore went eagerly in ſearch of them to other parts of the Mediterranean. Bonaparte, in the mean while, inſtead of ſteering in a direct line for Alexandria, had proceeded ſlowly, with his immenſe train of nearly 400 tranſports, along the coaſt of Greece, till he arrived at the eaſtern extremity of the iſland of Candia. Here he ſuddenly turned ſouthward; and in conſequence of his circuitous courſe, did not arrive at the coaſt of Egypt till Admiral Nelſon's fleet had left it. He landed his troops; and on the 5th of July took by ſtorm the city of Alexandria. The inhabitants defended themſelves very deſperately, but without ſkill; and for ſome time a ſcene of barbarous pillage and maſſacre enſued. The tranſports that had conveyed the army were now placed within the inner harbour of Alexandria, and the ſhips of war under Admiral Brueys caſt anchor in a line cloſe along the ſhore of what proved to them the fatal Bay of Aboukir.

337 Conqueſts of Bonaparte in Egypt.

The army proceeded to the Nile, and aſcended along the banks of that river, ſuffering great hardſhips from the heat of the climate. They were met and encountered by the Mamalukes, or military force that governed Egypt; but theſe barbarians could not reſiſt the art and order of European war. Cairo was taken on the 23d of July. On the 25th another battle was fought; and on the 26th the Mamalukes made a laſt effort in the neighbourhood of the celebrated pyramids for the preſervation of their empire. Two thouſand of them were killed on this occaſion, 400 camels laden with their baggage were taken, along with 50 pieces of cannon.

A proviſional government was now eſtabliſhed in Egypt. Proclamations were iſſued in the Arabian tongue, declaring that the French were friendly to the religion of Mahomet, that they acknowledged the authority of the Grand Signior, and had only come to puniſh the crimes committed by the Mamalukes againſt their countrymen trading to Egypt. Thus far all had gone well; but on the 1ſt of Auguſt the Britiſh fleet appeared at the mouth of the Nile; and the ſituation of the French fleet having been diſcovered, Admiral Nelſon prepared for an attack.

338 Admiral Nelſon attacks and deſtroys the French fleet.

In number of ſhips the fleets were equal; but in the number of guns and weight of metal the French ſquadron had the ſuperiority. It was drawn up, too, in a form which ſuggeſted to its ill fated commander the idea of its being invincible; but remaining at anchor, the Britiſh Admiral was enabled, by running ſome of his ſhips between thoſe of the enemy and the ſhore, to ſurround and engage one part of their fleet, while the reſt remained unemployed and of no ſervice. In executing this plan of attack, a Britiſh ſhip, the Culloden, run aground; but this accident only ſerved as a beacon to warn the others of the ſpot that ought to be avoided. The battle commenced at ſunſet, and was continued at intervals till daybreak. At laſt, nine ſail of the French line were taken; one ſhip of the line was burned by her own commander; a frigate was burned in the ſame manner, to prevent her being taken. The French Admiral's ſhip L'Orient took fire, and blew up during the action, and only a ſmall number of her crew of 1000 men eſcaped deſtruction. Two French ſhips of the line and two frigates were ſaved by a timely flight (F).

339 Conſequences of his victory.

No naval engagement has in modern times produced ſuch important conſequences as this. The unexampled military efforts made by France had gradually diſſolved the combination which the princes of Europe formed againſt her. By the train of victories which Bonaparte had gained, the houſe of Auſtria, her moſt powerful rival, had been humbled and intimidated. The whole continent looked towards the new Republic with conſternation; and when the Directory ſeized upon Rome and Switzerland, none were found hardy enough to interpoſe in their favour. The current of affairs was now almoſt inſtantaneouſly altered. Europe beheld Bonaparte, with his *invincible* army, exiled from its ſhores, and ſhut up in a barbarous country, from which the triumphant navy of Britain might for ever prevent his return. The enemies of France could not beforehand have conceived the poſſibility of the event which was now realiſed; and the hope was naturally excited of being able to form a new and more efficient coalition againſt a government which had ſo groſsly abuſed the temporary proſperity it had enjoyed. The northern powers began to liſten to the propoſals made to them by Great Britain for commencing hoſtilities anew, and the Italian ſtates prepared to make another effort for independence. The court of Naples in particular openly avowed its joy on account of the recent deſtruction of the French fleet. The king himſelf put to ſea to meet Admiral Nelſon on his return from the Nile. Illuminations took place in the capital, and vigorous preparations were made for war. The Grand Signior, who had poſſeſſed of late little authority in Egypt, and might perhaps have been induced to relinquiſh his claims on that province rather than engage his decaying empire in war, now entered into cloſe alliance with Britain, and engaged in hoſtilities againſt the French. Tippoo Sultan had ſtipulated for the aid of a French army againſt the Britiſh in India; but Bonaparte, on taking poſſeſſion of Suez and the other Egyptian ports on the Red Sea, found no ſhipping there fit to tranſport his army to the Indian peninſula. Inſtead of proceeding therefore upon any ſplendid ſcheme of farther conqueſt, he was compelled to remain in his preſent ſituation, and to contend for exiſtence againſt the whole force of the Ottoman empire.

340 Rebellio in Irelan

The French at this time did not venture to ſend forth any large fleet upon the ocean; but wherever their ſmaller ſquadrons appeared, the fortune of Britain overpowered them there no leſs than it had done in the Mediterranean. They had long promiſed aid to the diſaffected party in Ireland; but weary of fruitleſs expectation, the Iriſh had during this ſummer broken out into rebellion, without waiting the arrival of the troops whom the Directory had engaged to ſend to their aſſiſtance. While the rebellion was at its height, and although the inſurgents for ſome time occupied the ſea port of Wexford, the French did not arrive. Afterwards,

---

(F) The two ſhips of the line and one of the frigates have been ſince taken.

rench,
volution,
1798.

French
Revolution,
1798.

341
bly ſup
rted by
Direc.
y.

wards, however, when the rebellion had been totally ſubdued, they attempted to elude the vigilance of the Britiſh fleet, and to land men in ſmall parties. On the 22d of Auguſt, General Humbert came aſhore at Killala, at the head of about 1100 men. Even this ſmall party might have been dangerous had it arrived a month earlier; and it actually produced very ſerious alarm. It conſiſted of men ſelected with great care, and capable of enduring much fatigue. They were joined by a few of the moſt reſolute of the diſcontented Iriſh in the neighbourhood, and ſpeedily defeated General Lake, who advanced againſt them with a ſuperior force, taking from him ſix pieces of cannon. They next marched in different directions, for the purpoſe of raiſing the people, and maintained their ground in the country during three weeks. Finding, however, that he was not ſeconded by additional troops from France, that the rebellion in Ireland had been fully ſubdued, and that 25,000 men under Lord Cornwallis were cloſing round him, Humbert diſmiſſed his Iriſh aſſociates; and four days thereafter, having encountered one of the Britiſh columns in his march, he laid down his arms. Now, when it was too late, the Directory was very active in ſending troops towards Ireland; but all their efforts were defeated by the ſuperiority of the Britiſh navy. On the 12th of October, Sir John Borlaſe Warren took La Hoche, a ſhip of 84 guns, and four frigates, attempting to reach Ireland with nearly 3000 men on board. The other ſhips belonging to the French ſquadron, which conveyed 5000 men in all, contrived to make their eſcape by ſailing round by the north of the iſland. On the 20th of the ſame month another frigate bound for Ireland was taken; and the French finding that the ſea was completely occupied by the Britiſh fleet, were at laſt compelled to deſiſt from their enterpriſe.

342
Vhoſe ef-
orts are de-
eated by
he Britiſh
avy.

343
Negociations at
Raſtadt.

Ever ſince the treaty of Campo Formio had been concluded, a congreſs of miniſters from the French Directory, and from the German princes, had been negociating at Raſtadt a treaty between France and the empire. As theſe negociations terminated in nothing, and were tedious and unintereſting during their progreſs, it is unneceſſary to enter into a detail of the ſteps by which they were conducted. The intended reſult of them had been previouſly arranged between the Emperor and the Directory in the ſecret convention of Campo Formio, which has been already mentioned. That the articles of this convention might be concealed, the French miniſters at Raſtadt formally brought forward their propoſals in ſucceſſion for the diſcuſſion of the German deputies. The French demanded that the Rhine ſhould be the boundary of their Republic. The Germans reſiſted this. References were made to the diet of Ratiſbone, and long diſcuſſions and negociations took place among the different princes. When it was found that little was to be expected from the protection of Auſtria, the German deputies at Raſtadt were inſtructed to offer one half of the territory demanded. This offer was refuſed, and new negociations took place. The other half was at laſt yielded up, and a long diſcuſſion commenced about the debts due by the ceded territory, which the French refuſed to pay. The tolls upon the river, and upon the rivers flowing into the Rhine, alſo gave riſe to much altercation. It was even a matter of no ſmall difficulty, after all, to determine the preciſe boundary of France; whether her territory ſhould extend to the left bank, the right bank, or the thalweg, that is, the middle of the navigable channel of the river. It became alſo a queſtion how thoſe princes ought to be indemnified who loſt their revenues or territories by the new acquiſitions of France; and it was at length agreed that they ſhould receive portions of the eccleſiaſtical eſtates in Germany.

344
Preparations for
war on the
Continent.

Theſe diſcuſſions, conducted with endleſs formality and procraſtination, ſtill occupied the congreſs at Raſtadt; but it now became gradually more probable that no treaty would be concluded at that place. Auſtria began to ſtrengthen her armies in all quarters. Ruſſia, that had hitherto avoided any active interference in the conteſt, placed a large body of troops in Britiſh pay, and ſent them towards the German frontiers. The king of Naples avowedly and eagerly prepared for war. This impatient monarch, reſolving to attack without delay the French troops who occupied the Roman territory, procured General Mack and other officers from the court of Vienna to aſſume the command of his army. Without waiting, however, till Auſtria ſhould commence the attack, he raſhly began the war alone and unaided, excepting by the Britiſh fleet, and thus drew upon himſelf the whole force of the French Republic. The Directory did not ſuſpect ſuch imprudent conduct on the part of this prince; and accordingly, when General Mack entered the Roman territory, at the head of 45,000 men, the French troops in that quarter were altogether unequal to the conteſt. A French ambaſſador ſtill reſided at Naples when this event took place, and war was not declared. When the French General Championnet complained of the attack made upon his poſts under theſe circumſtances, he was informed in a letter by General Mack, that the king of Naples had reſolved to take poſſeſſion of the Roman territory, having never acknowledged its exiſtence as a Republic; he therefore required the French quietly to depart into the Ciſalpine ſtates; declaring, that any act of hoſtility on their part, or their entrance into the territory of Tuſcany, would be regarded as a declaration of war. Championnet finding himſelf unable to reſiſt the force now brought againſt him, actually evacuated Rome. He left, however, a garriſon in the caſtle of St Angelo, and endeavoured to concentrate whatever troops he could haſtily collect in the northern extremity of the Roman ſtate. Towards the end of November, General Mack entered Rome without oppoſition.

345
The Neapolitans
take poſſeſſion of
Rome.

When theſe events came to be known at Paris, war was immediately declared againſt the king of Naples, and alſo againſt the king of Sardinia. This laſt prince had made no attack upon France; but he was accuſed by the Directory, in their meſſage to the Councils, of *diſaffection* to the Republic, and of *wiſhing* to join the king of Naples in his hoſtile efforts. This accuſation could not well be falſe. From the period of Bonaparte's ſucceſsful irruption into Italy, the king of Sardinia had felt himſelf placed in the moſt humiliating circumſtances; his moſt important fortreſſes were occupied by the French; they levied in his country what contributions they thought fit; and when they recently required him to receive a garriſon into his capital, he found himſelf unable to reſiſt the demand. Even now, when they performed the uſeleſs ceremony of declaring war, he could make no effort in his own defence, and

346
Hard fate
of the king
of Sardinia.

French Revolution, 1798.

quietly gave them a formal reſignation in writing of his whole continental dominions, conſenting to retire to the iſland of Sardinia.

In the mean time, the conteſt with Naples was ſoon decided. The French on their retreat were much haraſſed by the people of the country. The Neapolitan troops regarded them with ſuch animoſity, that they ſcarcely obſerved the modern rules of war towards the priſoners who fell into their hands. Even their leaders ſeemed in this reſpect to have forgotten the practice of nations; for when General Bouchard, by order of General Mack, ſummoned the caſtle of St Angelo to ſurrender, he declared, that he would conſider the priſoners of war and the ſick in the hoſpitals as hoſtages for the conduct of the garriſon; and that for every gun that ſhould be fired from the caſtle, a man ſhould be put to death. It cannot well be imagined that the Neapolitan officers would have acted in this vehement manner, had they not expected countenance and ſupport from the immediate co-operation of Auſtrian troops. 347 Naples conquered by by the French. In their hopes from this quarter, however, they were completely diſappointed. Mindful of her recent calamities, and attentive only to her own aggrandiſement, Auſtria ſeems ſtill to have expected more from negociation than from war, and the territory of Naples ſoon fell into the hands of the French. Such indeed was the terror of the French name in Italy, or ſuch was the diſaffection or cowardice of the Neapolitan troops themſelves, that they were beaten by one-fourth of their number in different engagements, at Terni, Porto Fermo, Civita Caſtellana, Otricoli, and Calvi. At the commencement of the conteſt, a body of Neapolitans, with the aſſiſtance of the Britiſh fleet, had been landed at Leghorn, for the purpoſe of taking the French in the rear: but they, diſregarding this attempt on the part of ſuch an enemy, preſſed on towards Naples. By degrees, General Mack's army being reduced by the reſult of the battles which it fought, and by deſertion, to 12,000 men, he found it neceſſary to adviſe the king and royal family of Naples to take refuge on board the Britiſh fleet. They did ſo; and arrived at Palermo, in Sicily, on the 27th of December, in the Britiſh Admiral Lord Nelſon's ſhip. General Mack, in the mean time, requeſted an armiſtice, to afford an opportunity for making peace; but this was refuſed. Being driven from Capua, which is the laſt military poſt of any ſtrength in the Neapolitan territory, and his life being in no ſmall danger from the diſaffection of his own troops, he at laſt found it neceſſary to ſeek for ſafety, by ſurrendering himſelf, along with the officers of his ſtaff, to the French General. The governor of Naples, in the mean time, offered to the French a contribution in money, if the commander in chief would conſent to avoid entering that city. The offer was accepted, and the invading army remained at Capua. General Serrurier, on the 28th of December, at the head of a column of French troops, expelled the Neapolitans from Leghorn, and took poſſeſſion of that place. So far as the efforts of regular armies are to be conſidered, the war might now therefore be regarded as brought to a termination; but the French had ſpeedily a new and unuſual enemy to contend againſt.

1799. From the mildneſs of the climate, and the fertility of the ſoil, human life can be ſuſtained in the ſouthern parts of Italy with fewer efforts of induſtry than in almoſt any other country in Europe. Hence ariſes a general propenſity to idleneſs, which is increaſed by the numerous charitable inſtitutions to which the Roman Catholic religion gives riſe. French Revolution 1799. 348 The Lazzaroni riſe againſt the French. In the city of Naples there had long exiſted a body of perſons under the denomination of *Lazzaroni* or Beggars, amounting to the incredible number of from thirty to forty thouſand men, who did nothing, and ſubſiſted merely by charity, or by ſuch ſhifts as occaſionally occurred to them. One of theſe frequently was the menacing the ſtate with an inſurrection, in caſe their wants were not inſtantly ſupplied; which uſually drew from a feeble adminiſtration very liberal diſtributions of money and proviſions. On the preſent occaſion they demonſtrated abundance of loyalty; but the king had thought fit to avoid entruſting his ſafety to ſuch defenders. During the confuſion which followed the flight of the court and the approach of the French army, the Lazzaroni became mutinous. They heard that the French aboliſhed, wherever they came, all thoſe monaſteries and other religious eſtabliſhments which are the great ſources of public charity. The Lazzaroni, therefore, conceived the moſt violent hatred againſt them, and againſt all who were ſuſpected of favouring opinions hoſtile to royal government. In the beginning of January they began to ſhew ſymptoms of diſcontent, and in a few days broke out into open inſurrection. The members of the government left by the king, overcome by habitual terror of the Lazzaroni, conſulted merely their own perſonal ſafety, and made no effort to preſerve the public tranquillity. Prince Militorni had gained conſiderable applauſe on account of his vigorous defence of Capua againſt the French. The Lazzaroni therefore elected him their commander in chief; but he attempted in vain to reſtrain their violence and love of plunder. They declared hoſtility againſt the French and all the adviſers of the armiſtice. They broke open the priſons, and put to death all thoſe who were confined on account of political offences againſt the royal government. 349 Their outrages. They next ſpread themſelves over the city in ſearch of thoſe perſons whom they conſidered as favourable to the invaders, and committed murder and robbery in all quarters, concluding by burning the houſes of thoſe accounted diſaffected. An attempt was made by a conſiderable body of the inhabitants, who thought themſelves in the greateſt danger, to reſiſt their fury, by fortifying the convent of the Celeſtins, and retiring thither; but the Lazzaroni, after encountering the fire of cannon and of muſketry, ſucceeded in ſtorming the place, and deſtroyed all who had taken refuge there. Their power and their fury were now equally boundleſs, and the city became in many quarters a ſcene of maſſacre and pillage. Prince Militorni, therefore, went to Capua, and requeſted Championnet to reſcue Naples from utter ruin by occupying it with his army. For this purpoſe it was arranged, that a column of French troops ſhould ſecretly advance by a circuitous march, and ſuddenly enter the city from the oppoſite quarter. Before this plan could be fully executed, the Lazzaroni had adopted the daring reſolution of attacking the French within the fortifications of Capua. Accordingly two-thirds of them marched out upon this enterpriſe, and ſpent the 19th and 20th of January in attempting to take Capua by aſſault. Multitudes of theſe men here periſhed by the artillery of the place; for the

French,

ench lution, 99.

French, to favour the capture of Naples by the party that had been ſent eaſtward for that purpoſe, avoided making any ſally, and remained upon the defenſive. The Lazzaroni at Capua, however, having learned on the 21ſt that a French column had marched to Naples, and approached the gates, ſuddenly returned to the aſſiſtance of their brethren in the capital. They were cloſely purſued by the French; but they had leiſure, nevertheleſs, to barricade the ſtreets, and to form themſelves into parties for the defence of different quarters. A dreadful and ſanguinary conteſt now enſued, which laſted from the morning of the 22d to the evening of the 23d of January. The Lazzaroni, with ſome peaſants who had joined them, diſputed obſtinately every ſpot of ground; and by the energy which they diſplayed, caſt a ſevere reproach upon the feeble and unſkilful government, which had not been able to direct in a better manner the courage of ſuch men. At length, after having been gradually driven from ſtreet to ſtreet, the Lazzaroni rallied for the laſt time at one of the gates of the city, where they were nearly exterminated. The inhabitants rejoiced on account of their own eſcape from immediate ruin; and while the French armies found themſelves become odious in all the other countries which they had entered, they here found themſelves, from the peculiar circumſtances of the caſe, received with unfeigned welcome, in a city which holds the third place in population and ſplendour among the capitals of Europe.

350 y are ly ex inated.

This may be regarded as the laſt triumph enjoyed by the Directory. The conſequences of their conduct were now gathering faſt around them. They were deſervedly unpopular at home; not only from the violations they had offered to the conſtitution of their country, but alſo from the manner in which they conducted public affairs in detail. They ſet no bounds to their profuſion, or to the exactions with which their agents vexed the conquered countries. Championnet, aſhamed of the extortions of which the commiſſaries of the Directory were guilty, attempted in Italy to reſtrain them; and the conſequence was, that, upon the complaint of the commiſſary Taypoult, he was deprived of his command, and thrown into priſon. Scherer, the miniſter of war, was appointed his ſucceſſor. Under him the rapacity of the agents of government, and the embezzlement of the public ſtores, was carried to its height. The numbers of the armies were ſuffered to decline, that the Directory, the commiſſaries, and the generals, might become rich. Thus the ſtate was left totally unprepared againſt the ſtorm which was now rapidly gathering from abroad. Still, however, France was feared by the neighbouring nations, to whom the preſent ſtate of her internal affairs was obſcurely known. Though an army of 45,000 Ruſſians had advanced to the aid of Auſtria, yet that Cabinet heſitated to declare war. Pruſſia was eagerly ſolicited by Britain to take up arms againſt France, and large pecuniary aid was offered; but Sieyes, the Directory's ambaſſador at Berlin, artfully contrived to defeat this negociation, and to counteract the unpopularity of his country in Germany, by publiſhing the ſecret convention at Campo Formio, which we have already mentioned. This treaty demonſtrated ſo clearly to the German princes the utter unconcern with which their independence and their intereſts were regarded by the head of the empire, that no ſteady co operation with Auſtria could henceforth be expected from them. The greater number of them, therefore, reſolved to maintain their neutrality under the protection of Pruſſia.

351 acity of Direc-

French Revolution, 1799.

On the 2d of January, the French miniſters at Raſtadt preſented a note to the congreſs, in which they intimated, that the entrance of Ruſſian troops into Germany, if not reſiſted, would be regarded by them as a declaration of war. Some negociation took place in conſequence of this note, but no ſatisfactory anſwer was returned. On the 26th of that month, the ſtrong fortreſs of Ehrenbreitſtein ſurrendered, after having remained under blockade ſince the concluſion of the treaty of Campo Formio. By the poſſeſſion of this place, and of Mentz and Duſſeldorf, France was now rendered very formidable on the Rhine. As ſhe poſſeſſed alſo the ſtrong country of Switzerland, and all the fortified places of Italy, ſhe was well prepared, not only for defence, but for active operation; for it is now known, that the conferences of Raſtadt were purpoſely protracted, by orders from the Directory, till the French armies ſhould be ready to take the field with advantage againſt an enemy whoſe conduct betrayed the moſt culpable tardineſs. At this time Jourdan commanded on the Upper Rhine from Mentz to Huningen; Maſſena occupied with an army the eaſtern frontier of Switzerland towards the Griſon country; Scherer was commander in chief in Italy; Moreau acted as general of a diviſion under him; and Macdonald commanded the troops that occupied the territory of Rome and Naples. But theſe armies that kept in ſubjection, and were now to defend ſo many countries, ſcarcely amounted to 170,000 men in all, and were far outnumbered by the armies which Auſtria alone, without the aid of Ruſſia, could bring into the field. The Directory, however, confiding in the unity of its own plans, in the undecided politics of the court of Vienna, and in the conſequent ſlow movements of the Imperial armies, was eager to renew the war; and the two Councils, on the 13th of March, declared France to be at war with the Emperor of Germany and the Grand Duke of Tuſcany. The war, however, had already been begun. On the 1ſt of March Jourdan croſſed the Rhine at Straſburg, and occupied ſeveral ſtrong poſitions in Swabia. Manheim was taken, and Philipſburg ſummoned to ſurrender by Bernadotte (G), while St Cyr entered Stutgard. On the 4th of March the Auſtrians croſſed the Lech, under the command of the Archduke Charles, to oppoſe this army. Maſſena advanced into the territory of

352 War renewed on the Rhine.

(G) This ſummons was conceived in very extraordinary terms, and cannot be accounted for but upon the ſuppoſition that Bernadotte believed the Auſtrian officers infected with French principles. He calls upon the commander of the fortreſs to ſurrender without reſiſtance, and thus violate the truſt repoſed in him by his ſovereign. He tells him, that a diſcharge of his duty would produce the *defection of his officers and men*. He warns him of the folly and danger of leading troops to action *againſt their will*; and, laſtly, he threatens him with *vengeance* if he ſhould *dare to reſiſt!*

of the Griſons ; and ſurpriſing a ſtrong body of Auſtrians, took them all priſoners, together with their General Auffenburgh, and the whole of his ſtaff, after a deſperate reſiſtance under the walls of *Coire*. The reduction of the Griſons was the conſequence of this victory.

353 And in Switzerland.

But in order to complete the plan of the French, which was to effect a junction with their two armies, that of Maſſena in Switzerland with that of Jourdan in Germany, it was neceſſary to carry the important poſt of Feldkirch, which was occupied by the Auſtrian General Hotze, whoſe line extended from the frontiers of the Griſons, to the north-eaſt by the Vorelberg, to the eaſtern extremity of the Lake Conſtance. Vigorouſly repulſed in his firſt attack, Maſſena renewed it, five different times, with freſh forces, and increaſed impetuoſity. But all could not avail againſt the ſteady bravery of the Auſtrians, who drove back the aſſailants with immenſe ſlaughter. The French, however, being in poſſeſſion of the Griſons, the invaſion of the Engadine, and the county of Bormio, by a diviſion of the army of Italy cantoned in the Valteline, under the orders of General Caſabianca, was facilitated. The Auſtrians, too weak in that quarter to reſiſt them, retreated into the Tyrol, whither they were purſued by the French, who forced ſome of the defiles by which the entrance of that country was defended, and extended their deſtructive incurſions as far as Glurenz and Nauders.

354 The French are defeated in Swabia,

Meanwhile the van-guard of the main army of the Imperialiſts puſhed forward to meet the enemy. On the 20th of March it was attacked by Jourdan, who drove in the outpoſts ; but on the following day that general was himſelf attacked in the centre of his army, driven from his poſition, and compelled to retire during the night to Stockach. Both parties now prepared for a deciſive engagement. On the 24th, the Archduke encamped before Stockach, with his right wing towards Nellenburg, and his left near Wallenweis. On the 25th, at day break, the French army began the attack. They directed their chief efforts againſt the right wing of the Auſtrians commanded by General Meerfeldt. The battle was long and obſtinate. From five o'clock in the morning till paſt one of the afternoon, its termination remained extremely doubtful. The French ſucceeded in their attempt againſt General Meerfeldt. His poſition was forced, and he retreated into a wood between Liptingen and Stockach. Here he renewed the combat without ſucceſs. He was gradually driven to the extremity of the wood, though it is a German mile in breadth. The left wing of the Auſtrians, however, had in the mean time maintained its ground, and reinforcements were ſent from it to General Meerfeldt. With the aſſiſtance of theſe he at laſt ſucceeded in making a ſtand, and even obliged the French to retire in their turn. At length, about two o'clock, the French found it neceſſary to withdraw from this quarter. The battle, however, was continued in different points till night came on. The French remained upon the ground where they had begun the attack, and they even retained 4000 priſoners whom they had taken during the various movements of the day. The reſult of the battle, upon the whole, however, was fatal to their affairs. Their loſs was ſo great, and the ſuperiority of the Auſtrians ſo manifeſt, that Jourdan dared not to hazard another engagement. On the following day he retired to Weiller near Dutlingen ; and finding his army altogether unequal to offenſive operations, he ſent back one part of it to cover Kehl and Straſburg, while he withdrew with the other towards Switzerland. This event compelled Maſſena, who was preſſing upon Tyrol and the Engadine, to return to the defence of Switzerland. He was immediately intruſted with the chief command of the troops in this quarter, in the room of Jourdan, who was removed. The Auſtrians continued to advance in every direction, and immediately occupied the whole of the right, or German ſide, of the Rhine, from the lake of Conſtance to Mentz.

355 And in Italy.

In Italy the ſucceſs of the Auſtrians was equally conſpicuous, notwithſtanding the treachery of the French in attacking them before the expiration of the truce. The attempt of the latter to force the advanced poſts of the former, on the 26th of March, at Santa Lucia and Buſſelango, was rendered abortive ; and at Legnago, the Auſtrian general, Kray, obtained a complete victory, and compelled them to ſeek protection under the walls of Mantua. On the 5th of April, the Auſtrians again attacked them in their poſition at Memiruolo, which lies on the road from Mantua to Peſchiera, and compelled them, after an obſtinate conflict, once more to retreat. The loſs of the French in theſe different actions was undoubtedly great; but it is probably overrated at 30,000 men killed, wounded, and taken.

The ſucceſs of the Auſtrians, however, was not cheaply purchaſed. Scherer, who commanded the French army, gained over them, at firſt, ſome advantages, which, had he known how to improve them, might have given a different turn to the tide of affairs. One diviſion of his army had actually forced the Auſtrian poſts on the 26th of March, and taken 4000 priſoners ; but the other diviſion being repulſed, he withdrew his troops from their advanced poſition, and thus relinquiſhed the advantage which he had gained. Even on the 5th of April, Moreau's diviſion performed prodigies of valour, and took, it has been ſaid, 3000 priſoners ; but from the injudicious diſpoſitions which had been made by Scherer, that general was not ſupported, and the victory of the Auſtrians was complete. Kray now quickly drove the French from the Mantuan, and compelled them, after having ſuſtained new loſſes, to relinquiſh their ſtrong holds on the Mincio and the Adige, and to retreat to the Adda.

356 Moreau fortifies h camp.

On the banks of this river, rendered remarkable for the dear bought victories which Bonaparte had obtained at the bridge of Lodi, the French general Moreau, to whom the Directory had given the chief command of their army, prepared to make a vigorous defence. The military talents of this man had been rendered unqueſtionable by his celebrated retreat through a hoſtile country, and before a victorious army ably commanded. On the preſent occaſion he did not belie his former character. Nothing that could give courage or confidence to his troops was neglected. Entrenchments were thrown up wherever the river was conſidered as paſſable ; and a ſituation, remarkably ſtrong by Nature, was ſtrengthened by every means which art could ſupply.

Before this period, a conſiderable body of Ruſſians had joined the Imperialiſts ; and the chief command of the allied army was now aſſumed by Field Marſhal Suwarrow Rimniſki. This celebrated leader, whoſe cha-

rench
olution
1799.

357
rſhal
varrow

racter every democrate labours to miſrepreſent, had entered into the army at the age of twelve, and riſen from the ranks to the ſtation which he now holds, of Generaliſſimo of the Ruſſian armies. Poſſeſſed of ſtrong natural talents, he had likewiſe the benefit of an excellent education, and is ſaid, by thoſe who are perſonally known to him, as well as acquainted with the ſtate of literature in Ruſſia, to be one of the beſt claſſical ſcholars of all the natives of that great empire. He had ſtudied, in early life, mathematics and natural philoſophy, as branches of ſcience abſolutely neceſſary to the man whoſe higheſt ambition is to become a great commander; and his knowledge of the learned, as well as of the faſhionable languages, has enabled him to avail himſelf of all that has been written either by the ancients or the moderns on the art of war. This art has indeed been his chief ſtudy from his youth; it has been at once his buſineſs and his amuſement.

Poſſeſſed with his countrymen, in general, of the moſt undaunted courage, and formed by Nature to endure the greateſt fatigue, it is not ſurpriſing, that with all theſe advantages Suwarrow ſhould have long ago acquired the character of one of the ableſt generals of his time. It is indeed true, that, till the opening of the campaign of 1799, he had diſtinguiſhed himſelf only againſt the Turks, whom we are too apt to deſpiſe, and againſt the Poles when divided among themſelves; but let it be remembered, that the enthuſiaſtic courage of thoſe ſame Turks had found employment for the talents of ſome of the ableſt generals in Europe, a Laudohn and a Cobourg; and that the Poliſh armies which Suwarrow ſubdued were united by the ſtrongeſt of all ties—the knowledge that they muſt conquer or periſh. All this was ſo well known to Frederic the Great, that he held the military talents of the Ruſſian hero in the higheſt eſteem; and the attention of all Europe was now turned towards the quarter where thoſe talents were to be exerted in the ſupport of ſocial order, and of every thing which ennobles man. His operations in Italy did not diſappoint the higheſt expectations which had been formed of them. At an age conſiderably above ſixty, he began a campaign not leſs remarkable for its activity than any which had gone before it ſince the commencement of the French revolution. We are by no means prepared, however, to do juſtice to the various military efforts which were now made, or to explain clearly the means employed to inſure ſucceſs. If the work entitled the *Hiſtory of Suwarrow's Campaigns* be deſerving of credit, the ſuperiority of that commander over his rivals and opponents ſeems to have at all times conſiſted principally in the promptitude with which he formed his plans, and the rapidity with which he carried them into execution. It is likewiſe ſaid to be a maxim of his, always to *commence* the attack when he ſees a battle inevitable, from the perſuaſion that the ardour of the attacking army more than counterbalances the advantage of ground, if that advantage be not very great. Such was certainly the principle upon which he acted at preſent.

358
Attacks
him in his
intrenchments,

On the 24th of April the combined army advanced to the Adda; and having driven in Moreau's outpoſts, Suwarrow reſolved, on the 26th, to attack him in his entrenchments. For this purpoſe, while the ſhew of an attack was maintained along the whole line, a bridge was ſecretly thrown over among the rocks at the upper part of the river, where the French had thought ſuch an enterpriſe unlikely or impoſſible. A party of the combined army was thus enabled, on the following morning, after croſſing the river, to turn the French fortifications, and to attack their flank and rear, while the reſt of the army forced the paſſage of the river at different points. The French fought obſtinately, but were ſpeedily driven from all their poſitions, and compelled to retire to Pavia, leaving 6000 men on the field; while upwards of 5000 priſoners, including 4 generals, fell into the hands of the allies, together with 80 pieces of cannon.

French
Revolution,
1799.

359
And defeats him
with great
ſlaughter.

The advantage thus obtained over the French, in conſequence of the addreſs with which the Adda was croſſed, is ſaid to have gained for Suwarrow more eſtimation from his antagoniſts than they had originally been diſpoſed to grant to any military officer coming from Ruſſia, and who had never before had perſonal experience of the mode in which war is conducted in the ſouth of Europe. But this is probably affectation. The French had ſurely no cauſe to deſpiſe Ruſſian generals, ſince they could not but know that Laudohn was born in Ruſſia, that he had his military education there, and that he had riſen to a high rank in the army before he entered into the ſervice of the Empreſs Queen Maria Thereſa. Indeed it is evident, that while their orators were declaiming againſt Suwarrow and his Ruſſians as mercileſs barbarians, they were ſecretly trembling at his prowefs and reſources, which they could not but remember had more than once ſaved the armies of the Prince of Cobourg in the Turkiſh war.

Moreau now eſtabliſhed the wreck of the French army, amounting to about 12,000 men, upon the Po, between Aleſſandria and Valentia. On the 11th of May he compelled a body of Auſtrians to retire, though they had already paſſed the river, and took a great number of them priſoners. On the following day, 7000 Ruſſians croſſed the Po at Baſignano, and advanced on Pecetto. Moreau immediately fell upon them with his army. They maintained a long and deſperate conflict; but being at laſt thrown into confuſion, and refuſing to lay down their arms, about 2000 of them were drowned in recroſſing the river, and the French, with difficulty, took a ſmall number of them priſoners. But Suwarrow ſoon advanced, and terminated this active, but petty warfare, which was all that the French could now maintain. Moreau was under the neceſſity of retiring with his troops to occupy the Bochetta, and other paſſes which lead to the Genoeſe territory; and the combined army commenced vigorouſly, and at once, the ſiege of all the fortreſſes in the part of Italy which it now occupied. Peſchiera, Mantua, Ferrara, Tortona, Aleſſandria, and the citadels of Turin and Milan, were all attacked. The French were driven from the Engadine by Bellegarde; Maſſena, cloſely preſſed in Switzerland by the Archduke Charles, was compelled to retreat to the neighbourhood of Zurich, and almoſt all Piedmont had riſen in inſurrection againſt the French; ſo that in every quarter their affairs ſeemed deſperate. Few or no reinforcements arrived from the interior, and their generals were left to act upon the defenſive, and to detain the enemy at a diſtance from the frontiers of France as long as poſſible. One effort of offenſive war only remained, and, after ſome delay, it was made with much vigour.

360
Macdonald and Moreau concert meaſures for attacking the allies.

Macdonald was ſtill with a conſiderable French army in the ſouthern parts of Italy, and occupied the territories of Rome and Naples. No attempt was made on the part of the combined powers to cut off his retreat; probably from the conviction that ſuch an enterpriſe could not be accompliſhed with ſucceſs in the mountainous countries of Tuſcany and Genoa, through which it would be in his power to paſs. Aware of this circumſtance, he was in no haſte to remove, though the combined army now occupied almoſt the whole territory between him and France. He gradually concentrated his forces, however, and drew near to the ſcene of action. His army amounted to 30,000 men; and he was ordered by the Directory to evacuate the new-born republics of Rome and Naples, and to form a junction, if poſſible, with the army of Moreau. The preſent ſituation of the allies, however, tempted Macdonald to hazard an action by himſelf. Marſhal Suwarrow had extended his forces over Lombardy and part of Piedmont, in order to afford protection to the well-diſpoſed inhabitants of theſe countries; and Macdonald and Moreau had concerted between them a plan for dividing their antagoniſts, and vanquiſhing them, as the French generals had often vanquiſhed their enemies in detail. It was only by Macdonald, however, that any important blow could be ſtruck; but it was neceſſary that Moreau ſhould draw upon himſelf a great part of the Auſtro-Ruſſian forces, that the remainder might be more completely expoſed to his colleague's attack. For this purpoſe he had recourſe to a ſtratagem.

361
Junction of the French and Spaniſh fleets.

Towards the end of April, the French fleet, amounting to 16 ſhips of the line, had ventured out of Breſt harbour. Ireland was ſuppoſed to be the place of its deſtination; and the Britiſh fleet was ſtationed in the ſituations moſt likely to prevent its arrival there. The French, however, intending to form a junction with the Spaniſh fleet, which was ſtill blockaded in the port of Cadiz, ſailed ſouthward. When they approached Cadiz, a ſtorm aroſe, which prevented any attempt on their part to enter the harbour, and any effort on the part of the Britiſh admiral, Lord Keith, to bring them to an engagement. On the 4th and 5th of May, therefore, they paſſed the Strait of Gibraltar, and ſteered for Toulon. Lord Keith kept his ſtation near Cadiz till the 9th of May, and then entered the Mediterranean in queſt of the French fleet. The Spaniards immediately put to ſea, and went into the Mediterranean alſo. The French fleet entered Toulon, and afterwards went out in queſt of the Spaniſh fleet. They ſailed towards Genoa, and afterwards to Carthagena, where they met their allies. The two fleets being now united once more, paſſed Gibraltar, and ſailed round to Breſt, where they arrived in ſafety, without being overtaken by the Britiſh.

362
Partial ſucceſſes of Macdonald.

Moreau, in the mean time, took advantage of the arrival of the French and Spaniſh ſquadrons in the vicinity of Genoa, to ſpread a report that they had brought him a powerful reinforcement of troops, in the hope of withdrawing from Macdonald the attention of Suwarrow. This laſt officer was himſelf at Turin. His advanced troops poſſeſſed the paſſes of Suſa, Pignerol, and the Col d'Aſſiette; while, at the lower extremity of the vaſt track of country over which his army was ſcattered, General Hohenzollern was poſted at Modena with a conſiderable force, and General Ott was at Reggio with 10,000 men. On the 12th of June, Macdonald began his operations. His advanced diviſions attacked Hohenzollern at Modena on that day, defeated him, and took 2000 of his men priſoners. The French, at the ſame time, attacked General Ott; and, after obliging him to retreat, they entered Parma on the 14th of June. On the 17th, General Ott was again attacked, and compelled to retire upon Caſtel St Giovanni. But here the progreſs of Macdonald was arreſted.

363
He is completely defeated by Suwarrow.

Suwarrow had been informed of his approach and alarming ſucceſſes; and with that preſence of mind, and that promptitude of energy, which ſo ſtrongly mark the whole of his conduct, he ſuddenly left Turin on the 15th of June, at the head of 20,000 men; and having marched ſeventeen leagues in eight-and-forty hours, came up with Macdonald's army on the banks of the Tidone. The Ruſſian Generals Roſenberg and Foerſter commanded the right and the centre; the left wing was commanded by the Auſtrian General Melas; the Ruſſian General Prince Procration commanded the advanced guard, and Prince Lichtenſtein the reſerve. A deſperate action now commenced, which, conteſted with equal obſtinacy on both ſides, was fought during three ſucceſſive days. At length victory, ſtill faithful to the ſtandard of Suwarrow, declared for the allies. The French, driven on the 1ſt day from the Tidone to the Trebbia, were there ultimately defeated on the 19th, after a carnage on both ſides, ſuch as ſome of the oldeſt officers in the army declared that they had never before ſeen. The Ruſſians and French repeatedly turned each others line, and were mutually repulſed. Suwarrow, who appeared in perſon wherever the fire was heavieſt, and his troops moſt cloſely preſſed, is ſaid to have had 7 horſes killed under him, and to have ſtript himſelf to the ſhirt on the 19th, running on foot from rank to rank, to urge the troops forward by his preſence and example (H). With all theſe exertions of heroiſm, however, and greater have ſeldom been made, the iſſue of the conteſt continued doubtful, till the gallant Kray, in direct diſobedience to the pernicious orders of the Aulic Council at Vienna, arrived at the head of a large detachment from the army beſieging Mantua, and, on the 19th, decided the fate of the day.

The French fled during the night; and, on the morning of the 20th, Suwarrow purſued them with his army in two columns. It ſeldom happens that German troops can overtake the French in a march. The Ruſſians now did ſo, however; and at Zena the rear guard of the French, being ſurrounded, laid down their arms. The

---

(H) We had this information from an officer of high rank, now reſiding in Weimar, who was preſent in the action; and who added, that the Coſſacs, as ſoon as they ſaw their old commander in his *ſhirt*, ruſhed upon the enemy with an impetuoſity which nothing could withſtand. The ſtory is by no means incredible; for Suwarrow, who deſpiſes coſtume, is known to have fought repeatedly in his ſhirt againſt the Turks; and he would be as hot on the Trebbia as ever he was on the Danube.

The reſt of the French army found ſafety in the paſſes of the Appennines and the Genoeſe territory, after having loſt on this occaſion, in killed, wounded, and priſoners, not leſs than 17,000 men.

64 tual plaints uwar- and Aulic ncil.

Moreau, in the mean time, had attacked the Auſtrians under General Bellegarde in the vicinity of Alexandria. Though ſuperior to him in numbers, they were completely beaten; but Suwarrow having returned with infinite rapidity after his victory over Macdonald, the temporary advantage gained by Moreau became of no importance. Suwarrow complained loudly of the conduct of the Aulic Council on this occaſion; while they, in return, imputed their diſaſter under Bellegarde to his unſkilful diſtribution of the whole troops, which had expoſed an immenſe army to great danger from the enterpriſes of an handful of men. It is not our buſineſs to decide between them. The inſtructions of the Council to Kray not to co-operate with the commander in chief of the combined army, ſeem to us in the higheſt degree abſurd, if not treacherous; and we have heard a general officer, whoſe name, were we at liberty to give it, would do honour to theſe pages, ſay, that the diſtribution of the troops, of which that council complained, was the moſt maſterly thing that has been done during the war. Be this as it may, a diſtruſt and mutual miſunderſtanding thus commenced, or, at leaſt, made its firſt open appearance, which gave good reaſon to ſuſpect that little cordiality of co-operation would long exiſt between theſe allies. They continued, however, for ſome time to enjoy uninterrupted proſperity under the command of Suwarrow. The ſieges of the different Italian fortreſſes were very cloſely preſſed. They all ſurrendered in ſucceſſion; and the period appeared faſt approaching when it would be in the power of the allied armies to enter the ancient territory of France.

365 napar- s unſuc- ſful at- k of re.

If we turn our eyes to a different quarter, we ſhall find the French as much humbled at this time in Paleſtine by Britiſh valour, as they were in Italy by the united armies of Ruſſia and Auſtria. The hero of France, the conqueror of Italy, the boaſted legiſlator of Europe, after having defeated the Mamalukes, taken poſſeſſion of Alexandria and Cairo, and profeſſed himſelf a Mahometan in Egypt, led an army into Paleſtine with the avowed purpoſe, it has been ſaid, to take poſſeſſion of Jeruſalem, and by rebuilding the temple, and reſtoring the Jews, to give the lie to the prophecies of the Divine founder of the Chriſtian religion. At the head of a choſen band, exceeding 12,000 in number, and poſſeſſed of a ſtaff eminent for military ſkill and experience, he arrived at the ſmall town of Acre, ſituated on the ſea-coaſt, 28 miles ſouth of Tyre, and 37 north of Jeruſalem. To this town, which was wretchedly fortified, and defended only by a ſmall garriſon of Muſſelmans, he laid ſiege in form; and the governor would have ſurrendered unconditionally, had he not been, we ſay not *perſuaded*, but *decoyed*, by an Engliſh *naval* officer, to make a vigorous reſiſtance. We need not add, that the naval officer was Sir Sidney Smith, or that the beſieging general was Bonaparte.

The command of the garriſon being entruſted to Sir Sidney Smith, who was not to be bribed by French gold, or corrupted by French philoſophy, the hero who, by the aid of theſe allies, had ſo quickly routed armies, and conquered ſtates in Italy, was detained before the town of Acre *ſixty-nine* days; though the number of the allies who defended that town exceeded not 2000 men! Foiled in *eleven* different attempts to carry it by aſſault, one of which was made during the truce which he himſelf had ſolicited to bury the dead, he was ultimately obliged to retreat, leaving eight of his generals, eighty-five of his officers, and *one half* of his army behind him. The ſuperiority of the Britiſh over the Corſican hero was, during this ſiege, more fully diſplayed in conduct than even in courage. The true magnanimity evinced by the former; his temperate replies to the audacious calumnies and atrocious falſehoods of his adverſary; and the moderation and humanity which characteriſed his diſpatches, and invariably marked his behaviour to thoſe whom the fortune of war ſubjected to his power—give additional luſtre to the brilliant victory which his valour, his energy, and his perſeverance, ſo eſſentially contributed to ſecure.

But while we pay a tribute of juſtice to the merits of our gallant countryman, we muſt not omit to notice the high deſerts of the brave, the loyal, the virtuous Philipeaux, his gallant comrade, the partner of his toils, and the partaker of his glory. The ſkill of this French officer as an engineer was moſt ſucceſsfully diſplayed in the defence of Acre: and, indeed, his exertions on that memorable occaſion ſo far ſurpaſſed his ſtrength, that he actually periſhed through fatigue.

366 His vaſt projects, had he ſucceeded.

The defeat of Bonaparte at Acre, which effectually ſtopped his deſtructive career, will be conſidered as important indeed, when it is known that his arts of intrigue had ſo far ſucceeded as to prevail on the numerous tribe of the Druſes to join his ſtandard with *ſixty thouſand* men immediately after the reduction of that town. Had this junction been effected, it was intended to proceed to Conſtantinople, and, after plundering the city, to lay it in aſhes! It is ſcarcely poſſible to calculate the dreadful conſequences of ſuch an event on the political ſtate of Europe. If ſervices are to be eſtimated in proportion to their effects, we know of none, during the preſent war, fertile as it has been in brilliant atchievements, that deſerves a higher reward than the defeat of Bonaparte at Acre.

During theſe reverſes abroad, France had begun to ſuffer much internal agitation, and the Directory found itſelf in a very difficult ſituation. The elections, as uſual, were unfavourable to them; and amidſt the contempt with which they now began to be regarded, it was no longer poſſible to ſecure a majority in the Councils, by unconſtitutionally annulling the elections of their political opponents. They demanded money, and were anſwered by reproaches, on account of their profuſion, and the rapacity of their agents. The royaliſts in the ſouth and the weſt began to form inſurrections. They were ſubdued with much difficulty, on account of the abſence of the troops. The people had totally loſt that enthuſiaſm which, in the earlier periods of the revolution, induced them to ſubmit to ſo many evils, and to make the moſt violent efforts without murmuring. They beheld the renewal of the war with regret, and were unwilling to aſſiſt by their exertions to reſtore power and ſplendour to the faction which had trampled upon their freedom.

Amidſt all theſe difficulties, an event occurred which, for a time, gave the Directory the hope of being once more able to rouſe the dormant energies of their countrymen. After the defeat of Jourdan, a detachment from

French Revolution, 1799

from the army of the Archduke Charles had occupied Raſtadt, where the Congreſs ſtill ſat. On the 28th of April an order was ſent by an Imperial officer to the French miniſters, requiring them to quit Raſtadt in 24 hours. They demanded a paſſport from Colonel Barbaſcy, who had ſent the order; but this he could not grant, none having that power but the commander in chief.

367 Aſſaſſination of the French envoys.

They declared themſelves determined to depart without delay, although the evening approached. They were detained about an hour at the gate of the town, in conſequence of general orders which had been received by the military to ſuffer none to paſs. In conſequence of an explanation, however, and of the interpoſition of ſuperior officers, they were allowed to depart. The three miniſters, Bonnier, Roberjot, and Jean Debry, were in carriages. The wife of Roberjot, and the wife and daughters of Jean Debry, were along with them; and they were attended by the miniſters of the Ciſalpine republic. When they had advanced to a very ſhort diſtance from Raſtadt, they were met by about 50 huſſars of the regiment of Szeckler, who made the carriages to halt, and advancing to the firſt of them, containing Jean Debry, demanded his name. He told them his name; and added that he was a French miniſter returning to France. On receiving this anſwer, they immediately tore him from his carriage, wounded him in ſeveral places with their ſabres, and caſt him into a ditch, on the ſuppoſition that he was killed. They treated in the ſame manner the two other ambaſſadors, Bonnier and Roberjot, whom they murdered upon the ſpot. They offered no perſonal violence, however, to the reſt of the company, who were allowed to return to Raſtadt; but they robbed the carriages of whatever effects they contained; and the papers of the ambaſſadors were conveyed to the Auſtrian commander. After the departure of the ſoldiers, and the return of the carriages to Raſtadt, Jean Debry wandered about the woods all night, and returned alſo to Raſtadt on the following day. He claimed the papers belonging to the legation from the Auſtrian commander, but they were refuſed to be reſtored.

During the whole of the long period that the Congreſs had ſat, Raſtadt and its vicinity had been occupied by French troops, and it was only a few days ſince the Auſtrians had obtained poſſeſſion of it. This event therefore caſt, at leaſt, a ſevere reproach upon the diſcipline of the Auſtrian army. It did more; it made every honeſt man regret, that troops, engaged in the ſupport of a good cauſe, ſhould think to promote that cauſe by the murder even of the greateſt villains.

368 Turned by the Directory to its own advantage.

The Archduke Charles made haſte to diſclaim all knowledge of it in a letter to Maſſena; but the French Directory, regarding it as a fortunate occurrence, from its tendency to rouſe the reſentment of the nation, addreſſed to the two Councils, on the 5th of May, a meſſage, in which they aſcribed it to a deliberate purpoſe on the part of the Auſtrian government to inſult France by the aſſaſſination of her ambaſſadors. They thus converted the private act of a few deſperate individuals into a meaſure of public policy; as if the death of thoſe wretched miſcreants could have been of conſequence to the enemies of the *great* nation. The unpopularity of the Directory, however, and the obvious inutility of ſo groſs a crime, prevented this accuſation from obtaining much credit, or producing great effects upon the people. In a private letter which a friend of our's received at that period from the Continent, he was aſſured that the murder of the envoys "*fait plus de bruit que de ſenſation;*" and that the general opinion was, that the Directory itſelf knew more of the authors of that crime than the Archduke or the Auſtrian government.

French Revolutio 1799.

369 Diſſenſion in France.

Upon the introduction of the new third of this year into the Councils, a violent oppoſition to the Directory commenced. Sieyes, who was ambaſſador at Berlin, and who had enjoyed, during the whole progreſs of the revolution, a very conſiderable influence over all the parties that had ſucceſſively enjoyed the ſupreme authority, was elected into the Directory. At the firſt eſtabliſhment of the conſtitution he had refuſed to occupy this ſtation, and it excited much ſurpriſe when he readily accepted the office in the preſent calamitous ſtate of the Republic. His admiſſion into the Directory, however, did not reconcile the public or the two Councils to that body. A violent conteſt for power betwixt the Moderate and the Jacobin parties ſeemed to approach; but they ſoon came to a compromiſe. Treilhard was removed from the Directory, under the pretence that he had held an office in the ſtate within leſs than a year previous to his nomination. Merlin and Reveillere were compelled to reſign, to avoid an impeachment with which they were threatened; but Barras ſtill contrived to retain his ſtation. Moulins, Gohier, and Ducos, men little known, and by no means leaders of the contending parties, were appointed Directors. The power was underſtood to be divided, and that neither party greatly predominated. An attempt was made to revive public ſpirit, by encouraging anew the inſtitution of clubs, which had been ſuppreſſed by the Directory. The violent Jacobins were the firſt to take advantage of this licence. They reſumed their ancient ſtyle, their propoſals for violent meaſures, and their practice of denouncing the members and the meaſures of government. But the Directory becoming alarmed by their intemperance, obtained leave from the Councils to ſuppreſs their meetings before they were able to intereſt the public in their favour.

370 Warlike forts of t Director

Conſiderable efforts were now made by the French government to recruit their armies; but the deranged ſtate of the finances, which the votes of the Councils could not immediately remedy, prevented the poſſibility of their gaining a ſuperiority during the preſent campaign. The difficulty was alſo increaſed by the neceſſity of reſiſting immenſe armies in different quarters at the ſame time, France being aſſailed at once on the ſide of Holland, Switzerland, and Italy. Such, however, were the exertions of the Directory, that they ſeemed not deſtitute of the hope of being able ſpeedily to aſſume, on the frontier, a formidable, and even menacing poſture. In the beginning of Auguſt, their Italian army amounted to 45,000 men. The different bodies of troops of which it conſiſted had been drawn together, and concentrated nearly in the ſame poſitions which Bonaparte had occupied before his battles of Montenotte and Milleſimo.

371 Joubert aſſumes comma in Italy

The command of the whole was given to Joubert, a young man, who had been much diſtinguiſhed under Bonaparte; and who, in the ſtyle of gaſconade employed by that general, aſſured his government of victory, declaring, that he and Suwarrow ſhould not both ſurvive the firſt battle. In this boaſting declaration he ſeems to have been in earneſt;

72 cceſſes of allies.

earneſt; for, on taking the command, he prevailed with Moreau to remain in the army as a volunteer till the firſt battle ſhould be fought. The allies had now taken Turin, Aleſſandria, Milan, Peſchiera, and Ferrara, with a rapidity which would lead one to ſuppoſe that ſome new mode had been invented of materially abridging the duration of ſieges. The ſtrong citadel of Turin opened its gates, to the aſtoniſhment of Europe, after a bombardment of only *three days;* the citadel of Aleſſandria ſurrendered to the Auſtrian General Bellegarde, on the 22d of July, after a ſiege of *ſeven days;* and the ſtill more important fortreſs of Mantua ſurrendered to the brave General Kray, on the 29th of the ſame month, after a ſiege of only *fourteen days.* The garriſon of Aleſſandria amounted to 2400 men; that of Mantua to 13,000. The former were detained priſoners of war, and the latter were allowed to return to France on their *parole;* a parole which the commanders of the allied armies could not reaſonably expect to be kept. This has given riſe to a ſuſpicion, that the fortreſs was voluntarily ſurrendered to the Auſtrians, in order that the Directory might recruit its armies with the garriſon.

373 war- w's victory over ubert, ho is lled.

The allies next began to beſiege Tortona, and Joubert reſolved to attempt its relief. He hoped to accompliſh this object, and to gain ſome advantage over their army, before General Kray could arrive to the aſſiſtance of Suwarrow with the troops that had been occupied in the ſiege of Mantua. On the 13th of Auguſt, the French drove in the whole of the Auſtrian poſts, and took poſſeſſion of Novi. Here they encamped on a long and ſteep, but not high, ridge of hills, with their centre at Novi, their right towards Seravalle, and their left towards Baſaluzzo. On the 14th they remained quiet; and on the 15th they were attacked by Suwarrow, whoſe army was now reinforced by the arrival of General Kray from Mantua. The right wing of the allied army was commanded by Kray, its left by Melas, and its centre was occupied by the Ruſſians, under Prince Pongrazion (Procration) and Suwarrow in perſon. The attack began at 5 o'clock in the morning, and was continued during many hours. Soon after the commencement of the battle, while the French commander in chief, Joubert, was urging his troops forward to a charge with the bayonet, he received a muſquet ſhot in his body, and, falling from his horſe, immediately expired. Moreau inſtantly reſumed the command. After an obſtinate conteſt, the allied army gave way, and was compelled to fall back in all quarters. The attack, however, was repeatedly renewed, and much blood was ſhed. From the obſtinate manner in which they fought, the Ruſſians, in particular, ſuffered very ſeverely. They made three unſucceſsful efforts againſt the centre of the French army, and on each occaſion thoſe immediately engaged were rather deſtroyed than repulſed. The laſt attack along the whole line was made at three in the afternoon. The French remained unbroken; and the day muſt have terminated in the defeat of the allies, had not General Melas ſucceeded in turning the right flank of the French line. Their right wing was thus thrown into confuſion. Melas purſued his advantage till he obtained poſſeſſion of Novi, and the whole French army made a rapid retreat under the direction of Moreau.

374 Unaccountable conduct of the allies.

According to the accounts given by the Auſtrians, the French loſt in this battle 4000 killed and an equal number taken priſoners. They acknowledged their own loſs in killed to be equal to that of the French, but the loſs ſuſtained by the Ruſſians was never publiſhed. The general reſult of the battle was the total ruin of the French affairs in this quarter. The allies retained their decided ſuperiority; and there was no enterpriſe which, on the preſent theatre of the war, they might not have ventured to undertake. The French renounced all hope of defending Genoa, and prepared to evacuate that city and its territory. The Directory expected an immediate invaſion of the ſouth of France, and addreſſed a proclamation to the people, urging them to act with firmneſs and energy amidſt the calamities with which the country was now menaced. But theſe apprehenſions were unneceſſary. The court of Vienna had other objects in view that were leſs dangerous to their enemy. They neither invaded Genoa nor France, but quietly proceeded in the ſiege of Tortona. The vanquiſhed army was ſurpriſed to find itſelf unmoleſted after ſuch a defeat; and in a few days ventured to ſend back parties to inveſtigate the movements of the allies. The new commander Championnet, who had ſucceeded Joubert, found to his no ſmall aſtoniſhment that they had rather retreated than advanced; and he immediately occupied the ſame poſitions which his army had held before the battle of Novi.

375 Suwarrow leaves Italy, and marches to Switzerland.

Inſtead of purſuing the advantages they had gained in Italy, the Aulic council, or council of war at Vienna, now perſuaded Suwarrow to leave that country with his Ruſſians, and to ſet out for Switzerland to drive the French from thence. In the early part of the campaign, the Archduke Charles had ſucceeded, after various attacks, in driving the French from the eaſtern part of Switzerland beyond Zurich, of which laſt city he retained poſſeſſion. The Directory, however, had ſent their new levies chiefly towards this quarter; ſo that in the middle of the month of Auguſt Maſſena's army amounted to 70,000 men. The Archduke was now ſo far from being able to purſue the advantages he had gained, that of late the French had reſumed the offenſive, and threatened to endanger his poſition. Their right wing under Lecourbe had even ſucceeded in taking poſſeſſion of Mount St Gothard, which is the great paſs that leads from the centre and eaſtern part of Switzerland into Italy. The cabinet of Vienna probably wiſhed to throw the ſevereſt duties of the war upon their northern aſſociates. The veteran Suwarrow had never, during his long military career, ſuffered a ſingle defeat. His preſumption of ſucceſs was therefore high; and he perhaps felt himſelf not a little flattered by the requeſt to undertake an enterpriſe in which the Auſtrians had failed. though led by their moſt fortunate commander. It is indeed certain that he conſidered himſelf as called out of Italy too ſoon. Though confident of being properly ſupported, he agreed to proceed with his troops from Piedmont to Switzerland, where another Ruſſian army had lately arrived. Delays, however, were thrown in his way. Tortona did not fall quite ſo ſoon as was expected; and when he was ready to march, the Auſtrian commander in Italy refuſed to ſupply him with mules for the tranſport of his baggage. Unable to reply to the indignant expoſtulations of the Ruſſian hero, this man deſcended to a pitiful falſehood, by aſſuring him that he would find a ſufficient number of mules at Bellinzone, where, when he arrived, not one was to be had. He had now no other reſource but to diſmount the cavalry, and employ their horſes to drag along the baggage. Under all theſe difficulties, he arrived, by forced marches, on the confines of Switzerland, on the day appointed by him and the Archduke; but the Auſtrian cabinet had, in the mean time, taken a ſtep which made all his exertions uſeleſs.

376 Is deſerted, if not betrayed, by the Auſtrians.

Thinking it degrading to a Prince of the Imperial houſe, who had ſo long held the higheſt military rank, to ſerve under the Ruſſian General, and not having the confidence to require the moſt experienced leader in Europe to receive the orders of a man ſo young as the Archduke, they ſent that prince with his army to attack the French, who, in a ſmall body, had entered into Swabia. He began accordingly to draw off his troops in the beginning of September, before Suwarrow was in readineſs to leave Italy. The number which he took with him has been differently eſtimated, the loweſt computation ſtating it at 48,000, and the higheſt at 60,000. The former is the moſt probable; ſince it is well known that 20,000 would have been fully adequate to the purpoſe for which he marched. The army which he left behind him is more perfectly aſcertained: it conſiſted of 21,000 Ruſſians, 18,900 Auſtrians, Bavarians, and other auxiliaries, forming a total of 39,900 men.

Upon what principle of military tactics the Aulic council could ſuppoſe that a ſkilful and intrepid commander like Maſſena, with a force nearly double that of the allies, would remain in a ſtate of inactivity, it is not eaſy to conceive. He perceived at once the advantage which might be derived from this unaccountable movement of the Archduke. The French troops in Swabia were therefore ordered to advance rapidly, and to threaten the rear of the Archduke's army. As the repulſe of theſe troops, and the invaſion of France towards Alſace, formed a part of the Auſtrian commander's plan of operations, he marched againſt them with his army. The French made as much reſiſtance as the ſmallneſs of their force would permit. The Archduke, however, gradually drove them towards the Rhine. The better to carry on their plan of deception, they made a ſerious ſtand in the neighbourhood of Manheim, and were defeated with the loſs of 1800 men. The Auſtrians entered Manheim, and ſeemed ready to croſs the Rhine in this quarter.

377 The allies defeated in Switzerland.

All this while Switzerland was left completely expoſed to the enterpriſes of Maſſena. General Hotze, with the Auſtrians, occupied the right wing of the allied army there. The newly arrived Ruſſian army was ſtationed in the centre at Zurich, under the command of General Korſakof; and the left, conſiſting chiefly of Bavarians and other troops of the empire, was commanded by Nauendorf. Maſſena remained quiet till he learned that the Archduke had entered Manheim, and that Suwarrow, having taken Tortona, was on his march towards Switzerland by Mount St Gothard. This laſt poſition was defended by Lecourbe; and Maſſena reſolved, in the mean time, to anticipate the arrival of Suwarrow. On the 24th of September, having drawn the attention of the Ruſſians to another quarter by a falſe attack, he ſuddenly croſſed the Limmat, a river which divided the two armies near the convent of Farr, which is three leagues diſtant from Zurich. A part of the French troops engaged the Auſtrians, while the greater part of the army marched againſt the Ruſſians at Zurich. The Auſtrian General Hotze was killed in the commencement of the action. General Petrarch, who ſucceeded him in the command, contrived to avoid a total rout, and retired during the night with the loſs of about 4000 men. The conteſt with the Ruſſians was ſingularly obſtinate. In a mountainous country, to which they were ſtrangers, and contending againſt the moſt ſkilful military leaders that the ſouth of Europe had been able to produce, they laboured under every diſadvantage. They could not be put to flight, however; and even when different diviſions of them were ſurrounded, they refuſed to lay down their arms, and were ſlaughtered upon the ſpot. By the retreat of the Auſtrians on the evening of the 25th, they found themſelves on the 26th nearly ſurrounded in Zurich. They now began to retreat alſo; and we are only ſurpriſed at the ability of the Ruſſian General in effecting his retreat in ſuch good order, and with ſuch little loſs; for if the official accounts deſerve credit, his loſs in killed, wounded, and taken, did not exceed 3000 men. He was obliged, however, to abandon his baggage and cannon to the enemy.

378 Suwarrow's march.

During theſe operations, Suwarrow was advancing on the ſide of Italy with an army rated, in ſome accounts, at 18,000, in others at only 15,000; and forcing the French from their ſtrong poſitions on Mount St Gothard, deſcended, on the very day on which Maſſena made his general attack, into the valley of Urſeren; and driving Lecourbe before him, with conſiderable ſlaughter, advanced as far as Altorf. He even penetrated on the next day into the canton of Glaris, and took 1000 of the French priſoners; while the Ruſſian General Roſemberg was equally ſucceſsful in the canton of Schwitz, where General Auffenberg had effected a junction with him; and General Linken defeated and took another corps of French, conſiſting of 1300 men.

379 His admirable conduct.

Maſſena, however, now turned upon the Field-marſhal with the greater part of his army; and, by hemming him in on all ſides, expected to have made him, and the Grand Duke Conſtantine, priſoners. Suwarrow, however, defended himſelf againſt every attack with unexampled vigour and addreſs. A ſingle paſs among the mountains was all that remained unoccupied by the French. He diſcovered this circumſtance, and eſcaped, though cloſely purſued. He loſt his cannon, baggage, and proviſions, among the dreadful mountains and precipices with which that country abounds. He made his way, however, eaſtward through the Griſon country, and at length arrived at Coire with about 6000 men in great diſtreſs.

380 His indignation at the court of Vienna.

Nothing could exceed the indignation of this old warrior when he diſcovered the manner in which affairs had been conducted, the hazardous ſtate in which the Ruſſians had been abandoned by the Archduke, and the conſequent ruin which they had encountered. He conſidered himſelf and his countrymen as treacherouſly expoſed to deſtruction; he loudly complained of the Commander of the allied forces in Switzerland; publicly taxed the council of Vienna with ſelfiſhneſs and injuſtice; and refuſed all farther co-operation with the Auſtrian army. He ſent an account of the whole tranſaction to St Peterſburgh in a letter, of which the compoſition would do honour to the fineſt writer of the age, and withdrew with his troops to the neighbourhood of Augſburg to wait for farther orders.

0
In ion of
H and.

In the mean time, Great Britain prepared to invade Holland with an army of 40,000 men, conſiſting of Britiſh troops and Ruſſian auxiliaries. The firſt diviſion, under General Sir Ralph Abercromby, ſailed in the month of Auguſt, under the protection of a fleet commanded by Admiral Lord Duncan. Bad weather prevented a landing from being attempted till the 27th. On the morning of that day the troops landed without oppoſition upon the ſhore of Helder Point in north Holland, at the entrance to the Zuyder Sea. They had not been expected in this quarter, and the troops in the neighbourhood were conſequently few. The Britiſh, however, had no ſooner begun to move forward, than they were attacked by a conſiderable body of infantry, cavalry, and artillery, who had been haſtily aſſembled from the neareſt towns. The Dutch troops maintained the conteſt with much obſtinacy; but they were gradually fatigued by the ſteady oppoſition they encountered, and retired to the diſtance of two leagues. In the night they evacuated the fort of Helder, of which the Britiſh took poſſeſſion on the morning of the 28th. A detachment from the Britiſh fleet, commanded by Vice Admiral Mitchell, now entered the Zuyder Sea by the ſtrait of the Texel, to attack the Dutch fleet under Admiral Story. This laſt officer, inſtead of retiring for ſafety to any of the ports, or to the ſhallow water with which that ſea abounds, ſurrendered the whole fleet on the 30th of Auguſt without firing a gun, under pretence that his ſeamen were mutinous, and would not fight.

81
C ture of
t Dutch
f t.

Had the expedition terminated here, it might have been regarded as extremely fortunate, and as eſtabliſhing the power of the Britiſh navy without a rival. But it was reſolved to follow up this firſt ſucceſs by an effort on land to reſtore the authority of the Stadtholder, and the ancient government of the United Provinces. Many circumſtances were hoſtile to this enterpriſe. The whole army had not been ſent at once from Britain. As no more than the firſt diviſion had arrived, the troops could only reſt upon the ground they had gained till reinforcements ſhould be ſent. The terror ariſing from the firſt appearance of an invading army was thus allowed to paſs away, the enemies of the preſent Dutch government were diſcouraged, and leiſure was afforded to adopt effectual meaſures of defence. The place where the landing was effected was well choſen for an attack upon the Dutch fleet; but for an invaſion, with a view to the reſtoration of the Stadtholder, it was the worſt that could have been ſelected. North Holland, at the extremity of which it was made, is a narrow peninſula, everywhere interſected by canals and ditches, of about 40 miles in length. Here the invaders might be detained, and even ſucceſsfully reſiſted, by a force greatly inferior to their own. This alſo is the quarter of the country the moſt unfavourable to the cauſe of the Stadtholder. In Zealand, where his eſtates are ſituated, and in Rotterdam, which is full of Scotchmen and of families of Scottiſh extraction, his friends are numerous and powerful; but in Amſterdam, and in North Holland, which is under its influence, his enemies abound, and the reſiſtance to his power has been very great during every period of the Dutch hiſtory. When to all this it is added, that the rainy ſeaſon was approaching, and that a winter campaign in Holland is almoſt impoſſible, it will not appear ſurpriſing that this expedition was attended with little ultimate ſucceſs. It is ſaid that, amidſt the preſſure of the many difficulties which ſurrounded them, the French Directory heſitated much about undertaking the defence of Holland; but the place, and the time of landing the invading army, at once brought them to a determination. General Brune was ſent thither, with whatever troops could be haſtily collected, to ſupport the Dutch General Daendels.

382
Progreſs of
the invaders.

General Abercromby, in the mean time, remained upon the defenſive at Schager Brug, waiting for reinforcements. His inactivity encouraged the enemy on the 10th of September to venture an attack upon his poſition. They advanced in three columns, two of which conſiſted of Dutch and one of French troops. They were repulſed, however, in all quarters, and retired to Alkmaer. On the 13th the Duke of York arrived with additional troops, and aſſumed the chief command. The Ruſſian auxiliaries having alſo arrived, offenſive operations were immediately reſolved upon. On the 19th the army advanced. General Abercromby commanded the left, which proceeded along the ſhore of the Zuyder Sea againſt Hoorne. The centre columns were commanded by Generals Dundas and Pultney; and the right wing, conſiſting of Ruſſians, was commanded by their own General D'Herman. In conſequence of ſome ſtrange miſunderſtanding, the Ruſſians advanced to the attack ſoon after three o'clock in the morning, which was ſome hours previous to the movement of the reſt of the army. They were ſucceſsful in their firſt efforts, and obtained poſſeſſion of the village of Bergen; but preſſing eagerly forward, and being unſupported by the other columns, they were nearly ſurrounded. Their commander was taken priſoner; and though the Britiſh came in time to protect their retreat, they loſt at leaſt 3000 men. This failure on the right obliged the Britiſh Commander in Chief to recal his troops from the whole advanced poſitions they had gained, though General Abercromby had actually taken Hoorne with its garriſon, and although General Pultney's column had carried by aſſault the principal poſition of the Dutch army called *Ourds Carſpel*.

The ſeverity of the weather prevented another attack till the 2d of October, when, after an engagement that laſted from ſix in the morning till the ſame hour in the evening, the Britiſh army ſucceeded in driving the united Dutch and French troops from Alkmaer and the villages in its neighbourhood. The conteſt was chiefly conducted among the ſand hills in the vicinity of the ocean; and the battle was maintained with ſuch obſtinacy, that the fatigue of the troops, together with the difficult nature of the country, prevented the Britiſh from gaining any great advantage in the purſuit. The retreating army immediately occupied a new poſition between Baverwyck and Wyck op-zee. The Duke of York once more attacked them on the 6th; and after an obſtinate and bloody engagement, which was maintained till night, he remained in poſſeſſion of the field of battle. But this was the laſt ſucceſs of the invaders. Finding himſelf unable to make farther progreſs, in conſequence of the increaſing numbers of the enemy, the impracticable nature of the country, and the badneſs

383
Stopped by
the enemy
and the inclemency
of the weather.

French Revolution, 1799.

of the weather, which, during the whole of this year, was unuſually ſevere, the Duke of York retired to Schager Brug, and there waited for orders from England to return home. He was, in the mean time, cloſely preſſed by the United Dutch and French forces, ſo that his embarkation muſt have been attended with much hazard. He therefore entered into a convention with the French and Dutch generals; by which it was agreed, that they ſhould no farther moleſt him in his retreat, and that, in return, he ſhould not injure the country by breaking down any of the dykes which protect it againſt the ſea, and that Great Britain ſhould reſtore to France and Holland 8000 priſoners of war, taken previous to the preſent campaign.

In conſequence of theſe events, the affairs of France now began to aſſume a leſs unfavourable aſpect. They were indeed driven to the extremities of Italy, Championet was defeated in every effort which he there made againſt the Auſtrians during the reſt of the year, and Ancona, which was the laſt place of any ſtrength poſſeſſed by the French, alſo ſurrendered on the 13th of November to General Frolich; but they retained the Genoeſe territory, and Switzerland and Holland continued under their power. 384 Coalition againſt France ready to be diſſolved. The new coalition againſt them ſeemed once more ready to diſſolve. From the commencement of the French Revolution, a ſpirit of ſelfiſhneſs had mingled with all the efforts made by the continental powers of Europe againſt it, and had rendered them fruitleſs. To prevent the aggrandiſement of Auſtria, Pruſſia had early withdrawn, and ſtill ſtood aloof. Spain and Holland were retained under the influence of France by the efforts of her arms, and by the univerſal diffuſion of her wild principles among the people. Even the Britiſh cabinet, which of all the European powers has remained moſt true to the original purpoſe of the war, ſometimes forgot that object. Thus, when invading Holland, the Dutch were informed, by a proclamation, that their ancient government was to be reſtored; but no offer was made to reſtore their diſtant poſſeſſions. Of all the coaleſced powers, however, Auſtria purſued her ſeparate intereſts with the leaſt diſguiſe. With much facility ſhe relinquiſhed the Netherlands, and ſuffered the principal bulwarks of Germany, Mentz, and Ehrenbreitſtein, to fall into the hands of the French, upon obtaining in exchange the Venetian territories, which Bonaparte had conquered, and thought himſelf authoriſed to ſell. During the preſent campaign, the whole conqueſts made by the united efforts of the Auſtrian and Ruſſian forces were ſeized by Auſtria in her own name, and none of the Princes of Italy obtained leave to reſume the government of their own territories. This conduct on the part of the allies gave every advantage to the French. They broke off the negociations at Liſle, under the pretence of defending the Dutch and Spaniſh ſettlements which the Britiſh government refuſed to relinquiſh. They found it eaſy to alarm the King of Pruſſia, by diſplaying the unbounded ambition of the houſe of Auſtria; and the Emperor of Ruſſia, having publicly declared to the members of the German empire, that the purpoſe for which he had taken up arms was not to diſmember France, but to reſtore peace to Europe, became jealous of the Court of Vienna, when he ſaw it purſue a conduct ſo very different. This jealouſy was encreaſed by the misfortunes of the Ruſſian troops; and all circumſtances ſeemed now to promiſe that the new coalition would ſpeedily be deſerted by its northern auxiliary.

French Revolution, 1799.

385 Bonaparte vanquiſhes the Turks in Egypt. While affairs were in this ſtate, an event occurred which exhibited the French Revolution under a new aſpect. When Bonaparte found himſelf compelled to retreat, baffled and diſgraced, from the ruins of Acre, he learned that a Turkiſh army was ready to invade Egypt by ſea. He returned, therefore, with his uſual celerity, by way of Suez, acroſs the deſart of Arabia Petrea, which divides Syria from that country, and was in the neighbourhood of the Pyramids on the 11th of July, when an army of 18,000 Turks landed from 100 ſhips at Aboukir. They took this fort by aſſault, and gave no quarter to the French garriſon of 500 men that it contained. On the 15th, Bonaparte began to march down the country againſt them. On the 25th he came in ſight of them. at ſix o'clock in the morning.

It is not wonderful that thoſe barbarians afforded him an advantage which had ſo often been preſented by the armies of Auſtria. They had divided their force into two parts, which were encamped on the oppoſite ſides of a beautiful plain. He had now formed a conſiderable body of cavalry, by obtaining for his men fleet horſes from Arabia. Theſe advanced rapidly into the centre of the Turkiſh army, and cut off the communication between its different parts. His infantry then attacked the right, which was the weakeſt diviſion of the Turks. They being ſpeedily panic ſtruck, attempted to fly to their ſhips, and every man was drowned in the ſea. The left diviſion of the Turks was next attacked. It made a more obſtinate reſiſtance, but was ſoon alſo put to flight. Some caſt themſelves into the ſea, and periſhed in attempting to reach the boats of their fleet; the reſt took refuge in the fort of Aboukir. The news of this battle reached France towards the end of September, and revived the memory of Bonaparte's victories, contraſted with the reverſes which the Republican armies had lately experienced. On the 10th of October a diſpatch was received from him by the Directory, and read to the Councils, giving an account of the capture of the fort of Aboukir, with the whole remains of the Turkiſh army. 386 Arrives with his principal officers in France, On the 14th of the ſame month a meſſage from the Directory announced, to the aſtoniſhment of all men, that Bonaparte, along with his principal officers, had juſt arrived in France, and that they left the army in Egypt in a proſperous ſtate. This laſt part of the meſſage was ſoon afterwards proved, by the intercepted letters of Kleber, and the other generals left behind, to be a ſcandalous falſehood. In one of theſe letters, Pouſſielgue ſays, "Every victory carries off ſome of our beſt troops, and their loſs cannot be repaired. A defeat would annihilate us all; and however brave the army may be, it cannot long avert that fatal event."

Bonaparte, however, was received at Paris with diſtinction, though nobody could tell why he had deſerted his army and come thither. The parties in the government were equally balanced; and both the Jacobins, and what were called the *Moderates*, ſolicited his aſſiſtance. The Jacobins ſtill poſſeſſed a majority in the Council of Five Hundred; but in the other Council their antagoniſts were ſuperior. The Director Sieyes was underſtood to be of the party of the Moderates; and the Jacobins had of late unſucceſsfully attempted to

nch
ution,
99.

to remove him from his office, under the pretence that the interval appointed by the conſtitution had not elapſed between his going out of the Council of Five Hundred and his election to the office of director. Neither party was ſatisfied with the exiſting authorities; but none of the uſual indications of approaching hoſtilities appeared. The Jacobins were far from ſuſpecting that Sieyes had a plot ripe for execution, which was to overwhelm them in an inſtant. They were even in ſome meaſure laid aſleep by an artful ſcene of feſtivity, in which the whole members of the Councils were induced to engage, on the 6th of November, under pretence of doing honour to the arrival of Bonaparte. On the morning of the 9th, one of the committees of the Council of Ancients, called the committee of Inſpectors of the Hall, preſented a report; in which they aſſerted, that the country was in danger, and propoſed to adjourn the ſitting of the legiſlature to St Cloud, a village about ſix miles from Paris. We have already mentioned, that the conſtitution entruſted to the Council of Ancients the power of fixing the reſidence of the legiſlative bodies, and that this Council could in no other caſe aſſume the initiative, or propoſe any law; their powers of legiſlation being otherwiſe limited to the unconditional approbation or diſapprobation of the decrees paſſed by the Council of Five Hundred. The Council of Ancients now ſuddenly decreed, that both Councils ſhould meet next day at St Cloud. As the Council of Five Hundred had no conſtitutional right to diſpute the authority of this decree, and as the ruling party in it was completely taken by ſurpriſe, its members ſilently ſubmitted, and both Councils aſſembled on the 10th of November at the place appointed.

87
ſeizes
reins
overn-
t.

The Council of Five Hundred exhibited a ſcene of much agitation. They received a letter from Legarde, ſecretary to the Directory, ſtating, that four of its members had ſent reſignations of their offices, and that the fifth (Barras) was in cuſtody by order of General Bonaparte, who had been appointed commander of their guard by the Council of Ancients. While the Council were deliberating, Bonaparte entered the hall, attended by about twenty officers and grenadiers. He advanced towards the chair, where his brother Lucien Bonaparte ſat as preſident. Great confuſion enſued; he was called a Cromwell, a Cæſar, an uſurper. The members began to preſs upon him, and his countryman Arena attempted to ſtab him with a dagger. He was reſcued by his military eſcort. Lucien Bonaparte then left the chair, and caſt aſide the badge of office which he wore as a member of the Council. The confuſion did not diminiſh; but in a ſhort time a party of armed men ruſhed into the hall, and carried off Lucien Bonaparte. A tumultuous debate now began; in which it was propoſed that Bonaparte ſhould be declared an outlaw. The debate was ſoon terminated, however. The doors of the hall were once more burſt open. Military muſic was heard; and a body of troops proceeding into the hall in full array, the members were compelled to diſperſe. The Council of Ancients, in the mean time, ſetting aſide the conſtitution, paſſed a variety of decrees. They aboliſhed the Directory, and appointed in its ſtead an Executive Commiſſion; to conſiſt of Bonaparte, Sieyes, and Roger Ducos, under the appellation of Conſuls. They adjourned the ſittings of the legiſlative bodies till the 20th of February, and appointed two committees, conſiſting of twenty-one members, ſelected from each of the two councils, to act as legiſlators in the mean time. They alſo expelled a great number of members from their ſeats in the councils.

French
Revolution,
1799.

Moſt of the members of the Council of Five Hundred returned to Paris, after having been driven from their hall by the military; but a part of them remained at St Cloud, and, on the evening of the ſame day, confirmed all the decrees of the Council of Ancients. The new government entered upon its functions at Paris on the following day. That city remained tranquil, and the public funds even roſe upon the occaſion. On the 17th of November the conſuls decreed the tranſportation of a great number of the leading Jacobins and zealous republicans to Guiana, and ordered many others to be impriſoned; but theſe decrees were ſpeedily recalled, and affairs went on as quietly as if nothing unuſual had occurred.

388
Motions of Tippoo Sultan in India.

While Bonaparte was thus obtaining boundleſs perſonal aggrandiſement in Europe, the African expedition in which he had been engaged was utterly unſucceſsful in all its objects. The circumſtances which led to it, ſo far as concerned foreign nations, now came to light, and were ſhortly theſe: Tippoo Sultan, the ſon and ſucceſſor of the celebrated Hyder Ally, and ſovereign of the Myſore country, which forms a part of the peninſula of India, had been compelled to conclude a treaty of peace in the year 1792 with the Britiſh governor general, Lord Cornwallis, under the walls of Seringapatam his capital. By this treaty he reſigned to the invaders a part of his territory, and agreed to pay a large ſum of money. He was, moreover, under the humiliating neceſſity of conſenting that two of his ſons ſhould be delivered as hoſtages, to remain with the Britiſh till the pecuniary payments could be completed.

A war thus concluded could not become the foundation of much cordial amity between the parties. Tippoo had inherited from his father a deep ſentiment of hoſtility againſt the growing power of Britain in India. Though he ſubmitted on the occaſion now mentioned to the neceſſity of his circumſtances, yet he only waited a more fortunate opportunity to endeavour to recover what he had loſt; and even, if poſſible, to accompliſh the favourite object of all his enterpriſes, the complete expulſion of the Britiſh from India. At a former period, almoſt the whole of the native princes of this vaſt continent had entered into a combination againſt the power of Britain; but their deſigns had been defeated by the talents and exertions of Warren Haſtings, Eſq; The aſcendency of the Britiſh government in this quarter was now ſo great, that no ſuch combination could again be formed, and Tippoo felt that its power could only be ſhaken by the aid of an European army. France was the only country from which he could hope to obtain an adequate force. By the events of the revolution, however, and by the preſſure of the war at home, the rulers of France had been prevented from attending to diſtant views and intereſts. Their ſettlements in India had been ſeized by the Britiſh, and they had ceaſed to retain any poſſeſſions beyond the Cape of Good Hope, excepting the iſlands of Mauritius and Bourbon. In the year 1797, Tippoo reſolved to endeavour to renew his intercourſe with the French by means of theſe iſlands. One Repaud, who had once been a lieutenant in the French navy, and had reſided for ſome time at Seringapatam,

389
He renews his intercourſe with the French.

gapatam, had miſled Tippoo into a belief that the French had a great force at the Mauritius, which could immediately be ſent to his aid in caſe of a war. He therefore fitted out a ſhip, of which he gave the command to Ripaud, and ſent two perſons in it as his miniſters, with powers to negociate with the French leaders at the Mauritius. But, at the ſame time, to avoid exciting the ſuſpicions of the Britiſh government in his neighbourhood, he directed his meſſengers to aſſume the character of merchants, to act in that capacity in public, and to conduct their political negociations with ſecrecy. They arrived at the Mauritius towards the cloſe of the year 1797, and opened their propoſals to Malartic the governor, for an alliance between Tippoo and the French nation, with the view of obtaining the aid of an European army. They were received with great joy, and veſſels were inſtantly diſpatched to France to communicate their propoſals to the Directory.

390
His conduct watched by the Britiſh.

In the mean time, Malartic the governor of the Mauritius, from folly, from treachery, or from a deſire to involve Tippoo, at all hazards, in a quarrel with the Britiſh, took a ſtep which ultimately was in a great meaſure the means of defeating the plans, and accompliſhing the ruin of that prince. On the 30th of January 1798, he publiſhed and diſtributed a proclamation, in which he recited the whole private propoſals of Tippoo, and invited all French citizens to enliſt in his ſervice. Copies of this proclamation were ſpeedily conveyed by different veſſels, touching at the Mauritius, to the continent of India, to Britain, and to all quarters of the world. Accordingly, as early as the 18th of June 1798, the ſecret committee of the Court of Directors of the Eaſt India Company in London wrote to their governor general in India, requiring him, in conſequence of this proclamation, to watch the conduct of Tippoo, and even to engage in hoſtilities, if the meaſure ſhould appear neceſſary. Before that period, however, the government in India had been alarmed by the ſame means, and was making preparations for war. This, however, was no eaſy matter. It is the nature of European power, in theſe countries, gradually to decline. The nature of the climate, the view of returning home, and the diſtance from the ſeat of government, ſpeedily introduce a relaxation of the efforts and the vigilance by which dominion was originally acquired. The troops require to be continually renewed by levies from the parent country; and if this precaution is neglected for a very ſhort time, or negligently attended to, they become unable to protect the extenſive territories ſuch as Britain now poſſeſſed in India. When Lord Mornington, the governor-general, enquired into the ſtate of the Britiſh army at Madras, and whether he might hazard an offenſive war againſt Tippoo; he was informed, that three, if not ſix months would be neceſſary to aſſemble the ſcattered diviſions of the army, and to prepare them to defend their own territory. It was added, that ſuch was the feeble ſtate of the Britiſh forces in that quarter, that it might even be unſafe to excite ſuſpicion in Tippoo by military preparations, as he might, in that caſe, ruin them by a ſudden attack. Lord Mornington, however, reſolved to encounter every hazard, and ordered immediate and active preparations in every quarter.

In the meanwhile, Tippoo did not truſt for ſucceſs to the aid of France alone. He endeavoured to bring an attack upon the Britiſh and their allies, or ſubjects, in India, from the north weſt, by inviting Zemaun Shah to invade the country. This prince is at the head of a formidable kingdom, made up of provinces torn from both Perſia and India. It was founded about ſixty years ago by Ahmed Khaun Abdalla, an Affghan chief, who followed Nadir Shah on his invaſion of India in 1739. He himſelf afterwards invaded India no leſs than ſeven times; and, in particular, he overthrew, with dreadful ſlaughter, the united forces of the Mahratta empire, in the year 1761, on the plains of Paniput. He was ſucceeded, in 1773 by his ſon Timmur Shah, who died, and was ſucceeded by his own ſon, the preſent prince. The dominions of Zemaun Shah extend from the left bank of the river Indus, on the ſea-coaſt, as far northward as the latitude of Caſhmeer; and from eaſt to weſt they are 650 Engliſh miles in length, comprehending the provinces of Cabal, Candahar, Peiſhere, Ghizni, Gaur, Sigiſtan, and Koraſun. He uſually keeps in pay an army of 150,000 horſe, beſides infantry to garriſon his fortreſſes. In expectation of direct aid from France, by Bonaparte's expedition to Egypt, and of an important diverſion to be made by Zemaun Shah, Tippoo endeavoured to remain quiet, and to temporiſe with the Britiſh.

Since the firſt victories of Lawrence and of Clive, the native princes of India have been eager to introduce the European art of war among their ſubjects. For this purpoſe they retain European adventurers to command and diſcipline a part of their troops, and even endeavour to form a guard for their perſons of European ſoldiers. The Nizam, a prince in alliance with the Britiſh, though in a great meaſure under their influence, had long retained around his perſon a conſiderable body of French, and of troops under their management. Theſe, under the command of one Perou, now poſſeſſed great influence at Hydrabad, the capital of the Nizam. It was of much importance that theſe ſhould be removed out of the way, to enable the Britiſh to obtain the aid of this prince as an ally in the approaching conteſt with Tippoo. Lord Mornington procured this object to be accompliſhed with ſo much ſucceſs, that, on the 22d of October 1798, the French corps under Perou was ſurrounded and diſarmed without bloodſhed, and a Britiſh force was ſubſtituted as a guard to the Nizam in its ſtead. The military preparations being in a conſiderable ſtate of forwardneſs, Lord Mornington next warned Tippoo Sultan, in a letter dated the 8th of November 1798, of his having a knowledge of his hoſtile deſigns and connection with the French. He alſo propoſed to ſend an ambaſſador to treat about the means of reſtoring a good underſtanding between the ſtates. Tippoo avoided returning an anſwer till the 18th of December, and then merely denied the accuſation, and refuſed to receive the ambaſſador. On the 9th of January 1799, the Britiſh governor again urged in writing that the ambaſſador ſhould be received. No anſwer was returned for a month; and, in the mean time, an army of 5000 men having arrived from England, orders were iſſued to General Harris to advance at the head of the Madras army againſt the kingdom of Myſore. Tippoo now offered to receive the ambaſſador, providing he came without an attendance; but this conceſſion was not accounted ſufficient, and the army advanced. An army from

391
General Harris advances againſt him.

from Bombay was, at the ſame inſtant, advancing on the oppoſite ſide of his dominions. A part of Tippoo's forces encountered this army and were defeated; and within a few days thereafter, on the 27th of March, the reſt of his army was defeated by General Harris. When an European army in India is tolerably numerous, the detail of its military operations againſt the natives is by no means intereſting; for the inhabitants of theſe enfeebling and fertile regions can never be made, by any kind or degree of diſcipline, to poſſeſs that moral energy which enables men to encounter danger with coolneſs and ſelf-command. They can ruſh on death under the influence of rage or deſpair, but they cannot meet the hazard of it with calmneſs and recollection. It is ſufficient to remark that, on the 7th of April, General Harris ſat down before Seringapatam. On the 9th, Tippoo ſent a letter to this officer, alleging his own adherence to treaties, and enquiring into the cauſe of the war. He was anſwered by a reference to Lord Mornington's letters. On the 20th he made another attempt to negociate, by writing to General Harris, requeſting him to nominate commiſſioners to treat of a peace. In anſwer to this propoſal, certain articles were ſent to him as the only conditions that would be granted. By theſe he was required to ſurrender half his dominions, to pay a large ſum of money, to admit reſident ambaſſadors from the Britiſh and their allies, to renounce all connection with the French, and to give hoſtages for the fulfilment of theſe ſtipulations.

92 takes ngapa-

On the 28th of April Tippoo again wrote to General Harris, requeſting leave to treat by ambaſſadors; but his propoſal was refuſed, upon the footing that he was already in poſſeſſion of the only terms of peace which would be granted. Could Seringapatam have held out for little more than a fortnight longer, the invading army muſt have retreated. The rainy ſeaſon was about to commence; and, by ſome ſtrange effect of negligence or treachery, proviſions were ſo deficient in the camp, that it was only by reducing the troops to half allowance that they could be made to laſt till the 15th of May. On the 30th of April, the beſiegers began to batter the walls of Seringapatam; and a breach being made, the city was taken by aſſault on the 4th of May. One o'clock afternoon had been choſen for this purpoſe, as the hotteſt hour of the day, and conſequently the time when it would be leaſt expected. Tippoo was in his palace; but on being informed of the attack, he haſtened to the breach, and fell undiſtinguiſhed in the conflict. His treaſures, and the plunder of the city, which was immenſe, went to enrich the conquering army, after deducting a ſhare for the Britiſh government and Eaſt India Company. His kingdom immediately ſubmitted. The part of it which formed the ancient kingdom of Myſore, was beſtowed upon a deſcendant of the former race of its kings, whom Hyder Ally had deprived of the ſovereignty; the additional territories that had been conquered by Hyder Ally were divided between the Britiſh and their allies, the Nizam and the Mahrattas. The family of Tippoo were either taken in the capital, or voluntarily ſurrendered themſelves to the conquerors. They were removed from that part of the country, and allowed a conſiderable penſion.

393 Immenſe power of Britain in India.

In the mean time, Zemaun Shah had actually invaded India from the north-weſt. He advanced to the vicinity of Delhi, ſpreading terror and deſolation wherever he came. Had the French army in Egypt been able to detach a body of 15,000 men to the aſſiſtance of Tippoo, while all India was in the ſtate of alarm naturally produced by the approach of this northern invaſion, it is extremely probable that the Britiſh forces might ſpeedily have found themſelves deſerted by every ally, and ſunk under an unequal conteſt. But the actual reſult was very different. Satiſfied with the plunder he had obtained, Zemaun Shah ſoon withdrew; and the French army being detained in Egypt by the war with the Turks, and by the want of veſſels at Suez wherewith to reach India, Tippoo was left to contend, unaſſiſted, againſt the whole power of Britain, and of its allies in the eaſt. By the conqueſt and diviſion of his territory, the Britiſh power was left without a rival in that quarter of the world, and raiſed to ſuch a ſtate of impoſing ſuperiority, that if affairs are only preſerved in their preſent ſituation, by periodical ſupplies of European troops, no native prince, or even combination of princes, can henceforth bring it into danger. Thus, notwithſtanding the vaſt military efforts made by the people of France during this revolutionary war, yet all foreigners who truſted to their aid were ruined by placing confidence in them. In Italy, Germany, Switzerland, and Holland, the rapacity of the commiſſaries of the French government, ſoon rendered odious and intolerable the preſence of thoſe armies whoſe arrival had been eagerly deſired. In Ireland and in India, the promiſe and the hope of aſſiſtance which they were never able to beſtow, only ſerved to produce premature hoſtility, and to encreaſe and eſtabliſh the power of the Britiſh government.

But to return to the domeſtic hiſtory of France, which has now become only an hiſtory of the uſurpation of Bonaparte.

394 New conſtitution of France.

In the middle of the month of December, the Conſuls, with their legiſlative committees, produced to the public their plan of a new conſtitution, which they preſented to the primary aſſemblies, and which is ſaid to have been accepted by them without oppoſition, like all the former conſtitutions. It is a very ſingular production, and neither admits of repreſentative government, nor indeed of any other form of political freedom. Eighty men, who elect their own ſucceſſors, poſſeſs, under the appellation of a *Conſervative Senate*, the power of nominating the whole legiſlators and executive rulers of the ſtate; but cannot themſelves hold any office in either of theſe departments. The ſovereignty is concentrated in one man, who, under the title of *Chief Conſul*, holds his power for ten years, and may be re-elected. The whole executive authority is entruſted to him, and he enjoys the excluſive privilege of propoſing new laws. He is aſſiſted by two other conſuls, who join at his deliberations, but cannot controul his will. The legiſlative power is entruſted to two aſſemblies: the one, conſiſting of 100 members, called a *Tribunate;* and the other, of a *Senate*, of 300 members. When a law is propoſed by the Chief Conſul, the Tribunate may debate about it, but have no vote in its enactment. The Senate votes for or againſt its enactment, but cannot debate about it. Neither the Conſuls, nor the members of the legiſlative bodies, nor of the conſervative ſenate, are reſponſible for their conduct. The miniſters of ſtate, however, who are appointed by

French Revolution, 1799.

the Chief Conſul, are reſpoſible for the meaſures they adopt.

The people in the primary aſſemblies elect one-tenth of their number as candidates for inferior offices; perſons thus choſen, elect one tenth of themſelves as candidates for higher offices; and theſe again elect a tenth of themſelves as candidates for all the higheſt offices of the ſtate. Out of this laſt tenth the Conſervative Senate muſt nominate the conſuls, legiſlators, and members of their own body. But this laſt regulation is to have no effect till the ninth year of the republic. In the mean time, the ſame committees that framed the conſtitution, appointed alſo the whole perſons who were to exerciſe the government. Bonaparte was appointed Chief Conſul, and Cambaceres and Lebrun ſecond and third Conſuls. Sieyes, with his uſual caution, avoided taking any active ſhare in the management of public affairs, and was appointed, or appointed himſelf, a member of his own Conſervative Senate; the whole being regarded as produced by him. As a gratuity for his ſervices, the Chief Conſul and his legiſlators preſented to him an eſtate belonging to the nation, called *Croſne*, in the department of Seine and Oiſe.

395 Abſolute power of Bonaparte.

Thus, after all their ſanguinary ſtruggles for freedom, did the ſon of a Corſican drive from their ſtations the repreſentatives of the French nation, and aſſume quiet poſſeſſion of the government of that country, with a power more abſolute than ever belonged to its ancient monarchs. The eſtabliſhed privileges of the clergy, the nobles, and the parliaments, always reſtrained, in ſome degree, the deſpotiſm of the kings of France; theſe being now deſtroyed, the will of Bonaparte could meet with no controul. Though an uſurper, however, he has not hitherto been a tyrant. He has rather attempted to induce the French nation to acquieſce in his authority, in conſequence of the mildneſs with which it has been exerciſed, and of the ability and reputation of the men whom he has employed in the public ſervice. He immediately ſent propoſals for negociating peace to the different powers at war with France. Great Britain refuſed to liſten to him on account of the probable inſtability of his government, and Auſtria appears to have given a ſimilar refuſal. It is indeed difficult to believe that he wiſhed his propoſals to be accepted. They were not addreſſed to the belligerent powers in the aggregate, but to each individually, as if his object had been to ſow diſſention and miſtruſt between the allies. When he made theſe propoſals, he did not even know whether the people of France would accept of the conſtitution which he had offered them; and he had taken no meaſures to procure a repeal of thoſe revolutionizing decrees which were the immediate cauſe of the war with England.

396 Difficulty of his ſituation.

His ſituation is, in the mean time, attended with great difficulties. The want both of an hereditary title, and of a national repreſentation as the baſis of his power, renders his character as an uſurper ſo obvious, that it is only by very cautious meaſures that his elevation can be maintained. If he is either unſucceſsful abroad, or compelled to preſs the people for money at home, there is little doubt that his fall muſt follow. Even independent of either of theſe events, it is a poſſible caſe that the violent Jacobins may recover their loſt energy, and by force or fraud deſtroy the man who has baffled all their projects. From the royaliſts he has leſs to fear; for the men of ardent ſpirits and violent paſſions belonging to that party, from whom alone great efforts can ever be expected, were early tempted to leave the country by the hopes held out to them by the coaleſced powers, which, by weakening, has hitherto prevented their party from becoming of much importance in the interior of France.

French Revolution 1800.

1800.

In the mean time, Bonaparte has been ſucceſsful in ſuppreſſing a new royaliſt revolt which had ariſen in La Vendee, and has made great exertions to begin the campaign with vigour. The low ſtate of the French finances, however, have much enfeebled all his efforts towards aſſembling very numerous armies. The army which he left in Egypt, after concluding a treaty with the Grand Vizier, by the terms of which they were to be landed ſafe in France, have ſeen reaſon to break the truce which had been agreed on. Kleber has attacked and completely defeated the main body of the Turkiſh army, while a detachment of that army has entered Cairo, and maſſacred, it is ſaid, every Frenchman found in the city, not ſparing the members of the National Inſtitute. The probable conſequence of this is, that no part of the army of Egypt will ever return to Europe.

397 Army of Egypt.

398 Recommencemer of war in Europe.

War has been recommenced between the Auſtrians and France, both in Switzerland and in Swabia, and carried on with great vigour. Maſſena, after giving complete proofs of conſummate ſkill, and the moſt undaunted valour, has been for ſome time blocked up in Genoa; and unleſs he has been relieved by the vigorous exertions of the Chief Conſul, he muſt before this period (June the 12th) have ſurrendered to the Auſtrian General Melas. The affairs of the French in that quarter ſeem indeed to be deſperate; but in Germany they have hitherto been ſucceſsful. Moreau has diſplayed his wonted abilities, and the gallant Kray has retreated before him, whether from neceſſity or to draw him into inextricable difficulties, a very ſhort time will evince.

* * *

399 Abrupt conclufior of this na rative.

But here we muſt interrupt this detail, without the fainteſt proſpect of bringing it to a concluſion during the publication of the preſent Work. We cannot, however, diſmiſs the momentous ſubject without correcting ſome errors into which we fell in the account of the riſe and progreſs of this revolution which was publiſhed in the *Encyclopædia*. We do not conſider theſe errors as diſgraceful to ourſelves; for in the midſt of commotions which have convulſed all Europe, it is hardly poſſible to arrive at the truth. When time ſhall have cooled the paſſions of men, and annihilated the parties which now divide the nation, the calm voice of Truth may be everywhere heard; but when the article referred to was written, the ears of every man was ſtunned with the clamour of faction.

400 Errors in the form part of th article co rected.

So ſenſible of this are the editors of the only impartial periodical hiſtory * which we have, that they venture not to publiſh their volumes till ſeveral years have elapſed from the era of the tranſactions which theſe volumes record; whilſt their rivals—the panders of faction—ſeize the earlieſt opportunities of obtruding their partial ſtatements and falſe reaſonings on the public mind.

It cannot be ſuppoſed that one or two men, ſuperintending the publication of a work ſo extenſive, and treating of ſubjects ſo various, as ours, have leiſure or opportunity to examine with much attention the correſpondence of ambaſſadors, or to expiſcate truth from the contradictory publications of the day. We are therefore

---

* *Old A nual Reg ſter.*

French Revolution.

therefore obliged to draw our materials from ſuch works as profeſs to give a ſummary, but impartial, detail of what is acting on the theatre of the world; and by theſe works we have often been miſled. For the firſt error, however, which we ſhall notice in our former account of the riſe of the revolution, we cannot plead even this excuſe. We ought to have known, that the French clergy and French nobleſſe were not exempted from the payment of taxes; and, of courſe, we ought not to have aſſigned ſuch exemption as one of the cauſes of the REVOLUTION. See that article, *Encycl.* n° 8. and 9.

401 First error.

By a writer, to whoſe patriotic exertions this country is deeply indebted, it has been proved, with a force of argument which precludes all poſſibility of reply, that the exemption from taxes ſo loudly complained of was very trifling, that it was not confined to the nobility and clergy, and that it did not extend over the whole kingdom of France. "The *vingtiemes*, which may be conſidered as an impoſt merely territorial, was paid alike by the nobility and the *tiers-etat*. A great part of the clergy was indeed exempted; but their contributions, under a different form, conſtituted an ample equivalent. The duties upon the different articles of conſumption were of courſe paid by all the conſumers, except that in the *pays d'etat*, ſuch as Artois and Brittany; the two firſt orders were exempted from paying the tax upon liquors. But theſe exemptions cannot be deemed very important, when it is known, that in the province of Artois they did not exceed 800 guineas annually, even including the exemptions enjoyed by the privileged members of the *tiers-etat*." The Britiſh officers ſerving on board ſhips of war are exempted from the taxes paid by the other members of the ſtate on wine; and we believe no good ſubject has ever murmured at that exemption. The French nobility were ſubject to the pole-tax.

"Of the *teilles*, the impoſt from which it has been falſely aſſerted that the nobility and clergy enjoyed a total exemption, there were two ſpecies; the one *perſonal*, the other *real*. In one part of the kingdom, the right of exemption was annexed to the property; in the other, to the quality of the proprietor. In the firſt caſe, the privilege was enjoyed by every claſs of perſons, by the tenants as well as the proprietor of a fief; whilſt the gentleman, whoſe eſtate was holden by a different tenure, was obliged to pay the tax. In thoſe provinces where the other cuſtom obtained, the exemption was confined to a certain extent of property, and to *that* only while it continued in the actual occupation of the privileged perſon; but as it very ſeldom happened that the French nobility kept any land in their own hands, and as the tax payable by the farmers was of courſe deducted from the rent, the *teilles* was, in this caſe, ultimately paid by the landlord. The ſame obſervations apply, with ſtill greater force, to the clergy, who always let their eſtates."

In a word, it appears from a formal declaration made by M. Necker to the Conſtituent Aſſembly, that all the pecuniary exemptions enjoyed by the privileged claſſes did not exceed L.292,000; that the exemptions appertaining to the privileged perſons of the *tiers-etat* amounted to one half of that ſum; and the *drôits de controle*, or duty impoſed upon public deeds, and the high capitation tax (proportioned to their rank), paid by the nobility and clergy, made ample amends to the revenue for the partial exemptions which they enjoyed from other taxes. So far indeed were the *tiers-etat* from murmuring at the exemptions of the privileged orders, that, previous to the illuminiſm of the 18th century, they diſplayed, at every convention of the ſtates-general, the greateſt anxiety to maintain the rights of the nobility and clergy; and humbly ſupplicated their ſovereign to ſuffer no invaſion thereof, but to reſpect their franchiſes and immunities *.

402 Second error.

We muſt likewiſe acknowledge, that in n° 11. of our article REVOLUTION, we have drawn a very overcharged picture of the miſeries and oppreſſion of the French peaſants under the old government. It is indeed true, that they were obliged to ſerve in the militia, the eſtabliſhment of which was conducted in France nearly on the ſame principles as it is in England. The men were called out by ballot only for a few days in the year during peace, when they received regular pay; but if a militia forms the beſt conſtitutional defence of a ſtate, this ſurely ought not to have been conſidered as a grievance, eſpecially ſince married men were exempted from the ſervice. The nobility, too, were exempted from the riſk of being drawn, for the beſt of all reaſons—becauſe moſt of them had commiſſions in the regulars, and becauſe ſuch as had not were engaged in profeſſions, which rendered it impoſſible for them to ſerve in the militia. In France, as elſewhere, the peaſants would no doubt be averſe from this ſervice, and might look perhaps with an anxious eye to the ſuppoſed immunities of their privileged ſuperiors: but if mirth, good humour, and ſocial eaſe, may be conſidered as ſymptoms of felicity and content, theſe men ſurely were not miſerable; for theſe ſymptoms never appeared in any people ſo ſtrong as among the French peaſants. They were indeed liable to be called out by the intendants of the provinces to work a certain number of days every year on the public roads; but to this ſpecies of oppreſſion, if ſuch it muſt be called, the Scotch peaſants are liable, and were ſtill more ſo than at preſent, during that period when our parliamentary orators declare that the inhabitants of Britain enjoyed as much freedom as is conſiſtent with the public tranquillity. It ought to be remembered, too, that Louis XVI. whoſe higheſt gratification ſeems to have conſiſted in contributing to the eaſe and welfare of his ſubjects, thought he ſaw the neceſſity of aboliſhing the cuſtom of the *corvée*, and had made conſiderable advances towards the accompliſhment of that object ſome years before the commencement of the revolution.

403 The French monarch not deſpotic.

That the French monarch was deſpotic; that no man in the kingdom was ſafe; that nothing was unknown to the jealous inquiſition of the police; and that every man was liable, when he leaſt expected it, to be ſeized by *lettres de cachet*, and ſhut up in the gloomy chambers of the Baſtile—has long been common language in England, and language which we muſt confeſs that we have adopted (REVOLUTION, n° 12.) without due limitations. The French government was certainly not ſo free as that of Britain; but he who underſtood it better than we do, and whoſe writings betray no attachment to arbitrary power, expreſsly diſtinguiſhes between it and *deſpotiſm*. "If (ſays Monteſquieu) France has, for two or three centuries paſt, inceſſantly augmented her power, ſuch augmentation muſt not be aſcribed to fortune, *but to the excellence of her laws* †." This,

---

* See *Gifford's Letter to the Earl of Lauderdale*, 2d ed.

† *De l'Eſprit des Loix*, liv. 20. c. 20.

This, ſurely, is not the language of a man who thought himſelf governed by an arbitrary tyrant whoſe *caprice* is the law; nor will it be ſaid to be the language of one who was either afraid to ſpeak the truth or not maſter of his ſubject.

404 No change of the old conſtitution wiſhed by the people of France.

The inſtructions of all the different orders to their repreſentatives, before the fatal meeting of the States General under the unfortunate Louis, are drawn up in language ſimilar to that of this illuſtrious magiſtrate, and furniſh a complete proof that they knew themſelves to be ſafe under the government of their monarchs. "The conſtitution of the ſtate (ſay the clergy) reſults from the *fundamental laws*, by which the reſpective *rights* of the *king* and of the *nation are aſcertained*, and from which not the ſmalleſt deviation can be made. The firſt of theſe laws is, that the government of France is purely monarchical. The nation muſt preſerve inviolate the form of its government, which it acknowledges to be a *pure monarchy regulated by the laws*; and ſuch it will have it to remain."

On the 28th of November 1788, in a general committee of the nobles aſſembled at Verſailles, the Prince of Conti delivered a note to the preſident, which was ſanctioned by the concurrence of moſt of the other princes of the blood, and was ſuppoſed to ſpeak the general ſenſe of the nobility; in which it was inſiſted, that the *proſcription of all* NEW SYSTEMS *was neceſſary* to inſure the ſtability of the throne, of *the laws*, and of *order*; and that the conſtitution, *with the ancient forms*, ſhould be preſerved entire. In their inſtructions to their repreſentatives, they inſiſt that it ſhall be expreſsly and ſolemnly proclaimed, that the conſtitution of the French empire is ſuch, that its government is, and muſt remain, monarchical; that the king, as ſupreme chief of the French, is only ſubordinate to the fundamental law of the kingdom, according to which the conſtitution muſt be eſtabliſhed on the ſacred and immutable principles of monarchy, tempered by the laws; and this form of government cannot be replaced by any other conſtitution.

"Let our deputies (ſays the third eſtate), before they attend to any other object, aſſiſt in giving to France a truly monarchical conſtitution, which muſt invariably fix the *rights* of the *king* and of the *nation*. Let it be declared, that the monarchical is the only form of government admiſſible in France; and that in the *king alone*, as chief of the nation, is veſted the power of *governing according to the laws*." Is this the language of men groaning under the iron rod of deſpotiſm, or wiſhing to reduce the power of the crown?

Even after the power of the crown was almoſt annihilated, and the order of nobility done away, ſo far were theſe innovations from being acceptable to the enlightened part of the French nation, that in many departments of the kingdom they excited open inſurrections, whilſt the members of all the provincial parliaments oppoſed them with unanſwerable arguments furniſhed by the law. The chamber of vacation of the parliament of Toulouſe, in particular, proteſted againſt the proceedings of the States General, becauſe the deputies, who were empowered only to put an end to the ruinous ſtate of the finances, could not change the conſtitution of the ſtate without violating their inſtructions, and the faith ſworn to their conſtituents *.

405 Lettres de cachet.

That *lettres de cachet* were liable to abuſe, and that occaſionally they were groſsly abuſed, is certain. The uſe of them ought therefore to have been either annulled, or, which would have been infinitely better, ſubjected to ſuch rules as ſhould prevent all danger from them to the real liberties of the people; for the government would be of no uſe whatever which ſhould poſſeſs no power capable of being abuſed by deſpotiſm. Yet after all the noiſe that has been made about *lettres de cachet*, it is but juſtice to obſerve, that in the towers of the Baſtile, when it was taken by the mob, were found no more than ſeven priſoners; of whom four were confined for forgery; one was confined at the requeſt of his family on charges of the moſt ſerious nature; and two were ſo deranged that they were ſent next day, by thoſe philanthropiſts who had taken them out of comfortable chambers, to the mad houſe! That the chambers of the Baſtile were as comfortable as the chambers of a priſon could be, we are aſſured by M. Bertrand de Moleville, who can be under no inducement to deceive the Britiſh public, and whoſe opportunities of diſcovering the truth were ſuch as no man will call in queſtion.

406 Blunder of Necker.

In our account of the opening of the States General, we have expreſſed too much deference to the character of M. Necker. To that man's irreſolute, if not treacherous, conduct, may, with truth, be attributed all the ſubſequent miſeries of France. It was about the mode of verifying their powers that the three orders of the ſtate firſt differed; but that mode ſhould have been defined by the miniſtry in the letters ſent to the different bailliwicks for the convention of the ſtates. Even this omiſſion might have been repaired after the arrival of the deputies at Verſailles; for none of them ſhould have been admitted into the hall of the ſtates, far leſs ſhould the king have met them there, till the Council had been ſatisfied of their being duly elected. Had either of theſe cautions been obſerved, the *tiers-etat* never could have got the aſcendant over the other two orders, and the buſineſs of the nation would have been conducted as formerly in three different chambers. M. Necker's rejection of Mirabeau's advances ſhewed him to be very ill qualified to conduct the helm of affairs at ſuch a criſis; and his abſenting himſelf from the royal ſeſſion, a meaſure which he had adviſed, betrayed the utmoſt ingratitude to his gracious maſter.

407 Royal Seſſion.

In our account of the royal ſeſſion, we were led into a miſtake, which calls loudly for correction. The circumſtances of that ſeſſion were very different from what they appeared to us when we wrote nº 24. and 25. of the article REVOLUTION. The royal ſeſſion was proclaimed in conſequence of the violent uſurpations of the *tiers-etat*, and the irreconcileable differences which ſubſiſted between that body and the two higher orders; and ſo far is it from being true that the preſident and members of the third eſtate found their hall *unexpectedly* ſurrounded by a detachment of guards, that their ſittings were only *ſuſpended*, for the beſt of all reaſons, with thoſe of the other orders. To be convinced of this, we need but to attend to the following proclamation which was made by the heralds, on the 20th of June, between ſeven and eight o'clock in the morning, in the ſtreets and croſs-ways of Verſailles:

"June 20th. (By order of the King.) The King having reſolved to hold a royal ſitting in the States General, on Monday next the 22d of June, the preparations to be made in the three halls uſed by the aſſemblies

---

* See the proteſt at large in *Bertrand's Memoirs*, vol. iii. c. 13.

F nch Re ution. blies of the orders, make it neceſſary that thoſe aſſemblies ſhould be ſuſpended until after the ſaid ſitting. His Majeſty will give notice, by another proclamation, of the hour of his going to the Aſſembly of the States on Monday."

M. Bailly, the preſident of the *tiers-etat*, had been made acquainted with the object of this proclamation, by a private letter which was ſent to him by the Marquis de Brezé at ſeven o'clock in the morning; and to which he replied, "that having received no orders from the King, and the aſſembly having been announced for eight o'clock, he ſhould attend where his duty called him."

He repaired, accompanied by a great number of the members of the *tiers-etat*, to the door of the hall of the States, demanded admiſſion; and on being refuſed by the officer on guard, according to his orders, with which he acquainted him, he declared that he proteſted againſt ſuch orders, and that he ſhould give a report of them to the Aſſembly. To do this he had not far to go, as three fourths of the deputies of the *tiers-etat* were already collected round him, or in the avenue leading to the palace. There it was that, ſurrounded by an immenſe crowd of people, they declaimed in the moſt violent manner againſt this pretended act of deſpotiſm. "The National Aſſembly is to be diſſolved (ſaid they), and the country to be plunged into the horrors of a civil war. *Want* reigns every where; every where the people ſee *famine* ſtaring them in the face. This we were about to put an *end to*, by rending the veil which covers the manœuvres of the monopoliſts, the engroſſers, and the whole tribe of miſcreants. The Louiſes XI. and XIII. the Richelieus, the Mazarins, the Briennes, attacked with their deſpotiſm only individuals or ſmall bodies; but here it is the whole nation that is made the ſport of the whims of a deſpotic miniſtry. "Let us meet upon the *Place d'Armes* (ſaid one of thoſe orators); there we ſhall recal ſome of the nobleſt days of our hiſtory, *the National Aſſemblies of the field of May*." "Let us aſſemble in the gallery of the palace (ſaid another); there we ſhall preſent a new ſight, by ſpeaking the language of liberty, in that corrupt hall, where a little while ſince the head of him who ſhould have uttered that ſacred word would have been devoted to the executioner.—"No, no (ſaid a third), let us go to Marli, and hold our ſitting on the Terrace:—let the King hear us; he will come from his palace, and will have nothing more to do than to place himſelf in the midſt of his people to hold the royal ſitting."

408 F ious i lence of t aſſem- b

At the concluſion of theſe declamations, the ſole object of which was to alarm and exaſperate the people, the Aſſembly decided upon transferring their ſitting to the Tennis-court, in the ſtreet called *Rue du Vieux Verſailles*. There M. Bailly read the letter which he had received from M. de Brezé, and his anſwer to it; which he had ſcarcely done, when a ſecond letter from M. de Brezé was put into his hands, the contents of which were as follows:

"It was by the King's poſitive order, Sir, that I did myſelf the honour of writing to you this morning, to acquaint you that, his Majeſty purpoſing to hold a royal ſitting on Monday, and ſome preparations being requiſite in the three halls of the Aſſemblies of the orders, it was his intention that no perſon ſhould be admitted into them, and that the ſittings ſhould be ſuſpended till after that to be held by his Majeſty." French Revolution.

In this there was ſurely no marked diſreſpect to the repreſentatives of the people; but ſuch notions were countenanced by M. Necker, who appears indeed, on this occaſion, to have been in cloſe compact with the leaders of the mob. The popular violence that was employed to compel the majority of the clergy to join the *tiers-etat* is well known; and we have, in *Bertrand's Annals of the Revolution*, what amounts to evidence almoſt *legal*, and quite ſufficient to enforce conviction, that Necker directed that violence.

In our account of the commotions which were excited in Paris on the firſt diſmiſſion of that miniſter and his baniſhment from the kingdom, we have been led by our democratic journaliſts to give circulation to a groſs calumny publiſhed by them againſt the Prince de Lambeſc. (See REVOLUTION, n° 36. and 37.) The truth, which is ſo much diſguiſed in theſe two numbers, is as follows:

409 Conduct of the Prince de Lambeſc vindicated.

"A detachment of the Royal Allemand, ſent to diſperſe the mob which was patroling the ſtreets in proceſſion with the buſts of Necker and the infamous Orleans, received a volley from the French guards as they were paſſing their quarters on the *Chauſſee d'Antin*, ſtopped to return it, and continued their march without quickening their pace. There were ſome ſoldiers killed and wounded on both ſides, but fewer of the regiment of Royal Allemand than on that of the French guards.

"The detachment marched to the Place Louis XV. and there found a body of dragoons who had been diſperſing the proceſſion. The two buſts were broken to pieces; and the populace in their fright taking refuge in the garden of the Thuilleries, the Prince de Lambeſc purſued them thither, at the head of the detachment of Royal Allemand, according to the orders which he received. This ſmall troop coming up to the head of the *Pont-tournant* (or turning bridge), at the extremity of the garden, found a kind of barricade, haſtily formed by chairs heaped upon one another: while they were removing this obſtacle, they received a ſhower of ſtones, broken chairs, and bottles, from the two terraces, between which the Prince de Lambeſc drew up his troop, keeping conſtantly at their head. Some guns and piſtols were diſcharged at them, which did no hurt; but ſeveral of the troopers were much bruiſed by the things that had been thrown at them, and an officer was ſeverely wounded by a ſtone.

"The Prince de Lambeſc, keeping at ſix paces from the bridge, oppoſed only a ſteady front to the aggreſſions of the populace. Seeing that this poſt became untenable, and that it was impoſſible for him any longer to reſtrain his troopers from repelling force by force, he gave the order for retreating out of the garden. At the ſame inſtant a cry was heard from all ſides of, *turn the bridge, turn the bridge;* and ſome perſons, in conſequence, ran and began to do it. The Prince de Lambeſc, juſtly fearing that a moſt bloody carnage would be the inevitable conſequence of it, ordered ſome piſtols to be fired in the air towards the bridge, to awe thoſe who were ſtriving to turn it. As the report of this volley did not deter them, he rode up himſelf, and with his ſabre ſtruck one of thoſe who were working hardeſt. The man ran off; and the Prince paſſing the bridge with

with his detachment into the Place Louis XV. drew up near the Statue, and being ſoon joined by the Swiſs regiment of Chateauvieux, took his poſt with this force near the *Garde-meuble*, where he remained ſome time, having placed the infantry before him. At ten at night part of the troops were diſmiſſed to their quarters, and the reſt ſent to Verſailles." Theſe facts being all judicially confirmed, prove how much the Prince de Lambeſc's conduct was calumniated by thoſe journaliſts whoſe detail we raſhly adopted.

410 True account of the taking of the Baſtile;

In our account of the taking of the Baſtile, miſled by our treacherous guides, the journaliſts, we have greatly magnified the military ſkill and proweſs of the aſſailants. That celebrated fortreſs was defended by a garriſon conſiſting of no more than 114 men, of whom 82 were invalids. It was attacked by 30,000 men and women, armed with muſkets and pikes, and furniſhed with a train of artillery which they had found at the *Hotel des Invalids*, given up to them by the timidity of the governor. Even this multitude would have been quickly repulſed from the Baſtile, if the governor of that ſtate-priſon, who had received no orders from the court, had been leſs reluctant to ſhed the blood of his rebellious countrymen; for the Pariſian mob had then diſplayed nothing of determined courage. A few diſcharges of muſquetry, and one of caniſter-ſhot from a ſingle cannon, had thrown them into confuſion, and made them ſkulk behind the walls, when the ill-timed humanity of the governor made him enter into a treaty with the rebels, ſtipulating only that the garriſon ſhould not be maſſacred. How the ſtipulation was obſerved with reſpect to the governor himſelf, we have faithfully related; but we were miſtaken when we ſaid that the "French guards ſucceeded in procuring the ſafety of the garriſon." The guards, with the utmoſt difficulty, ſaved indeed ſome of them, but moſt of the invalids remaining in the courts of the caſtle were put to death in the moſt mercileſs manner.

411 And of the murder of M. de Fleſſelles.

Our account of the murder of M. de Fleſſelles (n° 40.) appears likewiſe to be very incorrect. This man was preſident of the Aſſembly of Electors at Paris (See REVOLUTION, n° 45.), and had not quitted the *Hotel de Ville*, where their rebellious meetings were held, during the whole time of theſe dreadful commotions. He had even ſigned all their atrocious reſolutions, but became ſuddenly ſuſpected from the conſternation which he manifeſted at the ſight of ſo many horrors, and eſpecially at the cruel and treacherous murder of the governor of the Baſtile. The conſequence was, that he was treacherouſly murdered himſelf by one of the villains compoſing that aſſembly in which he preſided. "The electors (ſays M. Bertrand de Molleville) hoped to extenuate the horror of this aſſaſſination, by cauſing it to be conſidered as a natural and almoſt lawful vengeance for a treachery, the proof of which they pretended to have. In fact, they declared, that when M. de Launay, the governor of the Baſtile, was arreſted, a letter had been found in his pocket from M. de Fleſſelles, containing this expreſſion: 'I am amuſing the Pariſians with cockades and promiſes; hold out till night, and you will receive a reinforcement.' But this ſuppoſed letter, which, had it exiſted, they would not have failed to preſerve very carefully, was never ſeen by any body; and I heard M. Bailly himſelf ſay, in a viſit he paid me when he left the mayoralty, that he had no knowledge of it, and that it was not in his power to refer to any one who had told him that he had read it."

412 Ambition and cowardice of the Duke of Orleans.

In our account of the earlier tranſactions of the Revolution, we omitted to mention a very extraordinary inſtance of ambition to which the Duke of Orleans was incited by Count Mirabeau, but which that unnatural monſter wanted courage to carry into effect. During the commotions which prevailed in the capital on the diſmiſſal of M. Necker from the miniſtry, Orleans was perſuaded by Mirabeau to offer his ſervices as mediator between the king and his rebellious ſubjects; but to ſtipulate, at the ſane time, for his appointment to the high office of lieutenant-general of the kingdom as neceſſary to give his mediation due weight with the rebels. The real object of the profligate Count, in this dangerous propoſal, and which he did not deign even to conceal, was to pave the way for the infamous Duke ſtepping into the throne of his relation and virtuous ſovereign. He even went ſo far as to compoſe the ſpeech with which Orleans was to addreſs the king on the occaſion; but that coward, when he arrived at the palace, was ſo embarraſſed by the conſciouſneſs of his own wicked deſigns, that inſtead of aſking the office of lieutenant general, he only requeſted permiſſion to retire into England!! A requeſt which was inſtantly granted.

This brought upon him the contempt and indignation of Mirabeau; but ſtill there was a party deſirous of placing him on the throne. This we think evident from an atrocious fact mentioned in all the journals, and confirmed by M. Bertrand. "When the king, on his firſt viſit to Paris (See n° 44.) had arrived at the *Champ Eliſées*, three or four guns were fired at once. It was never known whence they proceeded; but it is certain that an unfortunate woman in the crowd, who was in the direction of his Majeſty's carriage, was ſhot at the time, and fell dead on the ſpot." As the King's carriage held at the time exactly four perſons, M. Bertrand very naturally concludes that theſe four ſhots, fired at once in its direction, had been ordered and paid for; and we are unwilling to believe that at that period of the revolution there was any party diſpoſed to *pay* for the murder of the ſovereign but the Duke of Orleans and his infamous adherents. That he was equal to this wickedneſs cannot be doubted, when it is known that legal evidence was afterwards produced that he, with ſome other members of the Aſſembly, ſecretly directed the inſurrection of the 5th of October, and promoted the outrages of that and the ſucceeding day by the diſtribution of money and bread *.

413 M. Memmay vindicated.

We have ſaid (n° 48.), the origin of the report of a train of gunpowder being laid by M. de Memmay, to blow into the air a number of patriots, has never been well explained. It was proved judicially, that at the period when the feaſt was given by M. Memmay to the inhabitants of Veſoul, he was ſetting vines in a ſtony ſoil, where he was often obliged to blow up the greater rocks. Some ſoldiers running through, and ferreting every where in the houſe and out-houſes, unfortunately took a candle to the dark corner where the barrel of gunpowder was lodged, and ſet it on fire, in trying to ſee if it contained wine. Theſe facts, reported and atteſted in a memorial drawn up by M. Courvoiſier, ſo completely juſtified M. de Memmay, that the Aſſem-

---

* Bertrand's Annals, vol. ii. ch. 13.

F..ch Rev..tion.

bly could not avoid teſtifying his innocence by a decree iſſued the 4th of June.

414 The ..wers of t.. aſ-ſem.. in dan.. of bein.. re-call by its ..ſti-tue..

In n° 70. we have ſaid that the National Aſſembly, after its removal from Verſailles to Paris, was in tolerable ſecurity; but M. Bertrand has proved, by evidence the moſt incontrovertible, that it did not think itſelf ſecure; and that if the miniſters had been capable of employing events to their own advantage, the powers of that factious body muſt have been recalled by its own conſtituents. The horrible outrages committed on the 5th and 6th of October had ſhocked all France. The wanton confiſcation of the property of the church, had demonſtrated to every man of ſound judgment, that under the new order of things no property could be ſecure; and by the deſertion of its more virtuous and moderate members, the Aſſembly had become *a rump aſſembly*. It was therefore much alarmed when the intermediate commiſſion of the ſtates of Cambreſis entered, on the 9th of November, into a reſolution, in which, conſidering—"that certain decrees of the National Aſſembly are paving the way for the ruin of the kingdom, and the annihilation of religion; that if they have been able to place one ſpecies of property at the diſpoſal of the nation, men of all kinds of property may expect the ſame fate; they declare, from this moment, the power of the deputies of Cambreſis to the National Aſſembly to be null and revoked." Had M. Necker and his colleagues had addreſs to get ſimilar reſolutions entered into at the ſame time by the electors of all the bailiwicks of the kingdom, the Aſſembly muſt have been diſſolved, and France, even then, might have been ſaved; but thoſe miniſters were themſelves nothing more than the humble and docile agents of the Aſſembly.

415 T.. ac-co.. of the re.. book,

There is no part of our former narrative more incorrect, or more likely to miſlead the public, than our account of the *red-book* (n° 75.). It is ſuch, however, as was then current, without any addition or aggravation by us. The villains (K) who, in direct contradiction to their own ſolemn promiſe, as well as to every principle of honour, made part of that book public, had the impudence to affirm, that, by the ſuppreſſion of the ſuperfluous penſions regiſtered in it, a ſaving would be made to the public *of near a fifth in the bulk of the expences of every year*. M. Bertrand, taking for granted the accuracy of their ſtatements, for the exaggeration of which, however, he urges arguments more than plauſible, proves, if arithmetical calculation affords proof, that by the ſuppreſſion of ſuch penſions as even *they* called ſuperfluous, the ſaving in the bulk of the annual expences could not poſſibly have amounted to more than *the two hundredth part!* It was not therefore without reaſon that M. Necker, in anſwer to their publication, ſaid, "I know not whether the books of the finances of any ſovereign in Europe can ſhew a ſimilar total."

416 .. of the ..iny at N..cy.

Our account of the mutiny of the ſoldiers at Nancy (n° 83.) is very inaccurate. Far from being excited by the officers, that mutiny was the natural conſequence of the abſurd decrees of the Aſſembly; which having declared *all men equal*, and made it criminal to puniſh diſobedient ſoldiers in that ſummary way, without which no armed force can be commanded, had completely diſorganiſed the army, and ſubſtituted for martial law patriotic exhortations, legiſlative decrees, and the novel juriſdiction of municipalities. The ſoldiers knew their own ſtrength, of which indeed they were continually informed by the friends of the revolution; and while they ſhook off the authority of their military commanders, they laughed at the impotent decrees of the Aſſembly. At Nancy they had impriſoned two general officers, and committed other outrages of the moſt ſerious nature. It was the duty of the Marquis de Bouillé, as governor of the province, to reduce the inſurgents by force, if force ſhould be found neceſſary; but he had accompliſhed his object without ſhedding blood, and was congratulating the two liberated generals, and ſome of the principal inhabitants, upon ſo happy a termination of the affair, when the populace, and many ſoldiers who had not followed their colours, fired upon the troops under his command, and killed fifty or ſixty men. The troops immediately returned the fire; and a great number of the rebellious mob and mutinous garriſon were of courſe put to the ſword. That ſuch able and firm conduct in Bouillé excited indignation among the Jacobins of Paris, is very probable; but even the king himſelf did not expreſs higher approbation of it than the National Aſſembly, who were duly ſenſible that it ſaved themſelves from deſtruction, which, had he failed in his enterpriſe, would have been inevitable. Three months afterwards, indeed, when the fabrication of counter-revolutionary plots became part of the daily buſineſs of this enlightened Aſſembly, ſome cenſures were thrown by the Jacobins upon the Marquis's conduct on this occaſion; and thoſe cenſures were loudly applauded.

French Revolution.

417 M. de Bouillé vindicated.

We have likewiſe been led, by our fallacious guides, to accuſe this gallant officer (n° 91.) of having laid open the country to the inroads of foreign armies; and we have given an incorrect account of the king's flight from Paris. There is no evidence whatever for the truth of the charge againſt the Marquis de Bouillé, and it is directly contrary to his general character. He was indeed a royaliſt, and would doubtleſs have cooperated with the Prince of Condé and the other emigrants in reſtoring the king to his lawful authority; but he was likewiſe a Frenchman and a patriot in the beſt ſenſe of the word; and he would have died in defence of the rights and independence of his country. He certainly meant to protect the king in his journey from Paris to Montmedi, where it was to terminate; and he had ſtationed troops of dragoons on the road for that purpoſe; but the unfortunate Louis had delayed his journey a day longer than was agreed upon; and even when he ſet out, neglected to ſend couriers before him to warn the troops of his approach. He thus travelled unprotected; and the conſequence was ſuch as we have related. Yet the gallant Bouillé, tho' this journey was undertaken contrary to his advice, declared himſelf the author of it, in that letter in which he threatened the Aſſembly with vengeance of all Eu-

rope

(K) Theſe were the Marquis de Montcalm-Gozon, Baron Felix de Wimpfen, de Menou, Freteau, L. M. de Lepeaux, the Abbé Expilly, Camus, Goupil de Prefeln, Gautier de Biauzat, Treilhard, Champeaux-Palaſuc, and Cottin.

rope if they ſhould dare to touch a hair of the heads of the royal family.

418 Erroneous account in n° 90. corrected.

In n° 90. we have moſt unaccountably ſaid that the king was permitted to continue his journey to St Cloud. This is directly contrary to truth. The preſident, after hearing his complaint againſt thoſe who had prevented it, replied indeed in a ſpeech, containing ſome expreſſions of gratitude and affection, mixed with reflections on the refractory prieſts; but the Aſſembly determined nothing reſpecting the propriety of the journey. They did not even ſuffer a ſingle motion to be made on the ſubject; and threatened with impriſonment one of the members who propoſed to take it into conſideration! The king was therefore obliged to abandon this excurſion, though it was firſt undertaken from religious motives; and it was then that he ſeriouſly thought of attempting to elude the vigilance of his rebellious guards, and of taking up his reſidence at Montmedi.

419 Treaty of Pavia a forgery.

In n° 96. we have publiſhed, with doubts indeed of its authenticity, what was called the *treaty of Pavia* and the *convention at Pilnitz*. The terms in which we introduced that ſcandalous fabrication to the notice of our readers, and the principles which we have uniformly avowed through the whole of this voluminous work, furniſh, we hope, ſufficient evidence that we could have no intention to deceive the public. Truth, however, demands of us to acknowledge, in the moſt explicit terms, that the pretended treaty of Pavia is not only a forgery, but a bungling forgery, defective in ſome of the moſt uſual diplomatic forms; and that the conferences at Pilnitz between the Emperor, the King of Pruſſia, and the Count d'Artois, related to objects very different from a partition of the French territories.

So early as the month of May 1791, a plan had been digeſted by the Emperor, the King of Pruſſia, and the King of Spain, with the concurrence of Louis XVI. for liberating that unfortunate monarch from the confinement in which he was kept in his own capital. The means to be employed were a coalition among the principal powers on the continent to lead armies in every quarter to the borders of France. During the alarm which ſo menacing an appearance could not but excite in that kingdom, a declaration by the houſe of Bourbon, complaining of the cruel and iniquitous treatment of its head, was to be circulated through France, and to be immediately followed by the manifeſto of the combined powers. This, it was preſumed, would furniſh a ſufficient reaſon, even to the National Aſſembly, for the king's going to the frontiers, and placing himſelf at the head of the army; but if it ſhould not, petitions were to be procured from the army and the provinces, requeſting his preſence, as the only means left of preventing a civil as well as foreign war. Had this meaſure, which was partly ſuggeſted by Mirabeau and partly by Montmorin and Calonne, been ſteadily purſued, there can be little doubt but it would have proved completely ſucceſsful. It was defeated, however, by the king's ill-concerted attempt to eſcape to Montmedi, and by a very imprudent and degrading letter which he was afterwards perſuaded to ſend to every foreign power.

420 Real convention at Pilnitz.

At Pilnitz, where the Emperor and the King of Pruſſia met, on the 25th of Auguſt, to ſettle between themſelves ſome intereſts too delicate to be adjuſted by the uſual diplomatic modes, an agreement was entered into by them to ſupport the cauſe of the French princes, to liberate the king, and to ſave, if poſſible, the monarchy. They delivered, accordingly, to the Count d'Artois the following declaration:

" His Majeſty the Emperor, and his Majeſty the King of Pruſſia, having heard the deſires and the repreſentations of Monſieur and his Royal Highneſs the Count d'Artois, declare, conjointly, that they conſider the ſituation in which his Majeſty the King of France is at preſent placed, as a matter which concerns the intereſt of every ſovereign of Europe.—They hope that that intereſt will not fail to be acknowledged by the powers whoſe aſſiſtance is required; and that conſequently they will not refuſe to employ, in conjunction with their Majeſties, the moſt efficacious means, according to their abilities, to put the King of France in a ſituation to eſtabliſh, in perfect liberty, the foundations of a monarchical government, equally agreeable to the rights of ſovereigns and the welfare of the French; then, and in that caſe, their Majeſties are determined to act promptly and by mutual conſent, with the forces neceſſary to obtain the end propoſed by all of them. In the mean time they will give orders for their troops to be ready for actual ſervice.

" *Pilnitz, Auguſt 27th*, 1791.

" Signed by the Emperor and the King of Pruſſia."

Such was the agreement entered into at Pilnitz, which was ſo groſsly miſrepreſented by the French Jacobins, and by their zealous partizans in this country. Had not Louis XVI. accepted the conſtitution ſimply and unconditionally, the conſequence of this convention might have been the ſaving of the French monarchy, and the preſervation of peace in Europe; but that acceptance, ſo little looked for by the high contracting powers, completely thwarted their meaſures for a time; and before their armies were put in motion, the monarchy was overturned, and the monarch a priſoner.

421 The Frenc the aggre ſors in the war with Britain.

In our account of the origin of the war between Great Britain and France (n° 147, 148.), we have proved, by evidence which to ourſelves appears irreſiſtible, that the French regicides were the aggreſſors, and that the Britiſh miniſtry did all that could be done, conſiſtently with the independence of their own country, to maintain the relations of amity between the two nations. That we have interpreted fairly that decree of the Convention by which this kingdom was forced into the war, is rendered incontrovertible by a ſubſequent decree on the 15th of December, by which their generals were ordered to regulate their conduct in the countries which their armies then occupied, or *might afterwards occupy*. In the preamble to this decree, they expreſsly declared, that *their principles would not permit them to acknowledge any of the inſtitutions militating againſt the ſovereignty of the people*; and the various articles exhibit a complete ſyſtem of demolition. They inſiſt on the immediate *ſuppreſſion of all exiſting authorities*, the *abolition of rank and privilege* of every deſcription, and the *ſuppreſſion of all exiſting impoſts*. Nay, theſe friends to freedom even declare, that they will treat as enemies *a whole nation* (un peuple entier) which ſhall preſume to *reject liberty and equality*, or enter into *a treaty with a prince or privileged caſts!*

It is worthy of remark, that *the very day* on which this decree, containing a ſyſtematic plan for diſorganizing all lawful governments, paſſed the Aſſembly, the provi-

proviſional executive council wrote to their agent, Chauvelin, inſtructing him to diſavow all hoſtile intentions on the part of France, and to proclaim her deteſtation of the idea of a war with England! Yet the ſame proviſional council, in their comments on the 11th article of this decree, thus expreſs themſelves: "The right of natural defence, the duty of ſecuring the preſervation of our liberty, and the ſucceſs of our arms, the univerſal intereſt of reſtoring to Europe a peace, *which ſhe cannot obtain but by* THE ANNIHILATION OF THE DESPOTS *and their ſatellites*, every thing impoſes on us the obligation of exerciſing all the *rigours of war*, and the *rights of conqueſt*, towards a people ſo fond of their chains, ſo obſtinately wedded to their degradation, as to refuſe to be reſtored to *their rights*, and who are the accomplices, not only *of their own deſpots*, but even of all the *crowned uſurpers*, who divide among themſelves the dominion of the earth and its inhabitants." That Britain is one of thoſe countries which the aſſembly thought their armies might afterwards occupy, and that the great majority of Britons were a people towards whom their principles obliged them to exerciſe all the rigours of war, and the rights of conqueſt, is evident from the following extract of a letter, written on the 31ſt of December 1792, by Monge, a member of the council, and miniſter of the marine to the ſea-ports. "The King and his parliament mean to make war upon us. Will the *Engliſh republicans ſuffer it?* Already theſe free men ſhew their diſcontent, and the repugnance which they have to bear arms againſt *their brothers the French*. Well! we will fly to their ſuccour. We will make a deſcent on the iſland; we will lodge there 50,000 *caps of liberty*; we will plant there *the ſacred tree*; and we will ſtretch out our arms to our REPUBLICAN BRETHREN. *The tyranny of their government will be deſtroyed.*"

As theſe two decrees of November and December 1792 have never been repealed, and as their object is ſo plainly avowed in the commentaries of the executive council, and in this letter of the miniſter of marine, they would alone ſufficiently authoriſe us to adopt as our own the following reflections of M. Bertrand de Moleville*. With theſe, as they give a conciſe but perſpicuous view of the riſe and progreſs of that revolution, or, to ſpeak more correctly, that ſeries of revolutions which has for ſeven long years oppreſſed, not France alone, but all Europe, we ſhall conclude this long article.

422 Bertrand's view of the riſe and progreſs of the revolution.

"Popular inſurrections, and an army (ſays this able and uſeful writer), have hitherto been the uſual means, or chief inſtruments, of every revolution; but thoſe inſurrections being of the moſt ignorant and unthinking claſs of the people, were always fomented by a certain number of factious men, devoted to, and dependent upon, ſome ambitious chief, daring, brave, of military talents, ſole and abſolute conductor of every ſtep of the revolt, and maſter of all the means of the inſurrection. In the hands of this chief, the ſoldiers, or people armed, were but machines, which he ſet in motion or reſtrained according to his pleaſure, and of which he always made uſe to put an end to revolutionary diſorders and crimes, as ſoon as the object of the revolution was gained. So Cæſar and Cromwell, after they had uſurped the ſupreme power, loſt no time in ſecuring it to themſelves, by placing it on the baſis of a wiſe and well-regulated government; and they employed, in quelling the troubles that had favoured their uſurpation, thoſe very legions, that ſame army, which they had uſed to excite them.

"This was not the caſe in France: there, the revolution, or rather the firſt of thoſe it experienced, and of which the others were the inevitable conſequence, was not, whatever be ſuppoſed, the reſult of a conſpiracy, or preconcerted plan, to overturn the throne, or to place an uſurper upon it. It was unexpectedly engendered by a commixture of weakneſs, ignorance, negligence, and numberleſs errors in the government. The States General, however imprudent their convocation may have been, would have produced only uſeful reforms, if they had found the limits of their power marked out by a hand ſufficiently firm to have kept them within that extent. It was, however, but too evident that, even before their opening, they were dreaded, and that conſequently they might attempt whatever they pleaſed. From that time, under the name of *Clubs*, various aſſociations and factions ſprang up; ſome more violent than others, but all tending to the ſubverſion of the exiſting government, without agreeing upon the form of that which was to be ſubſtituted: and at that juncture alſo the projects of the faction, whoſe views were to have the Duke of Orleans appointed lieutenant-general of the kingdom, began to appear.

"This faction, or more properly this conſpiracy, was indeed of the ſame nature as thoſe that had produced all former revolutions, and might have been attended with the ſame conſequences, had the Duke of Orleans been poſſeſſed of that energy of character, that bravery and daring ſpirit, requiſite in the leader of a party. The people had already declared in his favour, and he might very eaſily have corrupted and brought over a great part of the army, had he been equal to the command of it: but, on the very firſt occaſion of perſonal riſk, he diſcovered ſuch cowardice and meanneſs, that he defeated his own conſpiracy, and convinced all thoſe who had entered into it, that it was impoſſible to continue the revolution, either in his favour or in conjunction with him. The enthuſiaſm the people had felt for him ended with the efforts of thoſe who had excited it.

"Mr Necker, whom the multitude had aſſociated with him in their homage, ſtill preſerved for ſome time his adorers, and that little cabal which was for ever exalting him to the ſkies. But as he was inferior even to the Duke of Orleans in military talents and diſpoſitions, he was as little calculated to be the leader of a revolution, or of a great conſpiracy: for which reaſon his panegyriſts then confined themſelves in their pamphlets and placards, with which the capital was overrun, to inſinuating, that the only means of ſaving the ſtate was to declare Mr Necker *Dictator*; or at leaſt to confer upon him, under ſome title more conſiſtent with the monarchy, the authority and powers attached to that republican office. In fact, if after his diſmiſſion, in the month of July 1789, he had dared to make this a condition of his return to the miniſtry, it is more than probable that the king would have been under the neceſſity of agreeing to it, and perhaps of re-eſtabliſhing in his perſon the office of mayor of the palace. At that moment he might have demanded any thing: eight days later, he might have been refuſed every thing;

---

* Introduction to the *Annals of the French Revolution*.

and very ſoon after, he was reduced to ſneak out of the kingdom, in order to eſcape the effects of the general contempt and cenſure which he had brought upon himſelf.

"General La Fayette, who then commanded the Pariſian National Guard, gathered the wrecks of all this popularity, and might have turned them to the greateſt advantage, if he had poſſeſſed 'that reſolute character and heroic judgment' of which Cardinal de Retz ſpeaks, and 'which ſerves to diſtinguiſh what is truly honourable and uſeful from what is only extraordinary, and what is extraordinary from what is impoſſible.' With the genius, talents, and ambition of Cromwell, he might have gone as great a length; with a leſs criminal ambition, he might at leaſt have made himſelf maſter of the revolution, and have directed it at his pleaſure: in a word, he might have ſecured the triumph of whatever party he ſhould have declared himſelf the leader. But as unfit for ſupporting the character of Monk as that of Cromwell, he ſoon betrayed the ſecret of his incapacity to all the world, and was diſtinguiſhed in the crowd of conſtitutional ringleaders only by his three-coloured plume, his epaulets, white horſe, and famous ſaying—'Inſurrection is the moſt ſacred of duties when oppreſſion is at its height.'

"The revolution, at the period when the faction that had begun it for the Duke of Orleans became ſenſible that he was too much a coward to be the leader of it, and when La Fayette diſcovered his inability to conduct it, was too far advanced to recede or to ſtop; and it continued its progreſs, but in a line that no other revolution had taken, viz. without a military chief, without the intervention of the army, and to gain triumphs, not for any ambitious conſpirator, but for political and moral innovations of the moſt dangerous nature; the moſt ſuited to miſlead the multitude, incapable of comprehending them, and to let looſe all the paſſions. The more violent combined to deſtroy every thing; and their fatal coalition gave birth to Jacobiniſm, that terrible monſter till then unknown, and till now not ſufficiently unmaſked. This monſter took upon itſelf alone to carry on the revolution; it directed, it executed, all the operations of it, all the exploſions, all the outrages: it every where appointed the moſt active leaders, and, as inſtruments, employed the profligates of every country. Its power far ſurpaſſed that which has been attributed to the inquiſition, and other fiery tribunals, by thoſe who have ſpoken of them with the greateſt exaggeration. Its centre was at Paris; and its rays, formed by particular clubs in every town, in every little borough, overſpread the whole ſurface of the kingdom. The conſtant correſpondence kept up between thoſe clubs and that of the capital; or, to uſe their own expreſſion, *des Sociétés populaires affiliées avec la Société mere*—'between the affiliated popular Societies and the parent Society,' was as ſecret and as ſpeedy as that of free-maſons. In a word, the Jacobin clubs had prevailed in cauſing themſelves to be looked up to as the real national repreſentation. Under that pretence, they cenſured all the authorities in the moſt imperious manner; and whenever their denunciations, petitions, or addreſſes, failed to produce an immediate effect, they gained their point by having recourſe to inſurrection, aſſaſſination, and fire. While Jacobiniſm thus ſubjected all France to its controul, an immenſe number of emiſſaries propagated its doctrines among foreign nations, and prepared new conqueſts for it.

"The National Aſſembly, the capital, indeed we may ſay all France, was divided into three very diſtinct parties. The moſt conſiderable in number, but unhappily the weakeſt through a deficiency of plan and reſolution, was the party purely Royal: it was adverſe to every kind of Revolution, and was ſolely deſirous of ſome improvements, with the reform of abuſes and pecuniary privileges:—the moſt able, and moſt intriguing, was the Conſtitutional party, or that which was deſirous of giving France a new monarchical conſtitution, but modified after the manner of the Engliſh, or even the American, by a houſe of repreſentatives. The third party was the moſt dangerous of all, by its daring ſpirit, by its power, and by the number of proſelytes it daily acquired in all quarters of the kingdom: it compriſed the Democrats of every deſcription, from the Jacobin clubs, calling themſelves *Friends of the Conſtitution*, to the anarchs and robbers.

"The Democratic party, which at firſt was only auxiliary to the Conſtitutional one, in the end annihilated it, and became itſelf ſubdivided into ſeveral other parties, whoſe fatal ſtruggles produced the ſubſequent revolutions, and may ſtill produce many more. But in principle, the Conſtitutionaliſts and the Democrats formed two diſtinct, though confederate, factions; both were deſirous of a revolution, and employed all the uſual means of accompliſhing it, except troops, which could be of no uſe to them, for neither of them had a leader to put at the head of the army. But as it was equally of importance to both that the king ſhould be deprived of the power of making uſe of it againſt them, they laboured in concert to diſorganiſe it; and the complete ſucceſs of that manœuvre was but too fully proved by the fatal iſſue of the departure of the royal family for Montmedi. The revolution then took a more daring and rapid ſtride, which was concluded by the pretended conſtitution act of 1791. The incoherence of its principles, and the defects of its inſtitutions, preſent a faithful picture of the diſunion of its authors, and of the oppoſite intereſts by which they were ſwayed. It was, properly ſpeaking, a compact between the faction of the Conſtitutionaliſts and that of the Democrats, in which they mutually made conceſſions and ſacrifices.

423
Conſtitution of 1791 completes the firſt revolution.

"Be that as it may, this abſurd conſtitution, the everlaſting ſource of remorſe or ſorrow to all who bore part in it, might have been got over without a ſhock, and led back to the old principles of monarchical government, if the Aſſembly who framed it had not ſeparated before they witneſſed the execution of it; if, in impoſing on the king the obligation to maintain it, they had not deprived him of the power and the means; and above all, if the certain conſequence of the new mode of proceeding at the elections had not been to ſecure, in the ſecond Aſſembly, a conſiderable majority of the Democratic againſt the Conſtitutional party.

"The ſecond Aſſembly was alſo divided by three factions, the weakeſt of which was the one that wiſhed to maintain the conſtitution. The other two were for a new revolution and a republic; but they differed in this, that the former, compoſed of the Briſſotins and Girondiſts, was for effecting it gradually, by beginning with diveſting the king of popularity, and allowing the public

French Revolution.

public mind time to wean itſelf from its natural attachment to monarchy ; and the latter, which was the leaſt numerous, was eager to have the republic eſtabliſhed as ſoon as poſſible. Theſe two factions, having the ſame object in view, though taking different roads, were neceſſarily auxiliaries to each other ; and the pamphlets, excitations to commotion, and revolutionary meaſures of both, equally tended to overthrow the conſtitution of 1791.

“ Thoſe different factions, almoſt entirely compoſed of advocates, ſolicitors, apoſtate prieſts, doctors, and a few literary men, having no military chief capable of taking the command of the army, dreaded the troops, who had ſworn allegiance to the conſtitution, and obedience to the king, and who moreover might be influenced by their officers, among whom there ſtill remained ſome royaliſts. The ſureſt way to get rid of all uneaſineſs on this ſubject, was to employ the army in defending the frontiers. For this purpoſe a foreign war was neceſſary, to which it was known that the king and his council were equally averſe. No more was wanting to determine the attack which was directed, almoſt at the ſame time, againſt all the miniſters, in order to compel them to retire, and to put the king under the neceſſity of appointing others more diſpoſed to ſecond the views of the parties. Unhappily this attempt was attended with all the ſucceſs they had promiſed themſelves ; and one of the firſt acts of the new miniſtry was to declare war againſt the emperor. At the ſame time, the emigration that had been provoked, and which was almoſt every where applauded, even by the loweſt claſs of people, robbed France of the flower of the royal party, and left the king, deprived of his beſt defenders, expoſed to the ſuſpicions and inſults that ſprang from innumerable calumnies, for which the diſaſters at the beginning of the war furniſhed but too many opportunities.

424
The ſecond revolution.

“ In this manner was prepared and accelerated the new revolution, which was accompliſhed on the 10th of Auguſt 1792, by the depoſition and impriſonment of the king, and by the moſt flagrant violation of the conſtitution of 1791. The latter, however, was not entirely abandoned on that day ; for the project of the Girondiſts, who had laid the plot of that horrible conſpiracy, was then only to declare the king's depoſition, in order to place the prince royal upon the throne, under the guidance of a regency compoſed of their own creatures ; but they were hurried away much farther than they meant to go, by the violence with which the moſt furious of the Jacobins, who took the lead in the inſurrection, conducted all their enterpriſes. The prince royal, inſtead of being crowned, was ſhut up in the Temple ; and if France at that moment was not declared a republic, it was leſs owing to any remaining reſpect for the conſtitution, than to the fear the legiſlative body was in of raiſing the army againſt it, and alſo the majority of the nation, who would naturally be angry to ſee a conſtitution which ſeemed to be rendered ſecure and ſtable by ſo many oaths, thus precipitately overthrown, without their having been conſulted.

“ It was on theſe conſiderations that the opinion was adopted, that a National Convention ſhould be convoked, to determine the fate of royalty. Prompt in ſeizing all the means that might enſure the ſucceſs of this ſecond revolution, the Aſſembly, under pretence of giving every poſſible latitude to the freedom of elections, decreed, that all its members ſhould be eligible for the National Convention.

French Revolution.

“ From that moment the Girondiſts daily loſt ground, and the moſt flaming members of the Democratic party, ſupported by the club of Jacobins, by the new Commune of Paris, and by the Tribunes, made themſelves maſters of every debate. It was of the utmoſt importance to them to rule the enſuing elections ; and this was ſecured to them by the horrible conſternation which the maſſacres of the 2d of September ſtruck throughout the kingdom. The terror of being aſſaſſinated, or at leaſt cruelly treated, drove from all the Primary Aſſemblies, not only the royaliſts and conſtitutionaliſts, but moderate men of all parties. Of courſe, thoſe aſſemblies became entirely compoſed of the weakeſt men and the greateſt villains exiſting in France ; and from among the moſt frantic of them were choſen thoſe members of the Convention who were not taken from the legiſlative body. Accordingly, this third Aſſembly, in the firſt quarter of an hour of their firſt ſitting, were heard ſhouting their votes for the abolition of royalty, and proclaiming the republic, upon the motion of a member who had formerly been a player.

425
The third revolution.

“ Such an opening but too plainly ſhewed what was to be expected from that horde of plunderers which compoſed the majority of the National Convention, and of whom Robeſpierre, Danton, Marat, and the other ringleaders, formed their party. That of the Briſſotins and Girondiſts ſtill exiſted, and was the only one really republican. Theſe ſemi-wretches, glutted with the horrors already committed, ſeemed deſirous of arreſting the torrent of them, and laboured to introduce into the Aſſembly the calm and moderation that were neceſſary to give the new republic a wiſe and ſolid organization. But the ſuperiority of their knowledge, talents, and eloquence, which their opponents could not diſpute, had no power over tigers thirſting for blood, who neither attended to nor ſuffered motions but of the blackeſt tendency. No doubt they had occaſion for atrocities upon atrocities to prepare the terror ſtruck nation to allow them to commit, in its name, the moſt execrable of all, the murder of the unfortunate Louis XVI : and that martyrdom was neceſſary to bring about a third revolution, already brewing in the brain of Robeſpierre. Fear had greatly contributed to the two former : but this was effected by terror alone, without popular tumults, or the intervention of the armies ; which, now drawn by their conqueſts beyond the frontiers, never heard any thing of the revolutions at home, till they were accompliſhed, and always obeyed the prevailing faction, by whom they were paid.

“ By the degree of ferocity diſcovered by the members of the Convention in paſſing ſentence upon the king, and in the debates relative to the conſtitution of 1793, Robeſpierre was enabled to mark which of the deputies were likely to ſecond his views, and which of them it was his part to ſacrifice.

“ The people could not but with tranſport receive a conſtitution which ſeemed to realiſe the chimera of its ſovereignty, but which would only have given a kind of conſtruction to anarchy, if the execution of this new code had not been ſuſpended under the pretext, belonging in common to all acts of deſpotiſm and tyranny, of *the ſupreme law of the ſafety of the ſtate.* This ſuſpenſion was effected, by eſtabliſhing the Proviſionary Government, which, under the title of Revolutionary Government, concentrated all the powers in the National Convention until there was an end to the war and all inteſtine troubles.

“ Although the faction, at the head of which Robeſpierre was, had a decided majority in the Aſſembly, and might conſequently have conſidered themſelves as really and excluſively exerciſing the ſovereign power, he was a demagogue of too deſpotic a nature to ſtomach even the appearance of ſharing the empire with ſo many co-ſovereigns. He greatly reduced their number, by cauſing all the powers inveſted in the National Aſſembly by the decrees that had eſtabliſhed the revolutionary government, to be transferred to a committee, to which he got himſelf appointed, and where he was ſure of the ſole rule, by obtaining for colleagues men leſs daring than himſelf, though equally wicked; ſuch as Couthon, St Juſt, Barrere, and others like them. This committee, who had the aſſurance to ſtyle themſelves the *Committee of Public Safety*, very ſoon ſeized upon both the legiſlative and executive powers, and exerciſed them with the moſt ſanguinary tyranny ever yet heard of. The miniſters were merely their clerks; and the ſubjugated Aſſembly, without murmur or objection, paſſed all the revolutionary laws which were propoſed, or rather dictated, by them. One of their moſt horrible and deciſive conceptions was that of thoſe Revolutionary Tribunals which covered France with ſcaffolds, where thouſands of victims of every rank, age, and ſex, were daily ſacrificed; ſo that no claſs of men could be free from that ſtupefying and general terror which Robeſpierre found it neceſſary to ſpread, in order to eſtabliſh and make his power known. He ſoon himſelf dragged ſome members of his own party, ſuch as Danton, Camille des Moulins, and others, whoſe energy and popularity had offended him, before one of thoſe tribunals, where he had them condemned to death. By the ſame means he got rid of the chief leaders among the Briſſotines and Girondiſts; while he cauſed all the moderate republican party who were ſtill members of the Aſſembly, except thoſe who had time and addreſs to eſcape, to be ſent to priſon, in order to be ſentenced and executed on the firſt occaſion.

426 The fourth revolution produces

“ In this manner ended the third revolution, in which the people, frozen with terror, did not dare to take a part. Inſtead of an army of ſoldiers, Robeſpierre employed an army of executioners and aſſaſſins, ſet up as revolutionary judges; and the guillotine, ſtriking or menacing all heads indiſcriminately, made France, from one end to the other, ſubmit to him, by the means of terror or of death. Thus was this nation, formerly ſo proud, even to idolatry, of its kings, ſeen to expiate, by rivers of blood, the crime of having ſuffered his to be ſpilt who was the moſt virtuous of all their monarchs.

“ In the room of that famous Baſtile, whoſe celebrated capture and demolition had ſet only ſeven priſoners at liberty, two of whom had been long in a ſtate of lunacy, the colleges, the ſeminaries, and all the religious houſes of the kingdom, were converted into ſo many ſtate priſons, into which were inceſſantly crowded, from time to time, the victims devoted to feed the ever-working guillotines, which were never ſuffered to ſtand ſtill for a day, becauſe they were at once the chief reſource of ſupplies for the government, and the inſtrument of its ferocity. ‘ The guillotine coins money for the republic,’ was ſaid in the tribune by one of Robeſpierre's vileſt agents *. In fact, according to the juriſprudence of the Revolutionary Tribunals, the rich of every claſs, being declared ſuſpected perſons, received ſentence of death, for no other reaſon than that of giving the confiſcation of their property a ſhow of judicial form.

“ Still blood flowed too ſlowly to ſatiſfy Robeſpierre; his aim was but partly attained by the proſcription of the nobles, the prieſts, and the wealthy. He fancied, not only an ariſtocracy of talents and knowledge, but of the virtues, none of which would his truſty orators and journaliſts admit, ſave that horrid *patriotiſm* which was eſtimated according to the enormity of the crimes committed in favour of the revolution. His plan was to reduce the French people to a mere plantation of ſlaves, too ignorant, too ſtupid, or too puſillanimous, to conceive the idea of breaking the chains with which he would have loaded them in the name of liberty; and he might have ſucceeded in it, had not his ambition, as impatient as it was jealous, too ſoon unveiled the intention of reſorting to the guillotine to ſtrike off the ſhackles with which an aſſembly of repreſentatives of the nation fettered, or might fetter, his power. He was about to give this deciſive blow, which he had concerted with the Commune of Paris, the Revolutionary Tribunal, the Club of Jacobins, and the principal officers of the National Guard, when the members of the Convention, who were marked out to be the firſt ſacrificed, anticipated him at a moment when he leaſt expected it, by attacking himſelf in the Aſſembly, with energy ſufficient to rouſe all the ſections of the capital againſt him and againſt the Jacobins. The parties came to blows, and victory remained uncertain for ſeveral hours; but at length declared againſt Robeſpierre. In the ſpace of a day, that execrable monſter was dragged from the higheſt pitch of power ever attained by any tyrant, to the very ſcaffold that was ſtill reeking with the blood of his laſt victims. His principal accomplices in the Committee of Public Safety, in the Commune, in the National Guard, in the Revolutionary Tribunal, and many of his agents in the provinces, met the ſame fate. The Revolutionary Tribunals were ſuppreſſed, and the priſons thrown open to all whom they had caſt into them.

427 The conſtitution of 1795.

“ This fourth revolution, in which the faction then eſteemed the moderate party overthrew the terroriſts, and ſeized the ſupreme power, was no leſs complete than thoſe which had preceded it, and produced the conſtitution of 1795. All France received as a great bleſſing a conſtitution that delivered them from the revolutionary government and its infernal policy. Beſides, it had, in ſpite of great defects, the merit of coming nearer than the two preceding ones, to the principles of order, of juſtice, and real liberty; the violation of which had, for five years before, been the ſource of ſo many diſaſters and ſo many crimes. The royaliſts, conſidering it as a ſtep towards monarchy, were unfortunately ſo imprudent as to triumph in it; and their joy, as premature as indiſcreet, alarmed the Aſſembly to ſuch a degree, that they paſſed the famous law, ordaining the Primary Aſſemblies to return two-thirds of the members of the Convention to the legiſlative body, which

---

* Barrere.

rench rolution.

was to ſucceed that aſſembly. It was thus that the ſpirit of the Convention continued, for the firſt year, to be diſplayed in the two councils.

" In the year following, the bias of the public mind, perhaps too haſtily turned towards royalty, ſhewed itſelf in the elections of the members for the new third, ſo clearly as to alarm the regicides who compoſed the Directory, and the Conventionaliſts, who ſtill made a third of the legiſlative body ; nor did they loſe a moment in deviſing means for their defence. That which appeared the ſureſt to them was, to publiſh notices of plots among the royaliſts, and annex one or more denunciations, in terms ſo vague as to leave room for implicating, when neceſſary, all their adverſaries ; while by the help of this impoſture they procured ſome ſecret information, artfully fabricated, and ever eaſily obtained through threats or rewards by thoſe who have at command the guillotine and the public treaſure.

" This maſked battery was ready to be opened before the members of the new third took their ſeats. Theſe at firſt confined themſelves to the ſecuring of a conſtant majority in the two councils in favour of the moderate opinions; but in a little time every ſitting was marked by the repeal of ſome revolutionary law, or by ſome decree tending to reſtrain the executive authority within the limits fixed by the conſtitution.

428 he fifth volution.

" The Directory, alarmed at the abridgment of their power, and dreading ſtill more ſerious attacks upon it, came to a reſolution of no longer poſtponing the blow they had been meditating againſt the legiſlative aſſembly : and they accompliſhed, in the manner related in nº 309, a fifth revolution, as complete as any of thoſe by which it was preceded. It differed indeed from them eſſentially in the facility and promptneſs with which it was effected, although the party which prevailed, that is to ſay, the majority of the Directory, and the minority of the Legiſlative Body, had to combat not only againſt the conſtitution, but againſt the opinion, and even againſt the indignation, of the public. That moral force, on which the majority of the two councils had unluckily placed all their reliance, vaniſhed in an inſtant before the phyſical force of a detachment of troops conſiſting of ſix or ſeven hundred men ; ſo true is it, that the power of the public opinion, ridiculouſly exaggerated in theſe days, is and can be no more, under a firm and well ordered government, than a mere fancy. Men accuſtom themſelves too eaſily to take for public opinion the private opinions made public by certain writers, whoſe caution or audaciouſneſs depends always upon the energy or feebleneſs of the ſupreme authority. It is the ſame thing with popular commotions : they are eaſily excited under a weak government, which does not poſſeſs the wiſdom to prevent or the ſpirit to ſuppreſs them ; but a vigorous, juſt, and ſtrict government has nothing to fear from them. The Directory, compelled to withdraw the larger body of troops, which they had thought neceſſary to enſure the revolution they were meditating, diſcovered, no doubt, great ability in ſecuring the two councils, by appearing to dread them : but it was chiefly to the energy of their meaſures, and to the concentration and promptneſs with which they were executed, that they owed their ſucceſs. Two days before, the legiſlative body might, without obſtruction, have impeached, arreſted, and even outlawed, the majority of the Directory, who were execrated by the public under the title of Triumvirate ; and, if requiſite, they would have been ſupported by more than 30,000 armed citizens, who, with Pichegru and Villot at their head, would ſoon have diſperſed, and perhaps brought over, the feeble detachments of troops of the line which the Directory had at their command. The legiſlative body, relying too much upon its popularity, did not ſufficiently conſider, that the people, whoſe impetuoſity is commonly deciſive when allowed to take advantage in attack, are always feeble on the defenſive, and totally unable to withſtand every aſſault made previous to an inſurrection, for it is always eaſy to prevent their aſſembling. It was on this principle that the Directory founded their operations, and the 5th of September too well proves how juſtly. That day reduced the legiſlative body, by the moſt degrading ſubjugation, to a mere diſguſting caricature of national repreſentation ; it inveſted the Directory with the moſt arbitrary and tyrannic power, and reſtored the ſyſtem of Robeſpierre, under a form leſs bloody, but not leſs pernicious ; for the Revolutionary Tribunals which that monſter had eſtabliſhed, were ſcarcely more expeditious than the military ones of the Directory. The power of arbitrary and unlimited tranſportation is, in time, as deſtructive as the guillotine, without poſſeſſing, like that, the advantage of exciting a ſalutary horror, which, by recovering the people from the ſtate of ſtupor and apathy, the conſtant effects of terror, gives them both recollection and force to break their chains. Though, in violating the moſt eſſential regulations of the conſtitution, the Directory obtained a temporary confirmation of their power, their example pointed out to Bonaparte and Sieyes the path which they purſued with infinite addreſs, and in which they accompliſhed a ſixth revolution."

429 The ſixth revolution, and conſular government.

How long the conſular government will continue, it is impoſſible to conjecture ; but we may, without preſumption, venture to predict, that it cannot be permanent. To the Jacobins and original conſtitutionaliſts it muſt be more obnoxious than the old government ; becauſe Bonaparte is more deſpotic than was Louis XIV ; and the royaliſts, though they may prefer the vigorous and comparatively mild government of one man, whoſe talents are indiſputable, to the ferocious tyranny of the loweſt of the rabble, muſt look with indignation at a foreign adventurer ſeated on the throne of their ancient monarchy.

RHABDOLOGY, or Rabdology, in arithmetic, a name given by Napier to a method of performing ſome of the more difficult operations of numbers by means of certain ſquare little rods. Upon theſe are inſcribed the ſimple numbers ; then by ſhifting them according to certain rules, thoſe operations are performed by ſimply adding or ſubtracting the numbers as they ſtand upon the rods. See Napier's *Rabdologia*, printed in 1617. See alſo the article Napier's *Bones*.

RHOMB Solid, conſiſts of two equal and right cones joined together at their baſes.

RICE (ſee that article, and Oryza, *Encycl.*) is ſtrongly recommended, in a late publication, as the beſt corrective of *ſprit* flour, of which there is a great quantity in Scotland every year, and of courſe a great deal of unpleaſant and unwholeſome bread. The gentleman, who writes the ſhort paper alluded to, directs ten pounds of flour and one pound of ground rice, with the uſual quantity of yeſt, to be placed, for about two hours before a fire, and then formed into bread in the common way. This addition of rice, beſides correcting the bad qualities of the damaged flour, adds, he ſays, much to its nutriment: and he is undoubtedly right; for the flour of rice, though very nutritious, is ſo dry, that it is difficult to make bread of it by itſelf. See *Bread of Rice*, in this *Suppl.*

As rice is a favourite ſubſtitute for bread in years of ſcarcity, it may not be diſagreeable to our readers to know the method of cultivating the plant in thoſe countries where it is the principal food of the inhabitants. We have the following full and perſpicuous account of the Chineſe practice by Sir George Staunton.

“ Much of the low grounds in the middle and ſouthern provinces of the empire are appropriated to the culture of that grain. It conſtitutes, in fact, the principal part of the food of all thoſe inhabitants, who are not ſo indigent as to be forced to ſubſiſt on other and cheaper kinds of grain. A great proportion of the ſurface of the country is well adapted for the production of rice, which, from the time the ſeed is committed to the ſoil till the plant approaches to maturity, requires to be immerſed in a ſheet of water. Many and great rivers run through the ſeveral provinces of China, the low grounds bordering on thoſe rivers are annually inundated, by which means is brought upon their ſurface a rich mud or mucilage that fertilizes the ſoil, in the ſame manner as Egypt receives its fecundative quality from the overflowing of the Nile. The periodical rains which fall near the ſources of the Yellow and the Kiang rivers, not very far diſtant from thoſe of the Ganges and the Burrumpooter, among the mountains bounding India to the north, and China to the weſt, often ſwell thoſe rivers to a prodigious height, though not a drop of rain ſhould have fallen on the plains through which they afterwards flow.

“ After the mud has lain ſome days upon the plains in China, preparations are made for planting them with rice. For this purpoſe, a ſmall ſpot of ground is incloſed by a bank of clay; the earth is ploughed up; and an upright harrow, with a row of wooden pins in the lower end, is drawn lightly over it by a buffalo. The grain, which had previouſly been ſteeped in dung diluted with animal water, is then ſown very thickly on it. A thin ſheet of water is immediately brought over it, either by channels leading to the ſpot from a ſource above it, or when below it by means of a chain pump, of which the uſe is as familiar as that of a hoe to every Chineſe huſbandman. In a few days the ſhoots appear above the water. In that interval, the remainder of the ground intended for cultivation, if ſtiff, is ploughed, the lumps broken by hoes, and the ſurface levelled by the harrow. As ſoon as the ſhoots have attained the height of ſix or ſeven inches, they are plucked up by the roots, the tops of the blades cut off, and each root is planted ſeparately, ſometimes in ſmall furrows turned with the plough, and ſometimes in holes made in rows by a drilling ſtick for that purpoſe. The roots are about half a foot aſunder. Water is brought over them a ſecond time. For the convenience of irrigation, and to regulate its proportion, the rice fields are ſubdivided by narrow ridges of clay, into ſmall incloſures. Through a channel, in each ridge, the water is conveyed at will to every ſubdiviſion of the field. As the rice approaches to maturity, the water, by evaporation and abſorption, diſappears entirely; and the crop, when ripe, covers dry ground. The firſt crop or harveſt, in the ſouthern provinces particularly, happens towards the end of May or beginning of June. The inſtrument for reaping is a ſmall ſickle, dentated like a ſaw, and crooked. Neither carts nor cattle are uſed to carry the ſheaves off from the ſpot where they were reaped; but they are placed regularly in frames, two of which, ſuſpended at the extremities of a bamboo pole, are carried acroſs the ſhoulders of a man, to the place intended for diſengaging the grain from the ſtems which had ſupported it. This operation is performed, not only by a flail, as is cuſtomary in Europe, or by cattle treading the corn in the manner of other Orientaliſts, but ſometimes alſo by ſtriking it againſt a plank ſet upon its edge, or beating it againſt the ſide of a large tub ſcolloped for that purpoſe; the back and ſides being much higher than the front, to prevent the grain from being diſperſed. After being winnowed, it is carried to the granary.

“ To remove the ſkin or huſk of rice, a large ſtrong earthen veſſel, or hollow ſtone, in form ſomewhat like that which is uſed elſewhere for filtering water, is fixed firmly in the ground; and the grain, placed in it, is ſtruck with a conical ſtone fixed to the extremity of a lever, and cleared, ſometimes indeed imperfectly, from the huſk. The ſtone is worked frequently by a perſon treading upon the end of the lever. The ſame object is attained alſo by paſſing the grain between two flat ſtones of a circular form, the upper of which turns round upon the other, but at ſuch a diſtance from it as not to break the intermediate grain. The operation is performed on a larger ſcale in mills turned by water; the axis of the wheel carrying ſeveral arms, which, by ſtriking upon the ends of levers, raiſe them in the ſame manner as is done by treading on them. Sometimes twenty of theſe levers are worked at once. The ſtraw from which the grain has been diſengaged is cut chiefly into chaff, to ſerve as provender for the very few cattle employed in Chineſe huſbandry.

“ The labour of the firſt crop being finiſhed, the ground is immediately prepared for the reception of freſh ſeeds. The firſt operation undertaken is that of pulling up the ſtubble, collecting it into ſmall heaps, which are burnt, and the aſhes ſcattered upon the field. The former proceſſes are afterwards renewed. The ſecond crop is generally ripe late in October or early in November. The grain is treated as before; but the ſtubble is no longer burnt. It is turned under with the plough, and left to putrefy in the earth. This, with the ſlime brought upon the ground by inundation, are the only manures uſually employed in the culture of rice.”

RIDEAU, in fortification, a ſmall elevation of earth, extending itſelf lengthwiſe on a plain; ſerving to cover a camp, or give an advantage to a poſt.

Rideau is ſometimes alſo uſed for a trench, the earth of which is thrown up on its ſide, to ſerve as a parapet for covering the men.

RIDLEY (Dr Gloſter), was of the ſame family with Dr Nicolas Ridley, Biſhop of London, and Martyr to the Reformation. (See Ridley, *Encycl.*) He was born at ſea, in 1702, on board the Glouceſter Eaſt Indiaman; to which circumſtance he was indebted for his idley.

his Chriſtian name. He received his education at Wincheſter ſchool, and thence was elected to a fellowſhip at New college, Oxford, where he proceeded B. C. L. April 29. 1729. In thoſe two ſeminaries he cultivated an early acquaintance with the muſes, and laid the foundation of thoſe elegant and ſolid acquirements for which he was afterwards ſo eminently diſtinguiſhed as a poet, an hiſtorian, and a divine. During a vacancy in 1728, he joined with four friends, viz. Mr Thomas Fletcher (afterwards Biſhop of Kildare), Mr (afterwards Dr) Eyre, Mr Morriſon, and Mr Jennens, in writing a tragedy called “The Fruitleſs Redreſs,” each undertaking an act on a plan previouſly concerted. When they delivered in their ſeveral proportions at their meeting in the winter, few readers would have known that the whole was not the production of a ſingle hand. This tragedy, which was offered to Mr Wilks, but never acted, is ſtill in MS. with another called “Jugurtha.” Dr Ridley in his youth was much addicted to theatrical performances. Midhurſt, in Suſſex, was the place where they were exhibited; and the company of gentlemen actors to which he belonged conſiſted chiefly of his coadjutors in the tragedy already mentioned. He is ſaid to have performed the characters of Marc Antony, Jaffier, Horatio, and Moneſes, with diſtinguiſhed applauſe; a circumſtance that will be readily believed by thoſe who are no ſtrangers to his judicious and graceful manner of ſpeaking in the pulpit.

For great part of his life he had no other preferment than the ſmall college living of Weſtow in Norfolk, and the donative of Poplar in Middleſex, where he reſided. To theſe his college added, ſome years after, the donative of Romford in Eſſex. “Between theſe two places the curricle of his life had (as he expreſſed it) rolled for ſome time almoſt perpetually upon poſtchaiſe wheels, and left him not time for even the proper ſtudies of economy, or the neceſſary ones of his profeſſion.” Yet in this obſcure ſituation he remained in poſſeſſion of, and content with, domeſtic happineſs; and was honoured with the intimate friendſhip of ſome who were not leſs diſtinguiſhed for learning than for worth.

In 1740 and 1741 he preached “Eight Sermons at Lady Moyer's Lecture,” which were publiſhed in 1742, 8vo. In 1756 he declined an offer of going to Ireland as firſt chaplain to the Duke of Bedford; in return for which he was to have had the choice of promotion, either at Chriſt-church, Canterbury, Weſtminſter, or Windſor. His modeſty inducing him to leave the choice of theſe to his patron, the conſequence was, that he obtained none of them. In 1763, he publiſhed the “Life of Biſhop Ridley,” in 4to, by ſubſcription, and cleared by it as much as brought him 800l. in the public funds. In the latter part of his life he had the misfortune to loſe both his ſons, each of them a youth of abilities. The elder, James, was author of “The Tales of the Genii,” and ſome other literary performances. Thomas, the younger, was ſent by the Eaſt India Company as a writer to Madras, where he was no ſooner ſettled than he died of the ſmall-pox. In 1765, Dr Ridley publiſhed his “Review of Philips's Life of Cardinal Pole;” and in 1768, in reward for his labours in this controverſy, and in another which “The Confeſſional” produced, he was preſented by Archbiſhop Secker to a golden prebend in the cathedral church of Saliſbury (an option), the only reward he received from the great during a long, uſeful, and laborious life, devoted to the duties of his function. At length, worn out with infirmities, he departed this life in 1774, leaving a widow and four daughters. His epitaph, which was written by Biſhop Lowth with his uſual elegance, informs us, that for his merits the univerſity of Oxford conferred upon him the degree of D. D. by diploma, which is the higheſt literary honour which that learned body has to beſtow.

Rienzi.

RIENZI (Nicolas Gabrini de), one of the moſt extraordinary men of the 14th century, was born at Rome, we know not in what year. His father, Lawrence Gabrini, was a mean vintner, or, as others ſay, a miller, and his mother a laundreſs. Theſe perſons, however, found the means of giving their ſon a liberal education; and to a good natural underſtanding he joined an uncommon aſſiduity, and made great proficiency in ancient literature. Every thing which he read he compared with ſimilar paſſages that occurred within his own obſervation; whence he made reflections, by which he regulated his conduct. To this he added a great knowledge in the laws and cuſtoms of nations. He had a vaſt memory: he retained much of Cicero, Valerius Maximus, Livy, the two Senecas, and Cæſar's Commentaries eſpecially, which he read continually, and often quoted by application to the events of his own times. This fund of learning proved the baſis and foundation of his riſe. The deſire he had to diſtinguiſh himſelf in the knowledge of monumental hiſtory, drew him to another ſort of ſcience, in which few men at that time exerted themſelves. He paſſed whole days among the inſcriptions which are to be found at Rome, and acquired ſoon the reputation of a great antiquary. Having hence formed within himſelf the moſt exalted notions of the juſtice, liberty, and ancient grandeur of the old Romans, words he was perpetually repeating to the people, he at length perſuaded not only himſelf, but the giddy mob his followers, that he ſhould one day become the reſtorer of the Roman republic. His advantageous ſtature, his countenance, and that air of importance which he well knew how to aſſume, deeply imprinted all that he ſaid in the minds of his audience.

Nor was it only by the populace that he was admired; he alſo found means to inſinuate himſelf into the favour of thoſe who partook of the adminiſtration. Rienzi's talents procured him to be nominated one of the deputies ſent by the Romans to Pope Clement VI. who reſided at Avignon. The intention of this deputation was to make his Holineſs ſenſible, how prejudicial his abſence was, as well to himſelf as to the intereſt of Rome. At his firſt audience, our hero charmed the court of Avignon by his eloquence and the ſprightlineſs of his converſation. Encouraged by ſucceſs, he one day took the liberty to tell the Pope, that the grandees of Rome were avowed robbers, public thieves, infamous adulterers, and illuſtrious profligates; who, by their example, authoriſed the moſt horrid crimes. To them he attributed the deſolation of Rome; of which he drew ſo lively a picture, that the Holy Father was moved, and exceedingly incenſed againſt the Roman nobility. Cardinal Colonna, in other reſpects a lover of real merit, could not help conſidering theſe reproaches as reflecting upon ſome of his family; and therefore found means of diſgracing Rienzi, ſo that he fell into extreme miſery, vexation, and ſickneſs, which, joined with indigence, brought him to an hoſpital. Nevertheleſs, the ſame hand that threw him down, raiſed him up again. The cardinal, who was all compaſſion, cauſed him to appear before the Pope, in aſſurance of his being a good man, and a great partizan for juſtice and equity. The Pope approved of him more than ever; and, to give him proofs of his eſteem and confidence, made him apoſtolic notary, and ſent him back loaded with favours.

Being returned to Rome, he began to execute the functions of his office; and by affability, candour, aſſiduity, and impartiality, in the adminiſtration of juſtice, he arrived at a ſuperior degree of popularity; which he ſtill improved by continued invectives againſt the vices of the great, whom he took care to render as odious as poſſible; till at laſt, for ſome ill-timed freedoms of ſpeech, he was not only ſeverely reprimanded, but diſplaced. From this time it was his conſtant endeavour to inſpire the people with a fondneſs for their ancient liberties; to which purpoſe he cauſed to be hung up in the moſt public places emblematic pictures, expreſſive of the former ſplendour and preſent decline of Rome. To theſe he added frequent harangues and predictions upon the ſame ſubject. In this manner he proceeded till one party looked on him only as a madman, while others careſſed him as their protector. At length he ventured to open himſelf to ſuch as he believed male contents. At firſt he took them ſeparately; afterwards, when he thought he had firmly attached a ſufficient number to his intereſt, he aſſembled them together, and repreſented to them the deplorable ſtate of the city, over-run with debaucheries, and the incapacities of their governors to correct or amend them. As a neceſſary foundation for the enterpriſe, he gave them an inſight into the immenſe revenues of the apoſtolic chamber: He demonſtrated, that the Pope could, only at the rate of fourpence, raiſe a hundred thouſand florins by firing, as much by ſalt, and as much more by the cuſtoms and others duties. As for the reſt, ſaid he, I would not have you imagine that it is without the Pope's conſent I lay hands on the revenues. Alas! how many others in this city plunder the effects of the church contrary to his will!

By this artful lie, he ſo animated his auditors, that they declared they would make no ſcruple of ſecuring theſe treaſures for whatever end might be moſt convenient; and that they were devoted to the will of him their chief. Having obtained ſo much, to ſecure his adherents from a revolt, he tendered them a paper, ſuperſcribed, "an *oath* to procure the good eſtabliſhment;" and made them ſubſcribe and ſwear to it before he diſmiſſed them. By what means he prevailed on the Pope's vicar to give a tacit ſanction to his project, is not certainly known; that he did procure that ſanction, and that it was looked on as a maſterpiece of policy, is generally admitted. "The 20th of May, being Whitſunday, he fixed upon to ſanctify in ſome ſort his enterpriſe; and pretended, that all he acted was by particular inſpiration of the Holy Ghoſt. About nine, he came out of the church bare-headed, accompanied by the Pope's vicar, ſurrounded by an hundred armed men. A vaſt crowd followed him with ſhouts and acclamations." The gentlemen conſpirators carried three ſtandards before him, on which were wrought devices, inſinuating, that his deſign was to re-eſtabliſh liberty, juſtice, and peace. In this manner he proceeded directly to the Capitol, where he mounted the roſtrum; and, with more boldneſs and energy than ever, expatiated on the miſeries to which the Romans were reduced: at the ſame time telling them, without heſitation, "that the happy hour of their deliverance was at length come, and that he was to be their deliverer, regardleſs of the dangers he was expoſed to for the ſervice of the Holy Father and the people's ſafety." After which, he ordered the laws of what he called the good eſtabliſhment to be read: "aſſured that the Romans would reſolve to obſerve theſe laws, he engaged in a ſhort time to re-eſtabliſh them in their ancient grandeur.".

The laws of the good eſtabliſhment promiſed plenty and ſecurity, which were greatly wanted; and the humiliation of the nobility, who were deemed common oppreſſors. Such laws could not fail of being agreeable to a people who found in them theſe double advantages; wherefore, "enraptured with the pleaſing ideas of a liberty to which they were at preſent ſtrangers, and the hope of gain, they came moſt zealouſly into the fanaticiſm of Rienzi. They reſumed the pretended authority of the Romans; they declared him ſovereign of Rome; and granted him the power of life and death, of rewards and puniſhments, of enacting and repealing the laws, of treating with foreign powers; in a word, they gave him the full and ſupreme authority over all the extenſive territories of the Romans.

Rienzi, arrived at the ſummit of his wiſhes, kept at a great diſtance his artifice: he pretended to be very unwilling to accept of their offers, but upon two conditions; the firſt, that they ſhould nominate the Pope's vicar (the Biſhop of Orvieto) his copartner; the ſecond, that the Pope's conſent ſhould be granted him, which (he told them) he flattered himſelf he ſhould obtain. "On the one hand, he hazarded nothing in thus making his court to the Holy Father; and, on the other, he well knew, that the Biſhop of Orvieto would carry a title only, and no authority. The people granted his requeſt, but paid all the honours to him: he poſſeſſed the authority without reſtriction; the good Biſhop appeared a mere ſhadow and veil to his enterpriſes. Rienzi was ſeated in his triumphal chariot, like an idol, to triumph with the greater ſplendour. He diſmiſſed the people replete with joy and hope. He ſeized upon the palace, where he continued after he had turned out the ſenate; and, the ſame day, he began to dictate his laws in the Capitol." This election, though not very pleaſing to the Pope, was ratified by him; nevertheleſs, Rienzi meditated the obtaining of a title, excluſive of the papal prerogative. Well verſed in the Roman hiſtory, he was no ſtranger to the extent of the tribunitial authority; and as he owed his elevation to the people, he choſe to have the title of their magiſtrate. He aſked it, and it was conferred on him and his copartner, with the addition of deliverers of their country. Our adventurer's behaviour in his elevation was at firſt ſuch as commanded eſteem and reſpect, not only from the Romans, but from all the neighbouring ſtates. But it is difficult for a perſon of mean birth, elevated at once, by the caprice of fortune, to the moſt exalted ſtation, to move rightly in a ſphere wherein he muſt breathe an air he has been unaccuſtomed to. Rienzi aſcended by degrees the ſummit of his fortune.

Rienzi.

Riches ſoftened, power dazzled, the pomp of his cavalcades animated, and formed in his mind ideas adequate to thoſe of princes born to empire. Hence luxury invaded his table, and tyranny took poſſeſſion of his heart. The Pope conceived his deſigns to be contrary to the intereſts of the holy ſee; and the nobles, whoſe power it had been his conſtant endeavours to depreſs, conſpired againſt him: they ſucceeded; and Rienzi was forced to quit an authority he had poſſeſſed little more than ſix months. It was to a precipitate flight that he was indebted, at this juncture, for his life; and to different diſguiſes for his ſubſequent preſervation.

Having made an ineffectual effort at Rome, and "not knowing where to find a new reſource to carry on his deſigns, he took a moſt bold ſtep, conformable to that raſhneſs which had ſo often aſſiſted him in his former exploits. He determined to go to Prague, to Charles king of the Romans, whom the year before he had ſummoned to his tribunal," and who, he foreſaw, would deliver him up to a Pope highly inceuſed againſt him. He was accordingly ſoon after ſent to Avignon, and there thrown into a priſon, where he continued three years. The diviſions and diſturbances in Italy, occaſioned by the number of petty tyrants that had eſtabliſhed themſelves in the eccleſiaſtical territories, and even at Rome, occaſioned his enlargement. Innocent VI. who ſucceeded Clement in the papacy, ſenſible that the Romans ſtill entertained an affection for our hero, and believing that his chaſtiſement would teach him to act with more moderation than he had formerly done, as well as that "gratitude would oblige him, for the remainder of his life, to preſerve an inviolable attachment to the holy ſee (by whoſe favour he ſhould be re-eſtabliſhed)," thought him a proper inſtrument to aſſiſt his deſign of reducing thoſe other tyrants; and therefore, not only gave him his liberty, but alſo appointed him governor and ſenator of Rome. He met with many obſtacles to the aſſumption of this newly-granted authority; all which, by cunnning and reſolution, he at length overcame. But giving way to his paſſions, which were immoderately warm, and inclined him to cruelty, he excited ſo general a reſentment againſt him, that he was murdered October 8. 1354.

"Such was the end of Nicolas Rienzi, one of the moſt renowned men of the age; who, after forming a conſpiracy full of extravagance, and executing it in the ſight of almoſt the whole world, with ſuch ſucceſs that he became ſovereign of Rome; after cauſing plenty, juſtice, and liberty, to flouriſh among the Romans; after protecting potentates, and terrifying ſovereign princes; after being arbiter of crowned heads; after re-eſtabliſhing the ancient majeſty and power of the Roman republic, and filling all Europe with his fame during the ſeven months of his firſt reign; after having compelled his maſters themſelves to confirm him in the authority he had uſurped againſt their intereſts—fell at length at the end of his ſecond, which laſted not four months, a ſacrifice to the nobility, whoſe ruin he had vowed, and to thoſe vaſt projects which his death prevented him from putting into execution*."

If the reader perceive any thing ſimilar at preſent to the riſe of this wonderful man to ſovereign authority, he may perhaps conſole himſelf with the hope that the modern conſul will in all probability fall like the modern tribune. Both roſe by diſplays of the moſt daring courage; the aſſociates of both were prieſts, who in the actual exerciſe of government were cyphers; both promiſed liberty and plenty to the people whom they ruled with abſolute ſway; and both have trampled upon the order of nobility.

Ring, || Rodney.

RING, in aſtronomy and navigation, an inſtrument uſed for taking the ſun's altitude, &c. It is uſually of braſs, about nine inches diameter, ſuſpended by a little ſwivel, at the diſtance of 45° from the point of which is a perforation, which is the centre of a quadrant of 90° divided in the inner concave ſurface. To uſe it, let it be held up by the ſwivel, and turned round to the ſun, till his rays, falling through the hole, make a ſpot among the degrees, which marks the altitude required. This inſtrument is preferred before the aſtrolabe, becauſe the diviſions are here larger than on that inſtrument.

ROBERVALLIAN LINES, a name given to certain lines uſed for the transformation of figures; thus called from their inventor Roberval, an eminent French mathematician, who died in 1675, aged 76 years. Theſe lines bound ſpaces that are infinitely extended in length, which are nevertheleſs equal to other ſpaces that are terminated on all ſides.

The Abbot Gallois, in the Memoirs of the Royal Academy, anno 1693, obſerves, that the method of transforming figures, explained at the latter end of Roberval's Treatiſe of Indiviſibles, was the ſame with that afterwards publiſhed by James Gregory, in his *Geometria Univerſalis*, and alſo by Barrow in his *Lectiones Geometricæ*; and that, by a letter of Torricelli, it appears, that Roberval was the inventor of this manner of transforming figures, by means of certain lines, which Torricelli therefore called *Robervallian lines*. He adds, that it is highly probable that J. Gregory firſt learned the method in the journey he made to Padua in 1668, the method itſelf having been known in Italy from the year 1646, though the book was not publiſhed till the year 1692.

This account has been, we think, completely refuted by David Gregory in his vindication of his uncle, publiſhed in the Philoſophical Tranſactions of 1694. The Abbot, however, rejoined in the Memoirs of the French Academy of 1703; and it is but fair to obſerve, that Dr Hutton, ſpeaking of the controverſy, expreſſes himſelf as if he thought it undecided.

RODNEY (Lord). In our ſhort ſketch of the life of that gallant officer (*Encycl.*), we mentioned with regret our not having heard of any monument being erected to his honour in his native country. We have ſince learned that there is a pillar upon the Brythen in Shropſhire, which was erected to his memory long before the publication of our article.

Having this great man again under our notice, we inſert with pleaſure the following extract of a letter, which we received from an obliging correſpondent ſoon after the publication of the volume which contains our biographical ſketch of the Admiral: "Whatever were Rodney's merits as a naval commander (ſays our correſpondent), there is a more brilliant part of his character which you have entirely neglected. Prior to his ſucceſs againſt the Spaniſh Admiral Don Langara, the Engliſh who had the misfortune to become priſoners of war to the Spaniards, were treated with the greateſt inhumanity, and it required more than a common ſtrength

---

* Biog. Dict. new edit.

ſtrength of conſtitution to exiſt for any length of time in a Spaniſh priſon. When the Spaniſh admiral fell into the hands of Rodney, he, his officers and ſeamen, expected to meet with the ſame treatment they had always inflicted, and which they would have inflicted on Rodney, his officers, and ſeamen, had the Spaniards been the victors; but, to their ſurpriſe, they found in Admiral Rodney (and, of courſe, in all that were under his command) a man who ſympathiſed in their misfortune, who miniſtered to their neceſſities, and, by a humane and polite behaviour to his priſoners, made an impreſſion on the minds of the Spaniards, which could not but have its effect in mitigating the ſufferings of the Engliſh in Spaniſh priſons: but he did not ſtop here; he took an opportunity, when their minds were expanded by gratitude (and in a ſtate to receive the full force of ſuch a repreſentation), to repreſent to them the miſerable condition of his countrymen who were priſoners in Spain, and obtained a promiſe (which, I believe, was punctually performed), that Engliſhmen, when priſoners in Spain, ſhould be made as comfortable as their ſituation would admit of. This was a piece of ſervice to his country which ſurely merits to be recorded, and which will exalt him as much in the opinion of good men as the moſt brilliant diſplay of *courage*, which is a quality as frequently diſcovered in the ſavage as in the cultivated mind."

ROEBUCK (John, M. D.), was born at Sheffield in Yorkſhire in the year 1718. His father was a conſiderable manufacturer and exporter of Sheffield goods, who by his abilities and induſtry had acquired a competent fortune. John, his eldeſt ſon, the ſubject of this memoir, was intended by his father for carrying on his own lucrative buſineſs at Sheffield; but was, from his early youth, irreſiſtibly attached to other purſuits, more calculated to gratify his ambition, and give fuller play to his powers. Notwithſtanding this diſappointment in his favourite object, his father had liberality enough to encourage his riſing genius, and to give him all the advantages of a regular education.

After he had gone through the uſual courſe of the grammar ſchool at Sheffield, both his father and mother being ſtrict diſſenters, they placed their ſon for ſome years under the tuition of the late Dr Doddridge, who was at that time maſter of an academy at Northampton, and had juſtly acquired high reputation among the diſſenters, both as a divine and as an inſtructor of youth. Under the Doctor's care Mr Roebuck made great proficiency, and laid the foundation of that claſſical taſte and knowledge for which he was afterwards eminently diſtinguiſhed. It would appear that Dr Doddridge had been much pleaſed with the ardour and enthuſiaſm, in the purſuit of knowledge, diſcovered by his pupil; for Mr Roebuck, in an after period of his life, uſed frequently to mention the ſubjects of converſation and inquiries of various kinds, in which the Doctor had engaged him. It was during his reſidence at this academy that he contracted an intimate acquaintance with his fellow-ſtudents, Mr Jeremiah Dyſon, afterwards much known in the political world, and Mr Mark Akenſide, afterwards Dr Akenſide, which terminated only with their lives.

From the academy at Northampton he was ſent to the univerſity of Edinburgh, where he applied to the ſtudy of medicine, and particularly to that of chemiſtry, which about that time began to attract ſome attention in Scotland. While he reſided there, he diſtinguiſhed himſelf much among his fellow-ſtudents in their literary ſocieties and converſations, by great logical and metaphyſical acuteneſs, and by great ingenuity and reſource in argumentation. The late ſagacious Dr Porterfield, to whom he had been introduced, obſerved and encouraged his riſing genius, and was greatly inſtrumental in promoting his improvement. There, too, he formed an intimate acquaintance with Mr Hume, Mr Robertſon, afterwards Dr Robertſon, Mr Pringle, afterwards Lord Alemoor, and ſeveral other perſons of literary eminence; a circumſtance which produced in his mind a partiality ever afterwards in favour of Scotland, and contributed not a little to his making choice of it for the chief field of his future exertions and induſtry.

After Mr Roebuck had gone through a regular courſe of medical education at Edinburgh, being now determined to follow the practice of phyſic, he next ſpent ſome time at the univerſity of Leyden, then in high reputation as the firſt ſchool of medicine in Europe. There, after the uſual reſidence and courſe of trials, he obtained a degree in medicine; and his diploma, dated 21ſt February 1743, has affixed to it the reſpectable names of Muſchenbroek, Oſterdyk, Van Royen, Albinus, Gaubius, &c. He left Leyden, after having viſited ſome part of the north of Germany, about the end of the year 1744.

Soon after his return from the continent, ſome circumſtances induced Dr Roebuck to ſettle as a phyſician at Birmingham. Before that time, Birmingham had begun to make a rapid progreſs in arts, manufactures, and population; and by the death of an aged phyſician, an opening was preſented to him, which afforded an immediate proſpect of encouragement in that line. His education, talents, and intereſting manners, were well calculated to promote his ſucceſs as a phyſician. He accordingly met there, at a period more early than he expected, with great encouragement; and was ſoon diſtinguiſhed, in that town and the country adjacent, for his ſkill, integrity, and charitable compaſſion, in the diſcharge of the duties of his profeſſion.

It appeared, however, ſoon after his reſidence was fixed at Birmingham, that his ſtudies and induſtry were turned to various objects beſides thoſe of his profeſſion. Strongly attached to the riſing ſcience of chemiſtry, he conceived high views of extending its uſefulneſs, and of rendering it ſubſervient to the improvement of arts and manufactures. With this view, he fitted up a ſmall laboratory in his own houſe, in which he ſpent every moment of his time which he could ſpare from the duties of his profeſſion. There, in the true ſpirit of his great maſter Lord Bacon, of whoſe philoſophy he was an ardent admirer, he carried on various chemical proceſſes of great importance, and laid the foundation of his future projects on well-tried and well-digeſted experiments.

The firſt efforts of his genius and induſtry, thus directed, led him to the diſcovery of certain improved methods of refining gold and ſilver, and particularly to an ingenious method of collecting the ſmaller particles of theſe precious metals, which had been formerly loſt in the practical operations of many of the manufacturers. By other chemical proceſſes, carried on about the ſame time in his little laboratory, he diſcovered alſo improved methods of making ſublimate, hartſhorn, and ſundry other articles of equal importance. After having received full ſatisfaction from the experiments upon which ſuch diſcoveries and improvement were founded, he next digeſted a plan for rendering them beneficial to himſelf, and uſeful to the public. A great part of his time being ſtill employed in the duties of his profeſſion, he found it neceſſary to connect himſelf with ſome perſon in whom he could repoſe confidence, and who might be, in other reſpects, qualified to give him ſupport and aſſiſtance in carrying on his intended eſtabliſhments. With this view, he choſe as his aſſociate Mr Samuel Garbet of Birmingham; a gentleman well qualified, by his abilities, activity, and enterpriſing ſpirit, for bearing his part in their future undertakings. Their firſt project was the eſtabliſhment of an extenſive laboratory at Birmingham, for the purpoſes above mentioned; which, conducted by Dr Roebuck's chemical knowledge, and Mr Garbet's able and judicious management, was productive of many advantages to the manufacturers of that place, and of ſuch emolument to themſelves, as contributed greatly to the boldneſs of their future projects. That laboratory has, ever ſince that time, continued at Birmingham, and is ſtill conducted by Mr Garbet. Dr Roebuck, long before his death, had given up his intereſt in it.

About this time, in 1747, the Doctor married Miſs Ann Roe of Sheffield, a lady of a great and generous ſpirit, whoſe temper and diſpoſition equally fitted her for enjoying the proſperous circumſtances of their early life, and for bearing her equal ſhare of thoſe anxieties and diſappointments in buſineſs which ſhaded, but did not obſcure, the later period of their lives.

Dr Roebuck's unremitted perſeverance in his chemical ſtudies, together with the ſucceſs that attended them, led him, ſtep by ſtep, to other reſearches of great public and private benefit.

The extenſive uſe of the vitriolic (ſulphuric) acid in chemiſtry, and the proſpect of its application to ſome of the mechanic arts, had produced a great demand for that article, and turned the attention of chemiſts to various methods of obtaining it. The late Dr Ward had obtained a patent for making it; and though the ſubſtances from which it might be obtained, as well as certain methods of obtaining it, had been known to others, and particularly pointed out by Lemery the Elder, and by Glauber, yet Dr Ward was the firſt, it is believed, who eſtabliſhed a profitable manufacture upon the diſcovery. Much, however, was wanting to render the acid of univerſal uſe in chemiſtry, and of extenſive utility in the arts, where great quantities of it were required. The price of it was high, ariſing from the great expence of the glaſs veſſels, which were made uſe of by Dr Ward in procuring it, and the frequent accidents to which they were liable in the proceſs.

Dr Roebuck had been for ſome time engaged in making experiments with a view to reduce the price, and at length diſcovered a method of preparing it, by ſubſtituting, in place of the glaſs veſſels formerly uſed, lead ones of a great ſize; which ſubſtitution, together with ſundry other improvements in different parts of the proceſs, completely effected his end.

After the neceſſary preparations had been made, Meſſrs Roebuck and Garbet eſtabliſhed a manufacture of the oil of vitriol at Preſtonpans, in Scotland, in the year 1749. This eſtabliſhment not a little alarmed Dr Ward, who attempted to defeat their plan, by taking out a patent for Scotland, in addition to the one he had formerly obtained. In this attempt he failed. Dr Roebuck's diſcovery was found not to come within the ſpecification of Dr Ward's patent.

The Preſtonpans company, convinced that patents are of little avail in preſerving the property of new inventions or diſcoveries, in conducting their vitriol works reſolved to have recourſe to the more effectual methods of concealment and ſecrecy. By that method they were enabled to preſerve the advantages of their ingenuity and induſtry for a long period of years, and not only ſerved the public at a much cheaper rate than had ever been done formerly, but, it is believed, they realized, in that manufacture, a greater annual profit from a ſmaller capital than had been done in any ſimilar undertaking. The vitriol work is ſtill carried on at Preſtonpans; but long before Dr Roebuck's death, he was obliged to withdraw his capital from it.

About this time Dr Roebuck was urged, by ſome of his friends, to leave Birmingham, and to ſettle as a phyſician in London, where his abilities might have had a more extenſive field of exertion. He had been early honoured with the acquaintance of the late Marquis of Rockingham, who, as a lover of arts, had frequently engaged him in chemical experiments at Rockingham-houſe. It was there, alſo, he became acquainted with the late Sir George Saville, and with ſeveral other perſons of rank and influence. His old friend and ſchool-fellow Mr Dyſon, too, by this time, had acquired conſiderable name and influence, and preſſed him much to take that ſtep. Under ſuch patronage, and with the energy of ſuch talents as Dr Roebuck poſſeſſed, there could be little doubt of his ſoon arriving at an eminent rank as a phyſician in London. But the chemical concerns, with which he was at that time deeply occupied, holding out to him a proſpect of a richer harveſt, determined him to give up the practice of medicine altogether, and to fix his reſidence for the greateſt part of the year in Scotland.

The ſucceſs of the eſtabliſhment at Preſtonpans, which had far exceeded their expectation, enabled the Doctor and his partner Mr Garbet to plan and execute other works of ſtill greater benefit and public utility. In the proſecution of his chemical ſtudies and experiments, Dr Roebuck had been led to beſtow great attention on the proceſſes of ſmelting iron-ſtone, and had made ſome diſcoveries, by which that operation might be greatly facilitated, particularly by uſing pit-coal in place of charcoal. Mr William Caddell of Cockenzie, in the neighbourhood of Preſtonpans, a gentleman earneſtly intent upon promoting manufactures in Scotland, had, for ſeveral years, laboured, without much ſucceſs, in eſtabliſhing a manufacture of iron; a circumſtance which may have probably contributed to turn Dr Roebuck's attention more particularly to that ſubject. As the capital which he and his partner Mr Garbet could appropriate for carrying on the iron manufacture was not equal to ſuch an undertaking, and chiefly depended upon the profits of their other works, their firſt intention was to attempt a ſmall eſtabliſhment of that kind in the vicinity of their vitriol works at Preſtonpans. But the flattering proſpects of ſucceſs, ariſing from a courſe of experiments which Dr Roebuck had lately made, encouraged them to extend their

Roebuck.

plan, and to project a very extenſive manufactory of iron. A ſufficient capital was ſoon procured, through the confidence which many of their friends repoſed in their abilities and integrity. In fact, the eſtabliſhment which they made, or rather the capital which gave it exiſtence, was the united capital of a band of relations and friends, who truſted to Dr Roebuck and Mr Garbet the management of a great part of their fortune. When all previous matters had been concerted reſpecting their intended eſtabliſhment, the chief exertions of chemical and mechanical ſkill, neceſſary in the execution, were expected from Dr Roebuck. It fell to his ſhare alſo to fix upon the beſt and moſt favourite ſituation for erecting their intended works. With that view Dr Roebuck examined many different places in Scotland, particularly thoſe on both ſides of the Frith of Forth; and after a careful and minute compariſon of their advantages and diſadvantages, he at length made choice of a ſpot on the banks of the river *Carron* as the moſt advantageous ſituation for the eſtabliſhment of the iron manufacture. There he found they could eaſily command abundance of water for the neceſſary machinery; and in the neighbourhood of it, as well as everywhere both along the north and ſouth-coaſts of the Frith, were to be found inexhauſtible quarries of ironſtone, limeſtone, and coal. From Carron, alſo, they could eaſily tranſport their manufactures to different countries by ſea. The communication with Glaſgow at that time by land carriage, which opened up to them a ready way to the American market, was ſhort and eaſy.

Many other things, that need not be here enumerated, fell to Dr Roebuck's ſhare in preparing and providing for the introduction of this new manufacture into Scotland, particularly with reſpect to the planning and erection of the furnaces and machinery. To inſure ſucceſs in that department, nothing was omitted which ability, induſtry, and experience could ſuggeſt. With this view, he called to his aſſiſtance Mr Smeaton, then by far the firſt engineer in England. It was from him he received plans and drawings of the water-wheels and blowing apparatus, which, notwithſtanding all the mechanical improvements which have been made ſince, remain unrivalled in any of the other iron-works erected in Britain. This was the firſt introduction of Mr Smeaton into Scotland, and was the occaſion of various other diſplays of the ſkill and experience of that celebrated engineer in that part of the iſland. With the ſame view, and to the ſame effect, in a future period of his operations, he employed Mr James Watt, then of Glaſgow, and had the merit of rendering that inventive genius, in the mechanical arts, better known both in this country and in England.

The neceſſary preparations for the eſtabliſhment of the iron-works at Carron were finiſhed in the end of the year 1759; and on the 1ſt January 1760 the firſt furnace was blown; and in a ſhort time afterwards a ſecond was erected.

No period of Dr Roebuck's life required from him more vigorous and laborious exertions than that of the eſtabliſhment of the Carron works, and the firſt trials of the furnaces and machinery. His family and friends remember well the ardour and intereſt which he diſcovered; the inceſſant labour and watchfulneſs which he exerted on that occaſion. Every thing was untried, the furnaces, the machinery, the materials, the workmen; the novelty of the undertaking in that country, its extent and difficulty, and the great ſtake at iſſue, were circumſtances that muſt have occaſioned much ſerious thought and anxiety to the partner, upon the credit of whoſe knowledge and experience the work had been undertaken. But the Doctor had great powers and great reſources; and the firſt trial gave ſufficient indications of future ſucceſs.

Roebuck.

For ſome time after the eſtabliſhment of the Carron works, Dr Roebuck continued to give his attention and aſſiſtance in the general management and ſuperintendance of them, and with him all meaſures of future operations were concerted. During this period, ſome alterations of great importance were ſuggeſted by him, and carried into effect. By carefully obſerving the progreſs of ſmelting in the furnaces, at firſt worked by bellows, beſides their being ſubject to various accidents, the Doctor diſcovered the neceſſity of rendering the blaſt both ſtronger and more equable; and propoſing, as a problem to Mr Smeaton, the beſt method of effecting that end, that celebrated engineer ſoon gave the plan of a blaſt by three or four cylinders, which was afwards tried, and ſucceeded even beyond expectation.

When the buſineſs at Carron ſunk by degrees into a matter of ordinary detail, and afforded leſs ſcope for the Doctor's peculiar talents, he was unfortunately tempted to engage in a new and different undertaking; from the failure of which he ſuffered a reverſe of fortune, was deprived of the advantages reſulting from his other works, and during the remainder of his life became ſubjected to much anxiety and diſappointment.

The eſtabliſhment of the Carron works, and the intereſt Dr Roebuck had in their ſucceſs, had naturally turned his attention to the ſtate of coal in the neighbourhood of that place, and to the means of procuring the extraordinary ſupplies of it which the iron-works might in future require. With the view, therefore, of increaſing the quantity of coal woked in that neighbourhood, by an adventure which he thought would alſo turn out to his own emolument, he was induced to become leſſee of the Duke of Hamilton's extenſive coal and ſalt works at Borrowſtounneſs. The coal there was repreſented to exiſt in great abundance, and underſtood to be of ſuperior quality; and as Dr Roebuck had made himſelf acquainted with the moſt improved methods of working coal in England, and then not practiſed in Scotland, he had little doubt of this adventure turning out beneficial and highly lucrative. In this, however, he was cruelly diſappointed. The opening of the principal ſtratum of coal required much longer time, and much greater expence, than had been calculated; and, after it was opened, the perpetual ſucceſſion of difficulties and obſtacles which occurred in the working and raiſing of the coal, was ſuch as has been ſeldom experienced in any work of that kind. The reſult was, that after many years of labour and induſtry, there were ſunk in the coal and ſalt works at Borrowſtounneſs, not only his own, and the conſiderable fortune brought him by his wife, but the regular profits of his more ſucceſsful works; and along therewith, what diſtreſſed him above every thing, great ſums of money borrowed from his relations and friends, which he was never able to repay; not to mention that, from the ſame cauſe, he was, during the laſt twenty years of his

his life, ſubjected to a conſtant ſucceſſion of hopes and diſappointments, to a courſe of labour and drudgery ill ſuited to his taſte and turn of mind, to the irkſome and teaſing buſineſs of managing and ſtudying the humours of working colliers. But all theſe difficulties his unconquerable and perſevering ſpirit would have overcome, if the never-ceaſing demands of his coal-works, after having exhauſted the profits, had not alſo compelled him to withdraw his capital from all his different works in ſucceſſion; from the refining work at Birmingham, the vitriol work at Preſtonpans, the iron-works at Carron, as well as to part with his intereſt in the project of improving the ſteam-engine, in which he had become a partner with Mr Watt, the original inventor, and from which he had reaſon to hope for future emolument.

It would be painful to mention the unhappy conſequences of this ruinous adventure to his family and to himſelf. It cut off for ever the flattering proſpect which they had of an independent fortune, ſuited to their education and rank in life. It made many cruel encroachments upon the time and occupations of a man whoſe mind was equally fitted to enjoy the high attainments of ſcience, and the elegant amuſements of taſte. As the price of ſo many ſacrifices, he was only enabled to draw from his colliery, and that by the indulgence of his creditors, a moderate annual maintenance for himſelf and family during his life. At his death, his widow was left without any proviſion whatever for her immediate or future ſupport, and without the ſmalleſt advantage from the extraordinary exertions and meritorious induſtry of her huſband.

Dr Roebuck had, ſome years before his death, been attacked by a complaint that required a dangerous chirurgical operation. That operation he ſupported with his uſual ſpirit, and reſolution. In a ſhort time he was reſtored to a conſiderable ſhare of his former health and activity; but the effects of it never entirely left him, and ſeveral ſlighter returns of the complaint gradually impaired his conſtitution. He ſtill, however, continued, till within a few weeks of his death, to viſit his works, and to give direction to his clerks and overſeers. He was confined to his bed only a few days; and died on the 17th July 1794, retaining to the laſt all his faculties, his ſpirit and good humour, as well as the great intereſt which he took, as a man of ſcience and reflection, in the uncommon events which the preſent age has exhibited.

From a man ſo deeply and ſo conſtantly engaged in the detail of active buſineſs, many literary compoſitions were not to be expected. Dr Roebuck left behind him many *works*, but few *writings*. The great object which he kept invariably in view was to promote arts and manufactures, rather than to eſtabliſh theories or hypotheſes. The few eſſays which he left, enable us to judge of what might have been expected from his talents, knowledge, and boldneſs of invention, had not the active undertakings in which, from an early period of life, he was engaged, and the fatiguing details of buſineſs, occupied the time for ſtudy and inveſtigation. A compariſon of the heat of London and Edinburgh, read in the Royal Society of London June 29. 1775; experiments on ignited bodies, read there 16th Feb. 1776; obſervations on the ripening and filling of corn, read in the Royal Society of Edinburgh 5th June 1784—are all the writings of his, two political pamphlets excepted, which have been publiſhed. The publication of the eſſay on ignited bodies was occaſioned by a report of ſome experiments made by the Comte de Buffon, from which the Comte had inferred, that *matter* is heavier when hot than when cold. Dr Roebuck's experiments, made with great accuracy before a committee of the Royal Society at London, ſeem to refute that notion.

It is the works and eſtabliſhments projected and executed by Dr Roebuck, with the immediate and more remote effects of them upon the induſtry, arts, and manufactures of Scotland, which urge a juſt claim to the reſpect and gratitude of his country. This tribute is more due from the diſcerning part of mankind, as this ſpecies of merit is apt to be overlooked by the buſy or the ſuperficial, and to fail in obtaining its due reward. The circumſtances of Dr Roebuck were, in this reſpect, peculiarly hard: for though, moſt certainly, the projector and author of new eſtabliſhments highly uſeful to his country, and every day becoming more ſo, he was, by a train of unfortunate events, obliged to break off his connection with them, at an unſeaſonable time, when much was yet wanting to their complete ſucceſs: and thus he left others in the poſſeſſion, not only of the lucrative advantages now derived from them, but even in ſome meaſure of the general merit of the undertaking, to a conſiderable part of which he had the moſt undoubted claim.

The eſtabliſhment of the laboratory at Birmingham in the year 1747, the firſt public exhibition of Dr Roebuck's chemical talents, was, at that particular period, and in the ſtate of the arts and manufactures at that time, highly beneficial, and ſubſervient to their future progreſs: and the continuance and ſucceſs of it, in that place, is a proof of the advantages which many of the manufacturers receive from it. Much had already been done, and many improvements made in arts and manufactures, chiefly by the ſuggeſtions of that ingenuity and experience which, in the detail of buſineſs, might be expected from the practical artiſt. Dr Roebuck was qualified to proceed a ſtep farther; to direct experience by principles, and to regulate the mechanical operation of the artiſt by the lights of ſcience. The effects of that eſtabliſhment extended, in a particular manner, to all that variety of manufactures in which gold and ſilver were required, to the preparing of materials, the ſimplifying of the firſt ſteps, to the ſaving of expence and labour, and to the turning to ſome account what had been formerly loſt to the manufacturer. It is well known that, while Dr Roebuck reſided at Birmingham, ſuch was the opinion formed of his chemical knowledge and experience by the principal manufacturers, that they uſually conſulted him on any new trial or effort to improve their ſeveral manufactures; and when he left that place, they ſincerely regretted the loſs of that eaſy and unreſerved communication they had with him on the ſubjects of their ſeveral departments.

On account of ſimilar circumſtances, the benefit to the public, from the eſtabliſhment of the vitriol works at Preſtonpans, in the extenſion and improvement of many of the arts, cannot now be exactly aſcertained. The vitriolic acid is one of the moſt active agents in chemiſtry, and every diſcovery which renders it cheap and acceſſible to the chemiſt muſt be greatly ſubſervient to the progreſs of that ſcience. By the eſtabliſhment at Preſtonpans, the price of that valuable acid was reduced from ſixteen to four-pence *per* pound. It is to Dr Roebuck, therefore, that chemiſts are indebted for being in poſſeſſion of a cheap acid, to which they can have recourſe in ſo many proceſſes.

But Dr Roebuck's object in the proſecution of that ſcheme, was not ſo much to facilitate the chemiſt's labour, as to render that acid, in a much higher degree than it had formerly been, ſubſervient to many of the practical arts. By rendering the vitriolic acid cheap, great uſe came to be made of it in preparing the muriatic acid, and Glauber's ſalts from common ſalts. Its uſe has been farther extended to many metallic proceſſes; and it has lately been employed in ſeparating ſilver from the clippings of plated copper, the uſe of which is very extenſive.

The project and eſtabliſhment, however, of the iron-works at Carron, the moſt extenſive eſtabliſhment of that kind hitherto in Britain, muſt be conſidered as Dr Roebuck's principal work. The great and increaſing demand for iron in the progreſſive ſtate of arts, manufactures, and commerce in Britain, and the great ſums of money ſent every year to the north of Europe for that article, turned the attention of chemiſts and artiſts to the means of promoting the manufacture of iron, with the view of reducing the importation of it. No perſon has a better founded claim to merit, in this particular, than Dr Roebuck. The ſmelting of iron by pitcoal, it is indeed believed, had been attempted in Britain in the beginning of the laſt century. In the reign of James I. ſeveral patents ſeem to have been granted for making hammered iron by pitcoal, particularly to the Hon. Dud Dudley and Simon Starlevant It does not appear, however, that any progreſs had been made in the manufacture in conſequence of theſe patents. In later times trials have been made by ſo many different perſons, and in ſo many different places in England, nearly about the ſame time, that it may be difficult to ſay where and by whom the firſt attempt was made, particularly as the diſcoverers of ſuch proceſſes wiſhed to conceal the knowledge they had gained as long as they could. But Dr Roebuck was certainly among the firſt who, by means of pitcoal, attempted to refine crude or pig iron, and to make bar iron of it, inſtead of doing it by charcoal, according to the former practice: And he was, without all queſtion, the perſon who introduced that method into Scotland, and firſt eſtabliſhed an extenſive manufacture of it. It is not meant to aſcribe to him the ſole merit of the eſtabliſhment at Carron. No man was ever more ready than he was to do juſtice to the abilities and ſpirit of his friends and partners Meſſrs Garbet, Caddell, &c. who firſt embarked with him in that great undertaking. But ſtill it may be ſaid with truth, that the original project of the iron-works at Carron, the chemical knowledge and experience on which they were founded, the complicated calculations which were previouſly required, the choice of the ſituation, the general conduct and direction of the buildings and machinery, the ſuggeſtion of many occaſional improvements, together with the removal of many unforeſeen obſtacles and difficulties, which occurred in the infant ſtate of that eſtabliſhment, were, in a great meaſure, the work and labour of Dr Roebuck. Nor can it, with the leaſt ſhadow of juſtice, detract from his merit, that a larger capital, and greater expence than was at firſt calculated, have been found neceſſary to bring the works at Carron to their preſent ſtate of perfection; or, that great alterations and improvements have taken place, during the courſe of forty years, in a great and progreſſive eſtabliſhment. In all works of that kind, the expence exceeds the calculation. The undertakers, even of the lateſt iron-works which have been erected, notwithſtanding all the advantages obtained from recent experience, will be ready to acknowledge, that, in theſe reſpects, there is little room to blame the original projector of the firſt eſtabliſhment of that kind in Scotland. But the beſt, and moſt infallible proof of Dr Roebuck's merit, and of the ſound principles on which theſe works were eſtabliſhed, is the preſent proſperous ſtate of that eſtabliſhment, the great perfection of many branches of their manufactures, and particularly the many extenſive and flouriſhing iron-works which have ſince been erected upon the model of Carron in different parts of Scotland, at Cleugh, Clyde, Muirkirk, and Devon. It cannot be denied that all theſe works have ſprung from the eſtabliſhment at Carron, and are ultimately founded upon the knowledge and experience which have been obtained from them; for ſome of the partners, or overſeers of theſe new works, and many of the workmen, have been, at one time or another, connected with that of Carron. Hence, then, it is owing to the projector and promoter of the eſtabliſhment at Carron, that Scotland is, at this moment, benefited to the amount of many hundred thouſand pounds, in working up the raw materials of that manufacture found in the country itſelf, and which, previous to that eſtabliſhment, was of no value whatever. Such are the *preſent*, but ſcarcely any idea can be formed of the *future*, advantages to this country, which may be derived from the extenſion of the iron manufacture. About 60,000 tons of iron have been annually imported into Great Britain for more than twenty years paſt; and though there has been for ſome time about 20,000 tons of bar iron made in Britain by pitcoal, yet the foreign imported iron has ſuffered little or no diminution in quantity. This great conſumption of iron, no doubt, is owing to the various improvements of late years, and the general extenſion throughout all Europe of commerce and the arts. The manufacture of iron muſt therefore continue to increaſe; and Scotland, abounding everywhere in ironſtone, pitcoal, and in command of water for machinery, has the proſpect of obtaining the largeſt ſhare of it.

To the eſtabliſhment of the Carron works, and to the conſequences of that eſtabliſhment, may be aſcribed alſo the exiſtence of other public works in Scotland of great importance and utility. The opening of a communication by water betwixt the Forth and the Clyde had long been projected, and frequently the ſubject of converſation in Scotland, but nothing in fact had been attempted. The eſtabliſhment of the iron-works at Carron ſoon called forth ſufficient intereſt and enterpriſe to bring about the execution of this grand deſign. Some of the partners of the Carron company, foreſeeing the advantages they would derive from ſuch a communication, propoſed, at their own expence, to execute a ſmall canal; and, after taking the preparatory ſteps, actually applied to Parliament to obtain authority for that purpoſe. But the project of the ſmall canal not meeting with the approbation of ſome noblemen and gentlemen in that part of Scotland, they oppoſed the bill, and obliged themſelves to execute a greater canal, which has now been many years finiſhed, and is found to be of the greateſt advantage to the trade and commerce of Scotland. The merit of this undertaking is not meant to be aſcribed to Dr Roebuck, excepting in ſo far as it neceſſarily aroſe from the eſtabliſhment of the Carron company, of which he was the original projector; and it may reaſonably be doubted whether, without that eſtabliſhment, it would have yet taken place. Several other canals have, ſince that time, been executed in different parts of Scotland, and other very important ones are at preſent projected.

The different eſtabliſhments which Dr Roebuck made at Borrowſtounneſs in carrying on the coal and ſalt works there, though ultimately of no advantage to himſelf, were attended, during the courſe of thirty years, with the moſt beneficial effects upon the trade, population, and induſtry of that part of Scotland. They were the means alſo of adding very conſiderably to the public revenue. Previous to the time theſe works fell under Dr Roebuck's management, they produced no advantage either to the proprietor, to the adventurers, or to the public. But by his mode of conducting them upon a more extenſive plan, by opening up new ſeams of coal, and of better quality, he was enabled to export a very conſiderable quantity, to increaſe the quantity of ſalt, and of courſe the revenue ariſing from theſe articles. In theſe works, and in the management of a large farm, Dr Roebuck gave employment to near a thouſand perſons at Borrowſtounneſs and in the neighbourhood.

Nor was it ſolely by the different eſtabliſhments which he projected and executed, but by many other things neceſſarily connected with them, that Dr Roebuck's labours were beneficial to Scotland. Along with them he may be ſaid to have introduced a ſpirit of enterpriſe and induſtry, before that time little known in Scotland, which ſoon pervaded many other departments of labour, and gave birth to many other uſeful projects. He brought from England, then much farther advanced in arts and induſtry, many ingenious and induſtrious workmen, at great expence, who, by their inſtructions and example, communicated and diffuſed ſkill and knowledge to others. At all times Dr Roebuck held out liberal encouragement to riſing genius and induſtrious merit; and ſpared no expence in making trials of improvements and diſcoveries which were connected with the different projects and works which he was carrying on.

Such was the active and uſeful life of Dr Roebuck, a man of no common caſt, who united, in a very high degree, a great number of ſolid and brilliant talents, which, even ſeparately, fall to the lot of but few individuals. Diſtinguiſhed by an ardent and inventive mind, delighting in purſuit and inveſtigation, always aſpiring at ſomething beyond the preſent ſtate of ſcience and art, and eagerly preſſing forward to ſomething better or more perfect, he thus united energies the moſt powerful with the moſt unwearied and perſevering induſtry. To that peculiarity of imagination, ſo fitted for ſcientific purſuit, which readily combines and unites, which ſteadily preſerves its combinations before the eye of the mind, and quickly diſcovers relations, reſults, and conſequences, was added, in his character, great promptitude and firmneſs in deciſion. Strongly and early impreſſed with the great importance of applying chemical and phyſical knowledge to the uſeful arts, to the melioration of civil life, he never loſt ſight of that favourite view, and diſcovered great boldneſs and reſource in the means and expedients which he adopted to promote it. He was certainly maſter of the beſt philoſophy of chemiſtry known in the earlier parts of his life; and though in every ſtage of that ſcience he marked and underſtood the progreſs of the diſcoveries, yet his numerous avocations did not permit him to follow them out by experimental proceſſes of his own. Upon that, and indeed almoſt upon every ſubject, his mind readily graſped the moſt uſeful and ſubſtantial points, and enabled him to throw out ſuch hints and hypotheſes as marked him the man of genius.

During the courſe of a regular education, both at Edinburgh and at Leyden, Dr Roebuck ſtudied the claſſic authors with great attention, particularly the hiſtorical and political parts of their works. Upon theſe ſubjects he had read much, ſelected with judgment, and was well acquainted with the facts and philoſophy of ancient governments. This taſte he carried with him, and improved in every period of his life, and in every ſituation. It abundantly rewarded him for the earneſtneſs and diligence with which it had been acquired. It became his favourite reſource, and indeed one of the chief enjoyments of his life. Poſſeſſing the happy talent of turning his mind from ſerious and fatiguing, to elegant and recreating purſuits, it was no uncommon thing with him to return from the laboratory or the coalpit, and draw relaxation or relief from ſome one or other of the various ſtores of claſſical learning.

No man was better acquainted with the hiſtory of his country than Dr Roebuck, or more admired and revered the conſtitution of its government. By temper and education he was a Whig, and at all times entered with great warmth into the political diſputes and controverſies which agitated parties in the different periods of his life. If the natural warmth of his temper, and his enthuſiaſm on theſe ſubjects, led him, on ſome occaſions, beyond the bounds of candid argumentation, his quick ſenſe of decorum, and his perfect habits of good manners, produced an immediate atonement, and reſtored the rights of elegant and poliſhed converſation.

The general acquaintance which Dr Roebuck had acquired with natural and experimental philoſophy, together with his claſſical and political knowledge, rendered him an agreeable companion to the learned almoſt of every department, and procured him the attachment and friendſhip of many of the firſt literary characters in Britain. With his friend Dr Black he lived till his death in cloſe habits of intimacy; and he often acknowledged, with much frankneſs, the advantages which he derived, in his various purſuits, from a free and unreſerved communication with that eminent chemiſt.

The amiable diſpoſitions of ſenſibility, humanity, and generoſity, which ſtrongly marked his character, in the general intercourſe of ſociety, were peculiarly preſerved and exerciſed in the boſom of his family, and in the circle of his friends. In the various relations of huſband, father, friend, or maſter, and in the diſcharge of the reſpective duties ariſing from them, it would not be eaſy to do juſtice to his character, or to determine in which of them he moſt excelled ; nor muſt it be forgot, for it reflected much honour on his benevolent heart, that his workmen not only found him at all times a kind and indulgent maſter, but many of them, when their circumſtances required it, a ſkilful and compaſſionate phyſician, who cheerfully viſited the humbleſt receſſes of poverty, and who attached them to his ſervice by multiplied acts of generoſity and kindneſs.

ROEMER (Olaus), a noted Daniſh aſtronomer and mathematician, was born at Arhuſen in Jutland, 1644; and at 18 years of age was ſent to the univerſity of Copenhagen. He applied aſſiduouſly to the ſtudy of the mathematics and aſtronomy, and became ſo expert in thoſe ſciences, that when Picard was ſent by Louis the XIV. in 1671, to make obſervations in the north, he was greatly ſurpriſed and pleaſed with him. He engaged him to return with him to France, and had him preſented to the king, who honoured him with the dauphin as a pupil in mathematics, and ſettled a penſion upon him. He was joined with Picard and Caſſini, in making aſtronomical obſervations; and in 1672 he was admitted a member of the Academy of Sciences.

During the ten years he reſided at Paris, he gained great reputation by his diſcoveries; yet it is ſaid he complained afterwards, that his coadjutors ran away with the honour of many things which belonged to him. Here it was that Roemer, firſt of any one, found out the velocity with which light moves, by means of the eclipſes of Jupiter's ſatellites. He had obſerved for many years, that when Jupiter was at his greateſt diſtance from the earth where he could be obſerved, the emerſions of his firſt ſatellite happened conſtantly 15 or 16 minutes later than the calculation gave them. Hence he concluded, that the light reflected by Jupiter took up this time in running over the exceſs of diſtance; and conſequently that it took up 16 or 18 minutes in running over the diameter of the earth's orbit, and 8 or 9 in coming from the ſun to us, provided its velocity was nearly uniform. This diſcovery had at firſt many oppoſers; but it was afterwards confirmed by Dr Bradley in the moſt ingenious and beautiful manner.

In 1681 Roemer was recalled to his native country by Chriſtian the Vth King of Denmark, who made him profeſſor of aſtronomy at Copenhagen. The king employed him alſo in reforming the coin and the architecture, in regulating the weights and meaſures, and in meaſuring and laying out the high roads throughout the kingdom; offices which he diſcharged with the greateſt credit and ſatisfaction. In conſequence he was honoured by the king with the appointment of chancellor of the exchequer and other dignities. Finally, he became counſellor of ſtate, and burgomaſter of Copenhagen, under Frederic the IV. the ſucceſſor of Chriſtian. Roemer was preparing to publiſh the reſult of his obſervations, when he died the 19th of September 1710, at 66 years of age: but this loſs was ſupplied by Horrebow, his diſciple, then profeſſor of aſtronomy at Copenhagen, who publiſhed, in 4to, 1753, various obſervations of Roemer, with his method of obſerving, under the title of *Baſis Aſtronomiæ*.—He had alſo printed various aſtronomical obſervations and pieces, in ſeveral volumes of the Memoirs of the Royal Academy of Sciences at Paris, of the inſtitution of 1666, particularly vol. 1. and 10. of that collection.

ROLLOCK (Robert), the firſt principal of the college of Edinburgh, was the ſon of David Rollock of *Poo houſe*, or, as it is now written, *Powis*, in the neighbourhood of Stirling. He was born in 1555; and learned the rudiments of the Latin tongue under one Mr Thomas Buchanan, who kept, ſays Archbiſhop Spottiſwood, a famous ſchool at that time, and was, according to Dr Mackenzie, one of the moſt eminent grammarians in Scotland. Where Mr Buchanan kept his ſchool, neither of theſe authors has informed us.

From ſchool Mr Rollock was ſent, we know not in what year, to the univerſity of St Andrews, and admitted a ſtudent in St Salvator's college. His progreſs in the ſciences, which were then taught, was ſo great and ſo rapid, that he had no ſooner taken his degree of M. A. than he was choſen a profeſſor of philoſophy, and immediately began to read lectures in St Salvator's college. This muſt have been at a very early period of life; for he quitted St Andrews in the year 1583, when, according to Mackenzie, he had taught philoſophy for ſome time in that univerſity.

Not long before this period, the magiſtrates of Edinburgh having petitioned the king to erect a univerſity in that city, he granted them a charter under the great ſeal, allowing them all the privileges of a univerſity; and the college being built in 1582, they made choice of Mr Rollock to be their principal and profeſſor of divinity.

At what time he was admitted into holy orders, by whom he was ordained, or indeed whether he ever was ordained, has been the ſubject of ſome acrimonious controverſy; but it is a controverſy which we ſhall not revive; for, conſidering the manner in which orders were then conferred in Scotland, the queſtion in debate is of very little importance. It is certain that he became famous in the univerſity, and among his countrymen in general, for his lectures in theology, and for the perſuaſive power of his preaching; for Calderwood aſſures us, that, in 1589, he and Mr Robert Bruce, another popular orator, made the Earl of Bothwel ſo ſenſible of his ſinful and vitious courſes, that, upon the 9th of November, his lordſhip humbled himſelf upon his knees in the eaſt church in the forenoon, and in the high church in the afternoon, confeſſing before the people, with tears in his eyes, his diſſolute and licentious life, and promiſing to prove, for the future, another man.

In the year 1593, Principal Rollock and others were appointed by the ſtates of parliament to confer with the popiſh lords; and in the next year he was one of thoſe who, by the appointment of the general aſſembly of the church, met at Edinburgh in the month of May, and preſented to his majeſty a paper, entitled, *The dangers which, through the impunity of* EXCOMMUNICATED PAPISTS, TRAFFICKERS WITH THE SPANIARDS, *and other enemies of the religion and eſtate, are imminent to the true religion profeſſed within this realm, his Majeſty's perſon, crown, and liberty of this our native country.* His zeal againſt Papiſts was indeed ardent; and he ſeems to have adopted that judaical doctrine, which was embraced in ſome degree by all the reformers, that it is the duty of the civil magiſtrate to puniſh idolatry with death.

In the year 1595 he was nominated one of the commiſſioners for the viſitation of colleges. Theſe comllock,

miſſioners were empowered to viſit all the colleges in the kingdom, to inquire into the doctrine and life of the ſeveral maſters, the diſcipline uſed by them, the ſtate of their rents and living, and to make their report to the next aſſembly.

In 1596, the factious behaviour of ſome of the miniſters having drawn upon them the juſt reſentment of the king, our principal was employed, on account of his moderation, to ſoften that reſentment, and to turn his majeſty's wrath againſt the *Papiſts!* In the year 1597, he was choſen moderator of the General Aſſembly—the higheſt dignity in the Scottiſh church; and he had the influence to get ſome great abuſes redreſſed. Being one of fourteen miniſters appointed by this aſſembly to take care of the affairs of the church, the firſt thing which he did was to procure an act of the legiſlature, reſtoring to the prelates their ſeats in parliament. He had here occaſion for all his addreſs; for he had to reconcile to this meaſure, not only ſuch of the miniſters as abhorred all kinds of ſubordination in the church, but likewiſe many of the lay lords, who were not delighted with the proſpect of ſuch aſſociates in parliament as the Scotch prelates were at that period (A).

Though he ſpent the greater part of his life in conducting the affairs of the church, we have the authority of Spottiſwood for ſaying, that he would have preferred retirement and ſtudy. To the buſtle of public life, eſpecially at that period of faction and fanaticiſm, his feeble conſtitution was not equal; and his inclination would have confined him to his college and his library. He was dreadfully afflicted with the ſtone; the torments of which he long bore with the fortitude and reſignation of a Chriſtian. He died at Edinburgh on the 28th of February 1598, in the 43d year of his age; having exhorted his brethren, with his dying breath, to carry themſelves more dutifully to their gracious ſovereign.

His works are, 1. A Commentary on the Firſt Book of Theodore Beza's Queſtions. 2. A Commentary on St Paul's Epiſtle to the Epheſians, 4to, Edinburgh, 1590. 3. A Commentary on the Prophet Daniel, 4to, Edinburgh, 1591. 4. A Logical Analyſis of St Paul's Epiſtle to the Romans, 8vo, Edinburgh, 1594. 5. Some Queſtions and Anſwers concerning the Covenant of Grace and the Sacraments, 8vo, Edinburgh, 1596. 6. A Treatiſe of Effectual Calling, 8vo, Edinburgh, 1597. 7. A Commentary on the Epiſtles of St Paul to the Theſſalonians and Philemon, 8vo, Geneva, 1597. 8. A Commentary upon Fifteen Select Pſalms, 8vo, Geneva, 1598. 9. A Commentary on the Goſpel of St John, with a harmony of the Four Evangeliſts upon the Death, Reſurrection, and Aſcenſion of Jeſus Chriſt, 8vo, Geneva, 1599. 10. Certain Sermons on Several Places of St Paul's Epiſtles, 8vo, Edinburgh, 1598. 11. A Commentary upon the Epiſtle to the Coloſſians, 8vo, publiſhed at Geneva, 1602. 12. A Logical Analyſis of the Epiſtle to the Hebrews, 8vo, Edinburgh, 1605. 13. A Logical Analyſis of the Epiſtle to the Galatians, 8vo, London, 1602. 14. A Commentary upon the Two Firſt Chapters of the Firſt Epiſtle of St Peter, 8vo, London, 1603. 15 and 16. A Treatiſe of Juſtification, and another of Excommunication, both in 8vo, London, 1604. All theſe works, except the ſermons, are in Latin. That Principal Rollock was held in high eſtimation in the college over which he preſided, is made at leaſt probable by the following epitaph:

Te Rolloce, extincto, Urbs mœſta, Academia mœſta eſt;
Et tota exequiis Scotia mœſta tuis.
Uno in te nobis dederat Deus omnia, in uno
Te Deus eripuit omnia quæ dederit.

Roſes, Rota.

ROSES Otter (or eſſential oil) of. In the *Encyclopædia*, under the word Roses, we have given one receipt for making this very high-priced perfume; and we ſhall here give another; which, whether it be as effectual or not, is at leaſt ſimpler and leſs expenſive. It is by an officer who was in the country where the *Otter* is prepared, and who aſſiſted in making it himſelf; and is as follows:

"Take a very large glazed earthen or ſtone jar, or a large clean wooden caſk; fill it with the leaves of the flowers of roſes, very well picked, and freed from all ſeeds and ſtalks; pour on them as much pure ſpring water as will cover them, and ſet the veſſel in the ſun, in the morning at ſun-riſe, and let it ſtand till the evening, then take it into the houſe for the night; expoſe it, in this manner, for ſix or ſeven ſucceſſive days, and, at the end of the third or fourth day, a number of particles, of a fine yellow oily matter, will float on the ſurface, which, in two or three days more, will gather into a ſcum, which is the otter of roſes. This is taken up by ſome cotton, tied to the end of a piece of ſtick, and ſqueezed with the finger and thumb into a ſmall phial, which is immediately well ſtopped; and this is repeated for ſome ſucceſſive evenings, or while any of this fine eſſential oil riſes to the ſurface of the water."

Dr Donald Monro, who communicated this receipt to the Royal Society of Edinburgh, ſays, that he has been informed, that ſome few drops of this eſſential oil have more than once been collected by diſtillation in London, in the ſame manner as the eſſential oils of other plants.

ROTA Ariſtotelica, or *Ariſtotle's Wheel*, denotes a celebrated problem in mechanics, concerning the mo-

---

(A) The conſtitution of the Scotch church was, at this period, a ſtrange ſyſtem of inconſiſtency and contradiction. It was, in fact, preſbyterian; for eccleſiaſtical diſcipline was adminiſtered then, as at preſent, by kirk-ſeſſions, preſbyteries, and general aſſemblies; and there was not a reformed biſhop in the kingdom. Whether provincial ſynods were then in uſe, the writer of this note does not at preſent recollect. The king, however, who was meditating the reſtoration of epiſcopacy, conferred the eſtates, or part of the eſtates, belonging to the different ſees, upon the moſt eminent parochial miniſters, and dignified them with the title of biſhops; though it does not appear that they had any juriſdiction over their brethren; and though they were certainly not *ex officio* ſo much as moderators of the preſbyteries within the bounds of which their churches were ſituated. Theſe were the men for whom Mr Rollock exerted himſelf to obtain ſeats in the parliament.

tion or rotation of a wheel about its axis; ſo called becauſe firſt noticed by Ariſtotle.

The difficulty is this. While a circle makes a revolution on its centre, advancing at the ſame time in a right line along a plane, it deſcribes, on that plane, a right line which is equal to its circumference. Now if this circle, which may be called the deferent, carry with it another ſmaller circle, concentric with it, like the nave of a coach wheel; then this little circle, or nave, will deſcribe a line in the time of the revolution, which ſhall be equal to that of the large wheel or circumference itſelf; becauſe its centre advances in a right line as faſt as that of the wheel does, being in reality the ſame with it

The ſolution given by Ariſtotle, is no more than a good explication of the difficulty.

Galileo, who next attempted it, has recourſe to an infinite number of infinitely little vacuities in the right line deſcribed by the two circles; and imagines that the little circle never applies its circumference to thoſe vacuities; but in reality only applies it to a line equal to its own circumference; though it appears to have applied it to a much larger. But all this is nothing to the purpoſe.

Tacquet will have it, that the little circle. making its rotation more ſlowly than the great one, does on that account deſcribe a line longer than its own circumference; yet without applying any point of its circumference to more than one point of its baſe. But this is no more ſatisfactory than the former.

After the fruitleſs attempts of ſo many great men, M. Dortous de Meyran, a French gentleman, had the good fortune to hit upon a ſolution. which he ſent to the Academy of Sciences; where being examined by Meſſ. de Louville and Soulmon, appointed for that purpoſe, they made their report that it was ſatisfactory. The ſolution is to this effect:

The wheel of a coach is only acted on. or drawn in a right line; its rotation or circular motion ariſes purely from the reſiſtance of the ground upon which it is applied. Now this reſiſtance is equal to the force which draws the wheel in the right line, inaſmuch as it defeats that direction; of conſequence the cauſes of the two motions, the one right and the other circular, are equal. And hence the wheel deſcribes a right line on the ground equal to its circumference.

As for the nave of the wheel, the caſe is otherwiſe. It is drawn in a right line by the ſame force as the wheel; but it only turns round becauſe the wheel does ſo, and can only turn in the ſame time with it. Hence it follows, that its circular velocity is leſs than that of the wheel, in the ratio of the two circumferences; and therefore its circular motion is leſs than the rectilinear one. Since then it neceſſarily deſcribes a right line equal to that of the wheel, it can only do it partly by ſliding, and partly by revolving, the ſliding part being more or leſs as the nave itſelf is ſmaller or larger.—*Hutton's Dictionary*.

ROWNING (John), an ingenious Engliſh mathematician and philoſopher, was fellow of Magdalen College, Cambridge, and afterwards Rector of Anderby in Lincolnſhire, in the gift of that Society. He was a conſtant attendant at the meetings of the Spalding Society, and was a man of a great philoſophical habit and turn of mind, though of a cheerful and companionable diſpoſition. He had a good genius for mechanical contrivances in particular. In 1738 he printed at Cambridge, A Compendious Syſtem of Natural Philoſophy, in 2 vols 8vo; a very ingenious work, which has gone through ſeveral editions. He had alſo two pieces inſerted in the Philoſophical Tranſactions, viz. 1. A Deſcription of a Barometer, wherein the Scale of Variation may be increaſed at pleaſure; vol. 38. p. 39. And, 2. Directions for making a Machine for finding the Roots of Equations univerſally, with the Manner of uſing it; vol. 60. p. 240.—Mr Rowning died at his lodgings in Carey-ſtreet, near Lincoln's-Inn Fields, the latter end of November 1771, at 72 years of age.

Though a very ingenious and pleaſant man, he had but an unpromiſing and forbidding appearance: he was tall, ſtooping in the ſhoulders, and of a ſallow downlooking countenance.

ROY-ROYAN, in Bengal, the chief officer in the revenue department, next to the Dewan under the native government.

RUTHERFORD (John, M. D.), one of the illuſtrious founders of the medical ſchool in the univerſity of Edinburgh, was the ſon of the Rev. Mr Rutherford miniſter of Yarrow, in the county of Selkirk, North Britain. He was born on the 1ſt Auguſt 1695, and received the rudiments of his education at the pariſh ſchool of Selkirk; where, from his future proficiency, there is every reaſon to believe that he made a rapid progreſs in the knowledge of the Latin and Greek languages.

After the death of his father, he went to Edinburgh in 1708 or 1710, where, in the univerſity, he applied himſelf to the ſtudy of claſſical literature, mathematics, and natural philoſophy. The celebrated Dr Pitcairn was then ſo highly reſpected for his medical ſkill, that it is not improbable but that a laudable deſire of obtaining a portion of ſimilar fame may have turned the attention of young Rutherford to the ſtudy of medicine. Be that as it may, he engaged himſelf apprentice to Mr Alexander Neſbit, at that time an eminent ſurgeon in Edinburgh, with whom he remained till 1716, when he went to London. There he attended ſome hoſpitals, and the lectures read on anatomy by Dr Douglas, on ſurgery by André, and on materia medica by Strother.

After a year's reſidence in London, he returned to Edinburgh; and having ſettled his affairs in that city, he went to Leyden, which, from the lectures of Boerhaave, was then the moſt celebrated medical ſchool in Europe. In 1719 he went into France, and was at the end of July in that year admitted to the degree of M. D. in the univerſity of Rheims He paſſed the following winter in Paris, chiefly for the ſake of Winſlow's private demonſtrations in anatomy; and in 1720 he returned to Britain.

In 1721 he ſettled as a phyſician in Edinburgh; and ſoon afterwards Drs Rutherford, Sinclair, Plummer, and Innes, purchaſed a laboratory, where they prepared compound medicines. This was an art then but little known in Scotland; and as a commercial ſpeculation, the laboratory muſt therefore have proved very advantageous to the partners. But they had higher objects in view than commerce. They demonſtrated, as far as they were then known, the operations of chemiſtry

Rutherford.

miſtry to a numerous audience; and ſoon afterwards, by the advice of their old maſter Boerhaave, they extended their lectures to the other branches of phyſic. In 1725 they were appointed joint profeſſors in the univerſity; where, we believe, each, for ſome time, read lectures in every department of medical ſcience, anatomy excepted, and carried forward their claſſes in rotation. The anatomical lectures were read by the elder Monro, who had been ſettled a year or two before them in Edinburgh, and whoſe eminence in that department is known to all Europe.

On the death of Dr Innes, a particular branch of medical ſcience was allotted to each of the other three profeſſors. Dr Plummer was appointed profeſſor of chemiſtry and materia medica, Dr Sinclair of the inſtitutes of phyſic, and Dr Rutherford of the practice; and thus was a regular medical ſchool eſtabliſhed in Edinburgh by Monro, Plummer, Sinclair, and Rutherford. The lectures on the inſtitutes and practice of phyſic were then, and for many years afterwards, delivered in Latin; and ſuch was Dr Rutherford's command of that language, that on every thing connected with medicine, he talked in it more fluently than in the language of his country.

Whether it was any improvement in the mode of medical education in Edinburgh to change the language of the lectures from Latin to Engliſh, is perhaps more than queſtionable. We have now diſperſed over the country a number of illiterate men, practiſing as ſurgeons, and even as phyſicians, who never could have boaſted of having gone through a regular courſe of medical inſtruction, had the lectures continued to be delivered in the language in which they were begun. Foreigners, too, would not have been under the neceſſity of learning a new language, before they could enter on the ſtudies, for the cultivation of which they came to Scotland; and though the medical claſſes might not have been ſo crowded perhaps as at preſent, the individuals compoſing them would have been at leaſt as reſpectable. Whether Dr Rutherford reaſoned in this way we know not; but he continued to lecture in Latin as long as he filled the practical chair

About the year 1748 he introduced a very great improvement in the courſe of medical education. Senſible that abſtract lectures on the ſymptoms and the mode of treating various diſeaſes, of which the ſtudents know little but the names, could ſcarcely be of any benefit, he had for ſome time encouraged his pupils to bring patients to him on Saturday, when he inquired into the nature of their diſeaſes, and preſcribed for them in the preſence of the claſs. This gave riſe to the courſe of *clinical* lectures; the utility of which was ſo obvious, that it was enacted, by a decree of the ſenate of the univerſity, that no man ſhould be admitted to an examination for his doctor's degree, who had not attended thoſe lectures; to which an excellent hoſpital, then lately erected (ſee EDINBURGH, in the *Encyclopædia*), gave the profeſſors every opportunity of doing ample juſtice. To men who mean to live by the practice of phyſic, and have no inordinate ambition to raiſe their fame by fanciful theories, this is perhaps the moſt valuable courſe of lectures that is given in Edinburgh; and if ſo, Dr Rutherford muſt be conſidered as one of the greateſt benefactors of the medical ſchool.

To untried theories in phyſic he was indeed no friend; and we have heard a favourite and very able pupil of his, who knew him well, and reſpected him highly, affirm that, to his knowledge, Dr Rutherford retained his profeſſorſhip longer than he otherwiſe would have choſen to do; merely that he might keep out a ſpeculatiſt, whom he knew to be aſpiring to the practical chair. Finding at laſt in the late Dr John Gregory (ſee GREGORY, *Encycl.*) a ſucceſſor entirely to his mind, he reſigned to him in 1765, after having taught medicine in its different departments for upwards of forty years. He lived, after this period, loved by his friends. and revered by many eminent phyſicians, who had been his pupils, till 1779, when he died in Edinburgh, where he had ſpent the greater part of his life, in the 84th year of his age.

S.

Saccharometer.

SACCHAROMETER, the name given, by Mr Richardſon of Hull, to an inſtrument invented by him for aſcertaining the value of worts, and the ſtrength of different kinds of malt liquors. In plain Engliſh, the name ſignifies a *meaſurer of ſweetneſs*; and therefore, if etymology were to be attended to, the inſtrument ſhould be employed merely as a meaſurer of the ſweetneſs of worts. It is in fact beſt adapted for this purpoſe, being merely an hydrometer contrived to aſcertain the ſpecific gravity of worts, or rather to compare the weight of worts with that of equal quantities of the water employed in the brewery where the inſtrument is uſed.

The principle which ſuggeſted the invention of the inſtrument to Mr Richardſon is as follows: The menſtruum or water, employed by the brewer, becomes heavier or more denſe by the addition of ſuch parts of the materials as have been diſſolved or extracted by, and thence incorporated with it: the operation of boiling, and its ſubſequent cooling, ſtill adds to the denſity of it by evaporation; ſo that when it is ſubmitted to the action of fermentation, it is more denſe than at any other period.

In paſſing through this operation of nature, a remarkable alteration takes place. The fluid no ſooner begins to ferment than its denſity begins to diminiſh; and as the fermentation is more or leſs perfect, the fermentable matter, whoſe acceſſion has been traced by the increaſe of denſity, becomes more or leſs attenuated; and in lieu of every particle thus attenuated, a ſpirituous particle, of leſs denſity than water, is produced: ſo that when the liquor is again in a ſtate of quietude, it is ſo much ſpecifically lighter than it was before, as the action of fermentation has been capable of attenuating the component parts of its acquired denſity; and, indeed, were it practicable to attenuate the whole, the liquor would become lighter or leſs denſe than water; becauſe the quantity of ſpirit produced from, and occupying the place of the fermentable matter, would diminiſh the denſity of the water in a degree bearing ſome proportion to that in which the latter had increaſed it.

From theſe facts, the reader, who is acquainted with hydroſtatical principles, will be able to conſtruct a saccharometer for himſelf. Brewers, who are ſtrangers to theſe principles, we muſt refer to Mr Richardſon's book for details, which our limits permit us not to give.

SAGITTA, in aſtronomy, the *Arrow* or *Dart*, a conſtellation of the northern hemiſphere near the eagle, and one of the 48 old aſteriſms.

SAHARA, or, as it is ſometimes written, ZAARA, the Great Deſert, is a vaſt ocean of ſand in the interior parts of Africa, which, with the leſſer deſerts of Bornou, Bilma, Barca, Sort, &c. is equal in extent to about one half of Europe. If the ſand be conſidered as the ocean, the Sahara has its gulphs and bays, as alſo its iſlands, or OASES, fertile in groves and paſtures, and in many inſtances containing a great population, ſubject to order and regular government.

The great body, or weſtern diviſion of this ocean, compriſed between Fezzan and the Atlantic, is no leſs than 50 caravan journeys acroſs, from north to ſouth; or from 750 to 800 G. miles; and double that extent in length: without doubt the largeſt deſert in the world. This diviſion contains but a ſcanty portion of iſlands (or oaſes), and thoſe alſo of ſmall extent: but the eaſtern diviſion has many, and ſome of them very large. Fezzan, Gadamis, Taboo, Ghanat, Agadez, Augela, Berdoa, are amongſt the principal ones: beſides which, there are a vaſt number of ſmall ones. In effect, this is the part of Africa alluded to by Strabo, when he ſays from *Cneius Piſo*, that Africa may be compared to a leopard's ſkin.

From the beſt inquiries that Mr Park could make when a kind of captive among the Moors at Ludamar, the Weſtern Deſert, he ſays, may be pronounced almoſt deſtitute of inhabitants; except where the ſcanty vegetation, which appears in certain ſpots, affords paſturage for the flocks of a few miſerable Arabs, who wander from one well to another. In other places, where the ſupply of water and paſturage is more abundant, ſmall parties of the Moors have taken up their reſidence. Here they live, in independent poverty, ſecure from the tyrannical government of Barbary. But the greater part of the deſert, being totally deſtitute of water, is ſeldom viſited by any human being; unleſs where the trading caravans trace out their toilſome and dangerous route acroſs it. In ſome parts of this extenſive waſte, the ground is covered with low ſtunted ſhrubs, which ſerve as land marks for the caravans, and furniſh the camels with a ſcanty forage. In other parts, the diſconſolate wanderer, wherever he turns, ſees nothing around him but a vaſt interminable expanſe of ſand and ſky; a gloomy and barren void, where the eye finds no particular object to reſt upon, and the mind is filled with painful apprehenſions of periſhing with thirſt. Surrounded by this dreary ſolitude, the traveller ſees the dead bodies of birds, that the violence of the wind has brought from happier regions; and, as he ruminates on the fearful length of his remaining paſſage, liſtens with horror to the voice of the driving blaſt; the only ſound that interrupts the awful repoſe of the deſert.

The few wild animals which inhabit theſe melancholy regions, are the antelope and the oſtrich; their ſwiftneſs of foot enabling them to reach the diſtant watering-places. On the ſkirts of the deſert, where the water is more plentiful, are found lions, panthers, elephants, and wild boars.

Of domeſtic animals, the only one that can endure the fatigue of croſſing the deſert is the camel. It is therefore the only beaſt of burden employed by the trading caravans which traverſe, in different directions, from Barbary to Nigritia. The fleſh of this uſeful and docile creature, though to our author's taſte it was dry and unſavory, is preferred by the Moors to all others. The milk of the female, he ſays, is in univerſal eſteem, and is indeed pleaſant and nutritive.

That the deſert has a dip towards the eaſt, as well as the ſouth, ſeems to be proved by the courſe of the Niger. Moreover, the higheſt points of North Africa, that is to ſay, the mountains of Mandinga and Atlas, are ſituated very far to the weſt. The deſert, for the moſt part, abounds with ſalt. But we hear of ſalt mines only in the part contiguous to Nigritia, from whence ſalt is drawn for the uſe of thoſe countries, as well as of the Mooriſh ſtates adjoining; there being no ſalt in the Negro countries ſouth of the Niger. There are ſalt lakes alſo in the the eaſtern part of the deſert.

SAI, a large town on the banks of the Niger, or at leaſt very near to that river, which Mr Park ſays ſtrongly excited his curioſity. It is completely ſurrounded by two very deep trenches, at about two hundred yards diſtant from the walls. On the top of the trenches are a number of ſquare towers; and the whole has the appearance of a regular fortification. Inquiring into the origin of this extraordinary entrenchment, our author learned from two of the towns people the following particulars; which, if true, furniſh a mournful picture of the enormities of African wars:

About fifteen years before our traveller viſited Sai, when the King of Bambarra deſolated Maniana, the Dooty of Sai had two ſons ſlain in battle, fighting in the king's cauſe. He had a third ſon living: and when the king demanded a further reinforcement of men, and this youth among the reſt, the Dooty refuſed to ſend him This conduct ſo enraged the king, that when he returned from Maniana, about the beginning of the rainy ſeaſon, and found the Dooty protected by the inhabitants, he ſat down before Sai with his army, and ſurrounded the town with the trenches which had attracted our author's notice. After a ſiege of two months, the towns-people became involved in all the horrors of famine; and whilſt the king's army were feaſting in their trenches, they ſaw with pleaſure the miſerable inhabitants of Sai devour the leaves and bark of the Bentang tree that ſtood in the middle of the town. Finding, however, that the beſieged would ſooner periſh than ſurrender, the king had recourſe to treachery. He promiſed, that if they would open the gates, no perſon ſhould be put to death, nor ſuffer any injury, but the Dooty alone. The poor old man determined to ſacrifice himſelf, for the ſake of his fellow-citizens, and immediately walked over to the king's army, where he was put to death. His ſon, in attempting to eſcape, was caught and maſſacred in the trenches; and the reſt of the towns-people were carried away captives, and ſold as ſlaves to the different Negro traders.

traders. Sai is placed by Major Rennel in 14° N. Lat. and 3° 7′ Weſt. Long.

SAINT CATHERINE, a Portugueſe iſland in the South Sea, not far diſtant from the coaſt of Brazil. It was viſited by La Perouſe, who aſcertained it to lie between 27° 19′ 10″, and 27° 49′ N. Lat. and its moſt northerly point to be in 49° 49′ longitude weſt from Paris Its breadth from eaſt to weſt is only two leagues; and it is ſeparated from the main land by a channel only 200 toiſes broad. On the point which ſtretches furtheſt into this channel is ſituated the city of Noſtra-Senora del Deſtero, the capital of the government, and the place of reſidence of the governor. It contains at moſt 3000 ſouls, and about 400 houſes. Its appearance is exceedingly pleaſant. According to Frezier's account, this iſland ſerved, in 1712, as a retreat to vagabonds, who made their eſcape from different parts of the Brazils; who were only nominal ſubjects of Portugal, and who acknowledged no authority whatever. The country is ſo fertile, that they were able to ſubſiſt without any ſuccour from the neighbouring colonies: and they were ſo deſtitute of money, that they could neither tempt the cupidity of the governor-general of the Brazils, nor inſpire him with any deſire of ſubduing them. The ſhips that touched at the iſland gave them in exchange for their proviſions nothing but clothes and ſhirts, of which they were in the utmoſt want. It was not till about 1740 that the court of Liſbon eſtabliſhed a regular government in the iſland of St Catherine, and the parts of the continent adjacent. This government extends ſixty leagues north and ſouth from the river San Franciſco to Rio Grande; its population being about 20,000 ſouls; but there are ſo great a number of children in the different families, that probably it will ſoon be much more conſiderable. The ſoil is exceedingly fertile, and produces all ſorts of fruit, vegetables, and corn, almoſt ſpontaneouſly. It is covered with trees of everlaſting green; but they are ſo interwoven with briars and creeping plants, that it is impoſſible to get through the foreſts otherwiſe than by opening a path with a hatchet. Danger is beſides to be apprehended from ſnakes, whoſe bite is mortal. The habitations, both on the iſland and continent, are all cloſe to the ſea ſide. The woods that ſurround them are delightfully fragrant, owing to the great number of orange trees and other odoriferous trees and ſhrubs that they contain. But, notwithſtanding all theſe advantages, the country is very poor, and totally deſtitute of manufactured commodities, ſo that the peaſants are almoſt naked, or elſe covered with rags. Their ſoil, which is very fit for the cultivation of ſugar, remains unproductive for the want of ſlaves, whom they are not rich enough to purchaſe. The whale fiſhery is very ſucceſsful; but it is the property of the crown, and is farmed by a company at Liſbon, which has three conſiderable eſtabliſhments upon the coaſt. Every year they kill about 400 whales; the produce of which, as well oil as ſpermaceti, is ſent to Liſbon by the way of Rio-Janeiro. The inhabitants are idle ſpectators of this fiſhery, from which they derive not the ſmalleſt advantage. La Perouſe gives a very amiable picture, however, of their hoſpitality to ſtrangers.

SALT. See CHEMISTRY-*Index*, in this *Suppl.*

Salt Mines, Saltpetre.

SALT-Mines of *Vielicza*, near Cracow in Poland, are very extraordinary caverns; for a deſcription of which we referred, in the article SALT (*Encycl.*) to M. Barniard in the *Journal de Phyſique* for the year 1786. Some of our readers have complained of this, and requeſted an account of them in the *Supplement*. With this requeſt we ſhall comply, by giving them Mr Wraxall's deſcription of theſe caverns *.

"After being let down (ſays he) by a rope to the depth of 230 feet, our conductors led us through galleries, which, for loftineſs and breadth, ſeemed rather to reſemble the avenues to ſome ſubterranean palace, than paſſages cut in a mine. They were perfectly dry in every part, and terminated in two chapels compoſed entirely of ſalt, hewn out of the ſolid maſs The images which adorn the altars, as well as the pillars and ornaments, were all of the ſame tranſparent materials; the points and ſpars of which, reflecting the rays of light from the lamps which the guides held in their hands, produced an effect equally novel and beautiful. Deſcending lower into the earth by means of ladders, I found myſelf in an immenſe hall or cavern of ſalt, many hundred feet in height, length, and dimenſions, the floor and ſides of which were cut with exact regularity. A thouſand perſons might dine in it without inconvenience, and the eye in vain attempted to trace or define its limits. Nothing could be more ſublime than this vaſt ſubterranean apartment, illuminated by flambeaux, which faintly diſcover its prodigious magnitude, and leave the imagination at liberty to enlarge it indefinitely. After remaining about two hours and a half under ground, I was drawn up again in three minutes with the greateſt facility."

SALTPETRE (ſee *Nitre*, CHEMISTRY-*Index*, in this *Suppl.*) is an article of ſo much importance, and ſometimes ſo difficult to be had, that it is wonderful more attention is not beſtowed in endeavouring to diſcover ſome eaſy method to increaſe the quantity. Such a method has been long practiſed by the farmers of Appenzell in Switzerland. In ſo hilly a country, moſt houſes and ſtables are built on ſlopes, one ſide of the edifice reſting on the hill, and the other being ſupported by two ſtrong poſts, elevated two or three feet above the ground; ſo that the air has a free current under the building. Immediately under the ſtable a pit is dug, uſually occupying both in breadth and length the whole ſpace of ground covered by the building; and inſtead of the clayey earth which is dug out, the pit is filled up with ſandy ſoil. This is the whole proceſs, and all the reſt is done by nature. The animal water, which is continually oozing through the planks of the floor, having drenched the earth contained in the pit for the ſpace of two or three years, the latter is emptied, and the ſaltpetre is refined and prepared in the uſual manner.

That manner, however, is not the beſt; and the French chemiſts, during the inceſſant wars occaſioned by the revolution, have, for the ſake of ſupplying their armies with gunpowder, turned their attention to the beſt method of refining ſaltpetre. The following are directions given for this purpoſe by Chaptal, Champy, and Bonjour.

The crude ſaltpetre is to be beaten ſmall with mallets, in order that the water may more eaſily attack every part of the maſs. The ſaltpetre is then to be put into tubs, five or ſix hundred pounds in each tub. Twenty *per cent.* of water is to be poured into each tub, and

---

* *Memoirs of the Courts of Berlin, Dreſden, Warſaw, and Vienna.*

and the mixture well ſtirred. It muſt be left to macerate or digeſt until the ſpecific gravity of the fluid ceaſes to augment. Six or ſeven hours are ſufficient for this firſt operation, and the water acquires the denſity of between 25 and 35 degrees. (Sp. gr. 1.21, and 1.306, aſcertained by Baumé's hydrometer. See Hydrometer, *Suppl.*

The firſt water muſt then be poured off, and a ſecond portion of water muſt be poured on the ſame ſaltpetre amounting to 10 *per cent.*; after which the mixture muſt be ſtirred up, ſuffered to macerate for one hour, and the fluid drawn or poured off.

Five *per cent.* of water muſt then be poured on the ſaltpetre; and after ſtirring the whole, the fluid muſt be immediately drawn off.

When the water is drained from the ſaltpetre, the ſalt muſt be thrown into a boiler containing 50 *per cent.* of boiling water. When the ſolution is made, it will mark between 66 and 68 degrees of the hydrometer. (Sp. gr. 1.848, and 1.898.)

The ſolution is to be poured into a proper veſſel, where it depoſits by cooling about two-thirds of the ſaltpetre originally taken. The precipitation begins in about half an hour, and terminates in between four and ſix hours. But as it is of importance to obtain the ſaltpetre in ſmall needles, becauſe in this form it is more eaſily dried, it is neceſſary to agitate the fluid during the whole time of the cryſtallization. A ſlight motion is communicated to this liquid maſs by a kind of rake; in conſequence of which the cryſtals are depoſited in very ſlender needles.

In proportion as the cryſtals fall down, they are ſcraped to the borders of the veſſel, whence they are taken with a ſkimmer, and thrown to drain in baſkets placed on treſſels, in ſuch a manner that the water which paſſes through may either fall into the cryſtallizing veſſel, or be received in baſons placed underneath.

The ſaltpetre is afterwards put into wooden veſſels in the form of a mill-hopper or inverted pyramid with a double bottom. The upper bottom is placed two inches above the lower on wooden ledges, and has many ſmall perforations through which water may paſs to the lower bottom, which likewiſe affords a paſſage by one ſingle aperture. A reſervoir is placed beneath. The cryſtallized ſaltpetre is waſhed in theſe veſſels with 5 *per cent.* of water; which water is afterwards employed in the ſolution of ſaltpetre in ſubſequent operations.

The ſaltpetre, after ſufficient draining, and being dried by expoſure to the air upon tables for ſeveral hours, may then be employed in the manufacture of gunpowder.

But when it is required to uſe the ſaltpetre in the ſpeedy and immediate manufacture of gunpowder, it muſt be dried much more ſtrongly. This may be effected in a ſtove, or more ſimply by heating it in a flat metallic veſſel. For this purpoſe the ſaltpetre is to be put into the veſſel to the depth of five or ſix inches, and heated to 40 or 50 degrees of the thermometer (or about 135° of Fahrenheit). The ſaltpetre is to be ſtirred for two or three hours, and dried ſo much that, when ſtrongly preſſed in the hand, it ſhall acquire no conſiſtence, nor adhere together, but reſemble a very fine dry ſand. This degree of dryneſs is not required when the powder is made by pounding.

From theſe circumſtances, we find that two ſaline liquids remain after the operation; (1) the water from the waſhing; and (2) that from the cryſtallizing veſſels.

We have already remarked, that the waſhing of the ſaltpetre is performed in three ſucceſſive operations, in which, upon the whole, the quantity of fluid made uſe of amounts to 35 *per cent.* of the weight of the crude ſaltpetre. Theſe waſhings are eſtabliſhed on the principle, that cold water diſſolves the muriats of ſoda, and the earthy nitrats and muriats, together with the colouring principle, but ſcarcely attacks the nitrat of potaſh.

The water of theſe three waſhings therefore contains the muriat of ſoda, the earthy ſalts, the colouring principle, and a ſmall quantity of nitrat of potaſh; the amount of which is in proportion to that of the muriat of ſoda, which determines its ſolution.

The water of the cryſtallizing veſſels contains a portion of the muriats of ſoda, and of the earthy ſalts which eſcaped the operation of waſhing, and a quantity of nitrat of potaſh, which is more conſiderable than that of the former ſolution.

The waters made uſe of at the end of the operation, to whiten and waſh the cryſtals depoſited in the pyramidal veſſel, contain nothing but a ſmall quantity of nitrat of potaſh.

Theſe waters are therefore very different in their nature. The water of the waſhings is really a mother water. It muſt be collected in veſſels, and treated with potaſh by the known proceſſes. It muſt be evaporated to 66 degrees (or 1,848 ſp. gr.), taking out the muriat of ſoda as it falls. This ſolution is to be ſaturated with 2 or 3 *per cent.* of potaſh, then ſuffered to ſettle, decanted, and poured into cryſtallizing veſſels, where 20 *per cent.* of water is to be added to keep the whole of the muriat of ſoda ſuſpended.

The waters which are thus obtained by treatment of the mother water may be mixed with the water of the firſt cryſtallization. From theſe the marine ſalt may be ſeparated by ſimple evaporation; and the nitrat of potaſh, which they hold in ſolution, may be afterwards obtained by cooling.

The ſmall quantity of water made uſe of to waſh and whiten the refined ſaltpetre, contains nothing but the nitrat of potaſh: it may therefore be uſed in the ſolution of the ſaltpetre when taken from the tubs.

From this deſcription it follows, that a manufactory for the ſpeedy refining of ſaltpetre ought to be provided with (1) mallets or rammers for pounding the ſaltpetre; (2) tubs for waſhing; (3) a boiler for ſolution; (4) a cryſtallizing veſſel of copper or lead, in which the ſaltpetre is to be obtained by cooling; (5) baſkets to drain the cryſtals; (6) a wooden caſe or hopper for the laſt waſhing and draining the ſaltpetre; (7) ſcales and weights for weighing; (8) hydrometers and thermometers, to aſcertain denſities and temperatures; (9) rakes to agitate the liquor in the cryſtallizing veſſel; (10) ſkimmers to take out the cryſtals, and convey them to the baſkets; (11) ſyphons or hand-pumps to empty the boilers.

The number and dimenſions of theſe ſeveral articles muſt vary according to the quantity of ſaltpetre intended to be refined.

Gum-SANDARAC, is ſaid, in the *Encyclopædia*, arac, ders.

to be produced from a ſpecies of juniper. This was long the common opinion; but M. Schouſboe has lately proved (A) it to be a miſtake. The *juniperus communis*, from which many have derived this gum, does not grow in Africa; and Sandarac ſeems to belong excluſively to that part of the world. The gum ſandarac of our ſhops is brought from the ſouthern provinces of the kingdom of Morocco. About ſix or ſeven hundred quintals of it are exported every year from Santa Cruz, Mogador, and Saffy. In the language of the country it is called *el graſſa*. The tree which produces it is a *Thuia*, found alſo by M. Vahl in the kingdom of Tunis. It was made known ſeveral years ago by Dr Shaw, who named it *Cypreſſus fructu quadrivalvi, Equiſeti inſtar articulatis*; but neither of theſe learned men was acquainted with the economical uſe of this tree; probably becauſe, being not common in the northern part of Barbary, the inhabitants find little advantage in collecting the reſin which exudes from it.

M. Schouſboe, who ſaw the ſpecies of *thuia* in queſtion, ſays that it does not riſe to more than the height of twenty or thirty feet at moſt, and that the diameter of its trunk does not exceed ten or twelve inches. It diſtinguiſhes itſelf, on the firſt view, from the two other ſpecies of the ſame genus, cultivated in gardens, by having a very diſtinct trunk, and the figure of a real tree; whereas in the latter the branches riſe from the root, which gives them the appearance rather of buſhes. Its branches alſo are more articulated and brittle. Its flowers, which are not very apparent, ſhew themſelves in April; and the fruit, which are of a ſpherical form, ripen in September. When a branch of this tree is held to the light, it appears to be interſperſed with a multitude of tranſparent veſicles which contain the reſin. When theſe veſicles burſt in the ſummer months, a reſinous juice exudes from the trunk and branches, as is the caſe in other coniferous trees. This reſin is the ſandarac, which is collected by the inhabitants of the country, and carried to the ports, from which it is tranſported to Europe. It is employed in making ſome kinds of ſealing-wax, and in different ſorts of varniſh. In 1793 a hundred weight of it coſt in Morocco from 13 to 13½ piaſtres, which make from about L. 3, 5s. to L 3, 7s. 6d. ſterling. The duty on exportation was about 7s. 6d. ſterling per quintal.

Sandarac, to be good, muſt be of a bright-yellow colour, pure and tranſparent. It is an article very difficult to be adulterated. Care, however, muſt be taken, that the Moors do not mix with it too much ſand. It is probable that a tree of the ſame kind produces the gum ſandarac of Senegal, which is exported in pretty conſiderable quantities.

Sanders.

SANDERS-RED (ſee PTEROCARPUS, *Encycl.*) is uſed as a dye ſtuff, but generally in a manner which is very diſadvantageous. In Crell's Chemical Annals are given, by Mr Vogler, the following directions for dyeing with this wood.

1. Into a ſolution of tin made with aquafortis (nitric acid), and mixed with three times as much ſalt water, put clean-waſhed wool, ſilk, linen, and cotton. After ſix hours, take them out, and waſh them carefully in three different quantities of clean cold water, wringing them well each time. Let them dry, and then put half the quantity of each article into the ſpirituous tincture of red ſanders, hereafter deſcribed in n° 6. letting them ſoak therein, without heat, from half an hour to an hour. To aſcertain the ſuperiority of his different proceſſes, the other half of each article muſt be boiled in the tincture of ſanders mixed with water, deſcribed in n° 7. a bare quarter of an hour. After being taken out, wrung, and dried in the ſhade, all of them will be dyed throughout of a fine rich poppy-colour.

2. Take three drams of powdered alum, and diſſolve it in twelve ounces of clean hot water. Into this ſolution, while yet warm, put ſome well-waſhed wool, ſilk, linen, and cotton. After ſuffering them to remain therein for the ſpace of twelve hours, take them out, waſh them well in three quantities of clean cold water (wringing them each time), and dry them. Then ſteep the half of each article in the cold ſpirituous tincture of ſanders (n° 6.), from half an hour to an hour; and boil the other half of each in the diluted tincture of ſanders (n° 7.) for the ſpace of ſix or ſeven minutes. After being taken out, wrung, and dried in the ſhade, they will be found to have acquired a very beautiful and rich ſcarlet colour.

3. Diſſolve three drams of blue vitriol, or vitriol of copper, in twelve ounces of hot water. Steep in this ſolution, for twelve hours, wool, ſilk, linen, or cotton; and having ſufficiently waſhed the ſtuff in clean cold water, immerſe the one half of it in the ſpirituous tincture of ſanders (n° 6.), from half an hour to an hour; and boil the other half of each for ſix or ſeven minutes in the diluted tincture, n° 7. Being then taken out, wrung, and dried in the ſhade, as before, they will have acquired a beautiful, rich, bright, crimſon colour.

4. Steep wool, ſilk, linen, and cotton, which has been well waſhed, during twelve hours, in a ſolution of three drams of white vitriol, or vitriol of zinc, in twelve ounces of hot water. After being taken out, well waſhed in clean cold water, and dried, immerſe one half of each in the cold ſpirituous tincture of ſanders (n° 6.) and boil the other half in the diluted tincture (n° 7.) as before. When taken out, wrung, and dried, they will be of a fine, rich, deep crimſon colour.

5. Diſſolve three drams of common green vitriol, or vitriol of iron, in twelve ounces of hot water: ſteep well-waſhed wool, ſilk, linen, and cotton, in the ſolution, for the ſpace of twelve hours. When taken out, waſhed ſeveral times in clean cold water, and dried, treat them, as in n° 4. and they will be generally found to be of a fine, rich, deep violet colour; though, on repeating his experiments, our author ſometimes found the colour a dark browniſh red.

The tincture in which the ſtuffs are to be dyed muſt be prepared in the following manner.

6. Take half an ounce of red ſanders wood, beat or ground to powder, as it is ſold at the colour ſhops or druggiſts. Having put it into a large glaſs bottle, pour upon it twelve ounces of malt ſpirit or common brandy; then cork the bottle, and ſet it in a moderately-warm place. In the ſpace of 48 hours, the ſpirit will have extracted all the colouring matter from the red ſanders, and thereby acquired a bright red colour. The bottle ſhould

---

(A) In a Daniſh Journal, intitled, *The Phyſical, Medical, and Economical Library*, Part III. 1799.

ſhould be often ſhaken during the digeſtion; and the tincture, thus prepared, may be uſed for dyeing without heat, and without ſeparating the powdered ſanders from the liquor. The articles to be dyed (after the application of the proper mordants, n° 1, 2, 3, 4, 5) are to be ſteeped in the tincture for half an hour, or a whole hour: they are then to be taken out, wrung, and dried in the ſhade. This tincture does not loſe its dyeing quality by age; but dyes ſubſtances, after being kept a long time, almoſt as well as when it is juſt made. Its colouring power is indeed weakened by the frequent immerſion and dyeing of different articles in it; and when that is the caſe, it muſt be again digeſted with ſome freſh ſanders-wood.

7. Mix the ſpirituous tincture of ſanders, juſt deſcribed, with from ſix to ten times as much clean cold water. The mixture was made by our author without any ſeparation of the colouring particles worth noticing; and in this diluted tincture, the various articles (having their proper mordants firſt applied, n° 1, 2, 3, 4, 5) were boiled, as before mentioned. Linen and cotton, by being dipped in glue-water, after the application of the mordants, acquire, in this diluted tincture, a much deeper and richer colour.

If a very fine and bright colour be deſired, the above ſpirituous tincture of ſanders ſhould not be too old, nor ſhould the digeſtion be protracted beyond 48 hours; for, after that period, the ſpirit appears to extract brown and yellow colouring particles from the wood. The powder of ſanders need not be ſeparated from the diluted tincture which is made uſe of by boiling; nor is it abſolutly neceſſary to waſh the articles in cold water after they are dyed; as the powder which adheres to them may eaſily be taken off by rubbing and ſhaking. M. Vogler, however, found it advantageous, after the articles were taken out of the dye, and wrung, to ſteep them for a few minutes in a cold ſolution of half an ounce of common ſalt, and a quarter of an ounce of alum, in 12 ounces of pure water. In this caſe, they ſhould afterwards be waſhed ſeveral times in clean cold water, then wrung and dried in the ſhade. By this method the colours are not only more beautiful, but are alſo more permanent. All the articles of wool, ſilk, linen, and cotton, which were dyed as is above mentioned, bore perfectly well the teſt of alkaline ley, ſoap, and acids; but, by expoſure to the open air and the ſun, the colours were more eaſily diſcharged, eſpecially from linen and cotton.

N. B. Red ſanders, by being ground to a fine powder, anſwers much better for dyeing by this proceſs, than when it is merely cut into ſmall pieces; but it muſt be remarked, that the powder of red ſanders which is ſold at the ſhops is ſometimes adulterated, by being mixed with other ſubſtances, and moiſtened with acids. The beſt kind is not light, but rather heavy; and is not of a dark red colour, but clear and bright.

GOODWIN SANDS, famous ſand banks off the coaſt of Kent, lying between the north and ſouth Foreland; and as they run parallel with the coaſt for three leagues together, at about two leagues and a half diſtant from it, they add to the ſecurity of that capacious road the Downs; for while the land ſhelters ſhips with the wind from ſouth-weſt to north-weſt only, theſe ſands break all the force of the ſea when the wind is at eaſt ſouth-eaſt. The moſt dangerous wind, when blowing hard on the Downs, is the ſouth-ſouth-weſt. Theſe ſands occupy the ſpace that was formerly a large tract of low ground belonging to Godwyn Earl of Kent, father of King Harold; and which being afterward given to the monaſtery of St Auguſtin at Canterbury, the abbot neglecting to keep in repair the wall that defended it from the ſea, the whole track was drowned, according to Salmon, in the year 1100, leaving theſe ſands, upon which ſo many ſhips have ſince been wrecked.

SANSANDING, a town in Africa, ſituated near the banks of the Niger, in Lat. 14° 24′ N. and 2° 23′ W. Long. It is inhabited by Moors and Negroes to the number of from eight to ten thouſand. The Negroes are kind, hoſpitable, and credulous; the Moors are at Sanſanding, as everywhere elſe in the interior parts of Africa, fanatical, bigotted, and cruel.

SAP, or SAPP, in building, as to ſap a wall, &c. is to dig out the ground from beneath it, ſo as to bring it down all at once for want of ſupport.

SAPHAN, in zoology. See MUS, *Encycl.* p. 467.

SAPHIES, a kind of charms, conſiſting of ſome ſcrap of writing, which the credulous Negroes believe capable of protecting them from all evil. The writers of ſaphies are generally Moors, who ſell ſcraps of the Koran for this purpoſe to a people who believe not either in the Koran or the prophet. Accordingly, any piece of writing may be ſold as a ſaphie; and Mr Park found the Negroes diſpoſed to place greater confidence in the ſaphies of a Chriſtian than in thoſe of a Moor. The manner in which theſe charms are ſuppoſed to operate, will be learned from the following ſtory:

Mr Park being at Koolikorro, a conſiderable town near the Niger, and a great market of ſalt, his landlord, hearing that he was a Chriſtian, immediately thought of procuring a ſaphie. For this purpoſe he brought out his *walha*, or writing board, aſſuring me (ſays our author) that he would dreſs me a ſupper of rice if I would write him a ſaphie to protect him from wicked men. The propoſal was of too great conſequence to me to be refuſed; I therefore wrote the board full, from top to bottom, on both ſides; and my landlord, to be certain of having the whole force of the charm, waſhed the writing from the board into a calabaſh with a little water; and having ſaid a few prayers over it, drank this powerful draught; after which, leſt a ſingle word ſhould eſcape, he licked the board until it was quite dry. A ſaphie writer was a man of too great conſequence to be long concealed: the important information was carried to the Dooty, who ſent his ſon with half a ſheet of writing-paper, deſiring me to write him a *naphula ſaphie* (a charm to procure wealth). He brought me, as a preſent, ſome meal and milk; and when I had finiſhed the ſaphie, and read it to him with an audible voice, he ſeemed highly ſatiſfied with his bargain, and promiſed to bring me in the morning ſome milk for my breakfaſt. Our author contrived to turn this abſurd ſuperſtition to his own advantage, by writing ſaphies for his ſubſiſtence when his money was exhauſted.

SARACOLETS, a Negro nation occupying the lands ſituated between the rivers of Senegal and Gambia. They are a laborious people, cultivate their lands with care, are plentifully ſupplied with all the neceſſaries of life, and inhabit handſome and well built villages; their houſes, of a circular form, are for the moſt part terra-

colets,
ville.

ced; the others are covered with reeds as at Senegal; they are incloſed with a mud wall a foot thick, and the villages are ſurrounded with one of ſtone and earth of double that ſolidity. There are ſeveral gates, which are guarded at night for fear of a ſurpriſe. This nation is remarkably brave, and it is very uncommon to find a Saracolet ſlave. They always defend themſelves with advantage againſt their aſſailants. Such Saracolets as are expoſed to ſale may be ſafely purchaſed, for (excepting when they are at war with the Poules) none are to be met with but ſuch as have been condemned by the laws for ſome miſdemeanour; in ſuch caſe, theſe wretches could not eſcape ſlavery even by taking refuge in their own country; for they would be reſtored to their maſters, or would be put to death, if the convoy ſhould have failed. The religious principles of this people are nearly allied to Mahometaniſm, and ſtill more to natural religion. They acknowledge one God; and believe that thoſe who ſteal, or are guilty of any crime, are eternally puniſhed. They admit a plurality of wives, and believe their ſouls to be immortal like their own. They think lightly of adultery; for as they allow themſelves ſeveral wives, they are not ſo unjuſt as to puniſh women who diſtribute their favours among ſeveral gallants; a mutual exchange is then permitted, one woman may be bartered for another, unleſs ſhe be free, or a native of the country. In this laſt caſe, the French cuſtom prevails; it is winked at, although the laws are particularly ſevere againſt the violation of the moſt ſacred of all property. This nation lies near that of the Poules. (See that article, *Suppl.*) Its extent up the country is unknown; all that we know is, that it is governed by four powerful princes, all bearing the name of Fouquet. The leaſt conſiderable, according to the teſtimony of the Sarcolets, is that of Tuago, who can aſſemble thirty thouſand horſe, and whoſe ſubjects occupy a territory two hundred leagues in extent, as well on the Senegal as on the track that reaches beyond the Felou; a rock which, according to the ſame report, forms cataracts, from whence proceed the Senegal and the river Gambia, equally conſiderable.

SAROS, in chronology, a period of 223 lunar months. The etymology of the word is ſaid to be Chaldean, ſignifying reſtitution, or return of eclipſes; that is, conjunctions of the ſun and moon in nearly the ſame place of the ecliptic. The Saros was a cycle like to that of Meto.

SARRASIN, or SARRAZIN, in fortification, a kind of port-cullis, otherwiſe called a herſe, which is hung with ropes over the gate of a town or fortreſs, to be let fall in caſe of a ſurpriſe.

Saville.

SAVILLE (Sir Henry), a very learned Engliſhman, the ſecond ſon of Henry Saville, Eſq; was born at Bradley, near Halifax, in Yorkſhire, November the 30th, 1549. He was entered of Merton College, Oxford, in 1561, where he took the degrees in arts, and was choſen fellow. When he proceeded maſter of arts in 1570, he read for that degree on the Almageſt of Ptolemy, which procured him the reputation of a man eminently ſkilled in mathematics and the Greek language; in the former of which he voluntarily read a public lecture in the univerſity for ſome time.

In 1578 he travelled into France and other countries; where, diligently improving himſelf in all uſeful learning, in languages, and the knowledge of the world, he became a moſt accompliſhed gentleman. At his return, he was made tutor in the Greek tongue to Queen Elizabeth, who had a great eſteem and liking for him.

In 1585 he was made warden of Merton College, which he governed ſix-and-thirty years with great honour, and improved it by all the means in his power.—In 1596 he was choſen provoſt of Eton College; which he filled with many learned men.—James the Firſt, upon his acceſſion to the crown of England, expreſſed a great regard for him, and would have preferred him either in church or ſtate; but Saville declined it, and only accepted the ceremony of knighthood from the king at Windſor in 1604. His only ſon Henry dying about that time, he thenceforth devoted his fortune to the promoting of learning. Among other things, in 1619, he founded, in the univerſity of Oxford, two lectures, or profeſſorſhips, one in geometry, the other in aſtronomy; which he endowed with a ſalary of 160l. a-year each, beſides a legacy of 600l. to purchaſe more lands for the ſame uſe. He alſo furniſhed a library with mathematical books, near the mathematical ſchool, for the uſe of his profeſſors; and gave 100l. to the mathematical cheſt of his own appointing: adding afterwards a legacy of 40l. a-year to the ſame cheſt, to the univerſity, and to his profeſſors jointly. He likewiſe gave 120l. towards the new building of the ſchools, beſide ſeveral rare manuſcripts and printed books to the Bodleian library; and a good quantity of Greek types to the printing-preſs at Oxford.

After a life thus ſpent in the encouragement and promotion of ſcience and literature in general, he died at Eton College the 19th of February 1622, in the 73d year of his age, and was buried in the chapel there. On this occaſion, the univerſity of Oxford paid him the greateſt honours, by having a public ſpeech and verſes made in his praiſe, which were publiſhed ſoon after in 4to, under the title of *Ultima Linea Savilii*.

As to the character of Saville, the higheſt encomiums are beſtowed on him by all the learned of his time: by Caſaubon, Mercerus, Meibomius, Joſeph Scaliger, and eſpecially the learned Biſhop Montague; who, in his *Diatribæ* upon Selden's Hiſtory of Tythes, ſtyles him, "that magazine of learning, whoſe memory ſhall be honourable amongſt not only the learned, but the righteous for ever."

Several noble inſtances of his munificence to the republic of letters have already been mentioned; in the account of his publications many more, and even greater, will appear. Theſe are,

1. Four Books of the Hiſtories of Cornelius Tacitus, and the Life of Agricola; with Notes upon them, in folio, dedicated to Queen Elizabeth, 1581.—2. A View of certain Military Matters, or Commentaries concerning Roman Warfare, 1598.—3 *Rerum Anglicarum Scriptores poſt Bedam*, &c. 1596. This is a collection of the beſt writers of our Engliſh hiſtory; to which he added chronological tables at the end, from Julius Cæſar to William the Conqueror.—4. The Works of St Chryſoſtom, in Greek, in 8 vols folio, 1613. This is a very fine edition, and compoſed with great coſt and labour. In the preface he ſays, "that having himſelf viſited, about 12 years before, all the public and private libraries in Britain, and copied out thence whatever he thought uſeful to this deſign, he then ſent ſome learned men into France, Germany,

Italy, and the Eaſt, to tranſcribe ſuch parts as he had not already, and to collate the others with the beſt manuſcripts." At the ſame time, he makes his acknowledgments to ſeveral eminent men for their aſſiſtance; as Thuanus, Velſerus, Schottus, Caſaubon, Ducæus, Gruter, Hoeſchelius, &c. In the 8th volume are inſerted Sir Henry Saville's own notes, with thoſe of other learned men. The whole charge of this edition, including the ſeveral ſums paid to learned men, at home and abroad, employed in finding out, tranſcribing, and collating the beſt manuſcripts, is ſaid to have amounted to no leſs than 8000l. Several editions of this work were afterwards publiſhed at Paris.—5. In 1618 he publiſhed a Latin work, written by Thomas Bradwardin, archbiſhop of Canterbury, againſt Pelagius, intitled, *De Cauſa Dei contra Pelagium, et de virtute cauſarum;* to which he prefixed the life of Bradwardin.—6. In 1621 he publiſhed a collection of his own Mathematical Lectures on Euclid's Elements, in 4to.—7. *Oratio coram Elizabetha Regina Oxoniæ habita,* anno 1592. Printed at Oxford in 1658, in 4to.—8. He tranſlated into Latin King James's Apology for the Oath of Allegiance. He alſo left ſeveral manuſcripts behind him, written by order of King James; all which are in the Bodleian library. He wrote notes likewiſe upon the margin of many books in his library, particularly Euſebius's Eccleſiaſtical Hiſtory; which were afterwards uſed by Valeſius, in his edition of that work in 1659.—Four of his letters to Camden are publiſhed by Smith, among Camden's Letters, 1691, 4to.

SAUSSURE (Horace Benedict de) was born at Geneva in 1740. His father, an intelligent farmer, to whom we are indebted for ſome memoirs relating to rural economy, reſided at Conches, a place ſituated on the banks of the Arve, at the diſtance of half a league from Geneva; and this country life, added to an active education, expanded no doubt in young De Sauſſure that phyſical ſtrength ſo neceſſary to the naturaliſt who devotes himſelf to travel. He repaired daily to town to enjoy the advantage of public inſtruction; and as he lived at the bottom of Saleve, a mountain which he has ſince rendered celebrated, he amuſed himſelf frequently with aſcending its ſteep and rugged ſides. Being thus ſurrounded by the phenomena of nature, and at the ſame time aided by ſtudy, he conceived a taſte for natural hiſtory, and avoided the error both of the learned, who form theories without having been out of their cloſets, and of thoſe farmers who, living too near to Nature, are incapable of admiring her beauties.

His earlieſt paſſion was botany: a variegated ſoil, abundant in plants of different kinds, invites the inhabitant of the banks of the Leman to cultivate that agreeable ſcience. This taſte produced an intimacy between De Sauſſure and the great Haller. He paid him a viſit in the year 1764, during his retreat to Bex; and he relates in his travels how much he admired that aſtoniſhing man, who excelled in every part of the natural ſciences. De Sauſſure was induced alſo to ſtudy the vegetable kingdom, by his connection with Ch. Bonnet, who had married his aunt, and who ſoon ſet a juſt value on the riſing talents of his nephew. Bonnet (See his life in this *Suppl.*) was then employed on the leaves of plants. De Sauſſure ſtudied theſe organs of vegetables alſo, and he publiſhed the reſult of his reſearches, under the title of Obſervations on the Bark of Leaves. This ſmall work, which appeared ſoon after the year 1760, contains new obſervations on the epidermis of leaves, and in particular on the miliary glands by which they are covered.

About that period, the place of profeſſor of philoſophy falling vacant, it was conferred upon De Sauſſure, who was then only twenty-one years of age. Experience proves, that if premature rewards extinguiſh the zeal of thoſe who labour merely for themſelves, they, on the contrary, ſtrengthen it in thoſe who labour only for truth. At that time the two profeſſors of philoſophy at Geneva taught phyſics and logic alternately. De Sauſſure diſcharged this double taſk with equal ſucceſs. He gave to his courſe of logic a practical, and, as one may ſay, experimental turn; and his method of teaching, which began by ſtudying the ſenſes to arrive at the general laws of the underſtanding, announced already an able obſerver of nature.

Phyſics, however, were the part for which he had the greateſt taſte, and which conducted him to the ſtudy of chemiſtry and mineralogy. He then began his travels through the mountains; not now to examine their vegetable productions, but to ſtudy the mountains themſelves, either in the ſtones of which they are compoſed, or the diſpoſition of their maſſes. Geology, a ſcience which was then ſcarcely in exiſtence, added charms to his numerous excurſions through the Alps; and it was then that the talents of the great philoſopher were really diſplayed. During the firſt fifteen or twenty years of his profeſſorſhip, he employed himſelf by turns in diſcharging the duties of his office, and in traverſing the different mountains in the neighbourhood of Geneva. He even extended his excurſions on one ſide as far as the banks of the Rhine, and on the other to Piedmont. At the ſame time he undertook a journey to Auvergne to examine there the extinguiſhed volcanoes, and another to Paris, England, and Holland. After that he viſited Italy, and even Sicily. Theſe were not mere journeys for the purpoſe of reaching any particular place; he undertook them only with a view of ſtudying nature; never travelled but ſurrounded by every inſtrument that could be of uſe to him, and never ſet out until he had drawn up a plan of the experiments and obſervations he intended to make. He often ſays in his works that he had found this method exceedingly uſeful.

In the year 1779 he publiſhed the firſt volume of his Travels through the Alps; which contains a minute deſcription of the environs of Geneva, and an excurſion as far as Chamouni, a village at the bottom of Mont Blanc. Philoſophers will read there with pleaſure the deſcription of his Magnetometer. The more he examined mountains, the more was he ſenſible of the importance of mineralogy. To ſtudy it with advantage, he learned the German language; and it may be ſeen, in the laſt volumes of his Travels, how much new mineralogical knowledge he had acquired.

Amidſt his numerous excurſions through the Alps, and at the time of the political troubles of Geneva in 1782, he found means to make his beautiful experiments on hygrometry, which he publiſhed in 1783, under the title of *Eſſays on Hygrometry.* This work, the beſt that ever came from his pen, eſtabliſhed fully his reputation as a philoſopher. We are indebted to him alſo for the invention of a new hygrometer. Deluc had already invented his whalebone hygrometer; and on that account there aroſe between him and De Sauſſure a ſort of conteſt, which degenerated into a pretty violent diſpute.

In the year 1786 De Sauſſure reſigned the profeſſor's chair, which he had filled for about twenty five years, to his pupil and fellow-labourer Pictet, who diſcharged with reputation the duties of an office rendered more difficult by ſucceeding ſo eminent a philoſopher.

When De Sauſſure was invited by the ſtate to take a ſhare in the public education, he made it one of the ſubjects of his meditations, and preſented the plan of a reform in the education of Geneva; the tendency of which was, to make young people early acquainted with the natural ſciences and mathematics. He even wiſhed that their phyſical education ſhould not be neglected, and with that view propoſed gymnaſtic exerciſes. This plan, which excited much attention in a city where every one is convinced of the importance of education, found admirers and partiſans; but the poverty of its pecuniary reſources was an obſtacle to every important innovation. It was beſides feared that, by altering eſtabliſhed forms, they might loſe the ſubſtance, and that things might be changed for the worſe. The Geneveſe were attached to their old ſyſtem of education; and they had reaſon to be ſo, becauſe it had not only proved the means of diffuſing knowledge generally amongſt them, but had called forth the talents of ſeveral eminent mathematicians (A) and philoſophers (B).

But De Sauſſure's attention was not confined to public education alone. He ſuperintended himſelf the education of his two ſons and a daughter, who have ſhewn themſelves worthy of ſuch an inſtructor. His daughter to the charms of her ſex unites an extenſive knowledge of the natural ſciences; and his eldeſt ſon has already made himſelf known by his phyſical and chemical labours.

The ſecond volume of his Travels was publiſhed in 1786. It contains a deſcription of the Alps around Mont Blanc, which the author conſiders as a mineralogiſt, a geologiſt, and a philoſopher. He gives alſo ſome intereſting experiments on electricity, and a deſcription of his electrometer, one of the moſt perfect that we have. We are indebted to him alſo for ſeveral inſtruments of meaſurement, ſuch as his *cyanometer*, deſtined to meaſure the degree of the blueneſs of the heavens, which varies according to the elevation of the obſerver; his *diaphanometer* (See PHOTOMETER, in this *Suppl.*), and his *anemometer*, which, by means of a kind of balance, meaſures the force of the wind.

Some years after the publication of the ſecond volume of his Travels, De Sauſſure was admitted as a foreign aſſociate of the Academy of Sciences of Paris; and Geneva could then boaſt of having two of its citizens in that claſs, which conſiſted only of ſeven members. De Sauſſure not only did honour to his country; he loved and ſerved it. He was the founder of the Society of Arts, to which Geneva is indebted for the high ſtate of proſperity it has attained within the laſt thirty years. He preſided over that ſociety till the laſt moment of his life; and one of his fondeſt wiſhes was the preſervation of this uſeful eſtabliſhment.

In conſequence of M. de Sauſſure's fatiguing labours in the Council of Two Hundred, of which he was a member, and afterwards in the National Aſſembly, his health began to be deranged, and in 1794 he was almoſt deprived of the total uſe of his limbs by a ſtroke of the palſy. However painful his condition then might be, his mind ſtill preſerved its activity; and after that accident he reviſed the two laſt volumes of his Travels, which appeared in 1796. They contain an account of his excurſions to the mountains of Piedmont and Swiſſerland, and in particular of his journey to the ſummit of Mont Blanc. Theſe volumes, inſtead of exhibiting any marks of his malady, preſent an enormous maſs of new facts and obſervations of the utmoſt importance to phyſics.

He rendered alſo an important ſervice to that ſcience by publiſhing the *Agenda*, which terminate his fourth volume, and in which that great man, ſurviving himſelf, conducts the young naturaliſt through the middle of mountains, and teaches him the method of obſerving them with advantage. Theſe *Agenda* are a proof of his genius, and of the ſtrength of mind which he retained amidſt his ſufferings. It was alſo during his illneſs that he directed the experiments made on the height of the bed of the Arve, and that he publiſhed Obſervations on the Fuſibility of Stones by the Blow-pipe, which were inſerted in the *Journal de Phyſique*.

Having gone for the ſake of his health to the baths of Plombiers, he ſtill obſerved the mountains at a diſtance, and cauſed to be brought to him ſpecimens of the ſtrata which he perceived in the ſteepeſt rocks. He had announced that he would conclude his travels with ſome ideas on the primitive ſtate of the earth; but the more he acquired new facts, and the more he meditated on the ſubject, the more uncertain did his opinions become in regard to thoſe grand revolutions which preceded the preſent epoch. In general he was a Neptunian; that is to ſay, aſcribed all the revolutions of our globe to water. He admitted the poſſibility of the mountains having been thrown up by elaſtic fluids diſengaged from the cavities of the earth.

Though the ſtate of his health began gradually to become worſe, he ſtill entertained hopes of recovery; and the French government having appointed him profeſſor of philoſophy at the Special School of Paris, he did not deſpair of being one day able to fill that office: but his ſtrength was exhauſted, a general languor ſucceeded the vigour he had always enjoyed, his ſlow and embarraſſed pronunciation no longer correſponded with the vivacity of his mind, and formed a melancholy contraſt with the pleaſantneſs by which he had been formerly diſtinguiſhed. It was a painful ſpectacle to ſee this great man reduced thus to imbecility at an age when meditation is beneficial, and when he might have enjoyed the fruits of his reputation and labours.

In vain did he try, for the re-eſtabliſhment of his health, all the remedies which medicine, enlightened by the

---

(A) Abauzit, Cramer, Lhuilier, J. Trembley, &c.

(B) Jalabert, A. Trembley, Bonnet, Leſage, Deluc, Senebier, Prévoſt, Pictet, and De Sauſſure himſelf.

the phyſical ſciences, could afford—all aſſiſtance was uſeleſs. The vital power quitted him with ſlow and painful ſteps. Towards the beginning of autumn 1798 his decay became more viſible, his mind loſt all its activity, and on the 22d of March 1799 he terminated his brilliant career, at the age of 59, lamented by a family to whom he was dear—by a country to which he had done honour—and by Europe, the knowledge of which he had extended.

SCALE, in architecture and geography, a line divided into equal parts, placed at the bottom of a map or draught, to ſerve as a common meaſure to all the parts of the building, or all the diſtances and places of the map.

SCALES, in mathematics, ſee SCALES (*Encycl.*), and likewiſe *LOGARITHMIC Lines*, under which title are mentioned ſome improvements by Mr Nicholſon on Gunter's ſcale. Theſe improvements are valuable; and the reader will find a fuller account of them in the firſt volume of the author's *Philoſophical Journal*.

SCANTLING, a meaſure, ſize, or ſtandard, by which the dimenſions, &c. of things are to be determined. The term is particularly applied to the dimenſions of any piece of timber, with regard to its breadth and thickneſs.

SCAPEMENT, in clock-work, a general term for the manner of communicating the impulſe of the wheels to the pendulum. The ordinary ſcapements conſiſt of the ſwing-wheel and pallets only; but modern improvements have added other levers or detents, chiefly for the purpoſes of diminiſhing friction, or for detaching the pendulum from the preſſure of the wheels during part of the time of its vibration. See *WATCH Making*, in this *Suppl.*

SCARFING, a term in carpentry; by which is meant the joining of two beams of wood together to increaſe the length: the beams in the joint are indented into one another, as in figures 19, 24, and 25, Plate X. *Supplement*.

SCARLET, a beautiful bright red colour given to cloth, either by a preparation of kermes (See that article in *Suppl.*), or more completely by the American cochineal. Profeſſor Beckmann, in the ſecond volume of his Hiſtory of Inventions, ſeems to have eſtabliſhed the following concluſions:

1*ſt*, Scarlet, or the kermes-dye, was known in the Eaſt in the earlieſt ages, before Moſes, and was a diſcovery of the Phœnicians in Paleſtine, but certainly not of the ſmall wandering Hebrew tribes. 2*d*, *Tola* was the ancient Phœnician name uſed by the Hebrews, and even by the Syrians; for it is employed by the Syrian tranſlator, Iſaiah, chap. 1. ver. 18. Among the Jews, after their captivity, the Aramæan word *zehori* was more common. 3*d*, This dye was known alſo to the Egyptians in the time of Moſes; for the Iſraelites muſt have carried it along with them from Egypt. 4*th*, The Arabs received the name kermes, with the dye, from Armenia and Perſia, where it was indigenous, and had been long known; and that name baniſhed the old name in the Eaſt, as the name ſcarlet has in the Weſt. For the firſt part of this aſſertion we muſt believe the Arabs. 5*th*, Kermes were perhaps not known in Arabia; at leaſt they were not indigenous, as the Arabs appear to have had no name for them. 6*th*, Kermes ſignifies always *red dye*; and when pronounced ſhort, it becomes *deep red*.

Concerning the origin of the name ſcarlet, which was in uſe ſo early as the 11th century, our author has many conjectures, which we need not tranſcribe, as he ſeems not quite ſatisfied with any of them himſelf. The following reflections upon the comparative excellence of the ancient and modern ſcarlet, together with the progreſs of the art of dyeing that colour, are worthy of notice:

“ Of the preparation and goodneſs of the ancient ſcarlet we certainly know nothing: but as we find in many old pieces of tapeſtry of the 11th century, and perhaps earlier, a red which has continued remarkably beautiful even to the preſent time, it cannot at any rate be denied, that our anceſtors extolled their ſcarlet not without reaſon. We can, however, venture to aſſert, that the ſcarlet prepared at preſent is far ſuperior, owing principally to the effects of a ſolution of tin. —This invention may be reckoned amongſt the moſt important improvements of the art of dyeing, and deſerves a particular relation.

“ The tincture of cochineal alone yields a purple colour, not very pleaſant, which may be heightened to the moſt beautiful ſcarlet by a ſolution of tin in aqua-regia (nitro muriatic acid). This diſcovery was made as follows: Cornelius Drebbel, who was born at Alkmaar, and died at London in 1634, having placed in his window an extract of cochineal, made with boiling water, for the purpoſe of filling a thermometer, ſome aqua-regia dropped into it from a phial, broken by accident, which ſtood above it, and converted the purple dye into a moſt beautiful dark red. After ſome conjectures and experiments, he diſcovered that the tin by which the window-frame was divided into ſquares had been diſſolved by the aqua regia, and was the cauſe of this change. He communicated his obſervation to Kuffelar, that excellent dyer at Leyden, who was afterwards his ſon-in-law. The latter brought the diſcovery to perfection, and employed it ſome years alone in his dye houſe, which gave riſe to the name of Kuffelar's colour. In the courſe of time the ſecret became known to an inhabitant of Menin, called Gulich, and alſo to another perſon of the name of Van der Vecht, who taught it to the brothers Gobelins in France. Giles Gobelin, a dyer at Paris, in the time of Francis I. had found out an improvement of the then uſual ſcarlet dye; and as he had remarked that the water of the rivulet Bievre, in the ſuburbs St Marceau, was excellent for his art, he erected on it a large dye-houſe; which, out of ridicule, was called *Folie Gobelins*, Gobelin's Folly. About this period, a Flemiſh painter, whom ſome name Peter Koek, and others Kloek, and who had travelled a long time in the Eaſt, eſtabliſhed, and continued to his death in 1650, a manufactory for dyeing ſcarlet cloth by an improved method. Through the means of Colbert, one of the Gobelins learned the proceſs uſed for preparing the German ſcarlet dye from one Gluck, whom ſome conſider as the above-mentioned Gulich, and others as Kloek; and the Pariſian ſcarlet dye ſoon roſe into ſo great repute, that the populace imagined that Gobelin had acquired his art from the devil. It is well known that Louis XIV. by the advice of Colbert, purchaſed Gobelin's building from his ſucceſſors in the year 1667, and transformed it into a palace, to which he gave the name of *Hôtel royal des Gobelins,* and which he aſſigned for the uſe of firſt-rate artiſts, particularly painters, jewellers, weavers of tapeſtry, and others. After that time the rivulet was no longer called Bievre, but Gobelins. About the year 1643, a Fleming, named Kepler, eſtabliſhed the firſt dye-houſe for ſcarlet in England, at the village of Bow, not far from London; and on that account the colour was called, at firſt, by the Engliſh, the *Bow dye.* In the year 1667, another Fleming, named Brewer, invited to England by King Charles II. with the promiſe of a large ſalary, brought this art there to great perfection."

SCHEME, a draught or repreſentation of any geometrical or aſtronomical figure, or problem, by lines ſenſible to the eye; or of the celeſtial bodies in their proper places for any moment; otherwiſe called a diagram.

SCIAGRAPHY, or SCIOGRAPHY, the profile or vertical ſection of a building; uſed to ſhew the inſide of it.

SCIAGRAPHY, in aſtronomy, &c. is a term uſed by ſome authors for the art of finding the hour of the day or night, by the ſhadow of the ſun, moon, ſtars, &c.

SCIOPTIC, or *Scioptric Ball,* a ſphere or globe of wood, with a circular hole or perforation, where a lens is placed. It is ſo fitted, that, like the eye of an animal, it may be turned round every way, to be uſed in making experiments of the darkened room.

SCOLYMUS (ſee that article *Encycl.*) is, by Pliny and Theophraſtus, reckoned to belong to the genus of the thiſtles. The former ſays, that, like moſt others of the ſame kind, the ſeeds were covered by a ſort of wool (*pappus*). It had a high ſtem, ſurrounded with leaves, which were prickly, but which ceaſed to ſting when the plant withered. It flowered the whole ſummer through, and had often flowers and ripe ſeed at the ſame time; which is the caſe alſo with our artichoke plants. The calyx of the *ſcolymus* was not prickly; the root was thick, black, and ſweet, and contained a milky juice. It was eaten both raw and cooked; and Theophraſtus obſerves, as ſomething very remarkable, that when the plant was in flower, or, as others explain the words, when it had finiſhed blowing, it was moſt palatable. What renders this circumſtance ſingular is, that moſt milky roots uſed for food loſe their milk, and become unfit to be eaten as ſoon as they have blown. This is the caſe with the goat's beard, which is eatable only the firſt year.

Profeſſor Beckmann has, with much labour and erudition, endeavoured to aſcertain what is really the plant which was known to the ancients by the name of *ſcolymus.* He ſeems to have proved ſufficiently, that it was not the *cactus,* the *carduus,* or the *cinara;* but he has not been able to come to any other concluſion. "Were I appointed or condemned (ſays he) to form a new Latin dictionary, I ſhould explain the article *ſcolymus* in the following manner: *Planta compoſita, capitata. Caulis longus, obſitus foliis ſpinoſis. Radix carnoſa, lacteſcens, nigra, dulcis, edulis. Calix ſquamis inermibus, diſco carnoſo, ante efflореſcentiam eduli. Semina pappoſa. Turiones edules.* This deſcription, ſhort as it is, contains every thing that the ancients have ſaid in order to characteriſe that plant."

SCONCES, ſmall forts, built for the defence of ſome paſs, river, or other place. Some ſconces are made regular, of four, five, or ſix baſtions; others are of ſmaller dimenſions, fit for paſſes or rivers; and others for the field.

SCOTALES, were meetings held formerly in England for the purpoſe of drinking ale, of which the expence was defrayed by joint contribution. Thus the tenants of South Malling in Suſſex, which belonged to the Archbiſhop of Canterbury, were, at the keeping of a court, to entertain the Lord or his bailiff with a drinking, or an *ale;* and the ſtated quotas towards the charge were, that a man ſhould pay three pence halfpenny for himſelf and his wife, and a widow and a cottager three halfpence. In the manor of Ferring, in the ſame county, and under the ſame juriſdiction, it was the cuſtom for the tenants named to make a *ſcotale* of ſixteen pence halfpenny, and to allow out of each ſixpence three halfpence for the bailiff.

Common ſcotales in taverns, at which the clergy were not to be preſent, are noticed in ſeveral eccleſiaſtical canons. They were not to be publiſhed in the church by the clergy or the laity; and a meeting of more than ten perſons of the ſame pariſh or vicinage was a ſcotale that was generally prohibited. There were alſo common drinkings, which were denominated *leet-ale, bride-ale, clerk-ale,* and *church-ale.* To a *leet-ale* probably all the reſidents in a manorial diſtrict were contributors; and the expence of a *bride-ale* was defrayed by the relations and friends of a happy pair, who were not in circumſtances to bear the charges of a wedding dinner. This cuſtom prevails occaſionally in ſome diſtricts of Scotland even at this day, under the denomination of a *penny bride-ale,* and was very common fifty or ſixty years ago. The *clerk's* ale was in the Eaſter holidays, and was the method taken to enable clerks of pariſhes to collect more readily their dues.

Mr Warton, in his Hiſtory of Engliſh Poetry, has inſerted the following extract from an old indenture, which ſhews clearly the deſign of a *church*-ale. "The pariſhioners of Elveſton and Okebrook, in Derbyſhire, agree jointly to brew four ales, and every ale of one quarter of malt, betwixt this and the feaſt of St John the Baptiſt next coming; and that every inhabitant of the ſaid town of Okebrook ſhall be at the ſeveral ales. And every huſband and his wife ſhall pay two pence, every cottager one penny; and all the inhabitants of Elveſton ſhall have and receive all the profits and advantages coming of the ſaid ales, to *the uſe and behoof of the ſaid church of Elveſton.*"

The *give-ales* were the legacies of individuals; and from that circumſtance entirely gratuitous. They ſeem to have been very numerous, and were generally left to the poor; though, from the largeneſs of the quantity of ale enjoined to be brewed, it muſt have been ſometimes intended that others were to partake of them. Theſe bequeſts were likewiſe, not unfrequently, made to the light or altar of a ſaint, with directions for ſinging maſſes at the obit, trenthal, or anniverſary of the teſtator. Hence, though ſcotales were generally kept in houſes of public reſort, the give-ales were ſometimes diſpenſed in the church, and often in the churchyard; by which means "Godde's houſe (as Sumner ſays in his Treatiſe on Gavelkind) was made a tavern of gluttons." Such certainly would be Chalk church, if in it

Scowring.

Scowri
Scyll

was kept the give-ale of William May of that pariſh ; for he ordered his wife to "make in bread ſix buſhels of wheat, and in drink ten buſhels of mault, and in cheeſe twenty-pence, to give to poor people for the health of his ſoull ; and he ordered that, after the deceaſe of his wife, his executors and feoffees ſhould continue the cuſtom for evermore."

SCOWRING OF STUFFS, is an art much more generally practiſed than underſtood. It ſuppoſes, ſays Chaptal, 1ſt, a knowledge of the different ſubſtances capable of ſtaining any kind of cloth ; 2d, of the ſubſtances to which recourſe muſt be had, in order to make thoſe depoſited on the ſtuff to diſappear ; 3d, a knowledge of the effects produced on colours by thoſe reagents, which it may be neceſſary to employ to deſtroy ſtains ; 4th, a knowledge of the manner in which the cloth is affected by thoſe re-agents ; 5th, of the art of reſtoring a colour changed or faded. Of thoſe bodies which occaſion ſpots on different kinds of cloth, ſome are eaſily diſtinguiſhed by their appearance, ſuch as greaſy ſubſtances ; but others have more complex effects, ſuch as acids, alkalies, perſpired matter, fruits, urine, &c. Acids redden black, fawn, violet, and pucecolour, and every ſhade communicated with orchillaweed, iron, aſtringents, and every blue except indigo and pruſſian blue. They render the yellows paler, except that of arnatto, which they change into orange.

Alkalies change to violet the reds produced by Brazil-wood, logwood, and cochineal. They render the greens on woollen cloth yellowiſh, make yellow browniſh, and change the yellow produced by arnatto to aurora. Perſpired matter produces the ſame effects as alkalies.

When the ſpots are produced by ſimple bodies on ſtuffs, it is eaſy to remove them by the means already known. Greaſy ſubſtances are removed by alkalies, ſoaps, the yolk of eggs, fat earths ; oxyds of iron, by the nitric and oxalic acids ; acids by alkalies, and reciprocally. Stains of fruit on white ſtuffs may be removed by the ſulphureous acid, and ſtill better by the oxygenated muriatic acid. But when the ſpots are of a complex kind, it will be neceſſary to employ ſeveral means in ſucceſſion. Thus, to deſtroy the ſtain of coom from carriage-wheels, after the greaſe has been diſſolved, the oxyd of iron may be removed by the oxalic acid.

As colours are often changed by re-agents, it will be neceſſary, in order to reſtore them, that the ſcowrer ſhould poſſeſs a thorough knowledge of the art of dyeing, and how to modify the means according to circumſtances. This becomes the more difficult, when it is neceſſary to reproduce a colour ſimilar to that of the reſt of the ſtuff, to apply that colour only in one place, and often to reſtore the mordant by which it was fixed, and which has been deſtroyed, or even the firſt tint which gave the colour its intenſity. It may be readily conceived, that the means to be employed muſt depend on the nature of the colour and the ingredients by which it was produced ; for it is known that the ſame colour may be obtained from very different bodies. Thus, after an alkali has been employed to deſtroy an acid ſpot on browns, violets, blues, poppies, &c. the yellow ſpot which remains may be made to diſappear by a ſolution of tin ; a ſolution of ſulphat of iron reſtores the colour to brown ſtuffs which have been galled ; acids reſtore to their former ſplendour yellows which have been rendered duſky or brown by alkalies ; blacks produced by logwood become red by acids ; alkalies change theſe red ſpots to yellow, and a little of the aſtringent principle makes them again become black. A ſolution of one part of indigo in four parts of ſulphuric acid, diluted with a ſufficient quantity of water, may be employed with ſucceſs to revive the blue colour of cotton or wool which has been changed. Scarlet may be revived by means of cochineal and a ſolution of the muriat of tin, &c.

The choice of re-agents is not a matter of indifference. Vegetable acids are preferable; the ſulphureous acid, however, may be employed for ſtains occaſioned by fruit ; it does not change the blue of ſilk nor colours produced by aſtringents ; it does not degrade the yellow of cotton. Ammonia ſucceeds better than fixed alkalies in removing ſpots produced by acids. It is employed in vapour ; its action is ſpeedy, and ſeldom alters the colour.

The means of removing greaſy ſpots are well known. This effect is produced by alkalies, fullers earth, volatile oils diſſolved in alcohol, a heat proper for volatilizing greaſe, &c. Spots occaſioned by ink, ruſt, or ironmould of any kind, and all thoſe produced by the yellow oxyd of iron, are removed by the oxalic acid : the colour may be reſtored by alkalies, or a ſolution of the muriat of tin. Theſe ſpots may be removed alſo by the oxygenated muriatic acid, when they are on white ſtuffs or paper.

The action of alkalies, and that of perſpired matter, are the ſame : their ſpots may be effaced by acids, or even by a weak ſolution of the muriat of tin. When theſe ſpots ariſe from ſeveral unknown cauſes, in order to deſtroy them, recourſe muſt be had to polychreſt compoſitions. The following may be conſidered as one of the moſt efficacious : Diſſolve white ſoap in alcohol, and mix this ſolution with the yolks of from four to ſix eggs ; add gradually eſſence of turpentine ; and incorporate with the whole ſome fullers earth, in ſuch a manner as to form balls of a ſuitable conſiſtence. Moiſten the ſpot ; and having rubbed it with theſe balls, the ſpot will be removed by waſhing the ſtuff. All ſpots, except iron-mould and ink, may be removed in this manner.

Waſhing deſtroys the luſtre, and leaves a tarniſhed place diſagreeable to the eye ; but the luſtre may be reſtored by drawing over the waſhed place, and in the direction of the pile, a bruſh moiſtened in water, impregnated with a little gum. You may then apply a ſheet of paper, or a piece of cloth, and a conſiderable weight, under which the cloth muſt be left to dry.

SCYLLA. Under this title we gave, in the *Encyclopædia*, an account of Scylla and Charybdis, which, though taken from a work which we thought good authority, appears to be far from correct. Theſe places, ſo famous in the poems of Homer and Virgil, were examined with minute attention by that accurate obſerver of nature the Abbé Spallanzani ; who thus deſcribes Scylla.

"It is a lofty rock, diſtant twelve miles from Meſſina, which riſes almoſt perpendicularly from the ſea on the ſhore of Calabria, and beyond which is the ſmall city of the ſame name. Though there was ſcarcely any wind, I began to hear, two miles before I came to the rock, a murmur and noiſe like a confuſed barking of dogs, and on a nearer approach readily diſcovered the cauſe. This rock, in its lower parts, contains a number of caverns, one of the largeſt of which is called by the people there *Dragara*. The waves, when in the leaſt agitated, ruſhing into theſe caverns, break, daſh, throw up frothy bubbles, and thus occaſion theſe various and multiplied ſounds. I then perceived with how much truth and reſemblance of nature Homer and Virgil, in their perſonifications of Scylla, had pourtrayed this ſcene, by deſcribing the monſter they drew as lurking in the darkneſs of a vaſt cavern, ſurrounded by ravenous barking maſtiffs, together with wolves, to increaſe the horror.

"Such is the ſituation and appearance of Scylla: let us now conſider the danger it occaſions to mariners. Though the tide is almoſt imperceptible in the open parts of the Mediterranean, it is very ſtrong in the ſtrait of Meſſina, in conſequence of the narrowneſs of the channel, and is regulated, as in other places, by the periodical elevations and depreſſion of the water. Where the flow or current is accompanied by a wind blowing the ſame way, veſſels have nothing to fear, ſince they either do not enter the ſtrait, both the wind and the ſtream oppoſing them, but caſt anchor at the entrance; or, if both are favourable, enter on full ſail, and paſs through with ſuch rapidity that they ſeem to fly over the water. But when the current runs from ſouth to north, and the north wind blows hard at the ſame time, the ſhip which expected eaſily to paſs the ſtrait with the wind in its ſtern, on its entering the channel is reſiſted by the oppoſite current, and, impelled by two forces in contrary directions, is at length daſhed on the rock of Scylla, or driven on the neighbouring ſands; unleſs the pilot ſhall apply for the ſuccour neceſſary for his preſervation. For, to give aſſiſtance in caſe of ſuch accidents, 24 of the ſtrongeſt, boldeſt, and moſt experienced ſailors, well acquainted with the place, are ſtationed night and day along the ſhore of Meſſina; who, at the report of guns fired as ſignals of diſtreſs from any veſſel, haſten to its aſſiſtance, and tow it with one of their light boats. The current, where it is ſtrongeſt, does not extend over the whole ſtrait, but winds thro' it in intricate meanders, with the courſe of which theſe men are perfectly acquainted, and are thus able to guide the ſhip in ſuch a manner as to avoid it. Should the pilot, however, confiding in his own ſkill, contemn or neglect this aſſiſtance, however great his ability or experience, he would run the moſt imminent riſk of being ſhipwrecked. In this agitation and conflict of the waters, forced one way by the current, and driven in a contrary direction by the wind, it is uſeleſs to throw the line to diſcover the depth of the bottom, the violence of the current frequently carrying the lead almoſt on the ſurface of the water. The ſtrongeſt cables, though ſome feet in circumference, break like ſmall cords. Should two or three anchors be thrown out, the bottom is ſo rocky that they either take no hold; or, if they ſhould, are ſoon looſened by the violence of the waves. Every expedient afforded by the art of navigation, though it might ſucceed in ſaving a ſhip in other parts of the Mediterranean, or even the tremendous ocean, is uſeleſs here. The only means of avoiding being daſhed againſt the rocks, or driven upon the ſands in the midſt of this furious conteſt of the winds and waves, is to have recourſe to the ſkill and courage of theſe Meſſineſe ſeamen."

Charybdis is ſituated within the ſtrait, in that part of the ſea which lies between a projection of land named *Punta Secca*, and another projection on which ſtands the tower called *Lanterna*, or the light-houſe, a light being placed at its top to guide veſſels which may enter the harbour by night. Every writer, who has hitherto deſcribed Charybdis, has ſuppoſed it to be a whirlpool; but this is a miſtake, as Spallanzani has completely proved, by aſcertaining what it really is.

"Charybdis is diſtant from the ſhore of Meſſina about 750 feet, and is called by the people of the country *Caloſaro*, not from the agitation of the waves, as ſome have ſuppoſed, but from καλος and φαρος; that is, *the beautiful tower*, from the light-houſe erected near it for the guidance of veſſels. The phenomenon of the Calofaro is obſervable when the current is deſcending; for when the current ſets in from the north, the pilots call it the *deſcending rema*, or current; and when it runs from the ſouth, the *aſcending rema*. The current aſcends or deſcends at the riſing or ſetting of the moon, and continues for ſix hours. In the interval between each aſcent or deſcent, there is a calm which laſts at leaſt a quarter of an hour, but not longer than an hour. Afterwards, at the riſing or ſetting of the moon, the current enters from the north, making various angles of incidence with the ſhore, and at length reaches the Calofaro. This delay ſometimes continues two hours; ſometimes it immediately falls into the Calofaro; and then experience has taught that it is a certain token of bad weather."

When our author obſerved Charybdis from the ſhore, it appeared like a group of tumultuous waters; which group, as he approached, became more extenſive and more agitated. He was carried to the edge, where he ſtopped ſome time to make the requiſite obſervations; and was then convinced, beyond the ſhadow of a doubt, that what he ſaw was by no means a vortex or whirlpool.

Hydrologiſts teach us, that by a whirlpool in a running water we are to underſtand that circular courſe which it takes in certain circumſtances; and that this courſe or revolution generates in the middle a hollow inverted cone, of a greater or leſs depth, the internal ſides of which have a ſpiral motion. But Spallanzani perceived nothing of this kind in the Calofaro. Its revolving motion was circumſcribed to a circle of at moſt 100 feet in diameter; within which limits there was no incurvation of any kind, nor vertiginous motion, but an inceſſant undulation of agitated waters, which roſe, fell, beat, and daſhed on each other. Yet theſe irregular motions were ſo far placid, that nothing was to be feared in paſſing over the ſpot, which he did; though their little bark rocked very much from the continual agitation, ſo that they were obliged conſtantly to make uſe of their oars to prevent its being driven out of the Calofaro. Our author threw ſubſtances of different kinds into the ſtream. Such as were ſpecifically heavier than the water ſunk, and appeared no more; thoſe which were lighter remained on the ſurface, but were ſoon driven out of the revolving circle by the agitation of the water.

Though from theſe obſervations he was convinced that there was no gulph under the Calofaro, as otherwiſe

Scylla, Sea ſick-neſs.

wiſe there would have been a whirlpool, which would have carried down into it the floating ſubſtances; he determined to ſound the bottom with the plummet, and found its greateſt depth did not exceed 500 feet. He was likewiſe informed, to his no ſmall ſurpriſe, that beyond the Calofaro, towards the middle of the ſtrait, the depth was double.

When the current and the wind are contrary to each other, and both in their greateſt violence, eſpecially when the ſcilocco, or ſouth wind, blows, the ſwelling and daſhing of the waves within the Calofaro is much ſtronger, more impetuous, and more extenſive. It then contains three or four ſmall whirlpools, or even more, according to the greatneſs of its extent and violence. If at this time ſmall veſſels are driven into the Calofaro by the current or the wind, they are ſeen to whirl round, rock, and plunge, but are never drawn down into the vortex. They only ſink when filled with water, by the waves beating over them. When veſſels of a larger ſize are forced into it, whatever wind they have they cannot extricate themſelves; their ſails are uſeleſs; and after having been for ſome time toſſed about by the waves, if they are not aſſiſted by the pilots of the country, who know how to bring them out of the courſe of the current, they are furiouſly driven upon the neighbouring ſhore of the Lanterna, where they are wrecked, and the greater part of their crews periſh in the waves.

From theſe facts, the claſſical reader will perceive, that the ancient deſcriptions of Charybdis are by no means ſo accurate as thoſe of Scylla. The ſaying, however, which became proverbial among the ancients, viz. that "he who endeavours to avoid Charybdis, daſhes upon Scylla," is, in a great meaſure, true. If a ſhip be extricated from the fury of Charybdis, and carried by a ſtrong ſoutherly wind along the ſtrait towards the northern entrance, it will indeed paſs out ſafely; but ſhould it meet with a wind in a nearly oppoſite direction, it would become the ſport of both theſe winds, and, unable to advance or recede, be driven in a middle courſe between their two directions, that is to ſay, full upon the rock of Scylla, if it be not immediately aſſiſted by the pilots. It is likewiſe obſerved, that in theſe hurricanes a land wind frequently riſes, which deſcends from a narrow paſs in Calabria, and increaſes the force with which the ſhip is impelled towards the rock.

SEA-SICKNESS is a diſorder which has been but little treated of, notwithſtanding the frequency of its occurrence, and the irkſomeneſs and diſtreſs to which the patient is ſubjected during its continuance It has been found to be very beneficial in ſeveral diſeaſes, among which the principal are aſthmatic and pulmonary complaints; and there are very few inſtances of its being attended with fatal conſequences. The ſea-ſickneſs ſeems to be a ſpaſmodic affection of the ſtomach, produced by the alternate preſſure and receſs of the contents of that viſcus againſt its lower internal ſurface, according as the riſe and fall of the ſhip oppoſes or recedes from the action of gravity.

Sea-ſi
neſs

The ſeas in which this diſorder attacks the paſſenger with the greateſt violence, are thoſe where the waves have long uninterrupted freedom of action; of courſe, bays, gulphs, and channels, may be navigated with leſs inconvenience, as the waves, meeting with more frequent reſiſtance, and the repercuſſion being conſiderably ſtronger, the veſſel does not experience that gentle uniform vacillation which ſickens the ſtomach, and renders the head giddy. By the ſame argument, a perſon feels leſs inconvenience from the diſorder on the wide ocean in a ſmall veſſel, on which the ſlighteſt motion of the waves makes a ſtrong impreſſion. He is likewiſe leſs expoſed to it in a very large veſſel, as in a ſhip of the line, or a large merchantman deeply laden; as the waves, in this caſe, ſcarcely affect the veſſel. It is in ſhips of the middling ſize, and which carry but a light cargo, that the paſſenger ſuffers moſt from the ſea ſickneſs. It has been obſerved, that this diſorder affects people in years leſs than young perſons; thoſe of a dark leſs than thoſe of a fair complection, and that it ſeldom attacks infants. The duration is not limited to any fixed period of time; with ſome it laſts only a few days, with others weeks, months, and even during the whole courſe of the voyage. The ſooner it takes place after embarkation, the greater probability is there of its continuance. It does not always ceaſe immediately on landing, but has been known, in ſome caſes, to continue for a conſiderable time. Even the oldeſt and moſt ſkilful ſeamen have experienced a relapſe, eſpecially if they have quitted the ſea ſervice for a long term of years.

There have been many modes recommended for mitigating, if not entirely preventing, this diſorder; among which the following ſeem the moſt efficacious:

1. Not to go on board immediately after eating; and, when on board, not to eat in any great quantity at any one meal.

2. To take ſtrong exerciſe, with as little intermiſſion as conveniently can be done; for inſtance, to aſſiſt at the pumps, or any other active employment, as indolent and ſlothful paſſengers always ſuffer moſt from the diſorder.

3. To keep much upon deck, even in ſtormy and rainy weather, as the ſea breeze is leſs liable to affect the ſtomach than the ſtagnated air of the cabin, which is frequently rendered infectious for want of ſufficient circulation.

4. Not to watch the motion of the waves, eſpecially when ſtrongly agitated with tempeſt.

5. To avoid carefully all employments which haraſs the mind, as reading, ſtudy, meditation, and gaming; and, on the other hand, to ſeek every opportunity of mirth and mental relaxation.

6. To drink occaſionally carbonic acids, as the froth of ſtrong fermented beer, or wine mixed with Seltzer water, and fermented with pounded ſugar, or a glaſs of Champaign.

7. It will be found of great ſervice to take the acid of ſulphur dulcified, dropped upon lump ſugar, or in peppermint-water; or ten drops of ſulphureous ether.

With regard to eating, it is adviſable to be very ſparing, at leaſt not to eat much at one meal. The proper diet is bread and freſh meat, which ſhould be eaten cold with pepper. All ſweet favoured food ſhould be carefully avoided; and the paſſenger ſhould refrain from fat, but eſpecially from all meat that is in the leaſt degree tainted. Even the odour of flowers is very pernicious; for which reaſon, it is not expedient to examine marine productions, as theſe generally have a nauſeating ſmell. The fumes of vinegar may be inhaled with great benefit. The drink ſhould conſiſt of tart wines, lemonade, or Seltzer water, but never of common water. The paſſenger would do well to drink little and often. As experience has proved, that an accidental diarrhœa has frequently relieved the patient from the ſea-ſickneſs, it will be prudent to follow the clue of nature, and take a gentle laxative, or, if circumſtances will permit, a clyſter of ſalt-water and Venice ſoap, which is the more neceſſary, as ſea-faring people are liable to obſtructions. It will further be found uſeful to apply to the pit of the ſtomach a tonic anodyne antiſpaſmodic emplaſtrum, ſpread upon leather, and covered with linen.

Where the above preventives have not been employed, or have not ſucceeded in ſecuring the paſſenger from the ſea-ſickneſs, he may, however, experience conſiderable relief from the following remedies :

If ſymptoms of vomiting appear, they may frequently be remedied by the patient proſtrating himſelf in a horizontal poſition, upon the back or belly, and lying perfectly ſtill. We would recommend likewiſe a gentle compreſſion of the abdomen. But if the fits of vomiting are too violent to be repreſſed, in that caſe, it is beſt to promote them by a ſtrong doſe of ſalt-water; an expedient, however, which muſt not be too often repeated, as it tends ſtill more to weaken the ſtomach. When the emetic takes effect, let the patient bend his body, advancing his knees towards his breaſt, and ſupport his head againſt a firm and ſolid reſting-place. He muſt be particularly careful to untie his garters and cravat, as this precaution will ſecure him from the riſk of a rupture, and from the ill effects of the blood ruſhing violently towards the head and breaſt.

After the vomiting has ſubſided, its return may be guarded againſt by preſerving a ſtate of repoſe, and even keeping the eyes ſhut for a conſiderable time. Let the patient chooſe a cool, ventilated place, remembering to keep himſelf warm and well clothed, as perſpiration is highly ſalutary. But he muſt not indulge in too long ſleep during the day-time, as this induces torpidneſs. In the morning he ſhould conſtantly take a gargle of ſugar diſſolved in vinegar. Let him eat often, but ſparingly; and if he can content himſelf with a diſh of chocolate, coffee, or ſtrong tea, he will reap ſtill greater benefit. He ſhould never drink water in its pure elementary ſtate, but mix it with brandy, vinegar, or wine. In the morning, inſtead of brandy, he may take a glaſs of wine, with an infuſion of orange peel, gentian root, or peruvian bark (*quinquina*). A glaſs of punch taken occaſionally will prove of very eſſential ſervice, as it promotes perſpiration.

Perſons in the habit of ſmoking, will find a pleaſant and ſalutary companion in the pipe; but thoſe who are not accuſtomed to it will be ſufferers by taking to the practice.

In concluſion, it is proper to add, that warm clothing, flannel ſhirts, trowſers, caps, &c. are efficacious remedies againſt exceſſive expectoration, and all other ſymptoms of this terrible diſorder.

SECTOR of a Sphere, is the ſolid generated by the revolution of the ſector of a circle about one of its radii; the other radius deſcribing the ſurface of a cone, and the circular arc a circular portion of the ſurface of the ſphere of the ſame radius. So that the ſpherical ſector conſiſts of a right cone, and of a ſegment of the ſphere having the ſame common baſe with the cone. And hence the ſolid content of it will be found by multiplying the baſe or ſpherical ſurface by the radius of the ſphere, and taking a third part of the product.

Sector *of an ellipſe*, or *of an hyperbola*, &c. is a part reſembling the circular ſector, being contained by three lines, two of which are radii, or lines drawn from the centre of the figure to the curve, and the intercepted arc or part of that curve.

SEEDS, Preservation of, in a ſtate fit for vegetation, is a matter of great and general importance, becauſe, if it can be accompliſhed, it will enable us to rear many uſeful plants in one country which are there unknown, being indigenous only in others at a great diſtance from it. There is a letter on this ſubject in the 16th volume of the *Tranſactions of the Society of Arts*, &c. from which we ſhall extract what is fit for our purpoſe.

"Many years ago (ſays the author), having obſerved ſome ſeeds which had got accidentally amongſt raiſins, and that they were ſuch as are generally attended with difficulty to raiſe in England after coming in the uſual way from abroad, I ſowed them in pots, within a framing; and as all of them grew, I commiſſioned my ſons, who were then abroad, to pack up all ſorts of ſeeds they could procure in abſorbent paper, and ſend ſome of them ſurrounded by raiſins, and others by brown moiſt ſugar; concluding that the former ſeeds had been preſerved by a peculiarly favourable ſtate of moiſture thus afforded them. It occurred, likewiſe, that as many of our common ſeeds, ſuch as clover, charlock, &c. would lie dormant for ages within the earth, well preſerved for vegetation whenever they might happen to be thrown to the ſurface, and expoſed to the atmoſphere, ſo theſe foreign ſeeds might be equally preſerved, for many months at leaſt, by the kindly covering and genial moiſture that either raiſins or ſugar afforded them: and this conjecture was really fulfilled, as not one in twenty of them failed to vegetate, when thoſe of the ſame kinds, that I ordered to be ſent lapped in common parcels, and forwarded with them, would not grow at all. I obſerved, upon examining them all before they were committed to the earth, that there was a prevailing dryneſs in the latter, and that the former looked freſh and healthy, and were not in the leaſt infeſted by inſects, as was the caſe with the others. It has been tried repeatedly to convey ſeeds (of many plants difficult to raiſe) cloſed up in bottles, but without ſucceſs; ſome greater proportion of air, as well as a proper ſtate of moiſture, perhaps, being neceſſary. I ſhould alſo obſerve, that no difference was made in the package of the ſeeds, reſpecting their being kept in huſks, pods, &c. ſo as to give thoſe in raiſins or ſugar any advantage over the others, all being ſent equally guarded by their natural teguments."

SEGALIEN, the name given by Europeans to a large iſland ſeparated by a narrow channel from the coaſt of Chineſe Tartary, and called by the natives *Tchoka*, and by the Chineſe *Oku-Jeſſo*. It lies between the 46th and 54th degrees of north latitude, but its breadth from eaſt to weſt is not known. Indeed hardly any thing about it was known till the year 1787, that M. La Perouſe penetrated almoſt to the bottom of the channel which ſeparates it from the continent, and which grew ſo very ſhallow as he advanced northward that, in all probability, the iſland will ſoon become a peninſula. The French frigates came to anchor in different bays on the coaſt of Segalien; and the fineſt of theſe bays, to which the Commodore gave the name of *Baie d'Eſtaing*, is ſituated in 48° 59′ N. Lat. and 140° 32′ Lon. Eaſt from Paris.

La Perouſe and M. Rollin, the ſurgeon of his ſhip, both deſcribe the natives of this iſland as a worthy and intelligent people. Of the preſents which were made to them, they ſeemed to ſet a value only on ſuch as were uſeful. Iron and ſtuffs prevailed over every thing; they underſtood metals as well as their gueſts, and for ornament preferred ſilver to copper, and copper to iron. They make uſe of looms, which, though ſmall, are very complete inſtruments; and by means of ſpindles they prepare thread of the hair of animals, of the bark of the willow, and the great nettle, from which they make their ſtuffs. They are of a moderate ſize, ſquat, and ſtrong built, with the muſcles of their bodies very exactly defined: their common height is five feet, and the greateſt does not exceed five feet four inches; but men of this ſize are very uncommon among them. They have all a large head, and a broader and more rounded face than Europeans; their countenance is animated and agreeable, though, upon the whole, it is deſtitute of that regularity and grace which we eſteem ſo eſſential to beauty: they have large cheeks, a ſhort noſe rounded at its extremity, with very broad noſtrils: their eyes are lively. of a moderate ſize, for the moſt part black, though ſome have blue ones among them: their eyebrows are buſhy, their mouth of the common ſize, their voice is ſtrong, their lips are rather thick, and of a dull red: M. Rollin remarked, that in ſeveral the upper lip was tattoed, and tinged of a blue colour: theſe, as well as their eyes, are capable of every variety of expreſſion: their teeth are white, even, and of the uſual number; their chin is rounded and a little advancing; their ears are ſmall: they bore and wear in them glaſs ornaments or ſilver rings.

The women are not ſo large as the men, and are of a more rounded and delicate figure, though there is but little difference between the features of their faces. Their upper lip is tattoed all over of a blue colour, and they wear their hair long and flowing: their dreſs hardly differs from that of the men; the colour of the ſkin in both ſexes is tawny, and that of their nails, which they ſuffer to grow to a great length, is a ſhade darker than that of Europeans. Theſe iſlanders are very hairy, and have long beards, which gives, eſpecially to the old men, a grave and venerable air: theſe laſt appear to be held in much reſpect by the younger part of the inhabitants. The hair of their head is black, ſmooth, and moderately ſtrong; in ſome it is of a cheſnut colour: they all wear it round, about ſix inches long behind, and cut into a bruſh on the top of their head and over the temples.

Their clothing conſiſts of a kind of ſurtout which wraps over before, where it is faſtened by little buttons, ſtrings, and a girdle placed above the haunches. This ſurtout is made of ſkin or quilted nankeen, a kind of ſtuff that they make of willow bark: it generally reaches to the calf of the leg, and ſometimes even lower, which for the moſt part renders the uſe of drawers unneceſſary: ſome of them wear ſeal ſkin boots, the feet of which, in form and workmanſhip, reſembles the Chineſe ſhoe; but the greater number of them go bare-footed and bare-headed: a few indeed wear a bandage of bear-ſkin round the head; but this is rather as an ornament than a defence againſt the weather.

Like the lower claſſes of the Chineſe, they all wear a girdle, to which they hang their knife as a defence againſt the bears, and ſeveral little pockets, into which they put their flint and ſteel, their pipe, and their box of tobacco; for they make a general practice of ſmoking.

Their huts are ſufficient to defend them againſt the rain and other inclemencies of the air, but are very ſmall in proportion to the number of the inhabitants which they contain. The roof is formed of two inclined planes, which are from ten to twelve feet high at their junction, and three or four on the ſides: the breadth of the roof is about fifteen feet, and its length eighteen: theſe cabins are conſtructed of frame work, ſtrongly put together, the ſides being filled up with the bark of trees, and the top thatched with dry graſs in the ſame manner as our cottages are.

On the inſide of theſe houſes is a ſquare of earth raiſed about ſix inches above the ground, and ſupported on the ſides by ſtrong planking; on this they make the fire: along the ſides of the apartment are benches twelve or fifteen inches high, which they cover with mats, on which they ſleep.

The utenſils that they employ in cooking their food conſiſt of an iron pot, ſhells, veſſels made of wood and birch bark, of various ſhapes and workmanſhip; and, like the Chineſe, they take up their food with little ſticks: they have generally two meals in the day, one at noon, and the other in the evening.

The habitations in the ſouth part of the iſland are much better built and furniſhed, having for the moſt part planked floors: our author ſaw in them ſome veſſels of Japan porcelain, on which the owners appeared to ſet great value, probably becauſe they are not to be procured but with great trouble and at conſiderable expence. They cultivate no kind of vegetable, living only on dried and ſmoked fiſh, and what little game they take by hunting.

Each family has its own canoe, and implements for fiſhing and hunting. Their arms are bows, javelins, and a kind of ſpontoon, which they uſe principally in bear-hunting. By the ſide of their houſes are the magazines, in which they lay up the proviſion which they have prepared and collected during ſummer for their winter ſubſiſtence. It conſiſts of dried fiſh, and a conſiderable quantity of garlic and wild celery, angelica, a bulbous root which they call *apè*, better known under the name of the yellow lily of Kamtſchatka, and fiſh oil, which they preſerve in the ſtomachs of bears, and other large animals. Theſe magazines are made of planks, ſtrongly and cloſely put together, raiſed above the ground on ſtakes about four feet high.

Dogs are the only domeſtic animals belonging to the natives of Tchoka; they are of a middling ſize, with ſhaggy hair, pricked ears, and a ſharp long muzzle; their cry is loud and not ſavage.

Theſe people, who are of a very mild and unſuſpecting diſpoſition, appear to have commercial intercourſe with the Chineſe by means of the Mantchou Tartars, with the Ruſſians to the north of their iſland, and the Japaneſe to the ſouth: but the articles of trade are of no great conſequence, conſiſting only of a few furs and whale oil This fiſh is caught only on the ſouthern coaſt of the iſland. Their mode of extracting the oil is by no means economical; they drag the whale on ſhore on a ſloping ground, and ſuffering it to putrify, receive in a trench, at the foot of the ſlope, the oil, which ſeparates ſpontaneouſly.

The iſland is well wooded, and mountainous towards the centre, but is flat and level along the coaſt, the ſoil of which appears admirably adapted to agriculture: vegetation is extremely vigorous here; foreſts of pine, willow, oak, and birch, cover nearly the whole ſurface. The ſea abounds with fiſh, as well as the rivers and brooks, which ſwarm with ſalmon and trout of an excellent quality. The weather is, in general, foggy and mild. All the inhabitants have an air of health and ſtrength, which they retain even to extreme old age; nor did our author obſerve among them any inſtance of defective organization, or the leaſt trace of contagious or eruptive diſorders.

SEGMENTS, LINE OF, are two particular lines, ſo called on Gunter's ſector. They lie between the lines of ſines and ſuperficies, and are numbered with 5, 6, 7, 8, 9, 10. They repreſent the diameter of a circle, ſo divided into 100 parts, as that a right line drawn through thoſe parts, and perpendicular to the diameter, ſhall cut the circle into two ſegments, the greater of which ſhall have the ſame proportion to the whole circle, as the parts cut off have to 100.

SEGO, the capital of the kingdom of Bambarra in Africa, is ſituated on the banks of the Niger, in 14° 4′ N. Lat. and 2° 1′ Weſt Long. It conſiſts, properly ſpeaking, of four diſtinct towns; two on the northern bank of the Niger, called Sego Korro, and Sego Boo; and two on the ſouthern bank, called Sego Soo Korro, and Sego See Korro. They are all ſurrounded with high mud-walls; the houſes are built of clay, of a ſquare form, with flat roofs; ſome of them have two ſtories, and many of them are whitewaſhed. Beſides theſe buildings, Mooriſh moſques are ſeen in every quarter; and the ſtreets, though narrow, are broad enough for every uſeful purpoſe in a country where wheel carriages are entirely unknown. Mr Park informs us, that from the beſt inquiries that he could make, he has reaſon to believe that Sego contains altogether about thirty thouſand inhabitants. The King of Bambarra conſtantly reſides at Sego See Korro; he employs a great many ſlaves in conveying people over the river, and the money they receive (though the fare is only ten kowrie ſhells for each individual) furniſhes a conſiderable revenue to the king in the courſe of a year. The canoes are of a ſingular conſtruction, each of them being formed of the trunks of two large trees, rendered concave, and joined together, not ſide by ſide, but endwiſe; the junction being exactly acroſs the middle of the canoe: they are therefore very long and diſproportionably narrow, and have neither decks nor maſts; they are, however, very roomy; for our author obſerved in one of them four horſes, and ſeveral people, croſſing over the river. The view of this extenſive city; the numerous canoes upon the river; the crowded population, and the cultivated ſtate of the ſurrounding country, formed altogether a proſpect of civilization and magnificence which he little expected to find in the boſom of Africa.

He met not, however, in Sego with that hoſpitality which he had experienced in ſome other African towns. The Moors, who abound in it, and whoſe bigotry renders them the implacable enemies of every white man ſuſpected of being a Chriſtian, contrived to perſuade the king that it was for no good purpoſe he had come into the territories of Bambarra. He was therefore ordered to take up his reſidence as a village a little diſtant, without being admitted into the royal preſence. Even there, ſo ſtrong was the prejudice that had been excited againſt him, no perſon would admit him into his houſe. About ſunſet, however, as he was preparing to paſs the night in the top of a tree, that he might not be in danger of being torn to pieces by wild beaſts, a poor Negro woman conducted him to her hut, dreſſed a fine fiſh for his ſupper, and furniſhed him with a mat to ſleep on. She then called to the female part of her family, who had ſtood gazing on him all the while with fixed aſtoniſhment, to reſume their taſk of ſpinning cotton; in which they continued to employ themſelves great part of the night. They lightened their labour by ſongs; one of which was compoſed extempore, for our author was himſelf the ſubject of it. It was ſung by one of the young women, the reſt joining in a ſort of chorus. The air was ſweet and plaintive, and the words, literally tranſlated, were theſe—"The winds roared, and the rains fell.—The poor white man, faint and weary, came and ſat under our tree.—He has no mother to bring him milk; no wife to grind his corn. *Chorus*. Let us pity the white man; no mother has he", &c. &c. "Trifling (ſays Mr Park) as this recital may appear to the reader, to a perſon in my ſituation the circumſtance was affecting in the higheſt degree."

Having remained three days in this village, he was diſmiſſed on the fourth, after receiving from the king 5000 kowries, to enable him to purchaſe proviſions in the courſe of his journey. Though this ſum amounted only to one pound ſterling, ſo cheap are the neceſſaries of life in Bambarra, that it was ſufficient to purchaſe proviſions for himſelf, and corn for his horſe, for fifty days.

SELL, in building, is of two kinds, viz. *Ground Sell*, which denotes the loweſt piece of timber in a wooden building, and that upon which the whole ſuperſtructure is raiſed; and *Sell of a Window*, or *of a Door*, which is the bottom piece in the frame of them, upon which they reſt.

SENN, a kind of itinerant cowkeeper in Switzerland, particularly in the canton of Appenzell. Theſe men do not grow ſo much hay themſelves as they require for their cattle during the winter ſeaſon, and ſome of them have no graſs lands at all. To ſupply this deficiency, they employ agents throughout the canton, who are to inform them where good hay may be obtained, which farmers made it in favourable weather, &c. and then the Senn, or the great cowkeeper, who is in want of fodder, makes his agreements for the winter with the wealthier farmers, to whom he ſucceſſively drives his cattle as ſoon as they return from graſs. Thus the itinerant Senn, with his cows, often viſits five different places during the winter ſeaſon. He who ſells the hay furniſhes the Senn not only with ſtabling for his beaſts, but boards and lodges him as well as his whole family. In return, the Senn, beſides paying the ſtipulated price for the hay, allows to his hoſt as much milk, whey, and *zieger* (a kind of lean cheeſe) as may be

Senn.

be uſed in the houſe, and leaves him alſo the manure of his cows. In the middle of April, when Nature revives, the Senn again iſſues forth with his herd to the meadows and fertile Alps, which he rents for the ſummer. Thus the life of theſe men is a conſtant migration, affording the moſt pleaſing variety, and bleſſing them with health, content, and cheerfulneſs; but they had not been then curſed with French fraternity.

Fine cattle are the pride of the cowkeeper who inhabits the Alps:—but, not ſatisfied with their natural beauty, he will likewiſe pleaſe his vanity. He adorns his beſt cows with large bells ſuſpended from broad thongs; and the expence in ſuch bells is carried even to a luxurious exceſs. Every Senn has an harmonious ſet of at leaſt two or three bells, chiming in with the famous *ranz des vaches* (A). The inhabitants of the Tyrol bring a number of ſuch bells, of all ſizes, to every fair kept in the canton of Appenzell. They are fixed to a broad ſtrap, neatly pinked, cut out, and embroidered; which is faſtened round the cow's neck by means of a large buckle. A bell of the largeſt ſize meaſures upwards of a foot in diameter, is of an uniform width at top, ſwells out in the middle, and tapers towards the end. It coſts from forty to fifty gilders; and the whole peal of bells, including the thongs, will ſometimes be worth between 140 and 150 gilders, while the whole apparel of the Senn himſelf, when beſt attired, does not amount to the price of twenty gilders. The fineſt black cow is adorned with the largeſt bell, and thoſe next in appearance have two ſmaller. Theſe ornaments, however, are not worn on every day, but only on ſolemn occaſions, viz. when, in the ſpring, they are driven up the Alps, or removed from one paſture to another; or when they deſcend in the autumn, or travel in the winter to the different farms, where their owner has contracted for hay. On ſuch days, the Senn, even in the depth of winter, appears dreſſed in a fine white ſhirt, of which the ſleeves are rolled up above the elbow; neatly embroidered red braces keep up his yellow linen trowſers, which reach down to the ſhoes; a ſmall leather cap, or hat, covers his head; and a new milk bowl, of wood ſkilfully carved, hangs acroſs the left ſhoulder. Thus arrayed, the Senn precedes ſinging the *ranz des vaches*, and followed by three or four fine goats; next comes the handſomeſt cow with the great bell; then the two other cows with ſmaller bells; and theſe are ſucceeded by the reſt of the cattle walking one after another, and having in their rear the bull with a one-legged milking ſtool hanging on his horns; the proceſſion is cloſed by a *traineau*, or ſledge, on which are placed the implements for the dairy. It is ſurpriſing to ſee how proud and pleaſed the cows ſtalk forth when ornamented with their bells. Who would imagine that even theſe animals are ſenſible of their rank, nay, touched with vanity and jealouſy! If the leading cow, who hitherto bore the largeſt bell, be deprived of her honours, ſhe very plainly manifeſts her grief at the diſgrace, by lowing inceſſantly, abſtaining from food, and growing lean. The happy rival, on whom the diſtinguiſhing badge of ſuperiority has devolved, experiences her marked vengeance, and is butted, wounded, and perſecuted by her in the moſt furious manner; until the former either recovers her bell, or is entirely removed from the herd. However ſingular this phenomenon may appear, it is placed beyond all doubt by the concurring teſtimony of centuries.

Serriſhtehdar || Shadows.

The cows, when diſperſed on the Alps, are brought together by the voice of the Senn, who is then ſaid to *allure* them (*locken*). How well the cattle diſtinguiſh the note of their keeper appears from the circumſtance of their haſtening to him, though at a great diſtance, whenever he begins to hum the *ranz des vaches*. He furniſhes that cow which is wont to ſtray fartheſt with a ſmall bell, and knows by her arrival that all the reſt are aſſembled.

SERRISHTEHDAR, in Bengal, keeper of records or accounts.

SEVEN STARS, a common denomination given to the cluſter of ſtars in the neck of the ſign Taurus, the bull, properly called the *Pleiades*. They are ſo called from their number Seven which appear to the naked eye, though ſome eyes can diſcover only ſix of them; but by the help of teleſcopes there appears to be a great multitude of them.

SEZAWUL, in Bengal, an officer deputed occaſionally to enforce the due payment of the revenue.

SHADOWS (COLOURED), a curious optical phenomenon, which was obſerved, a conſiderable number of years ago, by Profeſſor Scheiffer of Vienna, and more lately by Count Rumford. The Count made the diſcovery when proſecuting his experiments upon light; of which the reader will find ſome account under the titles LAMP and PHOTOMETER in this *Suppl.* "Deſirous (ſays he) of comparing the intenſity of the light of a clear blue ſky by day with that of a common wax-candle, I darkened my room, and letting the day-light from the north, coming thro' a hole near the top of the window-ſhutter, fall at an angle of about 70° upon a ſheet of very fine white paper, I placed a burning wax-candle in ſuch a poſition that its rays fell upon the ſame paper, and, as near as I could gueſs, in the line of reflection of the rays of day-light from without; when, interpoſing a cylinder of wood, about half an inch in diameter, before the centre of the paper, and at the diſtance of about two inches from its ſurface, I was much ſurpriſed to find that the two ſhadows projected by the cylinder upon the paper, inſtead of being merely ſhades without colour, as I expected; the one of them, that which, correſponding with the beam of day-light, was illuminated by the candle, was yellow; while the other, correſponding to the light of the candle, and conſequently illuminated by the light of the heavens, was of the moſt beautiful blue that it is poſſible to imagine. This appearance, which was not only unexpected, but was really in itſelf in the higheſt degree ſtriking and beautiful,

---

(A) This famous paſtoral ſong is never ſung by the cowherds with words to it: all the tones of it are ſimple, and moſtly formed within the throat. Hence the tune produces very little or no motion of the jawbones, and its ſounds do not reſemble thoſe which commonly iſſue from the human throat, but rather ſeem to be the tones of ſome wind inſtrument; particularly as ſcarcely any breathing is perceived, and as the cowherds ſometimes ſing for minutes together without fetching breath.

beautiful, I found upon repeated trials, and after varying the experiment in every way I could think of, to be ſo perfectly permanent, that it is abſolutely impoſſible to produce two ſhadows at the ſame time, from the ſame body, the one anſwering to a beam of day-light, and the other to the light of a candle or lamp, without theſe ſhadows being coloured, the one yellow, and the other blue.

"If the candle be brought nearer to the paper, the blue ſhadow will become of a deeper hue, and the yellow ſhadow will gradually grow fainter; but if it be removed farther off, the yellow ſhadow will become of a deeper colour, and the blue ſhadow will become fainter; and the candle remaining ſtationary in the ſame place, the ſame varieties in the ſtrength of the tints of the coloured ſhadows may be produced merely by opening the window-ſhutter a little more or leſs, and rendering the illumination of the paper, by the light from without, ſtronger or weaker. By either of theſe means, the coloured ſhadows may be made to paſs through all the gradations of ſhade, from the deepeſt to the lighteſt, and *vice verſa;* and it is not a little amuſing to ſee ſhadows thus glowing with all the brilliancy of the pureſt and moſt intenſe priſmatic colours, then paſſing ſuddenly through all the varieties of ſhade, preſerving in all the moſt perfect purity of tint, growing ſtronger and fainter, and vaniſhing and returning, at command."

With reſpect to the cauſes of the colours of theſe ſhadows, there is no doubt (ſays the Count) but they ariſe from the different qualities of the light by which they are illuminated; but how they are produced, does not appear to him ſo evident. With the utmoſt deference to this amiable and very ingenious philoſopher, we think all the phenomena of coloured ſhadows which he enumerates *, have been, or may be accounted for by Profeſſor Scherffer's theory, of which the reader will find, we hope, a perſpicuous view under *Accidental Colours*, in this *Supplement*.

SHAGREEN, or CHAGRIN, in commerce, a kind of grained leather; of the proceſs of preparing which, we gave the beſt account that we could then find in the *Encyclopædia*. That account, however, as we learn from Profeſſor Pallas, is very defective. He ſays, indeed, that no accurate account of it has ever been publiſhed in Europe previous to his own; of which we ſhall now lay an abridgement before our readers.

"All kinds of horſes or aſſes ſkin, which have been dreſſed in ſuch a manner as to appear grained, are, by the Tartars, called *ſauwer*, by the Perſians *ſogre*, and by the Turks *ſagri*, from which the Europeans have made *ſhagreen* or *chagrin*. The Tartars who reſide at Aſtracan, with a few of the Armenians of that city, are the only people in the Ruſſian empire acquainted with the art of making ſhagreen. Thoſe who follow this occupation not only gain conſiderable profit by the ſale of their production to the Tartars of Cuban, Aſtracan, and Caſan, who ornament with it their Turkey leather boots, ſlippers, and other articles made of leather, but they derive conſiderable advantage from the great ſale of horſes hides, which have undergone no other proceſs than that of being ſcraped clean, and of which ſeveral thouſands are annually exported, at the rate of from 75 to 85 roubles per hundred, to Perſia, where there is a ſcarcity of ſuch hides, and from which the greater part of the ſhagreen manufactured in that country is prepared. The hind part only of the hide, however, which is cut out in the form of a creſcent about a Ruſſian ell and a half in length acroſs the loins, and a ſhort ell in breadth along the back, can properly be employed for ſhagreen. The remaining part, as is proved by experience, is improper for that purpoſe, and is therefore rejected.

"The preparation of the ſkins, after being cut into the above form, is as follows:—They are depoſited in a tub filled with pure water, and ſuffered to remain there for ſeveral days, till they are thoroughly ſoaked, and the hair has dropped off. They are then taken from the tub, one by one, extended on boards placed in an oblique direction againſt a wall, the corners of them, which reach beyond the edges of the board, being made faſt, and the hair with the epidermis is then ſcraped off with a blunt iron ſcraper called *urak*. The ſkins thus cleaned are again put in pure water to ſoak. When all the ſkins have undergone this part of the proceſs, they are taken from the water a ſecond time, ſpread out one after the other as before, and the fleſh ſide is ſcraped with the ſame kind of inſtrument. They are carefully cleaned alſo on the hair ſide, ſo that nothing remains but the pure fibrous tiſſue, which ſerves for making parchment, conſiſting of coats of white medullary fibres, and which has a reſemblance to a ſwine's bladder ſoftened in water.

"After this preparation, the workmen take a certain kind of frames called *pälzi*, made of a ſtraight and a ſemicircular piece of wood, having nearly the ſame form as the ſkins. On theſe the ſkins are extended in as ſmooth and even a manner as poſſible by means of cords; and during the operation of extending them, they are ſeveral times beſprinkled with water, that no part of them may be dry, and occaſion an unequal tenſion. After they have been all extended on the frames, they are again moiſtened, and carried into the houſe, where the frames are depoſited cloſe to each other on the floor with the fleſh ſide of the ſkin next the ground. The upper ſide is then thickly beſtrewed with the black exceedingly ſmooth and hard ſeeds of a kind of gooſe foot (*chenopodium album*), which the Tartars call *alabuta*, and which grows in abundance, to about the height of a man, near the gardens and farms on the ſouth ſide of the Volga; and that they may make a ſtrong impreſſion on the ſkins, a piece of felt is ſpread over them, and the ſeeds are trod down with the feet, by which means they are deeply imprinted into the ſoft ſkins. The frames, without ſhaking the ſeeds, are then carried out into the open air, and placed in a reclining poſition againſt a wall to dry, the ſide covered with the ſeeds being next the wall, in order that it may be ſheltered from the ſun. In this ſtate the ſkins muſt be left ſeveral days to dry in the ſun, until no appearance of moiſture is obſerved in them, when they are fit to be taken from the frames. When the impreſſed ſeeds are beat off from the hair ſide, it appears full of indentations or inequalities, and has acquired that impreſſion which is to produce the grain of the ſhagreen, after the ſkins have been ſubjected to the laſt ſmoothing or ſcraping, and have been dipped in a ley, which will be mentioned hereafter, before they receive the dye.

"The operation of ſmoothing is performed on an inclined bench or board, which is furniſhed with an iron hook, and is covered with thick felt of ſheep's wool, on which the dry ſkin may gently reſt. The ſkin is ſuſpended in the middle of the bench or board to its iron hook, by means of one of the holes made in the edge of the ſkin for extending it in its frame as before mentioned; and a cord, having at its extremity a ſtone or a weight, is attached to each end of the ſkin, to keep it in its poſition while under the hands of the workman. It is then ſubjected to the operation of ſmoothing and ſcraping by means of two different inſtruments. The firſt uſed for this purpoſe, called by the Tartars *tckar*, is a piece of ſharp iron bent like a hook, with which the ſurface of the ſhagreen is pretty cloſely ſcraped to remove all the projecting inequalities. This operation, on account of the corneous hardneſs of the dry ſkin, is attended with ſome difficulty; and great caution is at the ſame time required that too much of the impreſſion of the *alabuta* ſeed be not deſtroyed, which might be the caſe if the iron were kept too ſharp. As the iron, however, is pretty blunt, which occaſions inequalities on the ſhagreen, this inconvenience muſt afterwards be remedied by means of a ſharp ſcraping iron or *urak*, by which the ſurface acquires a perfect uniformity, and only faint impreſſions of the *alabuta* ſeed then remain, and ſuch as the workman wiſhes. After all theſe operations, the ſhagreen is again put into water, partly to make it pliable, and partly to raiſe the grain. As the ſeeds occaſion indentations in the ſurface of the ſkin, the intermediate ſpaces, by the operations of ſmoothing and ſcraping, loſe ſome part of their projecting ſubſtance; but the points which have been depreſſed, and which have loſt none of their ſubſtance, now ſwell up above the ſcraped parts, and thus form the grain of the ſhagreen. To produce this effect, the ſkins are left to ſoak in water for 24 hours; after which they are immerſed ſeveral times in a ſtrong warm ley, obtained, by boiling, from a ſtrong alkaline earth named *ſchora*, which is found in great abundance in the neighbourhood of Aſtracan. When the ſkins have been taken from this ley, they are piled up while warm, on each other, and ſuffered to remain in that ſtate ſeveral hours; by which means they ſwell, and become ſoft. They are then left 24 hours in a moderately ſtrong pickle of common ſalt, which renders them exceedingly white and beautiful, and fit for receiving any colour. The colour moſt uſual for theſe ſkins is a ſea-green; but old experienced workmen can dye them blue, red, or black, and even make white ſhagreen.

"For the green colour nothing is neceſſary but filings of copper and ſal ammoniac. Sal ammoniac is diſſolved in water till the water is completely ſaturated; and the ſhagreen ſkins, ſtill moiſt, after being taken from the pickle, are waſhed over with the ſolution on the ungrained fleſh ſide, and when well moiſtened a thick layer of copper filings is ſtrewed over them: the ſkins are then folded double, ſo that the ſide covered with the filings is innermoſt. Each ſkin is then rolled up in a piece of felt; the rolls are all ranged together in proper order, and they are preſſed down in an uniform manner by ſome heavy bodies placed over them, under which they remain 24 hours. During that period, the ſolution of ſal ammoniac diſſolves a quantity of the cupreous particles ſufficient to penetrate the ſkin and to give it a ſea-green colour. If the firſt application be not ſufficient, the proceſs is repeated in the ſame manner; after which the ſkins are ſpread out and dried.

"For the blue dye, indigo is uſed. About two pounds of it, reduced to a fine powder, are put into a kettle; cold water is poured over it, and the mixture is ſtirred round till the colour begins to be diſſolved. Five pounds of pounded *alakar*, which is a kind of barilla or crude ſoda, prepared by the Armenians and Calmucs, is then diſſolved in it, with two pounds of lime and a pound of pure honey, and the whole is kept ſeveral days in the ſun, and during that time frequently ſtirred round. The ſkins intended to be dyed blue muſt be moiſtened only in the natrous ley *ſchora*, but not in the ſalt brine. When ſtill moiſt, they are folded up and ſewed together at the edge, the fleſh ſide being innermoſt, and the ſhagreened hair ſide outwards; after which they are dipped three times in the remains of an exhauſted kettle of the ſame dye, the ſuperfluous dye being each time expreſſed; and after this proceſs they are dipped in the freſh dye prepared as above, which muſt not be expreſſed. The ſkins are then hung up in the ſhade to dry; after which they are cleaned and paired at the edges.

"For black ſhagreen, gall-nuts and vitriol are employed in the following manner:—The ſkins, moiſt from the pickle, are thickly beſtrewed with finely pulveriſed gall nuts. They are then folded together, and laid over each other for 24 hours. A new ley, of bitter ſaline earth or *ſchora*, is in the mean time prepared, and poured hot into ſmall troughs. In this ley each ſkin is ſeveral times dipped; after which they are again beſtrewed with pounded gall-nuts, and placed in heaps for a certain period, that the galls may thoroughly penetrate them, and they are dried and beat, to free them from the duſt of the galls. When this is done, they are rubbed over, on the ſhagreen ſide, with melted ſheep's tallow, and expoſed a little in the ſun, that they may imbibe the greaſe. The ſhagreen-makers are accuſtomed alſo to roll up each ſkin ſeparately, and to preſs or ſqueeze it with their hands againſt ſome hard ſubſtance, in order to promote the abſorption of the tallow. The ſuperfluous particles are removed by means of a blunt wooden ſcraper *(urac)*; and when this proceſs is finiſhed, and the ſkins have lain ſome time, a ſufficient quantity of vitriol of iron is diſſolved in water, with which the ſhagreen is moiſtened on both ſides, and by this operation it acquires a beautiful black dye. It is then dreſſed at the edges, and in other places where there are any blemiſhes.

"To obtain white ſhagreen, the ſkins muſt firſt be moiſtened on the ſhagreen ſide with a ſtrong ſolution of alum. When the ſkin has imbibed this liquor, it is daubed over on both ſides with a paſte made of flour, which is ſuffered to dry. The paſte is then waſhed off with alum-water, and the ſkin is placed in the ſun till it is completely dry. As ſoon as it is dry, it is gently beſmeared with pure melted ſheep's tallow, which it is ſuffered to imbibe in the ſun; and to promote the effect, it is preſſed and worked with the hands. The ſkins are then faſtened in ſucceſſion to the before-mentioned bench, where warm water is poured over them, and the ſuperfluous fat is ſcraped off with a blunt wooden inſtrument. In the laſt operation the warm water is of great ſervice. In this manner ſhagreen perfectly white is obtained, and nothing remains but to pare the edges and dreſs it.

"But this white ſhagreen is not intended ſo much for remaining in that ſtate, as for receiving a dark red dye; becauſe, by the above previous proceſs, the colour becomes much more perfect. The ſkins deſtined for a red colour muſt not be immerſed firſt in ley of bitter ſalt earth (*ſchora*), and then in pickle, but after they have been whitened, muſt be left to ſoak in the pickle for 24 hours. The dye is prepared from cochineal, which the Tartars call *kirmitz*. About a pound of the dried herb *tſchagann*, which grows in great abundance in the neighbourhood of Aſtracan, and is a kind of ſoda-plant or kali (*ſalſola ericoides* (A), is boiled a full hour in a kettle containing about four common pailfuls of water; by which means the water acquires a greeniſh colour. The herb is then taken out, and about half a pound of pounded cochineal is put into the kettle, and the liquor is left to boil a full hour, care being taken to ſtir it that it may not run over. About 15 or 20 drams of a ſubſtance which the dyers call *lüter* (orchilla) is added, and when the liquor has been boiled for ſome time longer, the kettle is removed from the fire. The ſkins taken from the pickle are then placed over each other in troughs, and the dye-liquor is poured over them four different times, and rubbed into them with the hands, that the colour may be equally imbibed and diffuſed. The liquor each time is expreſſed; after which they are fit for being dried. Skins prepared in this manner are ſold at a much dearer rate than any of the other kinds."

SHARP (Abraham), an eminent mathematician, mechaniſt, and aſtronomer, was deſcended from an ancient family at Little-Horton, near Bradford, in the Weſt Riding of Yorkſhire, where he was born about the year 1651. At a proper age he was put apprentice to a merchant at Mancheſter; but his genius led him ſo ſtrongly to the ſtudy of mathematics, both theoretical and practical, that he ſoon became uneaſy in that ſituation of life. By the mutual conſent, therefore, of his maſter and himſelf, though not altogether with that of his father, he quitted the buſineſs of a merchant. Upon this he removed to Liverpool, where he gave himſelf up wholly to the ſtudy of mathematics, aſtronomy, &c.; and where, for a ſubſiſtence, he opened a ſchool, and taught writing and accounts, &c.

He had not been long at Liverpool when he accidentally fell in company with a merchant or tradeſman viſiting that town from London, in whoſe houſe it ſeems the aſtronomer Mr Flamſteed then lodged. With the view therefore of becoming acquainted with this eminent man, Mr Sharp engaged himſelf with the merchant as a book-keeper. In conſequence he ſoon contracted an intimate acquaintance and friendſhip with Mr Flamſteed, by whoſe intereſt and recommendation he obtained a more profitable employment in the dock-yard at Chatham; where he continued till his friend and patron, knowing his great merit in aſtronomy and mechanics, called him to his aſſiſtance, in contriving, adapting, and fitting up the aſtronomical apparatus in the Royal Obſervatory at Greenwich, which had been lately built, namely, about the year 1676. He was principally employed in the conſtruction of the mural arch; which in the compaſs of 14 months he finiſhed ſo greatly to the ſatisfaction of Mr Flamſteed, that he ſpeaks of him in terms of the higheſt praiſe. According to Mr Smeaton, this was the firſt good and valid inſtrument of the kind; and Mr Sharp the firſt artiſt who cut accurate and delicate diviſions upon aſtronomical inſtruments. At the time this inſtrument was conſtructed, Mr Flamſteed was 30 and Mr Sharp 25 years of age.

Sharp.

Theſe two friends continued together for ſome time, making obſervations on the meridional zenith diſtances of the fixed ſtars, ſun, moon, and planets, with the times of their tranſits over the meridian; alſo the diameters of the ſun and moon, and their eclipſes, with thoſe of Jupiter's ſatellites, the variation of the compaſs, &c.

Mr Sharp aſſiſted Mr Flamſteed alſo in making a catalogue of near 3000 fixed ſtars, with their longitudes and magnitudes, their right aſcenſions and polar diſtances, with the variations of the ſame while they change their longitude by one degree.

But from the fatigue of continually obſerving the ſtars at night, in a cold thin air, joined to a weakly conſtitution, he was reduced to a bad ſtate of health; for the recovery of which he deſired leave to retire to his houſe at Horton; where, as ſoon as he found himſelf on the recovery, he began to fit up an obſervatory of his own; having firſt made an elegant and curious engine for turning all kinds of work in wood or braſs, with a maundril for turning irregular figures, as ovals, roſes, wreathed pillars, &c. Beſide theſe, he made himſelf moſt of the tools uſed by joiners, clockmakers, opticians, mathematical inſtrument makers, &c. The limbs or arcs of his large equatorial inſtrument, ſextant, quadrant, &c. he graduated with the niceſt accuracy, by diagonal diviſions into degrees and minutes. The teleſcopes he made uſe of were all of his own making, and the lenſes ground, figured, and adjuſted with his own hands.

It was at this time that he aſſiſted Mr Flamſteed in calculating moſt of the tables in the ſecond volume of his *Hiſtoria Cæleſtis*, as appears by their letters, to be ſeen in the hands of Mr Sharp's friends at Horton. Likewiſe the curious drawings of the charts of all the conſtellations viſible in our hemiſphere, with the ſtill more excellent drawings of the planiſpheres both of the northern and ſouthern conſtellations. And though theſe drawings of the conſtellations were ſent to be engraved at Amſterdam by a maſterly hand, yet the originals far exceeded the engravings in point of beauty and elegance: theſe were publiſhed by Mr Flamſteed, and both copies may be ſeen at Horton.

The mathematician, ſays Dr Hutton, meets with ſomething extraordinary in Sharp's elaborate treatiſe of *Geometry Improved* (in 4to, 1717, ſigned A. S. Philomath): 1ſt, by a large and accurate table of ſegments of circles, its conſtruction and various uſes in the ſolution of ſeveral difficult problems, with compendious tables for

---

(A) The beautiful red Turkey leather is dyed with cochineal prepared in the ſame manner. Profeſſor Gmelin junior, in the ſecond part of his Travels through Ruſſia, explains the herb *tſchagann* by *artemiſia annua*, having doubtleſs been deceived by the appearance the plant acquires after it has been dried. Beſides, this *artemiſia* is found only in the middle of Siberia, and never on the weſt ſide of the Irtiſch.

for finding a true proportional part; and their uſe in theſe or any other tables exemplified in making logarithms, or their natural numbers, to 60 places of figures; there being a table of them for all primes to 1100, true to 61 figures. 2d, His conciſe treatiſe of Polyedra, or ſolid bodies of many baſes, both the regular ones and others: to which are added twelve new ones, with various methods of forming them, and their exact dimenſions in ſurds, or ſpecies, and in numbers; illuſtrated with a variety of copperplates, neatly engraved by his own hands. Alſo the models of theſe polyedra he cut out in boxwood with amazing neatneſs and accuracy. Indeed few or none of the mathematical inſtrument makers could exceed him in exactly graduating or neatly engraving any mathematical or aſtronomical inſtrument, as may be ſeen in the equatorial inſtrument above mentioned, or in his ſextant, quadrants, and dials of various ſorts; alſo in a curious armillary ſphere, which, beſide the common properties, has moveable circles, &c. for exhibiting and reſolving all ſpherical triangles; alſo his double ſector, with many other inſtruments, all contrived, graduated, and finiſhed, in a moſt elegant manner, by himſelf. In ſhort, he poſſeſſed at once a remarkably clear head for contriving, and an extraordinary hand for executing, any thing, not only in mechanics, but likewiſe in drawing, writing, and making the moſt exact and beautiful ſchemes or figures in all his calculations and geometrical conſtructions.

The quadrature of the circle was undertaken by him for his own private amuſement in the year 1699, deduced from two different ſeries, by which the truth of it was proved to 72 places of figures; as may be ſeen in the introduction to Sherwin's Tables of Logarithms; that is, if the diameter of a circle be 1, the circumference will be found equal to 3·14159265358979323846264338327950288419716939937510582097494459230781640 5, &c. In the ſame book of Sherwin's may alſo be ſeen his ingenious improvements on the making of logarithms, and the conſtructing of the natural ſines, tangents, and ſecants.

He alſo calculated the natural and logarithmic ſines, tangents, and ſecants, to every ſecond in the firſt minute of the quadrant; the laborious inveſtigation of which may probably be ſeen in the archives of the Royal Society, as they were preſented to Mr Patrick Murdoch for that purpoſe; exhibiting his very neat and accurate manner of writing and arranging his figures, not to be equalled perhaps by the beſt penman now living.

Mr Sharp kept up a correſpondence by letters with moſt of the eminent mathematicians and aſtronomers of his time, as Mr Flamſteed, Sir Iſaac Newton, Dr Halley, Dr Wallis, Mr Hodgſon, Mr Sherwin, &c. the anſwers to which letters are all written upon the backs, or empty ſpaces, of the letters he received, in a ſhort-hand of his own contrivance. From a great variety of letters (of which a large cheſtful remain with his friends) from theſe and many other celebrated mathematicians, it is evident that Mr Sharp ſpared neither pains nor time to promote real ſcience. Indeed, being one of the moſt accurate and indefatigable computers that ever exiſted, he was for many years the common reſource for Mr Flamſteed, Sir Jonas Moore, Dr Halley, and others, in all ſorts of troubleſome and delicate calculations.

Mr Sharp continued all his life a bachelor, and ſpent his time as recluſe as a hermit. He was of a middle ſtature, but very thin, being of a weakly conſtitution. He was remarkably feeble the laſt three or four years before he died, which was on the 18th of July 1742, in the 91ſt year of his age.

In his retirement at Little Horton, he employed four or five rooms or apartments in his houſe for different purpoſes, into which none of his family could poſſibly enter at any time without his permiſſion. He was ſeldom viſited by any perſons, except two gentlemen of Bradford, the one a mathematician, and the other an ingenious apothecary; theſe were admitted, when he choſe to be ſeen by them, by the ſignal of rubbing a ſtone againſt a certain part of the outſide wall of the houſe. He duly attended the diſſenting chapel at Bradford, of which he was a member, every Sunday; at which time he took care to be provided with plenty of halfpence, which he very charitably ſuffered to be taken ſingly out of his hand, held behind him during his walk to the chapel, by a number of poor people who followed him, without his ever looking back, or aſking a ſingle queſtion.

Mr Sharp was very irregular as to his meals, and remarkably ſparing in his diet; which he frequently took in the following manner. A little ſquare hole, ſomething like a window, made a communication between the room where he was uſually employed in calculations, and another chamber or room in the houſe where a ſervant could enter; and before this hole he had contrived a ſliding board: the ſervant always placed his victuals in this hole, without ſpeaking or making any the leaſt noiſe; and when he had a little leiſure, he viſited his cupboard to ſee what it afforded to ſatisfy his hunger or thirſt. But it often happened, that the breakfaſt, dinner, and ſupper, have remained untouched by him, when the ſervant has gone to remove what was left—ſo deeply engaged had he been in calculations.

SHARPS in flour, the finer part of what we have denominated Pollards. See that article, *Suppl.*

SHASTAH, the ſame as Shaster; which ſee, *Encycl.*

SHEA, the name of a tree, from the fruit of which the Negroes, in the interior parts of Africa between the tropics, prepare a kind of vegetable butter. Theſe trees are not planted by the natives, but are found growing naturally in the woods; and in clearing wood land for cultivation, every tree is cut down but the Shea. The tree itſelf very much reſembles the American oak; and the fruit, from the kernel of which being firſt dried in the ſun the butter is prepared, by boiling the kernel in water, has ſomewhat the appearance of a Spaniſh olive. The kernel is enveloped in a ſweet pulp, under a thin green rind; and the butter produced from it, beſides the advantage of its keeping the whole year without ſalt, is whiter, firmer, and, Mr Park ſays, to his palate, of a richer flavour than the beſt butter which he ever taſted made from cows milk. The growth and preparation of this commodity, ſeem to be among the firſt objects of African induſtry in this and the neighbouring ſtates; and it conſtitutes a main article of their inland commerce. In ſome places they dry the fruit in kilns, containing each about half a cart load of fruit, under which is kept up a clear wood fire. Our author, who ſaw the fruit in one of theſe kilns, was informed, that in three days the fruit would

would be ready for pounding and boiling ; and that the butter thus manufactured, is preferable to that which is prepared from fruit dried in the ſun ; eſpecially in the rainy ſeaſon, when the proceſs by inſolation is always tedious, and oftentimes ineffectual. Might it not be worth while, if practicable, to cultivate Shea-trees in ſome of our Weſt India iſlands ?

SHEAVE, in mechanics, a ſolid cylindrical wheel, fixed in a channel, and moveable about an axis, as being uſed to raiſe or increaſe the mechanical powers applied to remove any body.

SHEBBEARE (John) was born at Bideford, a conſiderable ſea-port and corporation town in Devonſhire, in the year 1709. His father was an attorney ; but having ſmall practice and little fortune, he carried on alſo the buſineſs of a corn factor. He had four children, two ſons and two daughters. Of the ſons, John, the ſubject of our preſent memoir, was the eldeſt. The other ſon was called Richard, and entirely the reverſe of his brother in diſpoſition ; he was bred to the ſea, and died young.

John received the rudiments of his education at the free grammar ſchool of Exeter, then conducted by the learned Mr Zachary Mudge (author of an Eſſay for a new Verſion of the Pſalms, and a volume of excellent Sermons), afterwards Rector of St Andrew in Plymouth. It has oftentimes been remarked, that the future life of a man may be nearly gueſſed at from his puerile character. Thus Shebbeare, while a ſchool-boy, gave the ſtrongeſt indications of his future eminence in miſanthropy and literature, by the remarkable tenaciouſneſs of his memory, and the readineſs of his wit, and no leſs ſo by the malignity of his diſpoſition ; being univerſally conſidered as a lad of ſurpriſing genius, while at the ſame time he was as generally deſpiſed for his malicious and ungrateful temper. This may eaſily be believed, when it is ſaid, that he formed not one connection, either at ſchool or afterwards, with any perſon in the way of friendſhip, except with a young barber of an abandoned character, but whoſe ſoul was perfectly congenial to that of Shebbeare's.

Such is the account of Shebbeare's boyiſh years which we have in the 14th volume of the *European Magazine*. It is probably much exaggerated ; for Shebbeare continued through life a ſtaunch Tory, if not a Jacobite ; and it is well known that many of our journaliſts conſider themſelves as at liberty to give what characters they pleaſe of ſuch men.

In the fifteenth or ſixteenth year of his age, young Shebbeare was bound apprentice to a very eminent and worthy ſurgeon in his native town ; in which ſituation he acquired a conſiderable ſhare of medical knowledge. His genius for lampoon appeared at this early period, and he could not forbear from exerciſing it on his maſter. No one indeed could give him the ſlighteſt offence with impunity ; for which reaſon almoſt every perſon avoided his acquaintance, as we would avoid the careſſing of an adder. The chief marks, however, of the arrows of his wit were the gentlemen of the corporation : one or other, and ſometimes all of them, were almoſt conſtantly expoſed in a libel upon the public poſts and corners of the ſtreets. But though the wiſer part of them only laughed at theſe harmleſs trifles, yet ſome were more irritable, and many a proſecution was commenced againſt, but not one could fix itſelf upon him, ſo artfully had he contrived to conceal himſelf. He was alſo ſeveral times ſummoned to appear at the ſeſſions, for daring to ſpeak and write irreverently of the worſhipful magiſtrates ; but the laugh was always on the ſide of Shebbeare, nor could they ever come at his back, ſo cloſely had he fitted on his armour, with the whip of authority.

Shebbeare.

When he was out of his time he ſet up trade for himſelf, and then ſhewed a taſte for chemiſtry; and ſoon after he married a very agreeable and amiable young woman, of no fortune, but of a genteel family. Whether his inſuperable propenſity to ſatire deprived him of friends and of buſineſs, or that he ſpent too much in chemical experiments, we know not; but failing at Bideford, he removed, about the year 1736, to Briſtol, where he entered into partnerſhip with a chemiſt, and never afterwards ſet his foot in his native town.

In the year 1739 he attracted the attention of the public, by an epitaph to the memory of Thomas Coſter, Eſq; member for Briſtol ; in which, it has been truly obſerved, that he has contrived to raiſe emotions of pity, grief, and indignation, to a very high degree. The next year he publiſhed a pamphlet on the Briſtol waters ; from which period there is a chaſm in our author's life we are unable to fill up. In this interval may probably be placed his failure in buſineſs, and his effort to obtain a higher ſituation in his profeſſion. It is certain that in the year 1752 he was at Paris, and there he obtained the degree, if he obtained it at all, which gave him the addition to his name which accompanied him during the reſt of his life, that of Doctor. Until this time he appears to have lived in obſcurity ; but at an age when vigorous exertion uſually ſubſides, he ſeems to have reſolved to place himſelf in a conſpicuous ſituation, whatever hazard might attend it, and commenced a public writer with a degree of celerity and virulence for which it would be difficult to find a parallel even in the moſt intemperate times. To read over his works now, when the paſſions they then raiſed have ſubſided, we feel ſurpriſe at the effect they produced ; and it is within the memory of many yet living, that their influence was very conſiderable. In the year 1754, he began his career with The Marriage Act, a political novel ; in which he treated the legiſlature with ſuch freedom, that it occaſioned his being taken into cuſtody, from whence, however, he was ſoon releaſed.

The performances, however, moſt celebrated, were a ſeries of Letters to the People of England, which were written in a ſtyle vigorous and energetic, though ſlovenly and careleſs, well calculated to make an impreſſion on common readers ; and were accordingly read with avidity, and circulated with diligence. They had a very conſiderable effect on the minds of the people, and galled the miniſtry, who ſeem to have been at firſt too eager to puniſh the author. On the publication of the Third Letter, we find warrants, dated 4th and 8th of March, 1756, iſſued by Lord Holderneſſe, to take up both Scott the publiſher and the author. This proſecution, however, ſeems to have been dropt, and the culprit proceeded for ſome time unmoleſted, " having declared (ſays one of his anſwerers) that he would write himſelf into a poſt or into the pillory ; in the laſt of which he at length ſucceeded." On the 12th of January 1758, a general warrant was ſigned by Lord Holderneſſe, to ſearch for the author, printer, and publiſhers of a wicked, audacious, and treaſonable libel, entitled, " A Sixth Letter to the People of England, on the progreſs of national ruin; in which is ſhewn that the preſent grandeur of France and calamities of this nation are owing to the influence of Hanover on the councils of England;" and them having found, to ſeize and apprehend, together with their books and papers.

At this juncture government ſeem to have been effectually rouſed; for having received information that a ſeventh letter was printing, by virtue of another warrant, dated January 23, all the copies were ſeized and entirely ſuppreſſed. In Eaſter Term an information was filed againſt him by Mr Pratt, then attorney general, afterwards Lord Camden; in which it is now worthy of remark, that the crown officer, in his application to the court, in expreſs terms admitted a point, ſince much diſputed, that of the jury's right to determine both the law and the fact in matters of libel. " What I urge (ſays the advocate) to the court, is only to ſhew there is reaſonable ground for conſidering this publication as a libel, and for putting it in a way of trial, and therefore it is I pray to have the rule made abſolute; for I admit, and your lordſhip well knows, that the jury in matter of libel are judges of the law as well as the fact, and have an undoubted right to conſider whether, upon the whole, the pamphlet in queſtion be, or be not, a falſe, malicious, and ſcandalous libel." On the 17th of June, the information was tried, when our author was found guilty; and on the 28th November, he received ſentence, by which he was fined five pounds, ordered to ſtand in the pillory December 5, at Charing Croſs, to be confined three years, and to give ſecurity for his good behaviour for ſeven years, himſelf in 500l. and two others in 250l. each.

On the day appointed, that part of the ſentence which doomed him to the pillory was put in execution, amidſt a prodigious concourſe of people aſſembled on the occaſion. The under ſheriff, at that time, happened to be Mr Beardmore, who had ſometimes been aſſiſted by the Doctor in writing the Monitor, a paper in its principles of the ſame tendency with the writings of the culprit, who conſequently might expect every indulgence from the officer to whom the execution of his ſentence was committed. The manner in which it was conducted may be learned from the affidavits on which afterwards the under ſheriff's conduct became the ſubject of animadverſion in the court of King's Bench, and which aſſert, " that the defendant only ſtood upon the platform of the pillory, unconfined, and at his eaſe, attended by a ſervant in livery (which ſervant and livery were hired for the occaſion only) holding an umbrella over head all the time: but his head, hands, neck, and arms, were not at all confined, or put into the holes of the pillory; only that he ſometimes put his hands upon the holes of the pillory in order to reſt himſelf." For this neglect of duty, Beardmore was fined 50l. and ſuffered two months impriſonment.

Some time before he was tried for the obnoxious publication already mentioned, the Ducheſs of Queensbury, as heir of Lord Clarendon, obtained an injunction in the Court of Chancery to ſtop the publication of the continuation of that nobleman's hiſtory; a copy of which had got into the hands of Francis Gwyn, Eſq; between whom and the Doctor there had been an agreement to publiſh it and equally divide the profits. The care and expences attending the uſhering this work into the world were to be wholly Dr Shebbeare's, who performed his part of the agreement, and cauſed it to be handſomely printed in quarto, with a Tory preface, containing frequent reflections on, and alluſions to recent events, and to living characters, which gave it the appearance rather of a temporary pamphlet than of a work calculated for poſterity. On the injunction being obtained, Dr Shebbeare was under the neceſſity of applying to the aid of law to recover the money expended by him in printing, amounting to more than 500l. Of that ſum more than half had been waſted on his ſide in the courts of law and equity. And ſome years afterwards, ſpeaking of the ſituation of his affairs, he ſays, " It may be eaſily imagined, that my circumſtances were not improved by three years impriſonment. I had no club of partizans to maintain me during that time, to diſcharge my debts, nor even the fine, which I was obliged to pay after a three years confinement for a ſingle offence. Notwithſtanding the difficulties which inevitably aroſe from theſe particulars, and although an inſolvent act was paſſed ſoon after his Majeſty's acceſſion to the throne, and my circumſtances might have apologiſed for my taking that opportunity which it offered; I nevertheleſs declined from availing myſelf of that occaſion to evade the payment of my debts. I preferred the labour of endeavouring to pay them, and the riſk of being again impriſoned if I did not ſucceed. But, thank Heaven, I am in no danger of a ſecond impriſonment on that account." During his confinement, he declares he never received as preſents more than twenty guineas from all the world.

While he was confined in the King's Bench, he ſolicited ſubſcriptions for the firſt volume of a Hiſtory of England, from the Revolution to the then preſent time. But at the perſuaſion of his friends he was induced to alter his deſign, and receipts were iſſued for a firſt volume of the Hiſtory of England, and of the Conſtitution thereof from its origin. That volume he wrote, and had tranſcribed. " But as it was impracticable (to uſe his own words), whilſt I was in confinement, to procure that variety of books, or to apply to manuſcript authorities, for all that was requiſite to the completing of this firſt volume, I found on being releaſed from my impriſonment, and on application to the former only, that the volume which I had written was incorrect, inſufficient, and erroneous, in too many particulars, to admit of its being publiſhed, without injuſtice to my ſubſcribers, and reprehenſions on myſelf. Into this diſpleaſing ſituation I had been miſled by relying on the authorities of modern hiſtorians, who pretend to cite the authors from whence their materials are taken, many of whom appear never to have ſeen them, but implicitly to have copied one another, and all of them manifeſtly defective; not only in the authorities they ſhould have ſought, but in their omiſſions and miſrepreſentations of thoſe whom they had conſulted: more eſpecially reſpecting thoſe parts of the old German codes, on which our conſtitution is erected, and without which it cannot be properly explained or underſtood. Such being the real ſituation of things, I perceived that more time than I could expect to live would be neceſſarily required for ſo extenſive a work as the whole hiſtory I had propoſed ; and that a ſingle volume, or even a few volumes of an hiſtory incomplete, would by no means anſwer either the intention of my ſubſcribers, or my own : I determined therefore to change my plan, and to include in one volume that which might require no others to complete this new deſign.

"In conſequence of this alteration, I reſolved to exert my beſt abilities, not only to trace the conſtitution of England from its origin in the woods of Germany, as M. de Monteſquieu expreſſes it, but from the firſt principles of human nature, from which the formation of all kinds of government is derived. With this view, I have attempted an analyzation of the mental and corporeal faculties, in order to ſhew in what manner they reciprocally influence each other in the various actions of man, not only as an individual, but as a gregarious being, impelled by nature to aſſociate in communities. From hence I have attempted to delineate in what manner legiſlature ſprang and proceeded from its ſource, through that variety of meanders which it hath formed in its current, both before and ſince the introduction of one common ſign, whereby to expreſs the intrinſic value, not only of all the productions of nature and of art, but even of the human faculties, as they are now eſtimated ; to compare the conſtitutions of thoſe different ſtates which have been, and are the moſt celebrated in ancient and modern hiſtory, with each other, and with that of England ; and then to derive ſome reaſonable grounds for the determination of that which ſeems to be the moſt conſentaneous with the primogenial inſtitutes of nature, and the happineſs of human kind. In conſequence of this intent, the manners that ſucceſſively aroſe and prevailed in ſuch ſtates, the benefits and miſchiefs which enſued from them, are delineated, in order to explain on what foundation the welfare of national communities may moſt probably be eſtabliſhed."

This plan, thus delineated, he at times employed himſelf in filling up ; but on being rudely attacked for not performing his promiſe with his ſubſcribers, he, in 1774, obſerved — "From the inevitable obligations, not only of ſupporting my own family, but thoſe alſo whom as ſon and brother it was my duty to ſuſtain for forty years, and which, reſpecting the claims of the latter, ſtill continues ; it will be eaſily diſcerned that many an avocation muſt have proceeded from theſe circumſtances, as well as from a ſenſe of gratitude to his majeſty, in defence of whoſe government I have thought it my duty occaſionally to exert my beſt abilities." He adds, however, that he did not intend to die until what he had propoſed was finiſhed ; a promiſe which the event has ſhewn he was unable to perform.

In priſon he was detained during the whole time of the ſentence, and with ſome degree of rigour ; for when his life was in danger from an ill ſtate of health, and he applied to the court of King's Bench for permiſſion to be carried into the rules a few hours in a day, tho' Lord Mansfield acceded to the petition, yet the prayer of it was denied and defeated by Judge Foſter. At the expiration of the time of his ſentence, a new reign had commenced ; and ſhortly afterwards, during the adminiſtration of Mr Grenville, a penſion was granted him by the crown. This he obtained by the perſonal application of Sir John Philips to the King, who, on that occaſion, was pleaſed to ſpeak of him in very favourable terms, which he promiſed undeviatingly to endeavour to deſerve by allegiance and gratitude.

From the time of that event we find Dr Shebbeare a uniform defender of the meaſures of Government, and the mark againſt whom every oppoſer of adminiſtration conſidered himſelf at liberty to throw out the groſſeſt abuſe. Even the friends of power were often adverſe to him. Dr Smollet introduced him in no very reſpectful light, under the name of Ferret, in the novel of Sir Launcelot Greaves, and Mr Hogarth made him one of the group in the third election print.

Scarce a periodical publication was without ſome abuſe of him, which he ſeems to have in general had the good ſenſe to neglect. In the year 1774, however, he departed from his general practice, and defended himſelf from ſome attacks at that time made upon him. In this pamphlet he repreſented the conduct and character of King William in ſuch a light as to excite the indignation of every Whig in the kingdom : he treated him in print with as great ſeverity as Johnſon uſed to do in converſation.

Early in life he appears to have written a comedy, which in 1766 he made an effort to get repreſented at Covent Garden. In 1768 he wrote the Review of Books in the Political Regiſter for three months, and was often engaged to write for particular perſons, with whom he frequently quarrelled when he came to be paid. This was the caſe with Sir Robert Fletcher, and we think of others. His pen ſeems to have been conſtantly employed, and he wrote with great rapidity, what certainly can now be read with little ſatisfaction, and muſt ſoon be forgotten. Though penſioned by government, he can ſcarce be ſaid to have renounced his opinions ; for in the pamphlet already mentioned, his abuſe of the Revolution is as groſs as in that for which he ſuffered the pillory. His violence defeated his own purpoſe, and made thoſe who agreed in party with him revolt from the virulence with which he treated his adverſaries. During the latter years of his life he ſeems to have written but little. He was a ſtrenuous ſupporter of the miniſtry during the American war, having publiſhed, in 1775, An Anſwer to the printed Speech of Edmund Burke, Eſq; ſpoken in the Houſe of Commons, April 19, 1774. In which his knowledge in polity, legiſlature, human kind, hiſtory, commerce, and finance, is candidly examined; his arguments are fairly refuted ; the conduct of adminiſtration is fully defended ; and his oratoric talents are clearly expoſed to view. — And An Eſſay on the Origin, Progreſs, and Eſtabliſhment of National Society ; in which the principles of Government, the definitions of phyſical, moral, civil, and religious Liberty contained in Dr Price's Obſervations, &c. are fairly examined, and fully refuted ; together with a juſtification of the Legiſlature in reducing America to obedience by force. To which is added, an Appendix on the Excellent and Admirable in Mr Burke's ſecond printed Speech of the 22d of March 1775, both 8vo.

His publications, ſatirical, political, and medical, amount to thirty-four, beſides a novel, entitled Lydia, or Filial Piety ; in which religious hypocriſy and bluſtering courage are very properly chaſtiſed. He died on the 1ſt of Auguſt 1788, leaving, among thoſe who knew him beſt, the character of a benevolent man ; a character which, from the manner in which he ſpeaks of his connections, he probably deſerved.

SHEERS, aboard a ſhip, an engine uſed to hoiſt or diſplace the lower maſts of a ſhip.

SHEIBON, a diſtrict in Africa, lying to the ſouth-eaſt of the kingdom of Dar-Fur (See Soudan in this volume), where much gold is found both in duſt and in ſmall pieces. The natives, who are idolaters and ſavages, collect the duſt in quills of the oſtrich and vulture, and in that condition ſell it to the merchants. They have a ceremony on diſcovering a large piece of gold, of killing a ſheep on it before they remove it. The people, who are all black, have ſome form of marriage, *i. e.* of an agreement between man and woman to cohabit. Women of full age wear a piece of platted graſs on their parts. The younger and unmarried are quite naked. The ſlaves, which are brought in great numbers from this quarter, are ſome priſoners of war among themſelves (for their wars are frequent), and ſome ſeduced by treachery, and ſold. But it is ſaid to be a common practice for a father in time of ſcarcity to ſell his children.

At Sheibon are ſome Mohammedans, who live among the idolaters, and wear clothing: it is not ſaid whether Arabs or not. Mr Browne, from whoſe travels we have taken this account of Sheibon, does not give its latitude or longitude.

SHILLUK, a town in Africa on the banks of the Bahr-el-abiad, or true Nile. The houſes are built of clay, and the inhabitants, who are idolaters, have no other clothing than bands of long graſs, which they paſs round the waiſt and between the thighs. They are all black; both ſexes are accuſtomed to ſhave their heads. The people of Shilluk have the dominion of the river, and take toll of all paſſengers, in ſuch articles of traffic as paſs among them. The name Shilluk is not Arabic, and its meaning is unknown.—When aſked concerning their name or country, the people reply Shilluk. When employed in tranſporting Mohammedans acroſs the ferry, they occaſionally exhibit the importance which their ſituation gives them. After the Muſlim has placed himſelf in the boat, they will aſk him, "Who is the maſter of that river?" The other replies, as is uſual, "Ullah or Rubbani"— God is the maſter of it. "No (anſwers the Shilluk), you muſt ſay that ſuch a one (naming his chief) is the maſter of it, or you ſhall not paſs." They are repreſented as ſhewing hoſpitality to ſuch as come among them in a peaceable manner, and as never betraying thoſe to whom they have once accorded protection. The particulars of their worſhip have not been deſcribed. In Mr Browne's map, Shilluck is placed in about 13° N. Lat. and 32° 26′ E. Long.

SHIP. See that article, and Shipbuilding (*Encycl.*), and likewiſe *Floating Bodies* (*Suppl.*) In the *Tranſactions of the Royal Society of London* for 1798, Mr Atwood has completed his diſquiſition on the *Stability* of Ships; but as the memoir cannot be abridged, we muſt refer the ſcientific naval architect to the original for much uſeful information.

A ſmall work has lately been publiſhed by Charles Gore, Eſq; of Weimar in Saxony, upon *the reſpective Velocity of Floating Bodies varying in Form.* It contains merely the reſults of two ſeries of experiments: from the firſt of which ſeries, it ſeems to appear that the form beſt calculated for velocity is a long parallel body, terminating at each end in a parabolic cuneus, and having the extreme breadth in the centre. Alſo, that making the cuneus more obtuſe than is neceſſary to break with fairneſs the curve line into the ſtraight, creates a conſiderable degree of impediment. And Mr Gore is inclined to think, that the length of ſhips, which has already been extended with ſucceſs, to four times the breadth, is capable, with advantage, of ſtill further extenſion, perhaps to five, and, in ſome caſes, even to ſix times.

The ſecond ſet of experiments was inſtituted to aſcertain the reſpective degrees of ſtability, or power of reſiſting the preſſure of the wind, in carrying ſail, on bodies of different forms. The bodies uſed in the experiments had their ſpecific capacities and weights preciſely equal, but their forms different; and from the reſults, it appears that the form of a midſhip body, beſt adapted for ſtability only, is a flat bottom, with perpendicular ſides; and that the next beſt adapted is a ſemicircle. But as there exiſts much difficulty in conſtructing the former with ſufficient ſtrength, beſides its being ill adapted to heavy ſeas, as, by the ſudden deſcent in pitching, the bottom will ſtrike the water nearly at right angles, and ſuſtain thereby a tremendous ſhock. And as the latter ſeems to be too inclinable to tranſverſe oſcillation, or rolling, and alſo to be deficient in capacity for many ſervices, our author is of opinion, that a midſhip body, of a compounded form, is moſt applicable to general purpoſes.

On account of the few documents before us, we are unable to ſpeak critically concerning this tract. To benefit naval architecture, we are of opinion, that the method of experiment is more ſure and expeditious than that of calculation: yet concluſions from experiments muſt be drawn with great caution. It is by no means certain that a reſult obtained for a body of a given bulk will obtain for ſimilar bodies which differ in dimenſions.

We ſhall conclude this ſhort article with a ſtatement of the principles upon which Patrick Miller, Eſq; of Dalſwinton (Scotland), propoſes to conſtruct ſhips and veſſels which cannot founder.

The veſſel is to be kept afloat, without the aid of its ſides, ſolely by the buoyancy of its bottom, which is flat; the bottom never being ſo deeply immerſed as to bring the upper ſurface thereof on a level with the water; ſuch veſſels not being conſtructed for the purpoſe of carrying cargoes, but for that of carrying paſſengers, with the neceſſary ſtores and proviſions; and as theſe veſſels are not kept afloat by the aid of their ſides, but by the buoyancy of their bottom, as above deſcribed, they cannot ſink, and therefore pumps are not required, nor are they in any reſpect neceſſary for the preſervation of ſuch veſſels. The ſaid veſſel is put in motion, during calms, and againſt light winds, by means of wheels. Theſe wheels project beyond the ſides of the veſſel, and are wrought by means of capſtans: the number and the dimenſions of the wheels depend upon the length of the veſſel. Theſe wheels are built with eight arms, which conſiſt entirely of plank. Sliders are uſed to work and to keep the veſſel to windward when under ſail. Theſe ſliders are placed in the centre of the veſſel, from ſtem to ſtern; they are made of plank, and the number and dimenſions muſt depend on the length of the veſſel; and they are raiſed and let down, either by the hand, or by means of a purchaſe, according to the ſize of the veſſel. Veſſels of this conſtruction draw water, in proportion to their dimenſions, as follows: a veſſel of forty feet in length, and from thirteen to nineteen feet in breadth, will draw from thirteen to ſixteen inches of water. One of fifty feet in length, and from ſeventeen to twenty-four feet in breadth, will draw from fifteen to eighteen inches of water. One ſixty feet long, and from twenty to twenty-eight feet broad, will draw from eighteen to twenty-one inches of water. One ſeventy feet long, and from twenty-three to thirty-two feet broad, will draw from twenty-one to twenty-four inches of water. One eighty feet long, and from twenty-ſeven to thirty-ſeven feet broad, will draw from twenty-four to twenty-ſeven inches of water. One ninety feet long, and from thirty to forty-two feet broad, will draw from twenty-ſeven to thirty inches of water. One of one hundred feet in length, and from thirty-three to forty-ſeven feet in breadth, will draw from thirty to thirty-three inches of water.

As, from the principle upon which this veſſel is conſtructed, ſhe cannot ſink, the invention muſt prove a means of ſaving many lives; and as it will give more room and height between the decks than any veſſel of the ſame dimenſions of another conſtruction, it muſt add greatly to the comfort and accommodation of perſons at ſea of all deſcriptions. It is expected that, from theſe advantages, a more general and friendly intercourſe amongſt nations will take place, which will have the effect to diffuſe knowledge, and to remove national prejudices, thereby promoting the general welfare of mankind. At preſent (ſays Mr Miller), it would be altogether improper to give any deſcription of ſhips of greater dimenſions, leſt it ſhould be converted to a purpoſe very different from that intended by the inventor.

SHIPWRECK, a well-known diſaſter, by which numbers of lives are yearly loſt. In that valuable miſcellany entitled, *The Philoſophical Magazine*, we have an account of means for preventing that loſs, when the ſhip is in danger within two or three hundred fathoms of the ſhore; and as the anonymous author (a Frenchman) ſays that he has by experiment aſcertained the efficacy of theſe means, we ſhall ſtate them to our readers.

The only certain means of ſaving the crew of a veſſel in ſuch a ſtate is, to eſtabliſh a rope of communication from the ſhore to the ſhip. But how is this to be done? The author ſays, by fixing the end of the rope to a bomb or cannon ball, and extending the rope afterwards, in a zig zag direction, before the morter or cannon, or ſuſpending it on a piece of wood raiſed ſeveral feet. A rope, ſo placed, will not break (he ſays) by the greateſt velocity which can be given to the bomb or ball; and thus the end of it can be ſent aſhore by a diſcharge of artillery. He prefers the bomb to the cannon ball, for reaſons which he does not aſſign. He propoſes, however, other means to effect his benevolent purpoſe.

"It ought to be remembered (ſays he), that a veſſel is never caſt away, or periſhes on the coaſt, but becauſe it is driven thither againſt the will of the captain, and by the violence of the waves and the wind, which almoſt always blows from the ſea towards the ſhore, without which there would be no danger to be apprehended: conſequently, in theſe circumſtances, the wind comes always from the ſea, either directly or obliquely, and blows towards the ſhore.

Ship, Silla.

"1*ſt*, A common paper kite, therefore, launched from the veſſel and driven by the wind to the ſhore, would be ſufficient to ſave a crew conſiſting of 1500 ſeamen, if ſuch were the number of a ſhip of war. This kite would convey to the ſhore a ſtrong packthread, to the end of which might be affixed a cord, to be drawn on board by means of the ſtring of the kite; and with this cord a rope, or as many as ſhould be neceſſary, might be conveyed to the ſhip.

"2*d*, A ſmall balloon, of ſix or ſeven feet in diameter, and raiſed by rarified air, would be alſo an excellent means for the like purpoſe: being driven by the wind from the veſſel to the ſhore, it would carry thither a ſtring capable of drawing a cord with which ſeveral ropes might be afterwards conveyed to the veſſel. Had not the diſcovery of Montgolfier produced any other benefit, it would be entitled on this account to be conſidered as of great importance.

"3*d*, A ſky-rocket, of a large diameter, would be of equal ſervice. It would alſo carry, from the veſſel to the ſhore, a ſtring capable of drawing a rope after it.

"*Laſtly*, A fourth plan for ſaving the crew of a ſhipwrecked veſſel, is that of throwing from the veſſel into the ſea an empty caſk with a cord attached to it. The wind and the waves would drive the caſk to the ſhore, and afford the means of eſtabliſhing that rope of communication already mentioned."

SILLA, a large town on the Niger, which bounded Mr Park's travels eaſtward. He gives no deſcription of the place, which he had not ſpirits or health to ſurvey; but fills a page of his work with the reaſons which determined him to proceed no farther. "When I arrived (ſays he), I was ſuffered to remain till it was quite dark, under a tree, ſurrounded by hundreds of people. But their language was very different from the other parts of Bambarra; and I was informed that, in my progreſs eaſtward, the Bambarra tongue was but little underſtood, and that when I reached Jenné, I ſhould find that the majority of the inhabitants ſpoke a different language, called *Jenné Kummo* by the Negroes, and *Kalam Soudan* by the Moors.

"With a great deal of entreaty, the Dooty allowed me to come into his baloon, to avoid the rain; but the place was very damp, and I had a ſmart paroxyſm of fever during the night. Worn down by ſickneſs, exhauſted with hunger and fatigue, half naked, and without any article of value, by which I might procure proviſions, clothes, or lodging, I began to reflect ſeriouſly on my ſituation. I was now convinced, by painful experience, that the obſtacles to my further progreſs were inſurmountable. The tropical rains were already ſet in with all their violence; the rice grounds and ſwamps were everywhere overflowed; and in a few days more, travelling of every kind, unleſs by water, would be completely obſtructed. The kowries which remained of the king of Bambarra's preſent were not ſufficient to enable me to hire a canoe for any great diſtance; and I had but little hopes of ſubſiſting by charity, in a country where the Moors have ſuch influence. But above all, I perceived that I was advancing more and more within the power of thoſe mercileſs fanatics; and from my reception both at SEGO and SANSANDING (ſee theſe articles, *Suppl.*), I was apprehenſive that, in attempting to reach even Jenné (unleſs under the protection of ſome man of conſequence amongſt them, which I had no means of obtaining). I ſhould ſacrifice my life to no purpoſe; for my diſcoveries would periſh with me. The proſpect either way was gloomy. In returning to the Gambia, a journey on foot of many hundred miles preſented itſelf to my contemplation, through regions and countries unknown. Nevertheleſs, this ſeemed to be the only alternative; for I ſaw inevitable deſtruction in attempting to proceed to the eaſtward. With this conviction on my mind, I hope my readers will acknowledge that I did right in going no farther. I had made every effort to execute my miſſion in its fulleſt extent which prudence could juſtify. Had there been the moſt diſtant proſpect of a ſucceſsful termination, neither the unavoidable hardſhips of the journey, nor the dangers of a ſecond captivity, ſhould have forced me to deſiſt. This, however, neceſſity compelled me to do; and whatever may be the opinion of my general readers on this point, it affords me inexpreſſible ſatisfaction, that my honourable employers have been pleaſed, ſince my return, to expreſs their full approbation of my conduct." He would be a very unreaſonable man, indeed, who could on this point think differently from Mr Park's employers. Silla is placed in the new map of Africa in about 14° 48′ N. Lat. and 1° 24′ W. Long.

SILLON, in fortification, an elevation of earth, made in the middle of the moat, to fortify it, when too broad. It is more uſually called the *envelope*.

SIMANCAS, a village on the eaſtern limit of the kingdom of Leon in Spain, two leagues below Valladolid, on the river Giſuerga. It is mentioned by Dr Robertſon in the introduction to his Hiſtory of America, and is remarkable for the archives or regiſter office of the kingdoms of Leon and Caſtile, kept in the caſtle there. This collection was begun when the kings reſided often at Valladolid; in which city to this day is the chancery or civil and criminal tribunal for almoſt all Spain to the north of the Tagus. It was thought convenient to have thoſe papers kept in the neighbourhood of that court; and this caſtle was particularly fit for that purpoſe, as it is all built of ſtone. Some years ago there were two large halls in this office filled with papers relating to the firſt ſettlement of the Spaniards in South America. There was alſo in the room called the *ancient royal patronage* a box containing treaties with England, in which are many letters and treaties between the kings of England and Spain from about the year 1400 down to 1600. There was alſo in the ſame archives a ſtrong box, with five locks, which, it is ſaid, has not been opened ſince the time of Philip II. and it is conjectured that it contains the proceſs againſt Philip's ſon Prince Charles. But it ſeems ſome of the ſtate papers have been removed to Madrid.

SITUS, in algebra and geometry, denotes the ſituation of lines, ſurfaces, &c. Wolfius delivers ſome things in geometry, which are not deduced from the common analyſis, particularly matters depending on the *ſitus* of lines and figures. Leibnitz has even founded a particular kind of analyſis upon it, called *calculus ſitus*.

SIWA, a town in Egypt, to the weſtward of Alexandria, built on a ſmall fertile ſpot or Oaſis, which is ſurrounded on all ſides by deſert land. A large proportion of this ſpace is filled with date trees; but there are alſo pomegranates, figs, and olives, apricots, and plantains; and the gardens are remarkably flouriſhing. They cultivate a conſiderable quantity of rice, which, however, is of a reddiſh hue, and different from that of the Delta. The remainder of the cultivable land furniſhes wheat enough for the conſumption of the inhabitants. Water, both ſalt and freſh, abounds; but the ſprings which furniſh the latter are moſt of them tepid; and ſuch is the nature of the water, air, and other circumſtances, that ſtrangers are often affected with agues and malignant fevers.

The greateſt curioſity about Siwa is a ruin of undoubted antiquity, which, according to Mr Browne, reſembles too exactly thoſe of the Upper Egypt, to leave a doubt that it was erected and adorned by the ſame intelligent race of men. The figures of Iſis and Anubis are conſpicuous among the ſculptures; and the proportions are thoſe of the Egyptian temples, though in miniature. What of it remains is a ſingle apartment, built of maſſy ſtones, of the ſame kind as thoſe of which the pyramids conſiſt; and covered originally with ſix large and ſolid blocks, that reach from one wall to the other. The length is 32 feet in the clear, the height about 18, the width 15. A gate, ſituated at one extremity, forms the principal entrance; and two doors, alſo near that extremity, open oppoſite to each other. The other end is quite ruinous; but, judging from circumſtances, it may be imagined that the building has never been much larger than it now is. There is no appearance of any other edifice having been attached to it, and the leſs ſo as there are remains of ſculpture on the exterior of the walls. In the interior are three rows of emblematical figures, apparently deſigned to repreſent a proceſſion; and the ſpace between them is filled with hieroglyphic characters, properly ſo called. The people of Siwa have no tradition concerning this edifice, nor attribnte to it any quality, but that of concealing treaſures, and being the haunt of demons. It has, however, been ſuppoſed, with ſome degree of probability, that Siwa is the *Siropum* of Pliny, and that this building was coeval with the famous temple of Jupiter Ammon, and a dependency on it. This may be ſo; but neither the natives of Siwa, nor the various tribes of Arabs who frequent that place, know any thing of the ruins of that temple, about which Mr Browne made every poſſible enquiry. "It may (as he obſerves) ſtill ſurvive the lapſe of ages, yet remain unknown to the Arabs, who traverſe the wide expanſe of the deſert; but ſuch a circumſtance is ſcarcely probable. It may be completely overwhelmed in the ſand; but this is hardly within the compaſs of belief."

The complexion of the people of Siwa is generally darker than that of the Egyptians. Their dialect is alſo different. They are not in the habitual uſe either of coffee or tobacco. Their ſect is that of Malik. The dreſs of the lower claſs is very ſimple, they being almoſt naked: among thoſe whoſe coſtume was diſcernible, it approaches nearer to that of the Arabs of the deſert than of the Egyptians or Moors. Their clothing conſiſts of a ſhirt of white cotton, with large ſleeves, and reaching to the feet; a red Tuniſine cap, without a turban; and ſhoes of the ſame colour. In warm weather they commonly caſt on the ſhoulder a blue and white cloth, called in Egypt *melayé*; and in winter they are defended from the cold by an *ihhram* or blanket. The liſt of their houſehold furniture is very ſhort; ſome earthen ware made by themſelves, and a few mats, form the chief part of it, none but the richer order being

being poſſeſſed of copper utenſils. They occaſionally purchaſe a few ſlaves from the Murzouk caravan. The remainder of their wants is ſupplied from Cairo or Alexandria, whither their dates are tranſported, both in a dry ſtate and beaten into maſh, which when good in ſome degree reſembles a ſweet meat. They eat no large quantity of animal food; and bread of the kind known to us is uncommon. Flat cakes, without leaven, kneaded, and then half baked, form part of their nouriſhment. The remainder conſiſts of thin ſheets of paſte, fried in the oil of the palm tree, rice, milk, dates, &c. They drink in great quantities the liquor extracted from the date-tree, which they term *date tree water*, though it have often, in the ſtate they drink it, the power of inebriating Their domeſtic animals are, the hairy ſheep and goat of Egypt, the aſs, and a very ſmall number of oxen and camels. The women are veiled, as in Egypt. After the rains, the ground in the neighbourhood of Siwa is covered with ſalt for many weeks. Siwa is ſituated in 29° 12′ N. Lat. and 44° 54′ E. Long.

SKIRMISH BAY, the name given by Lieutenant Broughton to a bay in an iſland, which was diſcovered by him in latitude 43° 48′ ſouth, and in longitude 183° eaſt. The Chatham armed tender, which Mr Broughton commanded, under Captain Vancouver in his voyage of diſcovery, worked up into the bay, and came to anchor about a mile from the ſhore. The Lieutenant, the maſter, and one of the mates, landed, and found the people ſo extremely inhoſpitable, that they were obliged to fire upon them in their own defence. The land, whether iſland or continent, is of conſiderable magnitude; the part which they ſaw extended nearly 40 miles from eaſt to weſt; and the appearance of the country, according to the deſcription given, is very promiſing. In many reſpects, the natives reſemble thoſe of New Zealand; from which country they are diſtant about 100 leagues: but their ſkins were deſtitute of any marks, and they had the appearance of being cleanly in their perſons. Their dreſſes were of ſeal or ſea-bear ſkin, and ſome had fine woven mats faſtened round the waiſt. "They ſeemed a cheerful race, our converſation (ſays Mr Broughton) frequently exciting violent burſts of laughter amongſt them. On our firſt landing, their ſurpriſe and exclamations can hardly be imagined: they pointed to the ſun, and then to us, as if to aſk, whether we had come from thence?" Their arms were ſpears, clubs, and a ſmall weapon reſembling the New Zealand patoo

SLIDING-RULE (ſee that article, as likewiſe *Gauging Rod*, GEOMETRY, and *Logarithmic Lines*, Encycl.) is introduced here, for the ſake of a new, and (except in working direct proportions) a more commodious method than the common, of applying the ſlider. This method, which is propoſed by the Rev. W. Pearſon of Lincoln, is as follows:

Invert the ſlider B on any common ſliding rule, whereby the numerical figures will aſcend on it, and on the fixed line A, in contrary directions: now, as the diſtance from unity to any multiplier, on Gunter's line, will invariably extend from any multiplicand to their product, it follows, that if any particular number on the inverted ſlider B be placed oppoſite to any other given number on A, the product of thoſe numbers will ſtand on the ſlider B, againſt unity on A; for, in any poſition of the inverted ſlider, the diſtance from unity to the multiplier on A, inſtead of being carried forward on B, as when the ſlider is in a direct poſition, is brought back thereby to unity again; ſo that unity (or *ten* on ſingle lines where the ſlider is too ſhort for the operation) is invariably the index for the product of any two coincident numbers throughout the lines.

In diviſion, by the ſame proceſs, if the dividend on B be put to the index, or unity on A, the diviſion and quotient will coincide on the two oppoſite lines; ſo that when one is given, and ſought for on either line, the other is ſeen on its oppoſite line at the ſame time.

The next operation which offers itſelf here is reciprocal proportion, which can be effected by no other method than by inverting the ſlider, but which is rendered as eaſy by this application, as direct proportion is in the common way; for if any antecedent number on B inverted be ſet to its conſequent on A, any other antecedent on B, in the ſame poſition, will ſtand againſt its conſequent on A, ſo as that the terms may be in a reciprocal ratio. In ſquaring any number, it will appear, from what has been already ſaid, that if the number to be ſquared be placed on B, inverted againſt the ſame on A, the ſquare will ſtand on B, againſt unity on A. Therefore, to extract the ſquare root of any number, let that number on B ſtand againſt unity on A; and then wherever the coincident numbers are both of the ſame value, that point indicates the root. If two dividing lines of the ſame value do not exactly coincide, the coincident point will be at the middle of the ſpace contained between thoſe two which are neareſt a coincidence; and as there is only one ſuch point, there can be no miſtake in readily aſcertaining it. The finding of a mean proportional between any two numbers is extremely eaſy at one operation; for if one of the numbers on B inverted be ſet to the other on A, the coincident point of two ſimilar numbers ſhews either of thoſe to be the mean, or ſquare root of their product, according to the preceding proceſs. Thus have we a ſhort and eaſy method of multiplying, dividing, working reciprocal proportion, ſquaring and extracting the ſquare root, at one poſition of the inverted ſlider, whereby the eye is directed to only one point of view for the reſult, after the ſlider is fixed: whereas, by the common method of extracting the ſquare root by A and B direct, the ſlider requires to be moved backwards and forwards by adjuſtment, the eye moving alternately to two points, till ſimilar numbers ſtand, one on B againſt unity on A, and the other on A againſt the ſquare number on B; which ſquare number, in the caſe of finding a mean proportional, muſt be found by a previous operation. Hence, for more convenience in the extraction of roots, and meaſuring of ſolids, an additional line called D has been added to the rule, which renders it more complex, and conſequently ſeldom underſtood by an artificer.

SNOW. See that article (*Encycl.*), where we have endeavoured to account for ſnow's contributing to the preſervation and growth of vegetables. It muſt be confeſſed, however, that if ſnow poſſeſſed only the property of preſerving vegetables, and of preventing them from periſhing by the ſeverity of the cold, it is not at all probable that the ancient philoſophers would have conſidered it as depoſiting on the earth nitrous ſalts, as they might have aſcertained, by a very ſimple experiment, that it contains none of that ſalt; for they did not aſcribe the ſame property to rain-water, but they remarked that ſnow burnt the ſkin in the manner of acids, as well as other bodies immerſed in it. Being induced to conclude that there was nitre in the air, it was natural that they ſhould aſcribe to this nitre the burning qualities of ſnow, and conſequently its influence on vegetation.

Such reflections induced Morveau, *alias* Citizen Guyton, to employ J. H. Haſſenfratz to inquire into the cauſe of the difference of the effects of ſnow and rain-water on various ſubſtances. Haſſenfratz found that theſe differences are occaſioned by the oxygenation of the ſnow; and that theſe effects are to be aſcribed to a particular combination of oxygen in this congealed water. He put 1000 grammes of ſnow in a jar, and 1000 grammes of diſtilled water in another. He poured into each of the jars an equal quantity of the ſame ſolution of turnſole. He placed both the jars in a warm temperature; and after the ſnow melted, he remarked that the dye was redder in the ſnow water than in the diſtilled water. He repeated this experiment, and with the ſame reſult. He put into a jar 1000 grammes of diſtilled water, and into another 1000 grammes of ſnow. Into each of the jars he put 6·5 grammes of very pure and clean ſulphat of iron. In the firſt, there was precipitated 0·150 grammes of the oxyd of iron, and 0·010 grammes in the other. As the oxyd of iron was precipitated from a ſolution of the ſulphat by oxygen, it thence follows, that the ſnow contained more oxygen than the diſtilled water; and it follows, from the firſt experiment, that this quantity of oxygen was conſiderable enough to redden the tincture of turnſole.

It is fully demonſtrated by theſe two experiments, that ſnow is oxygenated water, and that it muſt conſequently have on vegetation an action different from that of common ice. The experiments of Dr Ingenhouſs on the germination of ſeeds have taught us, that the preſence and contact of oxygen are abſolutely neceſſary for the plant to expand. They have ſhewn alſo, that the more abundant the oxygen is, the more rapidly will the ſeeds grow. Moſt plants ſuffered to attain to their perfect maturity ſhed on the earth a part of their ſeed. Theſe ſeeds, thus abandoned and expoſed to the action of cold, are preſerved by the ſnow which covers them, at the ſame time that they find in the water it produces by melting, a portion of oxygen that has a powerful action on the principle of germination, and determines the ſeeds that would have periſhed to grow, to expand, and to augment the number of the plants that cover the ſurface of the earth.

A very conſiderable number of the plants which are employed in Europe for the nouriſhment of men, are ſown in the months of September, October, and November. The ſeeds of ſeveral of theſe germinate before the cold commences its action upon them, and changes the principle of their life. The ſnow which covers the reſt, acting on the germ by its oxygenation, obliges them to expand, and to increaſe the number of uſeful plants which the farmer and gardener commit to the earth, and conſequently to multiply their productions.

Here, then, we have three effects of ſnow upon vegetation, all very different, which contribute each ſeparately to increaſe, every year, the number of our plants; to give them more vigour, and conſequently to multiply our crops. Theſe effects are: 1. To prevent the plants from being attacked by the cold, and from being changed or periſhing by its force. 2. To furniſh vegetables with continual moiſture, which helps them to procure thoſe ſubſtances neceſſary for their nutrition, and to preſerve them in a ſtrong healthy ſtate. 3. To cauſe a greater number of ſeeds to germinate, and conſequently to increaſe the number of our plants.

SOAP. See Chemistry *Index*, Suppl.

SOLDERING. Under this title, in the *Encyclopædia*, we have given directions for ſoldering ſilver, braſs, and iron: but there are other metals which muſt ſometimes be ſoldered; and the following account of different ſolders, taken from the *Philoſophical Magazine*, may be uſeful to many of our readers.

"When lead, tin, and biſmuth, are mixed in a certain proportion, they produce a metal exceedingly fuſible, which is known by the name of *ſoft ſolder*; but which, from its ſingular properties, may be applied with advantage to many other uſeful purpoſes. Newton, and after him Kraft and Muſchenbroek, obſerved, that five parts of biſmuth, three of tin, and two of lead, alſo five parts of biſmuth, four of tin, and one part of lead, melted with a heat of 220 degrees of Fahrenheit; and they found that various mixtures of this kind were fuſible by a heat not much greater than that of boiling water. At a later period, V. Roſe, a German naturaliſt, diſcovered, that a mixture of four parts of biſmuth, two of tin, and two of lead, as Kunkel recommended for ſoldering tin; and D'Arcet, among the French, that a mixture of eight parts of biſmuth, three of tin, and five of lead; or eight of biſmuth, four of tin, and four of lead; or eight of biſmuth, two of tin; and ſix of lead; alſo ſixteen of biſmuth, ſeven of tin, and nine of lead—all melted, or at leaſt became ſoft, in boiling water.

"According to the experiments made by Profeſſor Gmelin, reſpecting the fuſion of theſe three metals, a mixture, conſiſting of two parts of biſmuth, one part of tin, and one of lead, which is the ſame as Roſe propoſed, gave a metal that was fuſed in boiling water. A mixture of ſix or more parts of biſmuth, ſix of tin, and three of lead, or one part of biſmuth, two parts of tin, and two of lead, gave, according to Klein, the ſolder uſed by the tin button makers. The ſame workmen uſe alſo for ſoldering, according to Klein, a mixture of four parts of biſmuth, three parts of tin, and five parts of lead. Among the many ſoft ſolders employed by the tin men, a mixture of one part of biſmuth, two parts of tin, and one part of lead, is, according to Klein, very much employed. Reſpecting this kind of ſolder, the experiments of Profeſſor Gmelin give the following reſult: One part of biſmuth, two parts of tin, and one part of lead, melt in boiling water. According to Klein, the tin-men employ for ſoldering a mixture of one part of biſmuth, twenty four parts of tin, and four parts of lead. Eight parts of biſmuth, three of tin, and five of lead, gave a metal exceedingly like tin in its colour and brightneſs, but very brittle; in water beginning to boil, it became not only ſoft, but was completely fuſed. This imitation, however, may be better accompliſhed by the mixture of Profeſſor Lightenberg, which conſiſts of five parts of biſmuth, three

three of tin, and two of lead. This metal is very like the former, though not ſo brittle; but it ſeemed to melt in hot water even before it came to boil."

As this ſubject has again come under our notice, it may be proper to lay before our readers what M. Van Braam ſays of the Chineſe method of ſoldering frying-pans and other veſſels of caſt-iron, when cracked and full of holes. As the author admits that it *muſt* appear *impoſſible* to thoſe who have not *witneſſed* the proceſs, ſuch of our artiſts as have not been in China will give to the tale what credit they think it deſerves.

"All the apparatus of the workman conſiſts in a little box, 16 inches long and 6 wide, and 18 inches in depth, divided into two parts. The upper contains three drawers with the neceſſary ingredients; in the lower is a bellows, which when a fire is wanted is adapted to a furnace eight inches long and four inches wide. The crucibles for melting the ſmall pieces of iron intended to ſerve as ſolder are a little larger than the bowl of a common tobacco pipe, and of the ſame earth of which they are made in Europe: thus the whole buſineſs of ſoldering is executed.

"The workman receives the melted matter out of the crucible upon a piece of *wet paper*, approaches it to one of the holes or cracks in the frying-pan, and applies it there, while his aſſiſtant ſmooths it over by ſcraping the ſurface, and afterwards rubs it with a bit of *wet linen*. The number of crucibles which have been deemed neceſſary are thus ſucceſſively emptied, in order to ſtop up all the holes with the melted iron, which conſolidates and incorporates itſelf with the broken utenſil, and which becomes as good as new. The furnace which our author ſaw was calculated to contain eight crucibles at a time; and while the fuſion was going on, was covered with a ſtone, by way of increaſing the intenſity of the heat."—M. Van Braam affects frequently to correct the miſtakes of Sir George Staunton!

SOUDAN, literally ſignifies the country of the negroes; but it is likewiſe uſed as one of the names of an African kingdom, otherwiſe called DAR-FUR. We know not that this kingdom has been viſited by any European beſides Mr Browne, who places it between the 11th and 16th degrees of north latitude, and between the 26th and 30th degrees of eaſt longitude. Theſe numbers are not exact: it does not reach ſo far eaſt as the 30th degree, nor ſo far north as the 16th; but on his map minutes are not marked. On the north, it is bounded by a deſert which ſeparates it from Egypt; on the eaſt, by Kordofan, which is now ſubject to Soudan, and lies between it and Sennaar; and on the ſouth and eaſt, by countries of which the names are hardly known. Mr Browne was induced to viſit Soudan in hopes of being able to trace the Bahr-el-abiad, or true Nile, to its ſource: but he was diſappointed; for that river riſes in mountains conſiderably farther ſouth than the limits of this kingdom; and the Sultan, a cruel and capricious tyrant, detained him a priſoner at large almoſt three years.

Soudan, or Dar-fur, abounds with towns or villages, ill built, of clay, and none of them very large. Of theſe it is not worth while to give an account. Its ſeaſons are divided into rainy and dry. The perennial rains, which fall in Dar-Fur from the middle of June till the middle of September in greater or leſs quantity, but generally both frequent and violent, ſuddenly inveſt the face of the country, till then dry and ſteril, with a delightful verdure. Except where the rocky nature of the ſoil abſolutely impedes vegetation, wood is found in great quantity; nor are the natives aſſiduous completely to clear the ground, even where it is deſigned for the cultivation of grain. As ſoon as the rains begin, the proprietor, and all the aſſiſtants that he can collect, go out to the field; and having made holes at about two feet diſtance from each other, with a kind of hoe, over all the ground he occupies, the *dokn*, a kind of millet, is thrown into them, and covered with the foot, for their huſbandry requires not many inſtruments. The time for ſowing the wheat is nearly the ſame. The *dokn* remains ſcarcely two months before it is ripe; the wheat about three.

The animals in Soudan, both wild and tame, are the ſame as in other parts of Africa in the ſame latitude. Though the Furians breed horſes, and purchaſe very fine ones in Dongola, and from the Arabs to the eaſt of the Nile, the aſs is more uſed for riding; and an Egyptian aſs (for the aſſes of Dar-Fur are diminutive and indocile like thoſe of Britain) fetches from the value of one to that of three ſlaves. The villages of this country, like thoſe of Abyſſinia, are infeſted with hyenas; and in the unfrequented parts of the country are the elephant, the rhinoceros, the lion, the leopard, and all the other quadrupeds of Africa. The Arabs often eat the fleſh of the lion and the leopard; and ſometimes they ſo completely tame thoſe animals, as to carry them looſe into the market place. Our author tamed two lions, of which one acquired moſt of the habits of a dog. He ſatiated himſelf twice a week with the offal of the butchers, and then commonly ſlept for ſeveral hours ſucceſſively. When food was given them, they both grew ferocious towards each other, and towards any one who approached them. Except at that time, though both were males, he never ſaw them diſagree, nor ſhew any ſign of ferocity towards the human race. Even lambs paſſed them unmoleſted.

Among the birds, the *vultur perenopterus*, or white-headed vulture, is moſt worthy of notice. It is of ſurpriſing ſtrength, and is ſaid by the natives to be very long-lived, *ſed fides penes auctores*. "I have lodged (ſays Mr Browne) a complete charge of large ſhot, at about 50 yards diſtance, in the body of this bird: it ſeemed to have no effect on him, as he flew to a conſiderable diſtance, and continued walking afterwards. I then diſcharged the ſecond barrel, which was loaded with ball: this broke his wing; but on my advancing to ſeize him, he fought with great fury with the other. There are many thouſands of them in the inhabited diſtrict. They divide the field with the hyena: what carrion the latter leaves at night, the former come in crowds to feed on in the day. Near the extremity of each wing is a horny ſubſtance, not unlike the ſpur of an old cock. It is ſtrong and ſharp, and a formidable inſtrument of attack. Some fluid exudes from this bird that ſmells like muſk; but from what part of him I am uncertain." The ſerpents found in Soudan are the ſame as in Egypt; but the natives have not the art of charming them, like the Egyptians. The locuſt of Arabia is very common, and is frequently roaſted and eaten, particularly by the ſlaves.

In Dar-Fur there ſeems to be a ſcarcity of metals;

Soudan.

but in its neighbourhood to the ſouth and weſt all kinds are to be found. The copper brought by the merchants from the territories of certain idolatrous tribes bordering on Fur, is of the fineſt quality, in colour reſembling that of China, and appears to contain a portion of zinc, being of the ſame pale hue. Iron is found in abundance; but they have not yet learned the art of converting it into ſteel. Silver, lead, and tin, our author never heard mentioned in Soudan, but as coming from Egypt; but of gold, in the countries to the eaſt and weſt, the ſupply is abundant. Alabaſter, and various kinds of marble, are found within the limits of Fur, as is foſſil ſalt within a certain diſtrict; and there is a ſufficient ſupply of nitre, of which, however, no uſe is made.

The reſtraint under which Mr Browne was kept in this inhoſpitable country, prevented him from making a full catalogue of its vegetable productions. Of the trees which ſhade our foreſts or adorn our gardens in Europe, very few exiſt in Dar-Fur. The characteriſtic marks of thoſe ſpecies which moſt abound there, are their ſharp thorns, and the ſolid and unperiſhable quality of their ſubſtance. They ſeem to be much the ſame as thoſe which Bruce found in Abyſſinia. There is a ſmall tree called *enneb*, to the fruit of which they have given the name of grapes. It bears leaves of light green hue; and the fruit, which is of a purple colour, is attached, not in bunches, but ſingly to the ſmaller branches, and interſperſed among the leaves. The internal ſtructure of the fruit is not very unlike the grape, which it alſo reſembles in ſize: but the pulp is of a red hue, and the taſte is ſtrongly aſtringent. The water-melon *(cucurbita citrullus)* grows wild over almoſt all the cultivable lands, and ripens as the corn is removed. In this ſtate it does not attain a large ſize. The inſide is of a pale hue, and has little flavour. As it ripens, the camels, aſſes, &c. are turned to feed on it, and it is ſaid to fatten them. The ſeeds, as they grow blackiſh, are collected to make a kind of tar, *kutran*. Thoſe plants of the melon which receive artificial culture grow to a large ſize, and are of exquiſite flavour. Tobacco is produced in abundance; and our author ſpeaks of cochineal as found in Dar-Fur, or ſome of the neighbouring countries.

The harveſt is conducted in a very ſimple manner. The women and ſlaves of the proprietor are employed to break off the ears with their hands, leaving the ſtraw ſtanding, which is afterwards applied to buildings and various other uſeful purpoſes. They then accumulate them in baſkets, and carry them away on their heads. When thraſhed, which is aukwardly and incompletely performed, they expoſe the grain to the ſun till it become quite dry; after this a hole in the earth is prepared, the bottom and ſides of which are covered with chaff to exclude the vermin. This cavity or magazine is filled with grain, which is then covered with chaff, and afterwards with earth. In this way the maize is preſerved tolerably well. In uſing it for food, they grind it, and boil it in the form of polenta, which is eaten either with freſh or ſour milk, or ſtill more frequently with a ſauce made of dried meat pounded in a mortar, and boiled with onions, &c. The Furians uſe little butter; with the Egyptians and Arabs it is an article in great requeſt. There is alſo another ſauce which the poorer people uſe and highly reliſh; it is compoſed of an herb called *cowel* or *cawel*, of a taſte in part aceſcent and in part bitter, and generally diſagreeable to ſtrangers.

Soudan.

The magiſtracy of one, which ſeems tacitly, if it be not expreſsly, favoured by the diſpenſation of Mohammed, as in moſt other countries profeſſing that religion, prevails in Dar-Fur. The monarch indeed can do nothing contrary to the Koran, but he may do more than the laws eſtabliſhed thereon will authoriſe; and as there is no council to controul or even to aſſiſt him, his power may well be termed deſpotic. He ſpeaks in public of the ſoil and its productions as his perſonal property, and of the people as little elſe than his ſlaves.

His power in the provinces is delegated to officers, who poſſeſs an authority equally arbitrary. In thoſe diſtricts, which have always, or for a long time, formed an integral part of the empire, theſe officers are generally called *Meleks*. In ſuch as have been lately conquered, or, perhaps more properly, have been annexed to the dominion of the Sultan under certain ſtipulations, the chief is ſuffered to retain the title of Sultan, yet is tributary to and receives his appointment from the Sultan of Fur.

Deſpotic and arbitrary as he is, the Sultan here does not ſeem wholly inattentive to that important object, agriculture. Nevertheleſs, it may be eſteemed rather a blind compliance with ancient cuſtom, than individual public ſpirit, in which has originated a practice adopted by him, in itſelf ſufficiently laudable, ſince other o his regulations by no means conduce to the ſame end At the beginning of the *Hariſ*, or wet ſeaſon, which is alſo the moment for ſowing the corn, the king goes out with his Meleks and the reſt of his train; and while the people are employed in turning up the ground and ſowing the ſeed, he alſo makes ſeveral holes with his own hand. The ſame cuſtom, it is ſaid, obtains in Bornou and other countries in this part of Africa: It calls to the mind a practice of the Egyptian kings mentioned by Herodotus.

The population of Dar-Fur is not large. An army of 2000 men was ſpoken of, when Mr Browne was in the country, as a great one; and he does not think that the number of ſouls within the empire can much exceed 200,000. The troops of this country are not famed for ſkill, courage, or perſeverance. In their campaigns, much reliance is placed on the Arabs who accompany them, and who are properly tributaries rather than ſubjects of the Sultan. One energy of barbariſm they indeed poſſeſs in common with other ſavages, that of being able to endure hunger and thirſt; but in this particular they have no advantage over their neighbours. In their perſons the Furians are not remarkable for cleanlineſs. Though obſerving as Mahommedans all the ſuperſtitious formalities of prayer, their hair is rarely combed, or their bodies completely waſhed. The hair of the pubes and axillæ it is uſual to exterminate; but they know not the uſe of ſoap; ſo that with them poliſhing the ſkin with unguents holds the place of perfect ablutions and real purity. A kind of farinaceous paſte is however prepared, which being applied with butter to the ſkin, and rubbed continually till it become dry, not only improves its appearance, but removes from it accidental ſordes, and ſtill more the effect of continued tranſpiration, which, as there are no baths in the country, is a conſideration of ſome importance. The female ſlaves are dexterous in the application of it; and to undergo this operation is one of the refinements of African ſenſuality.

Nothing reſembling current coin is found in Soudan, unleſs it be certain ſmall tin rings, the value of which is in ſome degree arbitrary. The Auſtrian dollars, and other ſilver coins brought from Egypt, are all ſold as ornaments for the women.

The diſpoſition of the Furians is cheerful; and that gravity and reſerve which the precepts of Mahommediſm inſpire, and the practice of the greater number of its profeſſors countenances and even requires, ſeems by no means as yet to ſit eaſy on them. A government perfectly deſpotic, and not ill adminiſtered, as far as relates to the manners of the people, yet forms no adequate reſtraint to their violent paſſions. Prone to inebriation, but unprovided with materials or ingenuity to prepare any other fermented liquor than *buza*, with this alone their convivial exceſſes are committed. But though the Sultan publiſhed an ordnance (March 1795), forbidding the uſe of that liquor under pain of death, the plurality, though leſs publicly than before, ſtill indulge themſelves in it. A company often ſits from ſunriſe to ſun ſet, drinking and converſing, till a ſingle man ſometimes carries off near two gallons of that liquor. The buza has, however, a diuretic and diaphoretic tendency, which precludes any danger from theſe exceſſes. In this country dancing is practiſed by the men as well as the women, and they often dance promiſcuouſly.

The vices of thieving, lying, and cheating in bargains, with all others nearly or remotely allied to them, as often happen among a people under the ſame circumſtances, are here almoſt univerſal. No property, whether conſiderable or trifling, is ſafe out of the ſight of the owner, nor indeed ſcarcely in it, unleſs he be ſtronger than the thief. In buying and ſelling, the parent glories in deceiving the ſon, and the ſon the parent; and God and the Prophet are hourly invocated, to give colour to the moſt palpable frauds and falſehoods.

The privilege of polygamy, which, as is well known, belongs to their religion, the people of Soudan puſh to the extreme. By their law, they are allowed four free women, and as many ſlaves as they can maintain; but the Furians take both free women and ſlaves without limitation. The Sultan has more than a hundred free women, and many of the Meleks have from twenty to thirty. In their indulgence with women, they pay little regard to reſtraint or decency. The form of the houſes ſecures no great ſecrecy to what is carried on within them; yet even the concealment which is thus offered is not always ſought. The ſhade of a tree, or long graſs, is the ſole temple required for the ſacrifices to the Cyprian goddeſs. In the courſe of licentious indulgence, father and daughter, ſon and mother, are ſometimes mingled; and the relations of brother and ſiſter are exchanged for cloſer intercourſe.

Previouſly to the eſtabliſhment of Iſlamiſm* and kingſhip, the people of Fur ſeem to have formed wandering tribes; in which ſtate many of the neighbouring nations to this day remain. In their perſons they differ from the negroes of the coaſt of Guinea. Their hair is generally ſhort and woolly, though ſome are ſeen with it of the length of eight or ten inches, which they eſteem a beauty. Their complexion is for the moſt part perfectly black. The Arabs, who are numerous within the empire, retain their diſtinction of feature, colour, and language. They moſt commonly intermarry with each other. The ſlaves, which are brought from the country they call *Fertit* (land of idolaters), perfectly reſemble thoſe of Guinea, and their language is peculiar to themſelves.

The revenues of the crown conſiſt of a duty on all merchandiſe imported, which, in many inſtances, amounts to near a tenth; of a tax on all ſlaves exported to Egypt; of all forfeitures for miſdemeanors; of a tenth on all merchandiſe, eſpecially ſlaves, brought from every quarter but Egypt, and when ſlaves are procured by force, this tenth is raiſed to a fifth; of a tribute paid by the Arabs, who breed oxen, horſes, camels, ſheep; of a certain quantity of coin paid annually by every village; beſides many valuable preſents, which muſt be paid by the principal people, both at ſtated times and on particular occaſions. Add to all this, that the king is chief merchant in the country; and not only diſpatches with every caravan to Egypt a great quantity of his own merchandiſe, but alſo employs his ſlaves and dependents to trade with the goods of Egypt on his own account, in the countries adjacent to Soudan.

The commodities brought by the caravans from Egypt are, 1. Amber beads. 2. Tin, in ſmall bars. 3. Coral beads. 4. Cornelian beads. 5. Falſe cornelian beads. 6. Beads of Venice. 7. Agate. 8. Rings, ſilver and braſs, for the ancles and wriſts. 9. Carpets, ſmall. 10. Blue cotton cloths of Egyptian fabric. 11. White cotton ditto. 12. Indian muſlins and cottons. 13. Blue and white cloths of Egypt, called *Melayes*. 14. Sword blades, ſtrait (German), from Cairo. 15. Small looking-glaſſes. 16. Copper face-pieces, or defenſive armour for the horſes heads. 17. Fire arms. 18. Kohhel for the eyes. 19. Rhea, a kind of moſs from European Turkey, for food and a ſcent. 20. *She*, a ſpecies of abſynthium, for its odour, and as a remedy: both the laſt ſell to advantage. 21. Coffee. 22. *Mahleb*, *Krumphille*, *Symbille*, *Sandal*, nutmegs. 23. *Dufr*, the ſhell of a kind of fiſh in the Red Sea, uſed for a perfume. 24. Silk unwrought. 25. Wire, braſs and iron. 26. Coarſe glaſs beads, made at Jeruſalem, called *herſh* and *munjur* 27. Copper culinary utenſils, for which the demand is ſmall. 28. Old copper for melting and reworking. 29. Small red caps of Barbary. 30. Thread linens of Egypt—ſmall conſumption. 31. Light French cloths, made into beniſhes. 32. Silks of Scio, made up. 33. Silk and cotton pieces of Aleppo, Damaſcus, &c. 34. Shoes of red leather. 35. Black pepper. 36. Writing paper (*papier des trois lunes*), a conſiderable article. 37. Soap of Syria.

The goods tranſported to Egypt are, 1. Slaves, male and female. 2. Camels. 3. Ivory. 4. Horns of the rhinoceros 5. Teeth of the hippopotamus. 6. Oſtrich feathers. 7. Whips of the hippopotamus's hide. 8. Gum. 9. Pimento. 10. Tamarinds, made into round cakes. 11. Leather ſacks for water (*ray*) and dry articles (*geraub*). 12. Peroquets in abundance, and ſome monkeys and Guinea fowls. 13. Copper, white, in ſmall quantity.

SOUFFRIERE, a ſmall town, ſituated at the bottom of a bay, towards the leeward extremity of the iſland of St Lucia. There is nothing in the town itſelf which could

---

* bout a ce ry an a l f ago

could have entitled it to notice in this work; but the ground about it is very remarkable. It has been deſcribed by different authors; and our readers will probably not be ill pleaſed with the following deſcription of this wonderful ſpot by Dr Rollo.

"Souffriere (ſays he) is ſurrounded by hills covered with trees, the declivities of which, and every part capable of produce, are cultivated, and afford good ſugar-cane. This place has its marſhes, but not ſo extenſive, or ſo much to windward as thoſe about Carenage.

"The extremity of the ſouth ſide of Souffriere Bay runs into two ſteep hills of a conical figure, which are nearly perpendicular: they are reckoned the higheſt on the iſland, and are known by the name of the *Sugar-Loaf Hills*. From their height and ſtraitneſs it is impoſſible to aſcend them: we were told it was once attempted by two negroes, but they never returned. They are covered with trees and ſhrubs, and are the ſhelter of goats, ſeveral of which ſometimes deſcend, and are ſhot by the natives.

"After you paſs the hills to windward of Souffriere, a fine clear and level country preſents itſelf. From the back of the Sugar Loaf Hills, and all along the ſea-coaſt, to the diſtance, we ſuppoſe, of from fifteen to twenty miles, this flat or level extends: it is all cultivated and divided into rich eſtates, affording ſugar-cane equal to any in our iſlands. This beautiful ſpot is interſected by many rivers of very clear water, and theſe are conducted by art to the purpoſe of ſugar making. The rains in this part are leſs frequent than on any other part of he iſland; however, they have often a proportion more than ſufficient. The wind here blows from the ſea, or nearly ſo.

"We cannot finiſh this deſcription without taking notice of a volcano in the neighbourhood of Souffriere. You paſs over one or two ſmall hills to the ſouthward of the town, and before any mark of the place is perceived you are ſenſible of the ſmell of ſulphur. The firſt thing you diſcern is a rivulet of black running water, ſending forth ſteams as if nearly boiling. From the proſpect of this you ſoon open on the volcano, which appears in a hollow, ſurrounded cloſe on every ſide by hills. There are only two openings; the one we entered, and another almoſt oppoſite to it on the north ſide. In the hollow there are many pits of a black and thick boiling matter, which ſeems to work with great force. Lava is ſlowly thrown out; and in the centre of the hollow there is a large maſs of it, forming a kind of hill. This we aſcended; but were ſoon obliged to return from the exceſſive heat. The lava is a ſulphur mixed with a calcareous earth and ſome ſaline body. We found ſmall quantities of alum in a perfect ſtate. In the opening, at the north ſide of the hollow, there is a rivulet of very good water. On ſtirring the bottom, over which this water runs, we were ſurpriſed with feeling it very hot; and on placing a tumbler filled with ſome of the water cloſe to the bottom of the rivulet, it ſoon became ſo hot as not to be touched. The liquid which runs from the pits is ſtrongly impregnated with ſulphur, and reſembles a good deal the preparation ſold in the ſhops, known by the name of *aqua ſulphurata*, or *gas ſulphuris*."

SOUND-BOARD, the principal part of an organ, and that which makes the whole machine play. This ſound-board, or ſummer, is a reſervoir into which the wind, drawn in by the bellows, is conducted by a port-vent, and thence diſtributed into the pipes placed over the holes of its upper part. This wind enters them by valves, which open by preſſing upon the ſtops or keys, after drawing the regiſters, which prevent the air from going into any of the other pipes beſide thoſe it is required in.

Sound Board denotes alſo a thin broad board placed over the head of a public ſpeaker, to enlarge and extend or ſtrengthen his voice.

Sound-boards, in theatres, are found by experience to be of no ſervice; their diſtance from the ſpeaker being too great to be impreſſed with ſufficient force. But ſound boards immediately over a pulpit have often a good effect, when the caſe is made of a juſt thickneſs, and according to certain principles.

Sound-Poſt, is a poſt placed withinſide of a violin, &c. as a prop between the back and the belly of the inſtrument, and nearly under the bridge.

SOWAL, in the language of Bengal, a queſtion or requeſt.

SPALLANZANI (Lazarus), was born at Scandiano, in the dutchy of Modena, on the 10th of January 1729. He was ſon of Jean Nicholas Spallanzani, an eſteemed juriſconſult, and of Lucia Zugliani. He commenced his ſtudies in his own country, and at the age of fifteen years went to Reggio de Modena in order to continue them. The Jeſuits, who inſtructed him in the belles lettres, and the Dominicans, who heard of his progreſs, were each deſirous of attaching him to them; but his paſſion for extending his knowledge led him to Bologna, where his relation Laura Baſſi, a woman juſtly celebrated for her genius, her eloquence, and her ſkill in natural philoſophy and the mathematics, was one of the moſt illuſtrious profeſſors of the Inſtitute and of Italy. Under the direction of this enlightened guide, he learned to prefer the ſtudy of Nature to that of her commentators, and to judge of the value of the commentary by its reſemblance to the original. He inſtantly availed himſelf of the wiſdom of that lady's counſels, and was not long before he experienced the happy effects of it. How agreeable it is to ſee him in 1765 painting his gratitude for his inſtructor, to whom he dedicated a Latin diſſertation at that time, in which he mentions the applauſes that Laura Baſſi received at Modena, when ſhe entered the auditory of her pupil, then become profeſſor. The taſte of Spallanzani for philoſophy was not excluſive; he already thought, like all great men, that the ſtudy of antiquity and the belles-lettres was requiſite to give to ideas that clearneſs, to expreſſions that accuracy, and to reaſonings that connection, without which the fineſt thoughts become barren. He ſtudied his own language with care, and perfected himſelf in the Latin tongue; but above all, he attached himſelf to the Greek and the French. Homer, Demoſthenes, St Baſil, were his favourite authors. Spallanzani applied himſelf to juriſprudence at the inſtance of a father whom he tenderly loved: he was upon the point of receiving the degree of doctor of civil law, when Anthony Valliſneri, profeſſor of natural hiſtory at Padua, perſuaded him to renounce this vocation, by promiſing to obtain the conſent of his father, who was ſenſibly touched by his ſon's devotion to his will, and who thereby left him at liberty to follow his own inclinations. From that moment he gave himſelf up

Spallanzani.

up with more ardour than ever to the ſtudy of mathematics, continuing that alſo of the living and dead languages.

Spallanzani was preſently known all over Italy, and his own country was the firſt to do homage to his talents The univerſity of Reggio, in 1754, choſe him to be profeſſor in logic, metaphyſics, and Greek. He taught there for ten years; and during that period conſecrated all the time he could ſpare from his leſſons to the obſervation of Nature. Now and then an accidental diſcovery would increaſe his paſſion for natural hiſtory, which always augmented by new ſucceſſes. His obſervations upon the animalculæ of infuſions fixed the attention of Haller and of Bonnet; the latter of whom aſſiſted him in his glorious career, and thenceforth diſtinguiſhed him as one of the learned interpreters of Nature.

In 1760 Spallanzani was called to the univerſity of Modena; and although his intereſt would have made him accept the advantageous offers of the univerſity of Coimbra, of Parma, and of Ceſena; yet his patriotiſm and his attachment to his family confined his ſervices to his own country. The ſame conſiderations engaged him to refuſe the propoſitions made him by the academy of Peterſburg ſome years after. He remained at Modena till the year 1768, and he ſaw raiſed by his care a generation of men conſtituting at this time the glory of Italy. Among them may be counted *Venturi*, profeſſor of natural philoſophy at Modena; *Belloni*, biſhop of Carpi; *Luccheſini*, ambaſſador of the late king of Pruſſia; and the poet *Angelo Mazzo* of Parma.

During his reſidence at Modena, Spallanzani publiſhed, in 1765, *Saggio di Oſſervazioui Microſcopiche concernente il Syſtema di Needham e Buffon* He therein eſtabliſhes the *animality* of what had been called, but not generally aſſented to as, *microſcopic animalculæ*, by the moſt ingenious, and at the ſame time ſolid, experiments. He ſent this work to Bonnet, who formed his opinion of the author accordingly, and who lived to ſee the accompliſhment of the prophecy he drew from it. From that moment the moſt intimate acquaintance was formed between them, and it laſted during their lives, of which it conſtituted the chief happineſs. In the ſame year Spallanzani publiſhed a diſſertation truly original: *De Lapidibus ab Aqua reſilientibus*. In that work he proves, by ſatisfactory experiments, contrary to the commonly received opinion, that the ducks and drakes (as they are called) are not produced by the elaſticity of the water, but by the natural effect of the change of direction which the ſtone experiences in its movement, after the water has been ſtruck by it, and that it has been carried over the bend or hollow of the cup formed by the concuſſion.

In 1768 he prepared the philoſophers for the ſurpriſing diſcoveries he was about to offer them throughout his life, in publiſhing his *Prodromo di un Opera da Imprimerſi ſopra le Riproduzioni Animali.* He therein lays down the plan of a work which he was anxious to get up on this important ſubject; but this ſimple proſpectus contains more real knowledge than all the books which had appeared, becauſe it taught the method that ought to be followed in this dark reſearch, and contained many unexpected facts; ſuch as the pre-exiſtence of tadpoles at the fecundation, in many ſpecies of toads and frogs; the reproduction of the head cut off from ſnails, which he had already communicated to Bonnet in 1766, and which was diſputed for ſome time, in ſpite of the repeated confirmation of this phenomenon by Heriſſant and Lavoiſier. He demonſtrated it again afterwards in the *Memorie della Socicta Italiana;* as alſo the renewal of the tail, the limbs, and even the jaws, taken from the aquatic ſalamander. Theſe facts continue to aſtoniſh even at this day, when they are thought of, notwithſtanding every one has had the opportunity of familiariſing himſelf with them: and we hardly know which we ought moſt to admire, the expertneſs of Spallanzani in affording ſuch deciſive proofs, or his boldneſs in ſearching after them, and ſeizing them. We have to regret, that the project of his great undertaking is not realized; but various circumſtances prevented him from giving way to the ſolicitations of his friends for its accompliſhment. Perhaps he deſpaired of throwing upon every part of it all the light which at firſt he thought he might be able; and found it prudent to mature his ideas by new meditations: this may probably have been as powerful a cauſe as that other calls and occupations, perpetually accumulating, ſhould not have allowed him to purſue it as he had intended. He has always laid Nature open to full view; and the thinneſt veil darkened her till he ſucceeded in removing it altogether.

The phyſiology of Haller that Spallanzani ſtudied, fixed his attention upon the circulation of the blood, in which he diſcovered ſeveral remarkable phenomena. He publiſhed, in 1768, a ſmall tract: *Dell' Azione del Cuore ne' Vaſi Sanguigni nuovi Oſſervazioni*, and he reprinted it in 1773, with three new diſſertations, *De' Fenomeni della Circolazione oſſervata nel' Giro univerſali de' Vaſi; De' Fenomeni della Circolazione Languente; De' Moti del Sangue, independente del Azione del Cuore e del Pulſare delle Arterie.* This work, but little known, contains a ſeries of obſervations and experiments, of the moſt ingenious and delicate nature, upon a ſubject of which the ſurface only is known. It merits the attention of thoſe who are intereſted in the progreſs of phyſiology.

When the univerſity of Padua was re-eſtabliſhed upon a larger ſcale, the Empreſs Maria Thereſa directed the Count de Firmian to invite him to fill a chair, as profeſſor of natural hiſtory; his great reputation rendered him eligible for this diſtinction, ſolicited by many celebrated men, and he merited it by his ſucceſs, and by the crowd of ſtudents who thronged to his leſſons. Only great men make excellent maſters,. becauſe their ideas are the moſt perſpicuous, the moſt extenſive, and beſt connected.

Spallanzani united a vaſt extent of knowledge to a fine genius; a method ſimple, but rigorous in its nature; and he connected what he knew to principles firmly eſtabliſhed. His ardent love of truth made him diſcuſs, with the utmoſt care, the theories which prevailed; to ſound their ſolidity, and diſcover their weak ſides. The great art which he had acquired, of interpreting Nature by herſelf, diffuſed ſuch a light over his leſſons, as made every thing perſpicuous that was capable of affording inſtruction. An eloquence at once plain and lively animated his diſcourſe; the purity and elegance of his ſtyle charmed all who heard it: in ſhort, it was known that he always occupied himſelf about the

the means of rendering his leſſons uſeful, which he prepared a year beforehand. They became always new and engaging, by his new obſervations, and by the enlarged views that his meditations preſented to him. The learned perſons who attended his lectures were pleaſed to become his ſcholars, in order to know better what they already knew, and to learn that which otherwiſe they would perhaps never have known.

In arriving at the univerſity, Spallanzani took the *Contemplation de la Nature* of Bonnet for the text of his leſſons: he filled up the vacancies in it, he unfolded the ideas, and confirmed the theories by his experiments. He believed, with reaſon, that the book which inſpired him with the love of natural hiſtory by reading it, was the moſt proper to give birth to it in the minds of his diſciples.

He tranſlated it into Italian, and enriched it with notes; he added a preface to it, wherein he pointed out the ſubjects of the vegetable and animal economy, which in an eſpecial manner deſerved the attention of his pupils; and ſometimes pointing out to them the means of ſucceeding in their reſearches. It was thus he at firſt devoted himſelf to the pleaſing employment of inſtructor of his countrymen, and that he became the model of thoſe who were deſirous of inſtructing uſefully. He publiſhed the firſt volume of his tranſlation in 1769. and the ſecond in 1770.

The connection of Spallanzani with Bonnet had an influence upon his genius, which bent to the ſevere method of the philoſopher of Geneva. He prided himſelf in being his pupil, and he unceaſingly meditated upon his admirable writings; and thus it was that he became deſirous of ſeeking in Nature for the proofs of Bonnet's opinion upon the generation of organized bodies, and that this charming ſubject fixed his attention for a long time.

He publiſhed, in 1776, the two firſt volumes of his *Opuſcoli di Fiſica Animale e Vegetabile:* they are the explanation of a part of the microſcopic obſervations which had already appeared.

If the art to obſerve be the moſt difficult, it is nevertheleſs the moſt neceſſary of all the arts; but it ſuppoſes every quality, every talent: and further, though each believes himſelf more or leſs conſummate therein, yet it is obvious, that only great men have exerciſed it in a diſtinguiſhed manner. Genius alone fixes the objects worthy of regard; that alone directs the ſenſes to the obſcurities which it is neceſſary to diſſipate; it watches over them to prevent error; it animates them to follow by the ſcent, as it were, that which they have but a diſtant view of: it takes off the veil which covers what we are looking after; it ſupports the patience which waits the moment for gratifying the ſight in the midſt of obſtacles multiplying one upon another: in ſhort, it is genius that concentrates the attention upon an object, which communicates that energy to him for imagining, that ſagacity for diſcovering, that promptneſs for perceiving, without which we ſee only one ſide of truth, when we do not happen to let it eſcape altogether. But this is not all; for after Nature has been read with preciſion, it is neceſſary to interpret her with fidelity; to analyſe by the thought the phenomena anatomiſed by the ſenſes; to conſider of the ſpecies by obſerving the individual, and to anticipate the general propoſitions by conſidering the unconnected facts. Here prudence and circumſpection will not always ſecure us againſt error, if an ardent love for the truth does not aſſay obſervations and their conſequences in its crucible, and thereby reduce every thing to *ſcoriæ* which is not truth.

Such was Spallanzani in all his reſearches; ſuch we ſee him in all his writings. Occupied by the great phenomenon of generation, he examined the opinion of Needham to demonſtrate its want of foundation. The latter, not ſatisfied with the microſcopic obſervations of Spallanzani, which weakened the imagined vegetative force to put the matter in motion, challenged the profeſſor of Reggio to a reperuſal of what he had written; but he proved to the other, that we in common practice always ſee that which has been *well obſerved*, but that we never again ſee that which we have been contented with *imagining we ſaw*.

Spallanzani has received much praiſe for the politeneſs with which he carried on this controverſy, and for the ſevere logic with which he demonſtrates to Needham the cauſes of his error; and proves, that the animalculæ of infuſions are produced by germs; that there are ſome of them which defy, like certain eggs and ſeeds, the moſt exceſſive cold, as well as the heat of boiling water. On this occaſion, he treats on the influence of cold upon animals, and proves that the lethargic numbneſs of ſome, during winter, does not depend upon the impreſſion the blood may receive from it; ſince a frog, deprived of his blood, becomes lethargic when he is reduced to the ſame cold ſtate by an immerſion in ice, and ſwims as before when reſtored to warmth. In the ſame manner he ſhews that odours, various liquors, the vacuum, act upon animalculæ as upon other animals; that they are oviparous, viviparous, and hermaphrodite. Thus, in running over theſe diſtant regions of Nature with this illuſtrious traveller, we are always meeting with new facts, profound remarks, precious details, and ſome curious anecdotes; in ſhort, an univerſal hiſtory of thoſe beings which are the moſt numerous of the globe, although their exiſtence is ſcarcely ſuſpected, and whoſe organization is in many reſpects different from that of known animals.

The ſecond volume of this work is a new voyage into the moſt unknown parts: a ſublime pencil had already painted it, but the picture was not done after Nature. Spallanzani here gives a hiſtory of the ſpermatic animalculæ, which the eloquent hiſtorian above alluded to always confounds with the animalculæ of infuſions. We cannot but admire the modeſt diffidence of this new demonſtrator, ſtruggling againſt his own opinion and the authority of Buffon; and he appears to admit, with repugnance, the reſults of his multiplied, and in a thouſand ways varied, obſervations, which expoſe the feebleneſs of the ſyſtem of organic moleculæ.

Spallanzani afterwards deſcribes the volvox and the ſlow-moving animalculæ *(rotifère* and *tardigrade)*, thoſe coloſſuſes of the microſcopic world, ſo ſingular by their figure and organization, but more ſingular ſtill by their faculty of reſuming life, after a total ſuſpence of all the apparent acts of it during many years.

We will not here ſpeak of the experiments of Spallanzani on the death of animals in cloſe veſſels, becauſe he took up the ſubject again, and enlarged and exemplified it by the new lights of chemiſtry; but this collection

lection he concludes with another on the hiſtory of vegetable mould growing on the ſurface of liquors and moiſt ſubſtances, the ſeeds of which he ſhews to float in the air; and he remarks, that theſe microſcopic champignons or muſhrooms diſtinguiſh themſelves from other plants by their tendency to grow in all directions, without conforming to the almoſt univerſal law of perpendicularity of ſtalk to the ground.

Spallanzani was placed at the head of the univerſity's cabinet of natural hiſtory, but he was little more than titular depoſitary of a treaſure which no longer exiſted. He laid the foundations, however, for its renewal, and by his care it is become one of the moſt precious and uſeful. He enriched it through his repeated travels by land and ſea, in Europe, in Aſia, acroſs the Apennines, the Alps, the Krapacks, at the bottom of mines, on the top of volcanoes, at the mouth of craters: ſupported by his ardent paſſion in the midſt of perils, he preſerved the *ſang-froid* of the philoſopher to contemplate theſe wonders, and the piercing eye of an obſerver to ſtudy them. It is thus that he always diſtinguiſhed the proper objects for improving ſcience by favouring inſtruction; it is thus that he filled this depoſitary with treaſures, that all the gold in the world could not have obtained, becauſe gold never ſupplies the genius and the diſcernment of the enlightened naturaliſt.

In 1779 Spallanzani ran over Switzerland and the Griſons; he then went to Geneva, where he ſpent a month with his friends, who admired him the more in his converſations after having admired him in his writings. He then returned to Pavia, and publiſhed, in 1780, two new volumes of his *Diſſertazione di Fiſica Animale e Vegetabile.* He therein reveals the ſecrets of the interpretation of two very obſcure phenomena, concerning the vegetable and animal economy.

Some experiments made by Spallanzani upon *digeſtion*, for his leſſons, engaged him to ſtudy this dark operation: he repeated Reaumur's experiments upon the gallinaceous birds; and he obſerved that the trituration, which is in this caſe an aid to digeſtion, could not, however, be a very powerful means. He ſaw that the gizzard of thoſe birds which pulveriſe the ſtones of fruit to pieces, as if done with needles or other ſharp-pointed inſtruments, did not digeſt the powder ſo formed: that it was neceſſary it ſhould undergo a new operation in the ſtomach, before it could become fit chyle for affording the elements of the blood and other humours. He eſtabliſhed the point, that the digeſtion was performed in the ſtomach of numerous animals by the powerful action of a juice which diſſolves the aliments; and to render his demonſtration the more convincing, he had the courage to make ſeveral experiments on himſelf which might have proved fatal, and had the addreſs to complete his proofs by artificial digeſtions, made in glaſſes upon the table, by mixing the chewed aliments with the gaſtric juice of animals, which he knew how to extract from their ſtomachs. But this book, ſo original by the multitude of experiments and curious obſervations which it contains, is ſtill more worthy of attention by the philoſophic ſpirit which detected it.

This ſubject is one of the moſt difficult in phyſiology: the obſerver is always compelled to act and to look with darkneſs around him; he is obliged to manage the animal with care, to avoid the derangement of his operations; and when he has laboriouſly completed his experiments, it is neceſſary that he ſhould well diſtinguiſh the conſequences, ſometimes erroneous, which may be drawn from thoſe of obſervation, which never deceive when they are immediate. Spallanzani, in this work, is truly a fine ſpectacle; ſcrupulouſly analyſing the facts in order to diſcover their cauſes with certainty; inventing happy reſources for ſurmounting the obſtacles which renew themſelves; comparing Nature with his experiments, to judge of them; catching hold in his obſervations of every thing that is eſſential in them; meaſuring their ſolidity by the augmentation or diminution of ſuppoſed cauſes; drawing the beſt-founded concluſions, and rejecting the moſt plauſible hypotheſes; modeſtly expoſing the errors of thoſe who have gone before him, and employing analogy with that wiſe circumſpection which inſpires confidence in an inſtrument at once ſo dangerous and ſo uſeful. But let it be known, Spallanzani had a capacity in particular for diſcovering the truth, while the greater part of obſervators ſcarcely ever attain it; and then, after having deſcribed around them a circuitous trace, he runs upon it by a ſtraight line, and poſſeſſes himſelf of it ſo as that it cannot eſcape him.

This work put John Hunter out of humour; and he publiſhed, in 1785, *Some Obſervations upon Digeſtion*, wherein he threw out ſome bitter ſarcaſms againſt Spallanzani; who took ample revenge by publiſhing this work in Italian, and addreſſing to *Caldani*, in 1788, *Una Lettera Apologetica in Riſpoſta alle Oſſervazione del Signor Giovanni Hunter.* He expoſes, with moderation, but with an irreſiſtible logic, the overſights of the Engliſh phyſiologiſt, and points out his errors in a manner which left him no hope of a reply.

The ſecond volume treats of the generation of animals and plants. Spallanzani proves, by experiments as ſatisfactory as they are ſurpriſing, the pre-exiſtence of germs to fecundation; he ſhews the exiſtence of tadpoles in the females of five different ſpecies of frogs, in toads, and in ſalamanders, before their fecundation: he recounts the ſucceſs of ſome artificial fecundations upon the tadpoles of thoſe five ſpecies, and even upon a quadruped. He in the ſame manner ſhews the ſeed in the flowers, before the emiſſion of their farina; and by a ſubtle anatomy of which one can hardly form an idea, he exhibits to the eye in the flower of the *ſpartium junceum*, the ſiliqua, its ſeeds, with their lobes, and the embryo plant; he purſues them in their expanſion before and after fecundation, and leaves not a doubt but that the ſeeds and the pericarpia exiſted long before the bloſſoming of the buds, and conſequently a long time before they could have been fecundated. He has repeated theſe obſervations upon various ſpecies of plants with the ſame reſults; in ſhort, he has raiſed the individuals of plants with female flowers which have borne fecundated ſeeds, although they were out of the reach even of ſuſpicion of a communication with the farina of the male flowers. Such is the ſeries of ſurpriſing phenomena Spallanzani adds to the hiſtory of Nature.

According to cuſtom, he availed himſelf of the academical vacation of 1781, to make a journey, the object of which was to add to the cabinet of Pavia. He ſet out in the month of July for Marſeilles, where he commenced a new hiſtory of the ſea, which had preſented him with a crowd of novel and curious facts up-

Spallanzani.

on numerous genera of the inhabitants of the ocean. He went likewiſe to Finale, to Genoa, to Maſſa, and to Carrara, to obſerve the quarries of marble ſo famous with the ſtatuaries; he returned to Spezzia, and thence brought to Pavia an immenſe harveſt of fiſhes, cruſtaceous and teſtaceous, which he depoſited in that cabinet of which his voyages and travels had rendered him ſo worthy to be the guardian. He viſited, in the ſame view, and with the ſame ſucceſs, the coaſts of Iſtria in 1782; the Apennine Mountains in 1783, where he noticed the terrible hurricanes, and the ſurpriſing vapours which rendered that year ſo famous in meteorology. The cabinet of Pavia thus every year ſaw its riches increaſe; and in the ſame proportion it became the object of ſtrangers admiration; but every one admired ſtill more the immenſe labour of Spallanzani, who had collected every part of it.

The Emperor Joſeph knew this when he came into Lombardy: he deſired to have a converſation with Spallanzani; and his majeſty expreſſed his approbation by preſenting him with his medal in gold.

The univerſity of Padua offered to Spallanzani, in 1785, the chair of natural hiſtory, which the death of Anthony Valliſneri had left vacant, promiſing him more conſiderable advantages than thoſe which he enjoyed at Pavia; but the archduke doubled his penſion, and allowed him to accompany to Conſtantinople the Chevalier Zuliani, who had juſt been nominated ambaſſador from the republic of Venice.

He left this city the 21ſt of Auguſt; and during his voyage made ſeveral obſervations upon the marine productions he met with in thoſe climates, as well as upon the meteorological events of every day, among which he had the advantage of beholding a ſpecies of waterſpout. He touched at ſeveral iſlands in the Archipelago, which he examined, and went aſhore at Troy to viſit the places ſung by the poet whom he preferred to all others; and in treading upon that ground ſo anciently famous, he made ſome geological obſervations truly original. One may judge before hand of the intereſt we ſhall feel in reading the Voyage of Spallanzani, by ſome memoirs which have appeared in the *Memorie della Societa Italiana* upon the water-ſpouts at ſea, the ſtroke of the torpedo, divers marine productions, and the iſland of Cytherea, where he diſcovered a mountain compoſed of various ſpecies of foſſils. Spallanzani arrived at Conſtantinople the 11th of October, and remained there eleven months: he muſt have been greatly out of his element in that country of ignorance and ſuperſtition, if he had not had Nature to ſtudy, and Zuliani to hear him. The phyſical and moral phenomena of this country, quite new to him, fixed his attention; he ſtrayed over the borders of the two ſeas, and climbed up the neighbouring hills; he viſited the iſland of Chalki, where he made known to the Turks a mine of copper, the exiſtence of which they never ſo much as ſuſpected. He went to the Principi iſland, a few miles diſtant from Conſtantinople, where he diſcovered an iron mine equally unthought of by the Turks. He returned to Europe loaded with ſpoils from the Eaſt, compoſed of the creatures of the three kingdoms, peculiar to thoſe regions: after having been uſeful to the Orientals, who were incapable of appreciating his merit, or rather of imagining he could have any, he ſet out on his return for Italy the 16th of Auguſt, 1786.

A voyage by ſea was in every reſpect the moſt ſafe and the moſt commodious; but Spallanzani conſidered the dangers and the inconveniences of the road as nothing when employed in any beneficial purſuit; he braved all the perils of thoſe deſert regions, where there is no police, no ſecurity. When he arrived at Buchareſt, he was retained there during nine days by the celebrated and unhappy Mauroceni, hoſpodar of Walachia. This prince, the friend of ſcience, received him with diſtinction, preſented him with many of the rarities of his country, furniſhed him with horſes for travelling, and alſo gave him an eſcort of thirty troopers throughout the whole extent of his dominions. Spallanzani paſſed by Hermanſtadt in Tranſylvania, and arrived at Vienna the 7th of December, after having viewed the numerous mines of Tranſylvania, of Hungary, and of Germany, which lay in the neighbourhood of his route. Spallanzani remained five days in this capital of Auſtria; he had two very long audiences with the Emperor Joſeph II.; was well received by the higheſt nobility in that metropolis, and viſited by the men of letters. At length arrived at Pavia; the ſtudents came to meet him out of the gates of the city, and accompanied him home, manifeſting their joy all the way by repeated ſhouts. Their great deſire to hear him, drew him almoſt immediately to the auditory, where they forced him to aſcend the chair from which he had been accuſtomed to deliver his lectures to them. Spallanzani, affected by this ſcene, teſtified with eloquence his gratitude and attachment;—friendly wiſhes, cries of joy, clapping of hands, recommenced with more force, and he was obliged to requeſt them to deſiſt, and allow him to take in his houſe that repoſe which was more neceſſary than ever. He had in the courſe of this year above 500 ſtudents.

Spallanzani had acquired glory enough to merit the attacks of envy; but his diſcoveries were too new, too original, too ſolid to be diſputed; envy itſelf was therefore forced to admire him: but that unworthy paſſion, being tired out by the increaſing reputation of that great man, watched the moment to prove that it had not forgotten him. Envy and malignity then called in queſtion his uprightneſs in the adminiſtration of the cabinet of Pavia; the whole of which was the fruit of his own labours: but the darts aimed at his honour only made it ſhine with new luſtre. The integrity of Spallanzani appeared even more pure after the juridical examination of the tribunals. But let us ſtop here; Spallanzani had the fortitude to forget this event which had torn his heart to pieces; the greater part of his enemies acknowledged their miſtake, abjured their hatred, and did not deſpair of regaining his friendſhip.

The cabinet of Pavia was always the object of Spallanzani's thoughts; amidſt the numerous rarities which he had placed there, he only ſaw thoſe that were wanting. Struck with its deficiency in volcanic matters, which had neither ſeries nor order, and conſequently excited little intereſt, being a mute article with reſpect to inſtruction (although Italy was the theatre where the fires of volcanoes had for ſo many ages exerciſed their deſolating powers), he took the reſolution, with which his talents, his courage, and his zeal, inſpired

him

him. He was deſirous to inſtruct his pupils, his nation, himſelf, concerning the phenomena ſo ſtriking, and yet ſo little known, and to collect the documents of their hiſtory in the places where they have always been the terror of thoſe who ſurrounded them, and where they have been uſeleſsly the ſubject of the obſervations of the philoſopher. He therefore prepared himſelf for this great enterpriſe by deep ſtudies. He ſet out for Naples, in the ſummer of 1788, and aſcended mount Veſuvius; he looked attentively into its crater, examined and made notes in his books, and embarked for the Lipari iſlands. He diſſected, as it were, the uninhabited volcanoes, with the exactneſs of a naturaliſt anatomiſing a butterfly, and the intrepidity of a warrior defying the moſt imminent dangers. It was then that he had the boldneſs to walk over that ſulphurous cruſt, cleft with chinks, trembling, ſmoking, burning, and ſometimes treacherouſly covering the hearth of the volcano. He paſſed into Sicily, where he climbed up to Etna, and coaſted its immenſe crater. His curioſity not being exhauſted, he would collect around him, and have in his mind, all the ſingular phenomena that Sicily contained; he examined the ſtones and the mountains, and diſcovered many new marine animals; he approached Scylla and Charybdis, and in a boat croſſed the frothy billows of thoſe deadly rocks, celebrated for ſo many ſhipwrecks, and ſo often ſung by the poets; but in the very midſt of their frightful waves, he diſcovered the cauſe of their fury (See SCYLLA, *Suppl.*) It was thus that, at the age of 60, he picked up thoſe numberleſs anecdotes which fill his voyages in the two Sicilies; and that he compared the deſcription which Homer, Pindar, Virgil, Diodorus Siculus, and Strabo, have given of theſe ever famous places, with that which he made himſelf. In this manner he ſhewed the connection of ancient literature with natural hiſtory.

We find in the voyages of Spallanzani a new volcanology. He therein teaches the way to meaſure the intenſity of the fire of volcanoes, to glance at the cauſes, to touch almoſt, in the analyſis which he makes of the lava, that particular gas which, reſembling a powerful lever, tears from the bowels of the earth, and raiſes up to the top of Etna, thoſe torrents of ſtone in fuſion which it diſgorges; to ſurvey the nature of thoſe pumice ſtones, which he has ſince explained in his artificial pumice-ſtones. He concludes this charming work with ſome intereſting inquiries into the nature of ſwallows, their mild diſpoſitions, rapid flight; ſuggeſting that an advantage might be drawn from them in the way of aerial poſt; their migrations determined by the temperature of the air, and the birth of inſects it occaſions: in ſhort, he diſcuſſes the famous problem of their remaining benumbed during winter; and proves, that artificial cold, much greater than that ever naturally felt in our climates, does not render theſe birds lethargic. He next ſpeaks of a ſpecies of owl, hitherto very ill deſcribed; and, laſtly, of eels and their generation, which is a problem ſtill in ſome meaſure to be ſolved; but he carries it on by his inquiries to that ſtep which alone remains to be made for obtaining a complete ſolution; or to get over it eaſily by a ſmall number of obſervations in thoſe times and places pointed out, but which the academical occupations of Spallanzani forced him to give up to others.

Spallanzani.

Spallanzani followed the progreſs of the French chemiſtry with much ſatisfaction, nor was he long before he adopted it; it was calculated for a juſt conception like his, delighting to give an account of every phenomenon he obſerved. The ſolidity of principles in this new doctrine, the preciſion in its way of proceeding, the elegance of its interpretation, the generality of its conſequences, preſently replaced in his mind the heſitations and the obſcurities of the ancient chemiſtry; and his heart anticipated with pleaſure the triumphs that it was about to obtain.

In 1791, Spallanzani publiſhed a letter addreſſed to Profeſſor Fortis, upon the Pennet Hydroſcope. He there relates the experiments which he had directed to be made for aſcertaining the degree of confidence which might be allowed to the ſingular talents of this man; but he ingenuouſly confeſſes, that he is not decided upon the reality of the phenomenon.

Spallanzani has often diſcovered that which might have been deemed impoſſible. In 1795 he made a diſcovery of this nature, which he publiſhed in his *Lettere ſopra il ſoſpetto d'un nuovo ſenſo nei Pipiſtrelli.* We therein learn that the bats, if blinded, act in every reſpect with the ſame preciſion as thoſe which have their eyes; that they in the ſame manner avoid the moſt trifling obſtacles, and that they know where to fix themſelves on ceaſing their flight. Theſe extraordinary experiments were confirmed by ſeveral natural philoſophers, and gave occaſion to ſuſpect a new ſenſe in theſe birds, becauſe Spallanzani thought he had evinced by the way of excluſion, that the other ſenſes could not ſupply the deficiency of that ſight which he had deprived them of; but the anatomical details of Profeſſor Jurine, upon the organ of hearing in this ſingular bird, made him incline afterwards towards the idea, that the ſenſe of hearing might in this caſe ſupply that of ſight, as in all thoſe where the bats are in the dark.

Spallanzani concluded his literary carreer for the public, by a letter addreſſed to the celebrated Giobert; *Sopra la piante chiuſe ne' vaſi dentro l'aqua e l'aria, eſpoſte a l' immediàta lume ſolare e a l'ombra.* It is a misfortune for this part of the ſcience, that his death has deprived us of the diſcoveries he was about to make in it.

Theſe numerous works, printed and applauded, did not however contain all the ſeries of Spallanzani's labours. He had been occupied a conſiderable time upon the phenomena of reſpiration; their reſemblances and differences in a great number of ſpecies of animals; and he was buſily employed in reducing to order his reſearches upon this ſubject, which will aſtoniſh by the multitude of unforeſeen and unexpected facts. He has left a precious collection of experiments and new obſervations upon animal reproductions, upon ſponges, the nature of which he determines, and upon a thouſand intereſting phenomena which he knew how to draw out of obſcurity. He had almoſt finiſhed his voyage to Conſtantinople, and had amaſſed conſiderable materials for a Hiſtory of the Sea, when an end was put to his life and his labours.

On the 4th of February 1799, he was ſeized with a retention of urine, the ſame night was unquiet, and in the morning he loſt all powers of reaſon, which he never recovered but during very ſhort intervals. His intimate friends, Tourdes, a French phyſician, and the celebrated Profeſſor Scarpa, did every thing which could be expected from genius, experience, and friendſhip, to ſave him; but he died the 17th, after having edified thoſe around him by his piety. This lamentable event overwhelmed all his family in ſorrow, occaſioned the tears to flow from all his friends, filled his diſciples with a deep affliction, and excited the regret of a nation proud of having given him birth.

The reader cannot but have perceived in this ſketch the ſtrain of panegyric, rather than the calm narrative of impartial biography. It is, in fact, an abridged tranſlation of an *eloge* by a *citizen* philoſopher of Geneva, who has adopted the calendar, and probably the principles of republican France. Some abatement therefore will naturally be made by every Briton of the praiſes beſtowed upon the piety of Spallanzani; but after proper allowance of this kind, truth will proclaim him a very great man. Accordingly, France, Germany, England, all were eager to avail themſelves of his works by means of tranſlations. He was admitted into the academies and learned ſocieties of London, Stockholm, Gottingen, Holland, Lyons, Bologna, Turin, Padua, Mantua, and Geneva. He was a correſpondent of the academy of ſciences of Paris and of Montpelier: and received from the great Frederic himſelf the diploma of member of the academy of Berlin.

SPECIES, in algebra, are the letters, ſymbols, marks, or characters, which repreſent the quantities in any operation or equation.

Species, in optics, the image painted on the retina by the rays of light reflected from the ſeveral points of the ſurface of an object, received in by the pupil, and collected in their paſſage through the cryſtalline, &c.

SPECTACLES (See *Encycl.*) are certainly the moſt valuable of all optical inſtruments, though there is not the ſame ſcience and mechanical ingenuity diſplayed in the making of them as in the conſtruction of microſcopes and teleſcopes. A man, eſpecially if accuſtomed to ſpend his time among books, would be much to be pitied, when his ſight begins to fail, could he not, in a great meaſure, reſtore it by the aid of ſpectacles; but there are ſome men whoſe ſight cannot be aided by the uſe either of convex or concave glaſſes. The following method adopted by one of thoſe to aid his ſight is certainly worthy of notice:

When about ſixty years of age, this man had almoſt entirely loſt his ſight, ſeeing nothing but a kind of thick miſt, with little black ſpecks which appeared to float in the air. He knew not any of his friends, he could not even diſtinguiſh a man from a woman, nor could he walk in the ſtreets without being led. Glaſſes were of no uſe to him; the beſt print, ſeen through the beſt ſpectacles, ſeemed to him like a daubed paper. Wearied with this melancholy ſtate, he thought of the following expedient.

He procured ſome ſpectacles with very large rings; and, taking out the glaſſes, ſubſtituted in each circle a conic tube of black Spaniſh copper. Looking through the large end of the cone he could read the ſmalleſt print placed at its other extremity. Theſe tubes were of different lengths, and the openings at the end were alſo of different ſizes; the ſmaller the aperture the better could he diſtinguiſh the ſmalleſt letters; the larger the aperture the more words or lines it commanded; and conſequently the leſs occaſion was there for moving the head and the hand in reading. Sometimes he uſed one eye, ſometimes the other, alternately relieving each, for the rays of the two eyes could not unite upon the ſame object when thus ſeparated by two opaque tubes. The thinner theſe tubes, the leſs troubleſome are they. They muſt be totally blackened within ſo as to prevent all ſhining, and they ſhould be made to lengthen or contract, and enlarge or reduce the aperture at pleaſure.

When he placed convex glaſſes in theſe tubes, the letters indeed appeared larger, but not ſo clear and diſtinct as through the empty tube: he alſo found the tubes more convenient when not fixed in the ſpectacle rings; for when they hung looſely they could be raiſed or lowered with the hand, and one or both might be uſed as occaſion required. It is almoſt needleſs to add, that the material of the tubes is of no importance, and that they may be made of iron or tin as well as of copper, provided the inſides of them be ſufficiently blackened. See *La Nouvelle Bigarure* for February 1754, or *Monthly Magazine* for April 1799.

SPECTRE of the Broken, a curious phenomenon obſerved on the ſummit of the *Broken*, one of the Harz mountains in Hanover. We have the following account of it by M. Haue. "After having been here (ſays he) for the thirtieth time, and having procured information reſpecting the abovementioned atmoſpheric phenomenon, I was at length, on the 23d of May 1797, ſo fortunate as to have the pleaſure of ſeeing it; and perhaps my deſcription may afford ſatisfaction to others who viſit the Broken through curioſity. The ſun roſe about four o'clock, and, the atmoſphere being quite ſerene towards the eaſt, his rays could paſs without any obſtruction over the Heinrichſhöhe. In the ſouth-weſt, however, towards Achtermannſhöhe, a briſk weſt wind carried before it thin tranſparent vapours, which were not yet condenſed into thick heavy clouds.

"About a quarter paſt four I went towards the inn, and looked round to ſee whether the atmoſphere would permit me to have a free proſpect to the ſouth-weſt; when I obſerved, at a very great diſtance towards Achtermannſhöhe, a human figure of a monſtrous ſize. A violent guſt of wind having almoſt carried away my hat, I clapped my hand to it by moving my arm towards my head, and the coloſſal figure did the ſame.

"The pleaſure which I felt on this diſcovery can hardly be deſcribed; for I had already walked many a weary ſtep in the hopes of ſeeing this ſhadowy image, without being able to gratify my curioſity. I immediately made another movement by bending my body, and the coloſſal figure before me repeated it. I was deſirous of doing the ſame thing once more—but my coloſſus had vaniſhed. I remained in the ſame poſition, waiting to ſee whether it would return; and in a few minutes it again made its appearance on the Achtermannſhöhe. I paid my reſpects to it a ſecond time, and it did the ſame to me. I then called the landlord of the Broken; and having both taken the ſame poſition which I had taken alone, we looked towards the Achtermannſhöhe, but ſaw nothing. We had not, however, ſtood long, when two ſuch coloſſal figures were formed over the above eminence, which repeated our compliments by bending their bodies as we did; after which they vaniſhed. We retained our poſition; kept our eyes fixed on the ſame ſpot, and in a little the two figures again ſtood before us, and were joined by a third. Every movement that we made by bending our bodies theſe figures imitated—but with this difference, that the phenomenon was ſometimes weak and faint, ſometimes ſtrong and well defined. Having thus had an opportunity of diſcovering the whole ſecret of this phenomenon, I can give the following information to ſuch of my readers as may be deſirous of ſeeing it themſelves. When the riſing ſun, and according to analogy the caſe will be the ſame at the ſetting ſun, throws his rays over the Broken upon the body of a man ſtanding oppoſite to fine light clouds floating around or hovering paſt him, he needs only fix his eyes ſtedfaſtly upon them, and, in all probability, he will ſee the ſingular ſpectacle of his own ſhadow extending to the length of five or ſix hundred feet, at the diſtance of about two miles before him."

If our memory does not deceive us, there is in one of the volumes of the *Mancheſter Tranſactions* an account of a ſimilar phenomenon obſerved by Dr Ferrier, on a hill ſomewhere in England.

SPECULUM for reflecting teleſcopes. Under this title (*Encycl.*) we have given the compoſition of the mixt metal of which it has been found by experience that the beſt ſpeculums are made; we have likewiſe given, under the ſame title, ſome directions for caſting ſpeculums: but owing to a circumſtance in which the public can take no intereſt, we neglected to give directions for grinding and poliſhing them, and omitted ſome other circumſtances, which, though not ſo important as theſe, are certainly worthy of notice. Theſe omiſſions it is the object of this article to ſupply.

When the metal is taken out of the flaſks (See n° 3. of the article referred to), which it ſhould be as ſoon as it has become ſolid, and while it is yet red-hot, care muſt be taken to keep the face downwards to prevent it from ſinking. Holding it in that poſition by the git, force out the ſand from the hole in the middle of the mirror with a piece of wood or iron, and place the ſpeculum in an iron pot, with a large quantity of hot aſhes or ſmall coals, ſo as to bury the ſpeculum in them a ſufficient depth. If the ſand is not forced out of the hole in the manner above directed, the metal, by ſinking as it cools, will embrace the ſand in the middle of the ſpeculum ſo tight, as to cauſe it to crack before it becomes entirely cold. And if the metal is not taken out of the ſand, and put in a pot with hot aſhes or coals to anneal it, the moiſture from the ſand will always break the metal. Let the ſpeculum remain in the aſhes till the whole is become quite cold. The git may be eaſily taken off by marking it round with a common fine half round file, and giving it then a gentle blow. The metal is then to be rough ground and figured.

It may be proper, however, before we proceed to deſcribe that proceſs, to give an account of another compoſition for the ſpeculum of a reflecting teleſcope, which has been employed with great ſucceſs, by Rochon director of the marine obſervatory at Breſt. Of this compoſition the principal ingredient is platinum; which, in grains, muſt be purified in a ſtrong fire by means of nitre and the ſalt of glaſs, or that flux which in the Engliſh glaſs-houſes is called by the workmen *ſandifer*. To the platinum, when purified, add the eighth part of the metal employed in the compoſition of common ſpecula; for tin without red copper would not produce a good effect. This mixture is then to be expoſed to the moſt violent heat, which muſt be ſtill excited by the oxygen gas that diſengages itſelf from nitre when thrown into the fire. One melting would be inſufficient: five or ſix are requiſite to bring the mixture to perfection. It is neceſſary that the metal ſhould be in a ſtate of complete fuſion at the moment when it is poured into the mould. By this proceſs I have been enabled (ſays our author) to conſtruct a teleſcope with platinum, which magnifies the diameters of objects five hundred times, with a degree of clearneſs and diſtinctneſs requiſite for the niceſt obſervations. The large ſpeculum of platinum weighs fourteen pounds: it is eight inches in diameter, and its focus is ſix feet. Though the high price of platinum will, in all probability, for ever prevent it from coming into general uſe for the ſpeculums of teleſcopes, we thought it proper to notice this diſcovery, and ſhall now proceed to the grinding of the ſpeculum.

For the accompliſhing of this object, a very complicated proceſs is recommended in Smith's Optics, and one not much more ſimpler by Mr Mudge in the 67th volume of the *Philoſophical Tranſactions*; but according to Mr Edwards, whoſe ſpeculums are confeſſedly the beſt, neither of theſe is neceſſary. Beſides a common grindſtone, all the tools that he made uſe of are a rough grinder, which ſerves alſo as a poliſher, and a bed of hones. When the ſpeculum was cold, he ground its ſurface bright on a common grindſtone, previouſly brought to the form of the gage; and then took it to the rough grinder.

This tool is compoſed of a mixture of lead and tin, or of pewter, and is made of an elliptical form, of ſuch dimenſions, that the ſhorteſt diameter of the ellipſe is equal to the diameter of the mirror or ſpeculum, and the longeſt diameter is to the ſhorteſt in the proportion of ten to nine. This rough grinder may be fixed upon a block of wood, in order to raiſe it higher from the bench; and as the metal is ground upon it with fine emery, Mr Mudge, with whom, in this particular, Mr Edwards agrees, directs a hole or pit to be made in the middle of it as a lodgement for the emery, and deep grooves to be cut out acroſs its ſurface with a graver for the ſame purpoſe. By means of a handle, fixed on the back of the metal with ſoft cement, the ſpeculum can be whirled round upon this grinder ſo rapidly, that a common labourer has been known to give a piece of metal, four inches in diameter, ſo good a face and figure as to fit it for the hones in the ſpace of two hours. The emery, however fine, will break up the metal very much; but that is remedied by the ſubſequent proceſſes of honing and poliſhing.

When the metal is brought to a true figure, it muſt be taken to a convex tool, formed of ſome ſtones from a place called Edgedon in Shropſhire, ſituated between Ludlow and Biſhop's Caſtle. The common blue hones, uſed by many opticians for this purpoſe, will ſcarcely touch the metal of Mr Edwards's ſpeculums; but where they muſt be employed for want of the others, as little water ſhould be uſed as poſſible when the metal is put upon them; becauſe it is found by experience that they cut better when but barely wet, than when drenched with water. The ſtones, however, from Edgedon are greatly preferable; for they cut the metal more eaſily, and having a very fine grain, they bring it to a ſmooth face. Theſe ſtones are directed by Mr Mudge to be cemented in ſmall pieces upon a thick round piece of marble, or of metal made of tin and lead like the former compoſition, in ſuch a manner, that the lines between the ſtones may run ſtraight from one ſide to the other; ſo that placing the teeth of a very fine ſaw in each of theſe diviſions, they may be cleared from one end to the other of the cement which riſes between the ſtones. As ſoon as the hones are cemented down, this tool muſt be fixed in the lathe, and turned as exactly true to the gage as poſſible. It ſhould be of a circular figure, and but very little larger than the metal intended to be figured upon it. If it be made conſiderably larger, it will grind the metal into a larger ſphere and a bad figure; and if it be made exactly of the ſame ſize, it will work the metal indeed into a figure truly ſpherical, but will be apt to ſhorten its focus, unleſs the metal and tool be worked alternately upwards. On theſe accounts, Mr Edwards recommends it to be made about one twentieth part longer in diameter than the ſpeculum, becauſe he has found that it does not then alter its focus; and he earneſtly diſſuades the uſe of much water on the hone pavement at the time of uſing it, otherwiſe, he ſays, that the metal in different parts of it will be of different degrees of brightneſs.

When the metal is brought to a very fine face and figure by the bed of ſtones, it is ready to receive a poliſh, which is given to it by the elliptical rough grinder covered with pitch. With reſpect to the conſiſtency of this pitch, Mr Mudge and Mr Edwards give very different directions. Whilſt the former ſays that it ſhould be neither too hard nor too ſoft, the latter affirms that the harder the pitch is, the better figure it will give to the metal. Pitch may be eaſily made of a ſufficient hardneſs by adding a proper quantity of roſin; and when it is hardened in this way, it is not ſo brittle as pitch alone, which is hardened by boiling. Mr Edwards adviſes to make the mixture juſt ſo hard as to receive, when cold, an impreſſion from a moderate preſſure of the nail of one's finger. When the elliptical tool is to be covered with this mixture, it muſt be made pretty warm, and in that ſtate have the mixture poured upon it when beginning to cool in the crucible. Our author recommends this coating to be made everywhere of about the thickneſs of half-a-crown; and to give it the proper form, it muſt, when ſomewhat cool, be preſſed upon the face of the mirror, which has firſt been dipped in cold water, or covered over with very fine writing paper. If it be not found to have taken the exact figure from the firſt preſſure, the ſurface of the pitch muſt be gently warmed, and the operation repeated as before. All the ſuperfluous pitch is now to be taken away from the edge of the poliſher with a pen knife, and a hole to be made in the middle, accurately round, with a conical piece of wood. This hole ſhould go quite through the tool, and ſhould be made of the ſame ſize, or ſomewhat leſs than the hole in the middle of the ſpeculum. Mr Edwards ſays, that he has always found that ſmall mirrors, though without any hole in the middle, poliſh much better, and take a more correct figure, for the poliſher's having a hole in the middle of it.

The poliſher being thus formed, it muſt be very gently warmed at the fire, and divided into ſeveral ſquares by the edge of a knife. Theſe, by receiving the ſmall portion of metal that works off in poliſhing, will cauſe the figure of the ſpeculum to be more correct than if no ſuch ſquares had been made. Mr Mudge directs the poliſher to be ſtrewed over with very fine *putty*; but Mr Edwards prefers Colcothar of vitriol. (See that article, *Encycl.*) Putty (ſays he) gives metals a white luſtre, or, as workmen call it, a ſilver hue; but good colcothar of vitriol will poliſh with a very fine and high black luſtre, ſo as to give the metal finiſhed with it the complection of poliſhed ſteel. To know if the colcothar of vitriol is good, put ſome of it into your mouth, and if you find it diſſolves away it is good; but if you find it hard, and crunch between your teeth, then it is bad, and not well burned. Good colcothar of vitriol is of a deep red, or of a deep purple colour, and is ſoft and oily when rubbed between the fingers; bad colcothar of vitriol is of a light red colour, and feels harſh and gritty. The colcothar of vitriol ſhould be levigated between two ſurfaces of poliſhed ſteel, and wrought with a little water; when it is worked dry, you may add a little more water, to carry it lower down to what degree you pleaſe. When the colcothar of vitriol has been wrought dry three or four times, it will acquire a black colour, and will be low enough, or ſufficiently fine, to give an exquiſite luſtre. This levigated colcothar of vitriol muſt be put into a ſmall phial, and kept with ſome water upon it. When it is to be uſed, every part of the pitch-poliſher muſt be firſt bruſhed over with a fine camel's hair bruſh, which has been dipped in pure water, and rubbed gently over a piece of dry clean ſoap. The waſhed colcothar of vitriol is then to be put upon the poliſher; and Mr Edwards directs a large quantity of it to be put on at once, ſo as to ſaturate the pitch, and form a fine coating. If a ſecond or third application of this powder be found neceſſary, it muſt be uſed very ſparingly, or the poliſh will be deſtroyed which has been already attained. When the metal is nearly poliſhed, there will always appear ſome black mud upon its ſurface, as well as upon the tool. Part of this muſt be wiped away with ſome very ſoft waſh leather; but if the whole of it be taken away, the poliſhing will not be ſo well completed.

With reſpect to the *parabolic figure* to be given to the mirror, Mr Edwards aſſures us, that a very little experience in theſe matters will enable any one to give it with certainty, by poliſhing the ſpeculum in the common manner, only with croſs ſtrokes in every direction, upon an elliptical tool of the proper dimenſions.

SPINDLE, in geometry, a ſolid body generated by the revolution of ſome curve line about its baſe or double ordinate; in oppoſition to a conoid, which is generated by the rotation of the curve about its axis or abſciſs, perpendicular to its ordinate. The ſpindle is denominated circular, elliptic, hyperbolic, or parabolic, &c. according to the figure of its generating curve.

Spindle, in mechanics, ſometimes denotes the axis of a wheel, or roller, &c. and its ends are the pivots.

SPINNING machine. The ancient Greeks were not, like the modern philoſophers, unwilling to acknowledge their obligations to Providence for all the comforts and enjoyments of life, nor felt pride in deriving every thing from their own talents. They were even diſpoſed to think that thoſe very talents were inſpired. Their firſt inſtructors, the poets, gave to Apollo the honour of that power of invention and imagination by which they inſtructed and charmed their admiring hearers. The propheteſs dictated her oracles,

Sp ing-
M hine.

the poet ſung his enraptured ſtrain only when inſpired. The happy thought of twining a thread, and working it into a blanket, when viewed by that ingenious and acutely ſenſible people in all its importance, as the protector of the human race from the ſeverity of the weather, ſeemed a preſent from heaven, as the inſpiration of a divinity; and the diſtaff and the loom were Minerva's firſt title to a ſeat among the great gods on Olympus.

We are much inclined to be of the ſame opinion. When we obſerve, that in all the countries which have been diſcovered by the navigators of the three laſt centuries, the diſtaff and ſpindle, and the needle, have been found, we own ourſelves much diſpoſed to think that they are the reſults of inſtinct. Our inſtincts are not all ſimple and blind, like that which directs the new-born animal to the breaſt of its mother without knowing why. We have inſtincts of intellect as well as of appetite; and the logic of common converſation is an example of many ſuch. We doubt not but that the noble-minded inhabitants of Pelew would have worſhipped as a divinity an Engliſh maiden with her ſpinning wheel and fly. Surely he who ſhould carry them this homely but ingenious machine, and a potter's wheel, would do them more ſervice than if he taught them all the ſcience of a Newton, with all the philoſophy of the 18th century into the bargain. We do not know, except perhaps the ſteam engine, any mechanical invention that has made ſuch amazing addition to the activity and induſtry and opulence of this highly favoured iſland, as the invention of Mr Arkwright for ſpinning by water, where dead matter is made to perform all that the niceſt finger can do when directed by the never-ceaſing attention of the intelligent eye. Minerva has the undiſputed honours of the diſtaff and ſpindle. We know not to what benefactor we owe the fly-wheel. Mr Arkwright has the honour of combining them both, and inſpiring them with his own ſpirit; for we may truly ſay of the contrivance which pervades the wonderful machinery of a cotton mill,

Totoſque infuſa per artus
Mens agitat molem et magno ſe corpore miſcet.

To give an intelligible and accurate deſcription of a cotton mill would be abundant employment for a volume. Our limits admit of nothing like this; but as we are certain that many of our readers have viewed a cotton mill with wonder, but not with intelligence, nor with leiſure to trace the ſteps by which the wool from the bag ultimately aſſumes the form of a very fine thread. Bewildered by ſuch a complication of machinery, all in rapid motion, very few, we imagine, are able to recollect with diſtinctneſs and intelligence the eſſential part of the proceſs by which the form of the cotton is ſo wonderfully changed. Such readers will not think a page or two miſemployed, if they are thereby able to underſtand this particular, to which all the reſt of the proceſs is ſubſervient.

We paſs over the operation of carding, by which all the clots and inequalities of the cotton wool are removed, and the whole is reduced to an uniform thin fleece, about 20 inches broad. This is gradually detached from the finiſhing card, and, if allowed to hang down from it, would pile up on the floor as long as the mill continues to work; but it is guided off from the card, very tenderly, in a horizontal direction, by laying its detached end over a roller, which is ſlowly turned round by the machine. Another roller lies above the fleece, preſſing it down by its weight. By this preſſure, a gentle hold is taken of the fleece, and therefore the ſlow motion of the rollers draws it gently from the card at the ſame rate as it is diſengaged by the comb; but between the card and the rollers a ſet of ſmooth pins are placed in two rows, leading from the card to the rollers, and gradually approaching each other as we approach the rollers. By theſe pins the broad fleece is hemmed in on both ſides, and gradually contracted to a thick roll; and in this ſtate paſſes between the rollers, and is compreſſed into a pretty firm flat riband, about two inches broad, which falls off from the rollers, and piles up in deep tinplate cans ſet below to receive it.

Spinning-Machine.

It is upon this ſtripe or riband of cotton wool that the operation of ſpinning begins. The general effect of the ſpinning proceſs is to draw out this maſſive roll, and to twiſt it as it is drawn out. But this is not to be done by the fingers, pulling out as many cotton fibres at once as are neceſſary for compoſing a thread of the intended fineneſs, and continuing this manipulation regularly acroſs the whole end of the riband, and thus, as it were, nibbling the whole of it away. The fingers muſt be directed, for this purpoſe, by an attentive eye. But in performing this by machinery, the whole riband muſt be drawn out together, and twiſted as it is drawn. This requires great art, and very delicate management. It cannot be done at once; that is, the cotton roll cannot firſt be ſtretched or drawn out to the length that is ultimately produced from a tenth of an inch of the roll, and then be twiſted. There is not coheſion enough for this purpoſe; we ſhould only break off a bit of the roll, and could make no farther uſe of it. The fibres of cotton are very little implicated among each other in the roll, becauſe the operation of carding has laid them almoſt parallel in the roll; and though compreſſed a little by its contraction from a fleece of 20 inches to a riband of only 2, and afterwards compreſſed between the diſcharging rollers of the carding machine, yet they cohere ſo ſlightly, that a few fibres may be drawn out without bringing many others along with them. For theſe reaſons, the whole thickneſs and breadth of two or three inches of the riband is ſtretched to a very minute quantity, and then a very ſlight degree of twiſt is given it, viz. about three turns in the inch; ſo that it ſhall now compoſe an extremely ſoft and ſpungy cylinder, which cannot be called a thread or cord, becauſe it has ſcarcely any firmneſs, and is merely rounder and much ſlenderer than before, being ſtretched to about thrice its former length. It is now called ſlab, or roove.

Although it be ſtill extremely tender, and will not carry a weight of two ounces, it is much more coheſive than before, becauſe the twiſt given to it makes all the longitudinal fibres bind each other together, and compreſs thoſe which lie athwart; therefore it will require more force to pull a fibre from among the reſt, but ſtill not nearly enough to break it. In drawing out a ſingle fibre, others are drawn out along with it; and if we take hold of the whole aſſemblage, in two places, about an inch or two inches aſunder, we ſhall find that we may draw it to near twice its length without any riſk of its ſeparating in any intermediate part, or becoming much ſmaller in one part than another. It ſeems to yield equably over all.

Such is the ſtate of the ſlab or roove of the firſt formation. It is uſually called the *preparation*; and the operation of ſpinning is conſidered as not yet begun. This preparation is the moſt tedious and requires more attendance and hand labour than any ſubſequent part of the proceſs. For the ſtripes or ribands from which it is made are ſo light and bulky, that a few yards only can be piled up in the cans ſet to receive them. A perſon muſt therefore attend each thread of ſlab, to join freſh ſtripes as they are expended. It is alſo the moſt important in the manufacture; for as every inch of the ſlab meets with preciſely the ſame drawing and the ſame twiſting in the ſubſequent parts of the proceſs, therefore every inequality and fault in the ſlab (indeed in the fleece as it quits the finiſhing card) will continue through the whole manufacture. The ſpinning of cotton yarn now divides into two branches. The firſt, performed by what are called *jennies*, perfectly reſembles the ancient ſpinning with the diſtaff and ſpindle; the other, called *ſpinning of twiſt*, is an imitation of the ſpinning with the fly-wheel. They differ in the ſame manner as the ſpinning with the old wool or cotton-wheel differs from the ſpinning with the flax-wheel. Mr Arkwright's chief invention, the ſubſtitution of machinery for the immediate work of the human finger, is ſeen only in the manufacture of twiſt. We ſhall therefore confine our attention to this.

The reſt of the proceſs is little more than a repetition of that gone through in making the firſt ſlab or roove. It is formed on bobins. Theſe are ſet on the back part of the drawing frame; and the end of the ſlab is brought forwards toward the attending workman. As it comes forward, it is ſtretched or drawn to about $\frac{4}{3}$ of its former length, or lengthened $\frac{1}{3}$; and is then twiſted about twice as much as before, and in this ſtate wound up on another bobin. In ſome mills two rooves, after having been properly drawn, are brought together through one hole, and twiſted into one; but we believe that, in the greater number of mills, this is deferred to the ſecond drawing. It is only after the firſt drawing that the produce of the operation gets the name of *ſlab*; before this it is called *preparation*, or *roove*, or by ſome other name The ſlab is ſtill a very feeble, ſoft, and delicate yarn, and will not carry much more weight than it did before in the form of roove. The perfection of the ultimate thread or yarn depends on this extreme ſoftneſs; for it is this only which makes it ſuſceptible of an equable ſtretching; all the fibres yielding and ſeparating alike.

The next operation is the *ſecond drawing*, which no way differs from the firſt, except in the different proportions of the lengthening, and the proportion between the lengthening and the ſubſequent twiſt. On theſe points we cannot give any very diſtinct information. It is different in different mills, and with different ſpecies of cotton wool, as may be eaſily imagined. The immediate mechaniſm or manipulation muſt be ſkilfully accommodated to the nature of that friction which the fibres of cotton exert on each other, enabling one of them to pull others along with it. This is greatly aided by the contorted curled form of a cotton fibre, and a conſiderable degree of elaſticity which it poſſeſſes. In this reſpect it greatly reſembles woollen fibres, and differs exceedingly from thoſe of flax: and it is for this reaſon that it is ſcarcely poſſible to ſpin flax in this way: its fibres become lank, and take any ſhape by the ſlighteſt compreſſion, eſpecially when damp in the ſlighteſt degree. But beſides this, the ſurface of a cotton fibre has a harſhneſs or roughneſs, which greatly augments their mutual friction. This is probably the reaſon why it is ſo unfit for tents and other dreſſings for wounds, and is refuſed by the ſurgeon even in the meaneſt hoſpitals. But this harſhneſs and its elaſticity fit it admirably for the manufacture of yarn. Even the ſhortneſs of the fibre is favourable; and the manufacture would hardly be poſſible if the fibre were thrice as long as it generally is. If it be juſt ſo long that in the finiſhed thread a fibre will rather break than come out from among the reſt, it is plain that no additional length can make the yarn any ſtronger with the ſame degree of compreſſion by twining. A longer fibre will indeed give the ſame firmneſs of adherence with a ſmaller compreſſion. This would be an advantage in any other yarn; but in cotton yarn the compreſſion is already as ſlight as can be allowed; were it leſs, it would become woolly and rough by the ſmalleſt uſage, and is already too much diſpoſed to teazle out. It can hardly be uſed as ſewing thread. Now ſuppoſe the fibres much longer; ſome of them may chance to be ſtretched along the ſlab through their whole length. If the ſlab is pulled in oppoſite directions, by pinching it at each end of ſuch fibres, it is plain that it will not ſtretch till this fibre be broken or drawn out; and that while it is in its extended ſtate, it is acting on the other fibres in a very unequable manner, according to their poſitions, and renders the whole apt to ſeparate more irregularly. This is one great obſtacle to the ſpinning of flax by ſimilar machinery; and it has hitherto prevented (we believe) the working up of any thing but the *ſhorts* or tow, which is ſeparated from the long fine flax in the operation of hatcheling.

A third, and ſometimes even a fourth, drawing is given to the ſlab formed on the bobins of this ſecond operation. The ſlab produced is now a ſlender, but ſtill extremely ſoft cord, ſuſceptible of conſiderable extenſion, without riſk of ſeparation, and without the ſmalleſt chance of breaking a ſingle fibre in the attempt. In one or more of the preparatory drawings now deſcribed, two, and ſometimes three ſlabs, of a former drawing, are united before the twiſt is given them. The practice is different in different mills. It is plain, that unleſs great care be taken to preſerve the ſlab extremely ſoft and compreſſible during the whole proceſs, the ſubſequent drawing becomes more precarious, and we run a riſk of at laſt making a bad and looſe thread inſtead of a uniform and ſimple yarn. Such a thread will have very little lateral connection, and will not bear much handling without ſeparating into ſtrands. The perfection of the yarn depends on having the laſt ſlab as free of all appearance of ſtrands as poſſible.

The laſt operation is the ſpinning this ſlab. This hardly differs from the foregoing drawings in any thing but the twiſt that is given it after the laſt ſtretching in its length. This is much greater than any of the preceding, being intended to give the yarn hardneſs and firmneſs, ſo that it will now break rather than ſtretch any more.

The

The reader, moderately acquainted with mechanics, cannot but perceive that each of the operations now deſcribed, by which the roove is changed into the ſoft ſlab, and each of theſe into one ſlenderer and ſomewhat firmer, by alternately teazling out and twining the ſoft cord, is a ſubſtitute for a ſingle pull of the finger and thumb of the ſpinſter, which ſhe accommodates preciſely to the peculiar condition of the lock of wool which ſhe touches at the moment. She can follow this thro' all its irregularities; and perhaps no two ſucceeding plucks are alike. But when we cannot give this momentary attention to every minute portion, we muſt be careful to introduce the roove in a ſtate of perfect uniformity; and then every inch being treated in the ſame manner, the final reſult will be equable—the yarn will be uniform.

We are now to deſcribe the mechaniſm by which all this is effected. But we do not mean to deſcribe a cotton mill; we only mean to deſcribe what comes into immediate contact with the thread; and in ſo doing, to confine ourſelves to what is neceſſary for making the reader perceive its ability to perform the required taſk. We ſee many caſes where individuals can apply this knowledge to uſeful purpoſes. More than this would, we think, be improper, in a national point of view.

Let ABC repreſent the ſection of a roller, whoſe pivot D does not turn in a pivot hole, but in the bottom of a long narrow notch DE, cut in an iron ſtandard. *abc* is the ſection of another iron roller, whoſe pivot *d* is in the ſame notches at each end, while the roller itſelf lies or reſts on the roller ABC below it. The ſurfaces of theſe rollers are fluted lengthwiſe like a column; only the flutings are very ſmall and ſharp, like deep ſtrokes of engraving very cloſe together. It is plain, that if the roller ABC be made to turn ſlowly round its axis by mach[illegible] in the direction ABC (as expreſſed by the da[illegible] roughneſs of the flutings will take hold of the ſimilar roughneſs of the upper roller *abc*, and carry it round alſo in the direction of the dart, while its pivots are engaged in the notches DE, which they cannot quit. If therefore we introduce the end F of the cotton ſtring or riband, formed by the carding machine, it will be pulled in by this motion, and will be delivered out on the other ſide at H, conſiderably compreſſed by the weight of the upper roller, which is of iron, and is alſo preſſed down by a lever which reſts on its pivots, or other proper places, and is loaded with a weight. There is nothing to hinder this motion of the riband thus compreſſed between the rollers, and it will therefore be drawn thro' from the cans. The compreſſed part at H would hang down, and be piled up on the floor as it is drawn thro'; but it is not permitted to hang down in this manner, but is brought to another pair of ſharp fluted iron rollers K and L. Suppoſing this pair of rollers to be of the ſame diameter, and to turn round in the ſame time, and in the ſame direction with the rollers ABC, *abc*; it is plain that K and L drag in the compreſſed riband at I, and would deliver it on the other ſide at M, ſtill more compreſſed. But the roller K is made (by the wheelwork) to turn round more ſwiftly than ABC. The difference of velocity at the ſurface of the rollers is, however, very ſmall, ſeldom exceeding one part in 12 or 15. But the conſequence of this difference is, that the ſkein of cotton HI will be lengthened in the ſame proportion; for the upper rollers preſſing on the under ones with a conſiderable force, their ſharp flutings take good hold of the cotton between them; and ſince K and L take up the cotton faſter than ABC, and *abc* deliver it out, it muſt either be forcibly pulled through between the firſt rollers, or it muſt be ſtretched a little by the fibres ſlipping among each other, or it muſt break. When the extenſion is ſo very moderate as we have juſt now ſaid, the only effect of it is merely to begin to draw the fibres (which at preſent are lying in every poſſible direction) into a more favourable poſition for the ſubſequent extenſions.

The fibres being thus drawn together into a more favourable poſition, the cotton is introduced between a third pair of rollers O, P, conſtructed in the ſame way, but ſo moved by the wheelwork that the ſurface of O moves nearly or fully twice as faſt as the ſurface of K. The roller P being alſo well loaded, they take a firm hold of the cotton, and the part between K and O is nearly or fully doubled in its length, and now requires a little twining to make it roundiſh, and to conſolidate it a little.

It is therefore led ſloping downwards into a hole or eye in the upper pivot of the firſt fly, called a *jack*. This turns round an upright axis or ſpindle; the lower end of which has a pulley on it to give it motion by means of a band or belt, which paſſes round a drum that is turned by the machinery. This jack is of a very ingenious and complicated conſtruction. It is a ſubſtitute for the fly of the common ſpinning wheel. If made preciſely in the form of that fly, the thread, being ſo very bulky and ſpongy, and unable to bear cloſe packing on the bobin, would ſwag out by the whirling of the fly, and would never coil up. The bobin therefore is made to lie horizontally; and this occaſions the complication, by the difficulty of giving it a motion round a horizontal axis, in order to coil up the twiſted roove. Mr Arkwright has accompliſhed this in a very ingenious manner; the eſſential circumſtances of which we ſhall here briefly deſcribe. A is a roller of hard wood, having its ſurface cut into ſharp flutes longitudinally. On the axis, which projects through the ſide of the general frame, there is a pulley P, connected by a band with another pulley Q, turning with the horizontal axis QR. This axis is made to turn by a contrivance which is different in every different cotton mill. The ſimpleſt of all is to place above the pulley C (which is turned by the great band of the machinery, and thus gives motion to the jack), a thin circular diſc D, looſe upon the axis, ſo as to turn round on it without obſtruction. If this diſc exceed the pulley in breadth about $\frac{1}{10}$th of an inch, the broad belt which turns the pulley will alſo turn it; but as its diameter is greater than that of the pulley, it will turn ſomewhat ſlower, and will therefore have a relative motion with reſpect to the axis QR. This can be employed, in order to give that axis a very ſlow motion, ſuch as one turn of it for 20 or 30 of the jack. This we leave to the ingenuity of the reader. The bobin B, on which the roove is to be coiled up, lies on this roller, its pivots paſſing through upright ſlits in the ſides of the general frame. It lies on A, and is moved round by it, in the ſame manner as the uppermoſt of a pair of drawing rollers lies on the under one, and receives motion from it. It is evident that the fluted ſurface of A, by turning ſlowly

ſlowly round, and carrying the weight of the bobin, compreſſes a little the cotton that is between them; and its flutings, being ſharp, take a ſlight hold of it, and cauſe it to turn round alſo, and thus coil up the roove, pulling it in through the hole E in the upper pivot (which reſembles the fore pivot or eye of a ſpinning wheel fly) in ſo gentle a manner as to yield whenever the motion of the bobin is too great for the ſpeed with which the cotton ſkein is diſcharged by the rollers O and P.—*N. B.* The axis QR below, alſo gives motion to a guide within the jack, which leads the roove gradually from one end of the bobin to the other, and back again, ſo as to coil it with regularity till the bobin is full. The whole of this internal mechaniſm of the jack is commonly ſhut up in a tin cylinder. This is particularly neceſſary when the whirling motion muſt be rapid, as in the ſecond and third drawings. If open, the jacks would meet with much reſiſtance from the air, which would load the mill with a great deal of uſeleſs work.

The reader is deſired now to return to the beginning of the proceſs, and to conſider it attentively in its different ſtages. We apprehend that the deſcription is ſufficiently perſpicuous to make him perceive the efficacy of the mechaniſm to execute all that is wanted, and prepare a ſlab that is uniform, ſoft, and ſtill very extenſible; in ſhort, fit for undergoing the laſt treatment, by which it is made a fine and firm yarn.

As this part of the proceſs differs from each of the former, merely by the degree of twiſt that is given to the yarn, and as this is given by means of a fly, not materially different from that of the ſpinning wheel for flax, we do not think it at all neceſſary to ſay any thing more about it.

The intelligent reader is ſurely ſenſible that the yarn produced in this way muſt be exceedingly uniform. The uniformity really produced even exceeds all expectation; for even although there be ſome ſmall inequalities in the carded fleece, yet if theſe are not matted clots, which the card could not equaliſe, and only conſiſt of a little more thickneſs of cotton in ſome places than in others, when ſuch a piece of the ſtripe comes to the firſt roller, it will be rather more ſtretched by the ſecond, and again by the bobin, after the firſt very ſlight twining. That this may be done with greater certainty, the weights of the firſt rooving rollers are made very ſmall, ſo that the middle part of the ſkein can be drawn through, while the outer parts remain faſt held.

We are informed that a pound of the fineſt Bourbon cotton has been ſpun into a yarn extending a few yards beyond 119 miles!

ELATER SPRING, in phyſics, denotes a natural faculty, or endeavour, of certain bodies to return to their firſt ſtate, after having been violently put out of the ſame by compreſſing, or bending them, or the like. This faculty is uſually called by philoſophers *elaſtic force*, or *elaſticity*.

T. SQUARE, or *Tee Square*, an inſtrument uſed in drawing, ſo called from its reſemblance to the capital letter T.

STAPELIA, a genus of plants belonging to the claſs pentandria, in the Linnæan arrangement, and to the order digynia. The generic characters are the following: The *calyx* is monophyllous, quinquefid, acute, ſmall, and permanent. The *corolla* is monopetalous, flat, large, and divided, deeper than the middle, into five parts, with broad, flat, pointed *laciniæ*. The *nectarium* is ſmall, ſtar-ſhaped, flat, quinquefid, with linear *laciniæ*; and embracing with its ragged points the ſeed-forming parts. Another ſmall ſtar, which is alſo flat and quinquefid, covers the ſeminiferous parts with its entire acute *laciniæ*. The *ſtamina* are five in number; the *filaments* are erect, flat, and broad; and the *antheræ* are linear, on each ſide united to the ſide of the filament. The *piſtillum* has two *germina*, which are oval and flat on the inſide. There are no *ſtyles*; and the *ſtigmata* are obſolete. The *ſeed-veſſel* conſiſts of two oblong, awl-ſhaped, unilocular and univalved follicles. The *ſeeds* are numerous, imbricated, compreſſed, and crowned with a *pappus* or down.

This ſingular tribe of plants is peculiar to the ſandy deſerts of Africa and Arabia. They are extremely ſucculent. From this peculiarity of ſtructure, the power of retaining water to ſupport and nouriſh them, they are enabled to live during the prevalent droughts of thoſe arid regions. On this account the ſtapelia has been compared to the camel; and we are told that, by a very apt ſimilitude, it has been denominated "the *camel* of the vegetable kingdom." We muſt confeſs ourſelves quite at a loſs to ſee the propriety or aptitude of this compariſon. In many parts of the animal and vegetable economy there is doubtleſs a very obvious and ſtriking analogy: but this analogy has been often carried too far; much farther than fair experiment and accurate obſervation will in any degree ſupport. It is perhaps owing to this inaccuracy in obſerving the peculiarity of ſtructure and diverſity of functions, that a reſemblance is ſuppoſed to exiſt, as in the preſent caſe, where in reality there is none. The camel is provided with a bag or fifth ſtomach, in addition to the four with which ruminant animals are furniſhed. This fifth ſtomach is deſtined as a reſervoir to contain water; and it is ſufficiently capacious to receive a quantity of that neceſſary fluid, equal to the wants of the animal, for many days: and this water, as long as it remains in the fifth ſtomach, is ſaid to be perfectly pure and unchanged. The *ſtapelia*, and other ſucculent plants, have no ſuch reſervoir. The water is equally, or nearly ſo, diffuſed through the whole plant. Every veſſel and every cell is fully diſtended. But beſides, this water, whether it be received by the roots, or abſorbed from the atmoſphere, has probably undergone a complete change, and become, after it has been a ſhort time within the plant, a fluid poſſeſſed of very different qualities.

The peculiar economy in the ſtapelia, and other ſucculent plants, ſeems to exiſt in the abſorbent and exhalant ſyſtems. The power of abſorption is as much increaſed as the power of the exhalant or perſpiratory veſſels is diminiſhed. In theſe plants, a ſmall quantity of nouriſhment is required. There is no ſolid part to be formed, no large fruit to be produced. They generally have very ſmall leaves, often are entirely naked; ſo that taking the whole plant, a ſmall ſurface only is expoſed to the action of light and heat, and conſequently a much ſmaller proportion of water is decompoſed than in plants which are much branched and furniſhed with leaves.

Two ſpecies of ſtapelia only were known at the beginning of the century. The unfortunate Forſkâl, the companion

companion of Niebhur, who was ſent out by the king of Denmark to explore the interior of Arabia, and who fell a ſacrifice to the peſtilential diſeaſes of thoſe inhoſpitable regions, diſcovered two new ſpecies. Thunberg, in his *Prodromus*, has mentioned five more. Forty new ſpecies have been diſcovered by Mr Maſſon of Kew Gardens, who was ſent out by his preſent Majeſty for the purpoſe of collecting plants round the Cape of Good Hope. Deſcriptions of theſe, with elegant and highly finiſhed coloured engravings, have lately been publiſhed. They are chiefly natives of the extenſive deſerts called *Karro*, on the weſtern ſide of the Cape.

STAR, in fortification, denotes a ſmall fort, having five or more points, or ſaliant and re-entering angles, flanking one another, and their faces 90 or 100 feet long.

STARCH (ſee *Encycl.*) is commonly made of wheat, and the very beſt ſtarch can perhaps be made of nothing elſe. Wheat, however, is too valuable an article of food to be employed as the material of ſtarch, when any thing elſe will anſwer the purpoſe; and it has long been known that an inferior kind of ſtarch may be made of potatoes. Potatoes, however, are themſelves a valuable article of food; and it is therefore an object of importance to try if ſtarch may not be made of ſomething ſtill leſs uſeful.

On the 8th of March 1796, a patent was granted to Lord William Murray for his diſcovery of a method by which ſtarch may be extracted from horſe-cheſnuts. That method is as follows:

Take the horſe-cheſnuts out of the outward green prickly huſks; and then, either by hand, with a knife or other tool, or elſe with a mill adapted for that purpoſe, very carefully pare off the brown rind, being particular not to leave the ſmalleſt ſpeck, and to entirely eradicate the ſprout or growth. Next take the nuts, and raſp, grate, or grind them fine into water, either by hand, or by a mill adapted for that purpoſe. Waſh the pulp, which is thereby formed in this water, as clean as poſſible, through a coarſe horſe-hair ſieve; this again waſh through a finer ſieve, and then again through a ſtill finer, conſtantly adding clean water, to prevent any ſtarch from adhering to the pulp. The laſt proceſs is, to put it with a large quantity of water (about four gallons to a pound of ſtarch) through a fine gauze, muſlin, or lawn, ſo as entirely to clear it of all bran or other impurities. As ſoon as it ſettles, pour off the water; then mix it up with clean water, repeating this operation till it no longer imparts any green, yellow, or other colour to the water. Then drain it off till nearly dry, and ſet it to bake, either in the uſual mode of baking ſtarch, or elſe ſpread out before a briſk fire; being very attentive to ſtir it frequently to prevent its horning, that is to ſay, turning to a paſte or jelly, which, on being dried, turns hard like horn. The whole proceſs ſhould be conducted as quickly as poſſible.

Mention is here made of a mill which may be employed to grind the horſe-cheſnuts; but none is deſcribed as proper for that purpoſe. Perhaps the following mill, which was invented by M. Baumé for grinding potatoes, with a view to extract ſtarch from them, may anſwer for grinding horſe cheſnuts.

Plate LII.

He had a grater made of plate iron, in a cylindrical form (fig. 1.) about ſeven inches in diameter, and about eight inches high: the burs made by ſtamping the holes are on the inſide. This grater is ſupported upon three feet AAA, made of flat iron bars, ſeven feet high, ſtrongly rivetted to the grater; the bottom of each foot is bent horizontally, and has a hole in it which receives a ſcrew, as at A, fig. 4. A little below the upper end of the three feet is fixed a croſs piece B (fig. 1. and 4.), divided into three branches, and rivetted to the feet. This croſs piece not only ſerves to keep the feet at a proper diſtance from each other, and to prevent their bending; but the centre of it having a hole cut in it, ſerves to ſupport an axis or ſpindle of iron, to be preſently deſcribed.

Starch.

The upper end of this cylindrical grater has a diverging border of iron C (fig. 1. 4. and 7.), about ten inches in diameter at the top, and five inches in height.

Within this cylindrical grater is placed a ſecond grater (fig. 2. and 3.), in the form of a cone, the point of which is cut off. The latter is made of thick plate iron, and the burs of the holes are on the outſide; it is fixed, with the broad end at the bottom, as in fig. 4. At the upper end of the cone is rivetted a ſmall triangle, or croſs piece of iron, conſiſting of three branches D (fig. 2.), in the middle of which is made a ſquare hole, to receive an axis or ſpindle; to give more reſiſtance to this part of the cone, it is ſtrengthened by means of a cap of iron E, which is fixed to the grater by means of rivets, and has alſo a ſquare hole made in it, to let the axis paſs through.

Fig. 3. repreſents the ſame cone ſeen in front; the baſe F has alſo a croſs piece of three branches, rivetted to a hoop of iron, which is fixed to the inner ſurface of the cone; the centre of this croſs piece has alſo a ſquare hole for the paſſage of the axis.

Fig. 5. is a ſpindle or axis itſelf; it is a ſquare bar of iron about 16 inches long, and more than half an inch thick; round at the bottom, and alſo towards the top, where it fits into the croſs piece I, fig. 7. and B, fig. 1. and 4.; in theſe pieces it turns round, and by them it is kept in its place. It muſt be ſquare at its upper extremity, that it may have a handle, about nine inches long, fixed to it, by means of which the conical grater is turned round. At G, (fig. 5.), a ſmall hole is made through the axis, to receive a pin H, by means of which the conical grater is kept at its proper height within the cylindrical one.

Fig. 6. is a bird's-eye view, in which the mill is repreſented placed in an oval tub, like a bathing-tub. I is the fore-mentioned triangular iron croſs, fixed with ſcrews to the ſide of the tub; the centre of it has a round hole, for the axis of the mill to move in when it is uſed.

Fig. 7. repreſents the mill in the oval tub; it is placed at one end of it, that the other end may be left free for any operation to be performed in it which may be neceſſary. A part of the tub is cut off, that the inſide of it, and the manner of fixing the mill, may be ſeen. That the bottom of the tub may not be worn by the ſcrews which paſs through the feet of the mill, a deal board, about an inch thick, and properly ſhaped, is placed under the mill.

When we wiſh to make uſe of this mill, it is to be fixed by the feet, in the manner already deſcribed; it is alſo fixed at the top, by means of the croſs piece I, fig. 6. and 7. The tub is then to have water poured into it as high as K, and the top of the mill is to be filled with potatoes, properly waſhed and cut; the handle L is to be turned round, and the potatoes, after being ground between the two graters, go out gradually at the lower part, being aſſiſted by the motion produced in the water by the action of the mill.

It is not neceſſary, in the conſtruction of ſuch a mill, to be very particular with reſpect to its proportions; but, in order to make known thoſe which experience has proved to be good ones, a ſcale is given with the figures, to which recourſe may be had. With a mill of this ſize, 100 pounds of potatoes may be ground in the ſpace of two hours.

We are perſuaded that this mill will anſwer perfectly well for grinding horſe cheſnuts; and we hope, that where they can be had they will be uſed in preference to potatoes. We ſhall, however, give M. Baumé's method of extracting ſtarch from the ground potatoes, not only becauſe it will be acceptable to thoſe who have not horſe-cheſnuts, but alſo becauſe thoſe who have may, by following it, be able, perhaps, to make ſtarch of them, without encroaching upon Lord William Murray's patent.

In order to prepare ſtarch from potatoes, ſays M. Baumé, any quantity of theſe roots may be taken, and ſoaked in a tub of water for about an hour; they are afterwards to have their fibres and ſhoots taken off, and then to be rubbed with a pretty ſtrong bruſh, that the earth, which is apt to lodge in the inequalities of their ſurface, may be entirely removed; as this is done, they are to be waſhed, and thrown into another tub full of clean water. When the quantity which we mean to make uſe of has been thus treated, thoſe which are too large are to be cut into pieces about the ſize of eggs, and thrown into the mill; that being already fixed in the oval tub, with the proper quantity of water; the handle is then turned round, and as the potatoes are grated they paſs out at the bottom of the mill. The pulp which collects about the mill muſt be taken off from time to time with a wooden ſpoon, and put aſide in water.

When all the potatoes are ground, the whole of the pulp is to be collected in a tub, and mixed up with a great quantity of clean water. At the ſame time, another tub, very clean, is to be prepared, on the brim of which are to be placed two wooden rails, to ſupport a hair ſieve, which muſt not be too fine. The pulp and water are to be thrown into the ſieve; the flour paſſes through with the water, and freſh quantities of water are ſucceſſively to be poured on the remaining pulp, till the water runs through as clear as it is poured in. In this way we are to proceed till all the potatoes that were ground are uſed.

The pulp is commonly thrown away as uſeleſs; but it ſhould be boiled in water, and uſed as food for animals; for it is very nouriſhing, and is about $\frac{7}{8}$ths of the whole quantity of potatoes uſed.

To return from this ſhort digreſſion. The liquor which has paſſed through the ſieve is turbid, and of a browniſh colour, on account of the extractive matter which is diſſolved in it; it depoſits, in the ſpace of five or ſix hours, the flour which was ſuſpended in it. When all the flour is ſettled to the bottom, the liquor is to be poured off and thrown away, being uſeleſs; a great quantity of very clean water is then to be poured upon the flour remaining at the bottom of the tub, which is to be ſtirred up in the water, that it may be waſhed, and the whole is to ſtand quiet till the day following. The flour will then be found to have ſettled at the bottom of the tub; the water is again to be poured off as uſeleſs, the flour waſhed in a freſh quantity of pure water, and the mixture paſſed through a ſilk ſieve pretty fine, which will retain any ſmall quantity of pulp which may have paſſed through the hair ſieve. The whole muſt once more be ſuffered to ſtand quiet till the flour is entirely ſettled; if the water above it is perfectly clear and colourleſs, the flour has been ſufficiently waſhed; but if the water has any ſenſible appearance either of colour or of taſte, the flour muſt be again waſhed, as it is abſolutely neceſſary that none of the extractive matter be ſuffered to remain.

When the flour is ſufficiently waſhed, it may be taken out of the tub with a wooden ſpoon; it is to be placed upon wicker frames covered with paper, and dried, properly defended from duſt. When it is thoroughly dry, it is to be paſſed through a ſilk ſieve, that if any clotted lumps ſhould have been formed they may be divided. It is to be kept in glaſs veſſels ſtopped with paper only. See *Vegetable* SUBSTANCES, Suppl.

N. B. Almoſt all the flour of potatoes that is to be bought contains a ſmall quantity of ſand, which is perceived between the teeth; it is owing to the potatoes not having been properly waſhed; for the ſand which lodges in the knobs and wrinkles of theſe roots, is not always eaſy to get out.

STARLINGS, or STERLINGS, the name given to the ſtrong pieces of timber which were driven into the bed of the river to protect the piles, on the top of which were laid the flat beams upon which were built the baſes of the ſtone piers that ſupport the arches of London bridge. In general, ſtarlings are large piles placed on the outſide of the foundation of the piers of bridges, to break the force of the water, and to protect the ſtone work from injury by floating ice. They are otherwiſe called JETTES, which ſee in this *Supplement*; and their place is often ſupplied by large ſtones thrown at random round the piers of bridges, as may be ſeen at Stirling bridge when the river is low; and as was done by Mr Smeaton's direction round the piers of the centre arch of London bridge, when it was thought in danger of being undermined by the current. See SMEATON, *Encycl.*

STATIONARY, in aſtronomy, the ſtate of a planet when, to an obſerver on the earth, it appears for ſome time to ſtand ſtill, or remain immoveable in the ſame place in the heavens. For as the planets, to ſuch an obſerver, have ſometimes a progreſſive motion, and ſometimes a retrograde one, there muſt be ſome point between the two where they muſt appear ſtationary.

STEAM, STEAM-ENGINE. The few following corrections of theſe articles in the *Encycl.* were communicated by the author.

Page 745. col. 1.—It was not at the York Building waterworks in London that the boiler burſt, but in the country in an engine erected by Dr Deſaguilliers. See his *Experimental Philoſophy*, Vol. II. p. 489.

Page 746. col. 2.—The condenſation requires more cold water than is here allowed, as will appear by and bye; and we alſo ſuſpect that the rapidity is overrated with which a great volume of ſteam is condenſed by

REAPING SCYTHES PLATE XLII.

Fig. 1.

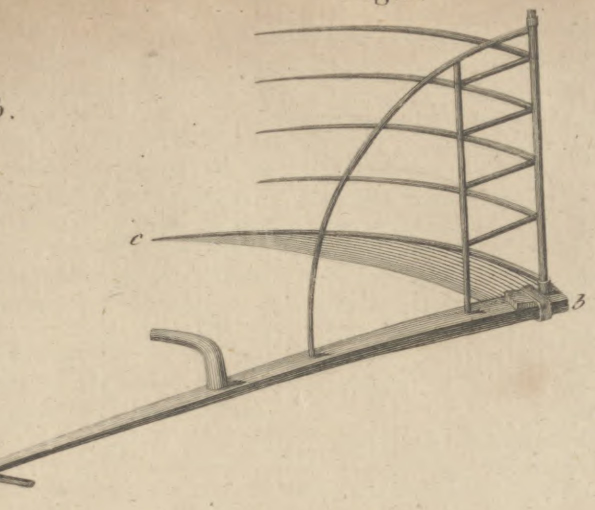
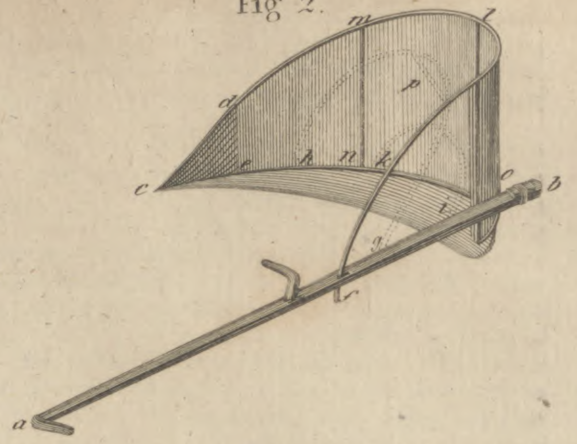


Fig. 3.

Fig. 2.



STARCH.

Fig. 1.

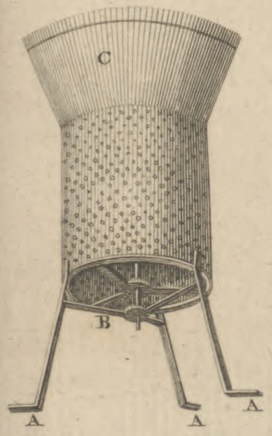


Fig. 2.

Fig. 3.

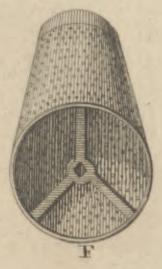


Fig. 4.

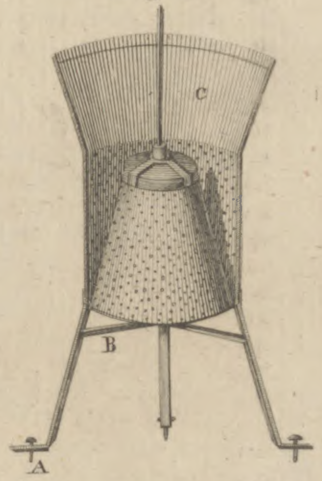


Fig. 5.

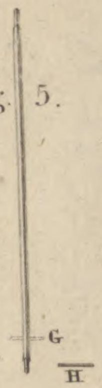


Fig. 7.

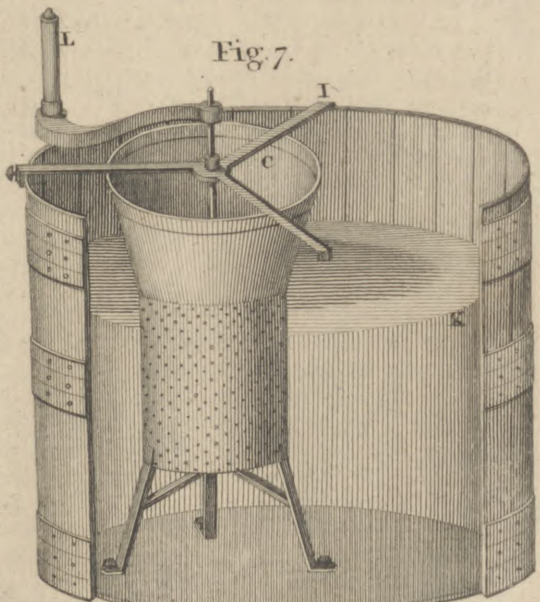
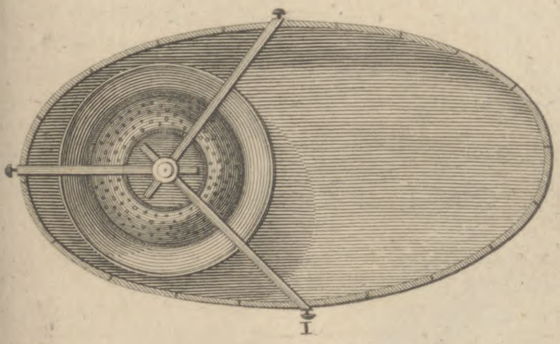


Fig. 6.



D. Lizars. Sculpt.

by the cold ſurface of a veſſel. We are well informed that Mr Watt was much diſappointed in his expectations from a conſtruction in which this mode of condenſation was adopted. The condenſer employed by Mr Cartwright (ſee *Phil. Mag.*) was one of the very firſt thought of and tried for this purpoſe, and was given up, as well as all others on the ſame principle; and the immediate contact of cold water was preferred as incomparably more effective. The great ſuperiority of the capacity of water for heat is now well known. It is true, that when we employ an extenſive cold ſurface of the condenſer, this ſurface is kept cold by the water round it; and therefore we ſtill avail ourſelves of this great avidity of water for heat. But this water muſt act through the intervention of the veſſel; and the ſubſtance of the veſſel does not convey heat to the ſurrounding water in an inſtant.

Page 749. col. 2.—No diſtinct experiment ſhews ſo great an expanſion of water, when converted into ſteam at the temperature 212°; and under the preſſure of the air Mr Watt never found it more than 1800 times rarer than water.

Page 753. col. 1.—The heat expended in boiling off a cubic foot of water is about ſix times as much as would bring it to a boiling heat from the medium temperature (55°) in this climate.

Page 758. col. 2.—The quantity of water neceſſary for injection may be determined on principle, at leaſt for an engine having a ſeparate condenſer. Every cubic foot of common ſteam produces about an inch of water when condenſed, and contains about as much latent heat as would raiſe 1100 inches of water one degree. This ſteam muſt not only be condenſed, but muſt be cooled to the temperature of the hot well; therefore as many inches of cold water muſt be employed as will require all this heat to raiſe it to the temperature of the hot well. Therefore let *x* be the cubic feet of ſteam, or capacity of the cylinder, and let *y* be the inches of cold water expended in condenſing it. Let *a* be the difference between 212° and the temperature of the hot well, and *b* the difference between the temperature of the well and the injection ciſtern. We have $yb = x \times \overline{1100 + a}$, or $y = \frac{\overline{1100 + a} \times x}{b}$.

Thus, if the temperature of the hot well be 100° (and it ſhould never be higher, if we would have a tolerable vacuum in the cylinder), and that of the injection ciſtern be 50°, we have $a = 112$, and $b = 50$, and $y = \frac{1212}{50}x, = 24{,}24\,x$, or $24\frac{1}{4}x$; that is, every foot of the capacity of the cylinder, or every inch of water evaporated from the boiler, requires more than 24 inches of water to condenſe the ſteam. A wine pint for every inch of water boiled off, or every cubic foot of capacity of the cylinder, may be kept in mind, as a large allowance. Or, more exactly, if the engine be in good order, and the injection water as low as 50°, and the hot well not above 100°, we may allow 25 gallons of injection for one gallon of water boiled off. This greatly exceeds the quantity mentioned in the caſe of a good Newcomen's engine, the cylinder of which contained almoſt 30 cubic feet of ſteam. And this circumſtance ſhews the ſuperiority of the engine with a ſeparate condenſer. The injection of Newcomen's engine had been adjuſted by experience, ſo as to make the beſt compenſation for the unavoidable waſte in the cylinder. We preſume that this machine was not loaded above eight pounds per inch, more likely with ſeven; whereas Watt's engine, working in the condition now deſcribed, bears a load not much below twelve, making at leaſt twelve ſtrokes per minute.

This is not a matter of mere curioſity; it affords a very exact rule for judging of the good working order of the engine. We can meaſure with accuracy the water admitted into the boiler during an hour, without allowing its ſurface to riſe or fall, and the water employed for injection. If the laſt be below the proportion now given (adapted to the temperatures 50° and 100°), we are certain that ſteam is waſted by leaks, or by condenſation in ſome improper place. The rule is not ſtrictly conformable to the latent heat of ſteam which balances the atmoſphere, 1100° being ſomewhat too great a value. It is accommodated to the actual performance of Watt's engines, when in their beſt working condition.

It is evident that it is of great importance to have the temperature of the hot well as low as poſſible; becauſe there always remains a ſteam in the cylinder, of the ſame, or rather higher temperature, poſſeſſing an elaſticity which balances part of the preſſure on the other ſide of the piſton, and thus diminiſhes the power of the engine. This is clearly ſeen by the barometer, which Mr Watt applies to many of his beſt engines, and is a moſt uſeful addition for the proprietor. It ſhews him, in every moment, the ſtate of the vacuum, and the real power of his engine, and tells him when there are leaks by which air gets in.

Page 762. cols. 1. 2.—Mr Watt's firſt experiment was not exactly as here related, but much more analogous to the preſent form of his engine. The condenſer was a cylinder of tinplate, fitted with a piſton, which was drawn up from the bottom to the top, before the eduction cock was opened. Without this previous rarefaction in the condenſer, there was no inducement for the ſteam to take this courſe, unleſs it were made much ſtronger than that of ordinary boiling water.

The deſcription of the firſt form of the engine is alſo faulty, by the omiſſion of a valve immediately below the eduction pipe. This valve is ſhut along with the valve I, to prevent the ſteam, which ſhould then go into the lower part of the cylinder, from alſo going down into the condenſer. This is not abſolutely neceſſary, but its advantage is evident.

Page 766. col. 1.—This form of the engine was very early put in practice by Mr Watt—about the year 1775. The ſmall engine at Mr Boulton's works at Soho was erected in 1776; and the engine at Shadwell waterworks, one of the beſt yet erected, had been working ſome time when we ſaw it in 1778. We mention this, becauſe we have been told that Mr Hornblower puts in ſome claim to priority in this invention. We do not think that Mr Hornblower erected any of his engines before 1782; and as Mr Hornblower was, we believe, working with Boulton and Watt before that time, we think it fully more probable that he has in this reſpect profited by the inſtruction of ſuch intelligent employers. We may alſo obſerve, that Mr Watt employed the ſame contrivance which we have deſcribed with much approbation in p. 772. *Encycl.* for keeping the

the collar round the piſton rods ſteam and air tight. He found them effectual, but that they required more attention for keeping them in fit condition than the uſual mode of packing. He made a ſimilar packing for the piſton, and with a ſimilar reſult.

Page 769. cols. 1. 2.—Mr Boulton eſtimates the performance of the engines in the following manner. Seeing that the great expence of the engine is the conſumption of fuel, he makes this the ſtandard of computation, and eſtimates the performance by the work which he *engages* to perform by the conſumption of one buſhel of good Newcaſtle coal, London meaſure, or containing 84 lbs. without regard to the time in which this buſhel is expended. This depends on the ſize of the engine.

The burning one buſhel of coal will,

1. Raiſe 30 million pounds one foot high.
2. It will grind and dreſs 11 buſhels of wheat.
3. It will ſlit and draw into nail rods 5 cwt. of iron.
4. It will drive 1000 cotton ſpindles, with all the preparation machinery, with the proper velocity.
5. It is equivalent to the work of ten horſes.

The general performance of the double ſtroke expanſive engines is ſomewhat beyond this; and their performance in cotton ſpinning, or as compared with horſe work, is much under rated. The firſt eſtimation is without ambiguity. Suppoſe the engine of ſuch a ſize as to conſume a buſhel of coals per hour. This will be found equivalent to raiſing 97 wine hogſheads of water ten feet high in a minute, which ten ſtout draught horſes cannot do for a quarter of an hour together. They can raiſe 60 in that time, and work at this rate eight or perhaps ten hours from day to day.

Mr Watt finds that, with the moſt judiciouſly conſtructed furnaces, it requires eight feet of ſurface of the boiler to be expoſed to the action of fire and flame to boil off a cubic foot of water in an hour, and that a buſhel of coals ſo applied will boil off from eight to twelve cubic feet.

Boulton and Watt now make ſteam-engines equivalent in power to one or two horſes. The cylinder and whole machinery does not occupy more room than a fine lady's working table, ſtanding in a ſquare of about 2½ feet, and about 5 feet high.

STEEL (ſee that article *Encycl.* and CHEMISTRY, n° 114. *Suppl.*) is compoſed of iron and carbon. In addition to the old proofs which we had of this fact, it occurred to *Morveau*, alias *Guyton*, to attempt to convert ſoft iron into ſteel, by uſing the diamond inſtead of charcoal in the proceſs of cementation. This expenſive experiment, which was ſuggeſted by M. Clouet, was made, by incloſing within a ſmall crucible of very ſoft iron a diamond, and ſhutting up the crucible by a ſtopper well adjuſted. This crucible of iron, with its contents, was placed, without the addition of any ſurrounding matter, in a very ſmall Heſſian crucible, and the latter in a ſecond crucible of the ſame earth; but the ſpace between the two latter crucibles was filled with ſiliceous ſand, free from all ferruginous particles. In the laſt place, the large crucible was luted with earth ariſing from pounded crucibles and unbaked clay, and the whole was expoſed about an hour to a three blaſt forge fire. When the whole was cooled, the iron was found in the interior Heſſian crucible converted into a ſolid ingot of caſt ſteel. Thus the diamond diſappeared by the affinity which iron exerciſed on it by the help of the high temperature to which they were both expoſed, in the ſame manner as a metal diſappears in the alloy of another metal. The diamond therefore furniſhed here the ſame principle as carbon, ſince the product of the union has the ſame properties.

The converſion into ſteel could not be doubted. The ingot having been poliſhed on a lapidary's wheel, a drop of weak nitrous acid immediately produced a dark-grey ſpot, abſolutely like that exhibited on Engliſh caſt ſteel, and on caſt ſteel produced by the proceſs of C. Clouet. Thoſe who have often tried ſteel by this kind of proof, long ago pointed out by Rinmann, had occaſion to remark, that the ſpot of caſt ſteel, tho' very ſenſible, is, however, leſs black than that of ſteel made by cementation, which depends perhaps on the different degree of oxydation of the carbon which they have taken in.

The proceſs of M. Clouet here mentioned, for producing caſt ſteel, conſiſts in nothing more than throwing a quantity of glaſs into the maſs of iron and charcoal during the formation of the former into ſteel. The ſame chemiſt has aſcertained that iron, during its converſion into ſteel, abſorbs 0.2013 of its weight of carbon; and that the affinity of iron for carbon is ſo ſtrong, that, at a white heat, it is capable of decompoſing carbonic acid gas. This he proved by the following experiment.

If ſix parts of iron be mixed with four parts of a mixture compoſed of equal quantities of carbonat of lime and clay, and kept in a crucible at a white heat for an hour or longer, according to the quantity, the iron will be converted into ſteel. The decompoſition of carbonic acid is evidently the conſequence of a compound affinity; part of the iron combining with the carbon, and another part with the oxygen of the carbonic acid gas. Accordingly the commiſſioners, who were appointed to examine the proceſs, remark, that a quantity of oxyd of iron was always mixed with the melted earthy ſubſtance, which was ſeparated from the ſteel.

STEEVENS (George), the moſt ſucceſsful of all the editors and commentators of Shakeſpeare, was born 1735. Of his parents we know nothing, but that they ſeem to have been in circumſtances which may be deemed affluent. George received the rudiments of his claſſical education at Kingſton-upon-Thames, under the tuition of Dr Woodeſon and his aſſiſtants; and had for a companion at that ſchool Gibbon the hiſtorian. From Kingſton he went to Eton, whence, after ſome years, he was admitted a fellow-commoner of King's College, Cambridge; but with the courſe of his ſtudies in the univerſity we are not acquainted. If we might hazard a conjecture, from the manner in which he employed his riper years, we ſhould ſuppoſe that he had little reliſh for thoſe mathematical ſpeculations which in Cambridge lead to academical honours. After he left the univerſity, he accepted a commiſſion in the Eſſex militia on its firſt eſtabliſhment: and he ſpent the latter years of his life at Hampſtead in almoſt total ſecluſion from the world; ſeldom mixing with ſociety but in the ſhops of bookſellers, in the Shakeſpeare Gallery, or in the morning *converſations* of Sir Joſeph Banks. He died January 1800.

This is a very meagre account of the incidents which muſt have taken place in the life of a man ſo conſpicuous in the republic of letters: but we have had no opportunity of improving it. His character, as drawn in the Monthly Magazine, believing it to be juſt, we ſhall adopt, as it will ſupply in ſome degree the defects of our narrative

Though Mr Steevens is known rather as a commentator than as an original writer; yet, when the works which he illuſtrated, the learning, ſagacity, taſte, and general knowledge which he brought to the taſk, and the ſucceſs which crowned his labours, are conſidered, it would be an act of injuſtice to refuſe him a place among the firſt literary characters of the age. Adorned by a verſatility of talents, he was indeed eminent both by his pen and his pencil. With the one there was nothing which he could not compoſe, and with the other there was nothing which he could not imitate ſo cloſely, as to leave a doubt which was the original and which the copy. But his chief excellence lay in his critical knowledge of an author's text; and the beſt ſpecimen of his great abilities is his edition of Shakeſpeare, in which he has left every competitor far behind him. He had, in ſhort, ſtudied the age of Shakeſpeare, and had employed his perſevering induſtry in becoming acquainted with the writings, manners, and laws of that period, as well as the provincial peculiarities, whether of language or cuſtom, which prevailed in different parts of the kingdom, but more particularly in thoſe where Shakeſpeare paſſed the early years of his life. This ſtore of knowledge he was continually increaſing, by the acquiſition of the rare and obſolete publications of a former age, which he ſpared no expence to obtain; while his critical ſagacity and acute obſervation were employed inceſſantly in calling forth the hidden meanings of the great dramatic bard, from their covert, and conſequently enlarging the diſplay of his beauties. This advantage is evident from his laſt edition of Shakeſpeare, which contains ſo large a portion of new, intereſting, and accumulated illuſtration. In the preparation of it for the preſs, he gave an inſtance of editorial activity and perſeverance which is without example. To this work he devoted ſolely, and excluſively of all other attentions, a period of 18 months; and during that time he left his houſe every morning at one o'clock with the Hampſtead patrole, and proceeded, without any conſideration of the weather or the ſeaſon, to his friend Mr Iſaac Read's chambers, in Barnard's Inn, where he was allowed to admit himſelf, and found a room prepared to receive him, with a ſheet of the Shakeſpeare letter preſs ready for correction. There was every book which he might wiſh to conſult; and to Mr Read he could apply, on any doubt or ſudden ſuggeſtion, as to a man whoſe knowledge of Engliſh literature was perhaps equal to his own. This nocturnal toil greatly accelerated the printing of the work; as while the printers ſlept the editor was awake; and thus, in leſs than twenty months, he completed his laſt ſplendid edition of Shakeſpeare, in fifteen large octavo volumes; an almoſt incredible labour, which proved the aſtoniſhing energy and perſevering powers of his mind.

That Mr Steevens contented himſelf with being a commentator, aroſe probably from the habits of his life, and his devotion to the name, with which his own will deſcend to the lateſt poſterity. It is probable that many of his *jeux d'eſprit* might be collected: there is a poem of his in Dodſley's Annual Regiſter, under the title of *The Frantic Lover*, which is ſuperior to any ſimilar production in the Engliſh language. Mr Steevens was a claſſical ſcholar of the firſt order. He was equally acquainted with the belles lettres of Europe. He had ſtudied hiſtory, ancient and modern, but particularly that of his own country. He poſſeſſed a ſtrong original genius, and an abundant wit; his imagination was of every colour, and his ſentiments were enlivened with the moſt brilliant expreſſions. His colloquial powers ſurpaſſed thoſe of other men. In argument he was uncommonly eloquent; and his eloquence was equally logical and animated. His deſcriptions were ſo true to nature, his figures were ſo finely ſketched, of ſuch curious ſelection, and ſo happily grouped, that he might be conſidered as a ſpeaking Hogarth. He would frequently, in his ſportive and almoſt boyiſh humours, condeſcend to a degree of ribaldry but little above O'Keefe—with him, however, it loſt all its coarſeneſs, and aſſumed the air of claſſical vivacity. He was indeed too apt to catch the ridiculous, both in characters and things, and indulge an indiſcreet animation wherever he found it. He ſcattered his wit and his humour, his gibes and his jeers, too freely around him, and they were not loſt for want of gathering.

Mr Steevens poſſeſſed a very handſome fortune, which he managed with diſcretion, and was enabled by it to gratify his wiſhes, which he did without any regard to expence, in forming his diſtinguiſhed collections of claſſical learning, literary antiquity, and the arts connected with it. His generoſity alſo was equal to his fortune; and though he was not ſeen to give eleemoſynary ſixpences to ſturdy beggars or ſweepers of the croſſings, few perſons diſtributed banknotes with more liberality; and ſome of his acts of pecuniary kindneſs might be named, which could only proceed from a mind adorned with the nobleſt ſentiments of humanity. He poſſeſſed all the grace of exterior accompliſhment, acquired at a period when civility and politeneſs were characteriſtics of a gentleman.

He has bequeathed his valuable Shakeſpeare, illuſtrated with near 1500 prints, to Lord Spencer; his Hogarth perfect, with the exception of one or two pieces, to Mr Windham; and his corrected copy of Shakeſpeare, with 200 guineas, to his friend Mr Read.

STEREOMETER, an inſtrument lately invented in France for meaſuring the volume of a body, however irregular, without plunging it in any liquid. If the capacity of a veſſel, or, which is the ſame thing, the volume of air contained in that veſſel, be meaſured, when the veſſel contains air only, and alſo when the veſſel contains a body whoſe volume is required to be known, the volume of air aſcertained by the firſt meaſurement, deducting the volume aſcertained by the ſecond, will be the volume of the body itſelf. Again, if it be admitted as a law, that the volume of any maſs of air be inverſely as the preſſure to which it is ſubjected, the temperature being ſuppoſed conſtant, it will be eaſy to deduce, from the mathematical relations of quantity, the whole bulk, provided the difference between the two bulks under two known preſſures be obtained by experiment.

Let it be ſuppoſed, for example, that the firſt preſſure is double the ſecond, or, which follows as a conſequence,

quence, that the ſecond volume of the air be double the firſt, and that the difference be fifty cubic inches, it is evident that the firſt volume of the air will likewiſe be fifty cubic inches. The ſtereometer is intended to aſcertain this difference at two known preſſures.

Plate XLIII.

The inſtrument is a kind of funnel AB (fig. 1.), compoſed of a capſule A, in which the body is placed, and a tube B as uniform in the bore as can be procured. The upper edge of the capſule is ground with emery, in order that it may be hermetically cloſed with a glaſs cover M ſlightly greaſed. A double ſcale is paſted on the tube, having two ſets of graduations; one to indicate the length, and the other the capacities, as determined by experiment.

When this inſtrument is uſed, it muſt be plunged in a veſſel of mercury with the tube very upright, until the mercury riſes within and without to a point C of the ſcale. See fig. 2.

The capſule is then cloſed with the cover, which being greaſed will prevent all communication between the external air and that contained within the capſule and tube.

In this ſituation of the inſtrument, in which the mercury ſtands at the ſame height within and without the tube, the internal air is compreſſed by the weight of the atmoſphere, which is known and expreſſed by the length of the mercury in the tube of the common barometer.

The inſtrument is then to be elevated, taking care to keep the tube conſtantly in the vertical poſition. It is repreſented in this ſituation, fig. 2. ſecond poſition. The mercury deſcends in the tube, but not to the level of the external ſurface, and a column DE of mercury remains ſuſpended in the tube, the height of which is known by the ſcale. The interior air is therefore leſs compreſſed than before, the increaſe of its volume being equal to the whole capacity of the tube from C to D, which is indicated by the ſecond ſcale.

It is known therefore that the preſſures are in proportion to the barometrical column, and to the ſame column diminiſhed by the ſubtraction of DE. And the bulks of the air in theſe two ſtates are inverſely in the ſame proportion; and again the difference between theſe bulks is the abſolute quantity left void in the tube by the fall of the mercury; from which data, by an eaſy analytical proceſs, the following rule is deduced: Multiply the number which expreſſes the leſs preſſure by that which denotes the augmentation of capacity, and divide the product by the number which denotes the difference of the preſſures. The quotient will be the bulk of the air when ſubject to the greater preſſure.

To render this more eaſy by an example, ſuppoſe the height of the mercury in the barometer to be 78 centimetres, and the inſtrument being empty to be plunged in the mercury to the point C. It is then covered, and raiſed until the ſmall column of mercury DE is ſuſpended, for example, at the height of ſix centimetres. The internal air, which was at firſt compreſſed by a force repreſented by 78 centimetres, is now compreſſed only by a force repreſented by 78—6, or 72 centimetres.

Suppoſe it to be obſerved, at the ſame time, by means of the graduations of the ſecond ſcale, that the capacity of the part CD of the tube which the mercury has quitted is two cubic centimetres. Then by the rule $\frac{72}{6} \times 2$ give 24 cubical centimetres, which is the volume of the air included in the inſtrument when the mercury roſe as high as C in the tube.

The body of which the volume is to be aſcertained muſt then be placed in the capſule, and the operation repeated. Suppoſe, in this caſe, the column of mercury ſuſpended to be eight centimetres, when the capacity of the part CD of the tube is equal to two centimetres cube. Then the greateſt preſſure being denoted by 78 centimetres, as before, the leaſt will be 70 centimetres, the difference of the preſſures being 8, and the difference of the volumes two cubical centimetres. Hence $\frac{70}{8} \times 2$ gives the bulk of the included air under the greateſt preſſure 17,5 cubic centimetres. If therefore 17,5 centimetres be taken from 24 centimetres, or the capacity of the inſtrument when empty, the difference 6,5 cubic centimetres will expreſs the volume of the body which was introduced. And if the abſolute weight of the body be multiplied by its bulk in centimetres. and divided by the abſolute weight of one cubic centimetre of diſtilled water, the quotient will expreſs the ſpecific gravity of the body in the common form of the tables where diſtilled water is taken as unity, or the term of compariſon.

After this deſcription and explanation of the uſe of his inſtrument, the author proceeds with the candour and acuteneſs of a philoſopher to aſcertain the limits of error in the reſults; an object ſeldom ſufficiently attended to in the inveſtigation of natural phenomena. From his reſults it appears, that with the dimenſions he has aſſumed, and the method preſcribed for operating, the errors may affect the ſecond figure. He likewiſe gives the formulæ by means of which the inſtrument itſelf may be made to ſupply the want of a barometer in aſcertaining the greateſt preſſure. He likewiſe adverts to the errors which may be produced by change of temperature. To prevent theſe as much as poſſible, the actual form of the inſtrument and arrangements of its auxiliary parts are ſettled, as in fig. 3. by which means the approach of the hand near the veſſel and its tube is avoided. In this figure the vertical poſition of the tube is ſecured by the ſuſpenſion of the veſſel, and a perforation in the table through which the tube paſſes. The table itſelf ſupports the capſule in its firſt poſition, namely, that at which the cover is required to be put on.

Mr Nicholſon, from whoſe Journal this abſtract is immediately taken, ſuppoſes, with great probability, that the author of the invention had not finiſhed his meditations on the ſubject, when the memoir giving an account of it was publiſhed. If he had, ſays the ingenious journaliſt, it is likely that he would have determined his preſſures, as well as the meaſures of bulks by weight. For it may be eaſily underſtood, that if the whole inſtrument were ſet to its poſitions by ſuſpending it to one arm of a balance at H (fig. 3.), the quantity of counterpoiſe, when in equilibrio, might be applied to determine the preſſures to a degree of accuracy much greater than can be obtained by linear meaſurement.

STEWART-DENHAM (Sir James) was born at Edinburgh on the 10th of October, O. S. in the year 1713. His father was Sir James Stewart of Goodtrees, Bart. Solicitor-general for Scotland; and his mother

ther was Anne, daughter of Sir Hugh Dalrymple of North Berwick, Bart. preſident of the college of juſtice.

The firſt rudiments of his education he received at the grammar-ſchool of North-Berwick, which at the time of his father's death he quitted at the age of fourteen, with the reputation of being a good ſcholar, but without any extraordinary advancement in knowledge.

It is remarkable, that many men who have been ſingularly uſeful to ſociety have not ſhewn early ſymptoms of the greatneſs of their intellectual powers. A great underſtanding muſt be the offspring of happy organization in a healthy body, with co-operation of time, of circumſtance, and of inſtitution, without being forced into prematurity by exceſſive cultivation. This holds with reſpect to the growth and perfection of every creature; and the truth appears remarkable with reſpect to our own ſpecies, becauſe we are apt to miſtake the flimſy attainments of artificial education for the ſteady and permanent foundations of progreſſive knowledge.

From the ſchool of North-Berwick Sir James was ſent to the univerſity of Edinburgh, where he continued until the year 1735, when he paſſed advocate before the Court of Seſſion, and immediately afterwards went abroad to viſit foreign countries. He was then in the 23d year of his age, had made himſelf well acquainted with the Roman law and hiſtory, and the municipal law of Scotland. He had likewiſe maturely ſtudied the elements of juriſprudence; was verſed in the general, as well as the particular, politics of Europe; and was bent upon applying his knowledge to the inveſtigation of the ſtate of men and of manners in other nations, with a view to promote the benefit of his own, and to confirm himſelf in the love of a free conſtitution of government, by contemplating the baneful effects of unlimited monarchy in Germany, Italy, and Spain, and of extravagant attachment to a king and nobility, to war, and to pernicious ſplendour in France.

He travelled firſt, however, into Holland, with a view to ſtudy the conſtitution of the empire before he ſhould viſit Germany, and to attend ſome of the lectures of the moſt eminent profeſſors at Utrecht and Leyden, on public law and politics. From thence he paſſed into Germany, reſided about a year in France, travelled thro' ſome part of Spain, where he had a fever, that obliged him, for his perfect recovery from its effects, to go by the advice of his friends to the ſea-coaſt of the lovely province of Valencia; thence returning, he croſſed the Alps, and by Turin made the tour of Italy, where chiefly at Rome and Florence he reſided till the beginning of the year 1740; when, having ſpent five years on his travels, he returned to Scotland, and married the Lady Frances Wemyſs, eldeſt daughter of the Earl of Wemyſs, about two years after his return.

A few months after his marriage the repreſentation of the county of Mid-Lothian became vacant, by the member being made a lord of trade and plantation. The candidates were the late member and Sir John Baird of Newbyth. On the day of election Mr Dundas of Arniſton, one of the ſenators of the college of juſtice, was choſen preſes of the meeting; and ſome how or other omitted to cauſe the name of Sir James Stewart to be called on the roll of freeholders. For this illegal uſe of his temporary power, Sir James commenced a ſuit againſt the preſident; and reſuming the gown as an advocate, pleaded his own cauſe with great energy and eloquence, and with the applauſe of the bench, the bar, and the public. This called Lord Arniſton from the bench to plead in his own defence at the bar; and Sir James could not have been oppoſed to an antagoniſt better qualified to call forth all his powers; for that judge is talked of at this day in Edinburgh as the profoundeſt lawyer and the ableſt pleader that ever graced the Scottiſh bench or the Scottiſh bar.

With the iſſue of this conteſt we are not acquainted; but it drew upon Sir James Stewart very general attention, and convinced the public, that had he continued at the bar, he muſt have riſen rapidly to the head of his profeſſion. On his travels, however, he had contracted friendſhips with Lord Mariſchal, and other eminent men, attached to the pretenſions of the royal family of Stuart, and had received flattering attentions from the Pretender to the Britiſh throne; the impreſſion ariſing from which, added to the irritations of his controverſy with the powerful party in Scotland attached to the court, led him, unadviſedly, into connections with the movers of the rebellion in 1745.

As he was by far the ableſt man of their party, the Jacobites engaged him to write the Prince Regent's manifeſto, and to aſſiſt in his councils. Information having been given of his participation in theſe affairs, he thought it prudent, on the abortion of this unhappy attempt, to leave Britain; and by the zeal, it is ſaid, of Arniſton, he was excepted afterwards from the bill of indemnity, and rendered an exile from his country.

He choſe France for his reſidence during the ten firſt years of his baniſhment; and was chiefly at Angouleſme, where he ſuperintended the education of his ſon; from thence he went to Tubingen in Suabia, for the benefit of its univerſity, in proſecution of the ſame dutiful and laudable deſign; but in the end of the war 1756, having been ſuſpected by the court of Verſailles of communicating intelligence to the court of London, he was ſeized at Spa, and kept ſome time in confinement; from which being liberated, after the acceſſion of the preſent king of Great Britain, he came, by toleration, to England, and reſided at London, where he put the laſt hand to his Syſtem of Political Economy, the copy right of which he ſold to Andrew Millar; and being permitted to dedicate this work to the king, he applied for a *noli proſequi*, which, after ſome malicious objections, he obtained, and had the comfort of returning to his family eſtate in Scotland.

Having nothing profeſſional to do during his long reſidence in France, the active mind of Sir James was occupied in ſtudy. His book on the Principles of Political Economy contains moſt of the fruits of it. He turned himſelf, in the intervals of leiſure, to conſider the reſources of France, that he might the better compile that part of his great work which was to treat of revenue and expenditure. It was by ſtudying the language of the finances, without which nobody can aſk a proper queſtion concerning them, ſo as to be underſtood, that he attained his great purpoſe.

As ſoon as he could aſk queſtions properly, he applied in familiar converſation to the intendants and their ſubſtitutes in the provinces where he reſided, whom he found extremely deſirous to learn the ſtate of the Britiſh finances, under the branches of the land-tax, cuſtoms, exciſe, and other inland duties. This led him to

compare

compare the ſtate of the two nations. The information he gave was an equivalent for the information he received; curioſity balanced curioſity, each was ſatisfied and inſtructed. The department of the intendants in France was confined to the taxes which compoſed the *recettes generales*, namely, the *taille*, the *capitation*, and the *twentieths*, or *vingtiemes*. All the intendants had been *Maitres des Requetes*, bred at Paris, and could not fail to have much knowledge of the general *fermes* and other branches of the revenue. He carefully noted down at all times the anſwers he got; and when he came to reſide at Paris, he obtained more ample information, both from the gentlemen of the revenue, and from perſons of the parliament of Paris, who to the number of 25 had been for 15 months exiled in the province where he had ſo long reſided at Angouleſme.

With theſe advantages, with much ſtudy and attention to arrangement, he was enabled to compoſe the ſixth chapter of the fourth part of the fourth book of his Syſtem of Political Economy; a portion of that great work well worthy the attention of thoſe who wiſh to know the ſtate of France in reſpect of revenue under the old government.

Although Sir James Stewart's leiſure, during the firſt ten years of his exile, was chiefly employed in ſocial intercourſe with the moſt learned, elegant, and poliſhed characters in France, who delighted in the converſation and friendſhip of a man who poſſeſſed at once immenſe information, on almoſt every ſubject, important or agreeable to ſociety, and the talent of clearly and beautifully expreſſing his ſentiments in flowing and animated converſation; yet he did not allow the pleaſures of the circle and of the table to blunt the fine feelings of a man of genius and ſcience. The labour of collecting materials for his great political work was oppreſſive, and he relieved himſelf with various enquiries, ſuited to the exalted ambition of his cultivated underſtanding, while he turned the charms of converſation to the permanent delight of his aſſociates and of poſterity. The motto of Apelles, "*Nulla dies ſine linea*," was the emblem of his employment; and it is amazing what may be done by daily attention for improvement, without appearing to abſtract any extraordinary time from the common offices and rational pleaſures of ſociety.

In the beginning of the year 1755, Sir James wrote his Apology, or Defence of Sir Iſaac Newton's Chronology, which at that time he intended to publiſh, but was prevented by other engagements. It was communicated to ſeveral perſons of eminence in France and Germany in MS. and produced, in the month of December that year in the "*Mercure de France*," an anſwer from M. Deſhoulieres, to which Sir James ſoon after replied.

The great Newton, applying aſtronomical and ſtatiſtical principles to the ancient chronology of Greece, had chaſtiſed the vanity of nations, and arreſted the progreſs of infidelity in delineating the hiſtory of the world. Loſt in the confuſion of exceſſive pretenſions to an antiquity beyond all meaſure, and diſguſted by the ſuperſtitious aids that were aſſumed to ſupport theſe pretenſions among ancient nations, the revivers of learning in Europe, during the laſt and the preceding century, turmoiled themſelves with controverſies between the comparative merits of the ancients and moderns; and the abettors of the latter, entrenching themſelves behind the falſehoods of the ancients, on the ſcope of their remote hiſtory, gave the lie to all antiquity, and in deſpair plunged themſelves into the ocean of ſcepticiſm.

Happy had it been for ſociety if this ſcepticiſm had confined itſelf to the hiſtory of ancient nations in general; but the ſame ſpirit, taking diſguſt at the horrors of Chriſtian ambition and bigotry, and contemplating with deriſion the ridiculous legends of modern miracles, gave the lie to all religious ſcripture of the Jews and Chriſtians, and attempted to baniſh divine intelligence, the ſuperintending providence of Deity, and the true dignity of the human ſpecies, from the face of the earth!

It was a noble undertaking, therefore, in Sir James, to attempt to diſperſe this miſt of error, by diſpaſſionately and ſcientifically explaining and ſupporting the chronology of Sir Iſaac Newton. He has done it with great preciſion and effect; and it is a book well worth the peruſal of thoſe who wiſh to read ancient hiſtory with improvement, or to prevent themſelves from being bewildered in the mazes of modern conjecture. It was printed in 4to at Franckfort on the Maine, for John Bernard Eichemberg the Elder, in 1757

In the year 1758, and the following, the Britiſh Houſe of Commons took up the conſideration of a ſtatute to regulate a general uniformity of weights and meaſures throughout the united kingdoms, which had been ſo often unſucceſsfully attempted.

This called the attention of Sir James, not only to the inveſtigation of the particular ſubject that engaged that of the Houſe of Commons, but to deviſe a method of rendering an uniformity of weights and meaſures univerſal. He thought the cauſe of former diſappointments in this uſeful purſuit had been the miſtaken notion that one or other of our preſent meaſures ſhould be adopted for the new ſtandard. After the plan had been relinquiſhed by the parliament of England, he digeſted his notes and obſervations on this important diſquiſition into the form of an epiſtolary diſſertation, which he tranſmitted to his friend Lord Barrington, and reſolved, if there had been a congreſs aſſembled, as was once propoſed, to adjuſt the preliminaries of the general peace in 1763, to have laid his plan before the miniſters of the different nations, who were to prepare that ſalutary pacification of the contending powers.

This epiſtolary diſſertation Sir James afterwards reduced at Coltneſs, in the year 1777, into a form more proper for the public eye, and ſent a corrected copy to a friend, reſerving another for the preſs, which was printed 1790 for Stockdale in Piccadilly.

In this tract the author ſhews, from the ineffectual attempts that have been made to alter partially, by innovation, the ſtandards of meaſures or weights, that the effectual plan to be adopted, is to depart entirely from every meaſure whatſoever now known, and to take, *ad libitum*, ſome new maſs inſtead of our pound, ſome new length inſtead of our ell, ſome new ſpace inſtead of our acre, and ſome new ſolid inſtead of our gallon and buſhel.

For this purpoſe Sir James propoſes as the unit a maſs to be verified with the greateſt poſſible accuracy, equal in weight to ten thouſand Troy grains. The pendulum, as it ſwings at London, to beat ſeconds of time, he propoſes to be the meaſure of length; and after having laid down his fundamental principles, he propoſes an ingenious plan for rendering their adoption univerſal through the whole world.

Having obtained his pardon, Sir James Stewart retired to Coltheſs, in the county of Lanark, the paternal eſtate of his family, where he turned his attention to the improvement of his neighbourhood by public works and police, and drew the firſt good plan for a turnpike bill, ſuited to the circumſtances of Scotland, which has been ſince generally adopted. He repaired his houſe, planted, improved, and decorated his eſtate, and in ſocial intercourſe rendered himſelf the delight of his neighbourhood and country.

Never was there a man who, with ſo much knowledge, and ſo much energy of expreſſion in converſation, rendered himſelf more delightful to his company, or was more regretted by his acquaintance when he died. Nor was the active mind of Sir James unemployed for the general benefit of his country during his retreat. He was engaged by the directors of the Eaſt India Company of England to digeſt a code for the regulation of the current coin of Bengal; the plan for which important regulation he printed, and received from the court of directors a handſome diamond ring, as a mark of their approbation.

He prepared for the preſs, but never publiſhed, an antidote to the *Syſteme de la Nature* by Mirabeau, wherein the parallelogiſms and fooliſh reaſoning of that infidel work are examined, detected, and confuted. It is written in French; and were the work of Mirabeau worth refutation, might be printed with much advantage to Sir James's reputation as a controverſial writer.

This great and good man died in November 1780, and was buried at Cambuſnethan, in Lanarkſhire, on the 28th of the ſame month; the Duke of Hamilton and his neighbours performing the laſt offices to the remains of their highly valued friend, and bedewing his aſhes with their tears.

For this ſhort ſketch of the principal events in the life of Sir James Stewart-Denham, we are indebted to his nephew the Earl of Buchan, who, juſtly proud of his relation to ſuch a man, cannot be ſuppoſed to view all his projects, or even all his reaſonings, with the cool impartiality of ſtrangers. His plan, for inſtance, of a univerſal ſtandard of weights and meaſures for the *whole world*, though certainly a grand conception, we cannot help conſidering as romantic and impracticable. The author indeed was ſenſible, that time would be requiſite for its execution; and ſo large a portion of time, that, compared with it, a thouſand years are but as one day, when compared with the ordinary life of man: but ſchemes of this magnitude are not for creatures ſo blind and weak as we are, who, when we wander to a diſtance beyond the limits of our narrow ſphere, with the ambitious view of benefiting poſterity, are almoſt certain to injure ourſelves, without a probability of ſerving thoſe for whom we dream that we are exerting our abilities. Sir James's Political Economy, however, is a very great work, which has not received half the praiſes to which it is entitled, and which, we ſuſpect, provoked the envy of another great writer on ſimilar ſubjects, who exerted himſelf privately to leſſen its fame. The defence of Newton's chronology is likewiſe very valuable, though we certainly do not think that part of the ſyſtem invulnerable, in which the great aſtronomer attempts to prove, that *Oſiris*, *Seſoſtris*, and *Seſac*, are three names of the ſame Egyptian king. This, however, is a very trifling miſtake; and the modern ſciolist, who can lay hold of it to reject the whole, has certainly never read, or, if he has read, does not underſtand the defence of the ſyſtem by Sir James Stewart.

SUBCONTRARY POSITION, in geometry, is when two equiangular triangles are ſo placed, as to have one common angle at the vertex, and yet their baſes not parallel; conſequently the angles at the baſes are equal, but on the contrary ſides.

SUBDUCTION, in arithmetic, the ſame as *Subtraction*.

ANIMAL AND VEGETABLE SUBSTANCES.

THE reader will recollect, that the article CHEMISTRY, in this *Supplement*, was divided into four parts; of which only the firſt three, comprehending the elements of the ſcience, were given under the word CHEMISTRY. The *fourth part*, which was entitled an examination of bodies as they are preſented to us by nature in the mineral, vegetable, and animal kingdoms, naturally ſubdivides itſelf into three parts, comprehending reſpectively, 1. Minerals; 2. Vegetables; 3. Animals.

1 ure of article.

The firſt of theſe ſubdiviſions, which has been diſtinguiſhed by the name of MINERALOGY, we have treated of already in a former part of this Volume. As the other two ſubdiviſions have not hitherto received any appropriate name, we have ſatiſfied ourſelves with the word SUBSTANCE, by which chemiſts have agreed to denote the objects which belong to theſe ſubdiviſions. This name, it muſt be acknowledged, is not unexceptionable; but we did not conſider ourſelves as at liberty to invent a new one.

The preſent article, then, ſeems to divide itſelf into two parts: the firſt part comprehending *vegetable*; the ſecond *animal* ſubſtances. But there are certain animal and vegetable ſubſtances diſtinguiſhed from all others by being uſed as articles of clothing. It is uſual to tinge theſe of various colours, by combining with them different colouring matters for which they have an affinity. This proceſs, well known by the name of DYEING, is purely chemical; and as it belongs excluſively to animal and vegetable ſubſtances, it comes naturally to be examined here. We ſhall therefore add a *third part*, in which we ſhall give a view of the preſent ſtate of DYEING, as far, at leaſt, as is conſiſtent with the nature of a ſupplementary article.

2 Diviſion of it.

PART I. OF VEGETABLE SUBSTANCES.

VEGETABLES, or plants, as they are alſo called, are too well known to require any definition. Their number is prodigious, and their variety, regularity, and beauty, are wonderful. But it is not our intention in this place either to enumerate, to deſcribe, or to claſſify plants. Theſe taſks belong to the botaniſt, and have been ſucceſsfully accompliſhed by the zeal, the ſingular addreſs, and the indefatigable labour of Linnæus and his followers.

3 Chemical examination of vegetables. It is the buſineſs of the chemiſt to analyſe vegetables, to diſcover the ſubſtances of which they are compoſed, to examine the nature of theſe ſubſtances, to inveſtigate the manner in which they are combined, to detect the proceſſes by which they are formed, and to aſcertain the chemical changes to which plants, after they have ceaſed to vegetate, are ſubject. Hence it is evident, that a chemical inveſtigation of plants comprehends three particulars:

1. An account of the *ſubſtances* of which plants are compoſed.
2. An account of the *vegetation* of plants, as far as it can be illuſtrated by chemiſtry.
3. An account of the *changes* which plants undergo after they ceaſe to vegetate.

We therefore divide this part into three chapters, aſſigning a chapter to each of theſe particulars.

CHAP. I. OF THE INGREDIENTS OF PLANTS.

THE ſubſtances hitherto found in the vegetable kingdom, all of them at leaſt which have been examined with any degree of accuracy, may be reduced to the following heads:

1. Sugar,
2. Starch,
3. Gluten,
4. Albumen,
5. Gum,
6. Jelly,
7. Extract,
8. Tan,
9. Oils,
10. Camphor,
11. Reſins,
12. Caoutchouc,
13. Wax,
14. Wood,
15. Acids,
16. Alkalies,
17. Earths,
18. Metals.

Theſe ſhall form the ſubject of the following ſections:

SECT. I. *Of SUGAR.*

SUGAR, which at preſent forms ſo important an article in our food, ſeems to have been known at a very early period to the inhabitants of India and China. 4 Diſcovery of ſugar. But Europe probably owes its acquaintance with it to the conqueſts of Alexander the Great. For ages after its introduction into the weſt, it was uſed only as a medicine; but its conſumption gradually increaſed, and during the time of the Cruſades, the Venetians, who brought it from the eaſt, and diſtributed it to the northern parts of Europe, carried on a lucrative commerce with ſugar. It was not till after the diſcovery of America, and the extenſive cultivation of ſugar in the Weſt Indies, that its uſe in Europe, as an article of food, became general [*].

Sugar is obtained from the *arundo ſaccharifera*, or *ſugar cane.* The juice of this plant is preſſed out and

boiled in as low a temperature as poſſible, till the ſugar precipitates in the form of confuſed cryſtals. Theſe cryſtals, known by the name of *raw ſugar*, are again 5 How obtained. diſſolved in water, the ſolution is clarified, and purer cryſtals are obtained by a ſubſequent evaporation. But for the particulars of the art of manufacturing ſugar, we refer the reader to the article SUGAR in the *Encyclopædia.*

6 Its properties. Sugar, after it has been purified, or *refined* as the manufacturers term it, is uſually ſold in Europe in the form of a white opake maſs, well known by the name of *loaf ſugar*. Sometimes alſo it is cryſtallized, and then it is called *ſugar candy*.

Sugar has a very ſtrong ſweet taſte; when pure it has no ſmell; its colour is white, and when cryſtallized it is ſomewhat tranſparent. It has often a conſiderable degree of hardneſs; but it is always ſo brittle that it can be reduced without difficulty to a very fine powder. It is not altered by expoſure to the atmoſphere.

7 Solubility in water. It is exceedingly ſoluble in water. At the temperature of 48°, water, according to Mr Wenzel, diſſolves its own weight of ſugar. The ſolvent power of water increaſes with its temperature; when nearly at the boiling point, it is capable of diſſolving any quantity of ſugar whatever. Water thus ſaturated with ſugar is known by the name of *ſyrup*.

Syrup is thick, ropy, and very adheſive; when ſpread thin upon paper, it ſoon dries, and forms a kind of varniſh, which is eaſily removed by water. Its ſpecific caloric, according to the experiments of Dr Crawford, is 1.086. 8 Its cryſtals. When ſyrup is ſufficiently concentrated, the ſugar which it contains precipitates in cryſtals. The primitive form of theſe cryſtals is a four-ſided priſm, whoſe baſe is a rhomb, the length of which is to its breadth as 10 to 7; and whoſe height is a mean proportion between the length and breadth of the baſe. The cryſtals are uſually four or ſix-ſided priſms, terminated by two ſided, and ſometimes by three-ſided ſummits [†].

Sugar is ſoluble in alcohol, but not in ſo large a proportion as in water. According to Wenzel, four parts of boiling alcohol diſſolve one of ſugar [§]. It unites 9 Solubility in alcohol. readily with oils, and renders them miſcible with water. A moderate quantity of it prevents, or at leaſt retards, the coagulation of milk; but Scheele diſcovered that a very large quantity of ſugar cauſes milk to coagulate [‖].

Sugar abſorbs muriatic acid gas ſlowly, and aſſumes a brown colour and very ſtrong ſmell [‡].

Sulphuric acid, when concentrated, readily decompoſes ſugar; water is formed, and perhaps alſo acetous 10 Action of acids. acid; while charcoal is evolved in great abundance, and gives the mixture a black colour, and a conſiderable degree of conſiſtency. The charcoal may be eaſily ſeparated by dilution and filtration. When heat is applied the ſulphuric acid is rapidly converted into ſulphurous acid.

11 Of potaſh. When ſugar is mixed with potaſs, the mixture acquires a bitter and aſtringent taſte, and is inſoluble in alcohol, though each of the ingredients is very ſoluble in that liquid. When the alkali is ſaturated with ſulphuric

---

[*] See Falconer's *Hiſtory of Sugar*, *Mancheſter Memoirs*, iv. 291. and *Mozeley's Hiſtory of Sugar.*

[†] *Gillot. Ann. de Chim.* xviii. 317.

[§] *Enc. Meth. Chim.* i. 271.

[‖] *Scheele* ii. 52. Dijon tranſlation.

[‡] *Prieſtley*, ii. 291.

ric acid, and precipitated by means of alcohol, the ſweet taſte of the ſugar is reſtored; a proof that it had undergone no decompoſition from the action of the potaſs, but had combined with it in the ſtate of ſugar *.

Lime boiled with ſugar produces nearly the ſame effect as potaſs; when an alkali is added to the compound, a ſubſtance precipitates in white flakes. This ſubſtance is ſugar combined with lime †. Sugar and chalk compoſe, as Leonardi informs us, a kind of cement ‡.

Sugar, when thrown upon a hot iron, melts, ſwells, becomes browniſh black, emits air bubbles, and exhales a peculiar ſmell, known in French by the name of *caromel*. At a red heat it inſtantly burſts into flames with a kind of exploſion. The colour of the flame is white with blue edges.

14

When ſugar is diſtilled in a retort, there comes over a fluid which, at firſt, ſcarcely differs from pure water; by and bye it is mixed with pyromucous acid, afterwards ſome empyreumatic oil makes its appearance; and a bulky charcoal remains in the retort. This charcoal very frequently contains lime, becauſe lime is uſed in refining ſugar; but if the ſugar, before being ſubmitted to diſtillation, be diſſolved in water, and made to cryſtallize by evaporation in a temperature ſcarcely higher than that of the atmoſphere, no lime whatever, nor any thing elſe, except pure charcoal, will be found in the retort. During the diſtillation, there comes over a conſiderable quantity of carbonic acid, and carbonated hydrogen gas*. Sugar therefore is decompoſed by the action of heat; and the following compounds are formed from it: Water, pyromucous acid, oil, charcoal, carbonic acid, carbonated hydrogen gas. The quantity of oil is inconſiderable; by far the moſt abundant product is pyromucous acid. Sugar indeed is very readily converted into pyromucous acid; for it makes its appearance always whenever ſyrup is raiſed to the boiling temperature. Hence the ſmell of caromel, which ſyrup at that temperature emits. Hence alſo the reaſon that, when we attempt to cryſtallize ſyrup by heat, there always remains behind a quantity of incryſtallizable matter, known by the name of *molaſſes*; whereas if the ſyrup be cryſtallized without artificial heat, every particle of ſugar may be obtained from it in a cryſtalline form †. Hence we ſee the importance of properly regulating the fire during the cryſtallization of ſugar, and the immenſe ſaving that would reſult from conducting the operation at a low heat.

15

It follows from theſe facts, and from various other methods of decompoſing ſugar, that it is compoſed of oxygen, hydrogen, and carbon; for all the ſubſtances obtained from ſugar by diſtillation may be reſolved into theſe elements. Lavoiſier has made it probable, by a ſeries of very delicate experiments, that theſe ſubſtances enter into the compoſition of ſugar in the following proportions:

	64 oxygen,
	28 carbon,
	8 hydrogen.
	100

Of the way in which theſe ingredients are combined in ſugar, we are ſtill entirely ignorant. Lavoiſier's concluſions can only be conſidered as approximations to the truth.

Sugar is conſidered as a very nouriſhing article of food. It is found moſt abundantly in the juice of the ſugar cane, but many other plants alſo contain it. The juice of the acer ſaccharinum, or *ſugar maple*, contains ſo much of it, that in North America ſugar is often extracted from that tree *. Sugar is alſo found in the roots of carrot, parſnip, beet, &c. Mr Achard has lately pointed out a method of increaſing the quantity of ſugar in beet ſo much, that, according to his own account, it is at preſent cultivated in large quantities in Pruſſia, and ſugar extracted from it with advantage †. Parmentier has alſo aſcertained that the grains of wheat, barley, &c. and all the other ſimilar ſeeds which are uſed as food, contain at firſt a large quantity of ſugar, which gradually diſappears as they approach to a ſtate of maturity. This is the caſe alſo with peas and beans, and all leguminous ſeeds, and is one reaſon why the flavour of young peas is ſo much ſuperior to that of old ones.

Starch.

16 Plants containing it.

* *Ruſſ. Tranſ Phil.* iii. 64.

† *Ann. de Chim.* xxxii. 163.

SECT. II. *Of STARCH.*

WHEN a quantity of wheat flour is formed into a paſte, and water poured upon it till it runs off colourleſs, this water ſoon depoſits a very fine whitiſh powder; which, when properly waſhed and dried, is known by the name of *ſtarch*. When firſt prepared, it is of a grey colour; but the ſtarchmakers render it white by ſteeping it in water ſlightly acidulated. The acid ſeems to diſſolve and carry off the impurities.

17 Method of obtaining ſtarch.

Starch was well known to the ancients. Pliny informs us, that the method of obtaining it was firſt invented by the inhabitants of the iſland of Chio†.

† *Lib* xviii. c. 7.

Starch has a fine white colour, and is uſually concreted in longiſh maſſes; it has ſcarcely any ſmell, and very little taſte. When kept dry, it continues for a long time uninjured though expoſed to the air.

18 Its properties.

Starch does not diſſolve in cold water, but very ſoon falls to powder. It combines with boiling water, and forms with it a thick paſte. Linen dipt into this paſte, and afterwards dried ſuddenly, acquires, as is well known, a great degree of ſtiffneſs. When this paſte is left expoſed to damp air it ſoon loſes its conſiſtency, acquires an acid taſte, and its ſurface is covered with mould.

19 How acted on by water,

Starch is ſo far from diſſolving in alcohol, even when aſſiſted by heat, that it does not even fall to powder.

20 Alcohol,

When ſtarch is thrown into any of the mineral acids, at firſt no apparent change is viſible. But if an attempt is made to break the larger pieces while in acids to powder, they reſiſt it, and feel exceedingly tough and adheſive. Sulphuric acid diſſolves it ſlowly, and at the ſame time a ſmell of ſulphurous acid is emitted, and ſuch a quantity of charcoal is evolved, that the diſh containing the mixture may be inverted without ſpilling any of it. Indeed if the quantity of ſtarch be ſufficient, the mixture becomes perfectly ſolid. The charcoal may be ſeparated by dilution and filtration. In muriatic acid ſtarch diſſolves ſtill more ſlowly. The ſolution reſembles mucilage of gum arabic, and ſtill retains the peculiar odour of muriatic acid. When allowed to ſtand for ſome time, the ſolution gradually ſeparates into two parts; a perfectly tranſparent ſtraw-coloured liquid below, and a thick, muddy, oily, or rather mucilaginous ſubſtance, above. When water is poured in, the muriatic ſmell inſtantly diſappears, and a ſtrong ſmell is exhaled, preciſely ſimilar to that which is felt in corn-mills,

21 Acids,

mills. Ammonia occaſions a ſlight precipitate, but too ſmall to be examined.

Nitric acid diſſolves ſtarch more rapidly than the other two acids; it acquires a green colour, and emits nitrous gas. The ſolution is never complete, nor do any cryſtals of oxalic acid appear unleſs heat be applied. In this reſpect ſtarch differs from ſugar, which yields oxalic acid with nitric acid, even at the temperature of the atmoſphere. When heat is applied to the ſolution of ſtarch in nitric acid, both oxalic and malic acid is formed, but the undiſſolved ſubſtance ſtill remains. When ſeparated by filtration, and afterwards edulcorated, this ſubſtance has the appearance of a thick oil, not unlike tallow; but it diſſolves readily in alcohol. When diſtilled, it yields acetous acid, and an oil having the ſmell and the conſiſtence of tallow *.

22 Heat. When ſtarch is thrown upon a hot iron, it melts, blackens, froths, ſwells, and burns with a bright flame like ſugar, emitting, at the ſame time, a great deal of ſmoke; but it does not explode, nor has it the caromel ſmell which diſtinguiſhes burning ſugar. When diſtilled, it yields water impregnated with an acid, ſuppoſed to be the pyromucous, and mixed with a little empyreumatic oil. The charcoal which remains is eaſily diſſipated when ſet on fire in the open air; a proof that it contains very little earth.

23 Its compoſition. Barley grain conſiſts almoſt entirely of ſtarch, not however in a ſtate of perfect purity. In the proceſs of malting, which is nothing elſe than cauſing the barley to begin to vegetate, a great part of the ſtarch is converted into ſugar. During this proceſs oxygen gas is abſorbed, and carbonic acid gas is emitted. Water, too, is abſolutely neceſſary; hence it is probable, that it is decompoſed, and its hydrogen retained †. Starch, then, ſeems to be converted into ſugar by diminiſhing the proportion of its carbon, and encreaſing that of its hydrogen and oxygen. Its diſtillation ſhews us that it contains no other ingredients than theſe three.

24 Subſtances containing it. Starch is contained in a great variety of vegetable ſubſtances; moſt commonly in their ſeeds or bulbous roots; but ſometimes alſo in other parts. Mr Parmentier, whoſe experiments have greatly contributed towards an accurate knowledge of ſtarch, has given us the following liſt of the plants from the roots of which it may be extracted.

Arctium lappa,
Atropa belladonna,
Polygonum biſtorta,
Bryonia alba,
Colchicum autumnale,
Spiræa filipendula,
Ranunculus bulboſus,
Scrophularia nodoſa,
Sambucus ebulus,
——— ——— nigra,
Orchis morio,
Imperatoria oſtrutheum,
Hyoſcyamus niger,
Rumex obtuſifolius,
——— acutus,
——— aquaticus,
Arum maculatum,
Orchis maſcula,
Iris pſeudacorus,
——— fœtidiſſima,
Orobus tuberoſus,
Bunium bulbocaſtanum.

It is found alſo nearly pure in the following ſeeds:

Oats,
Rice,
Maiz,
Millet,
Cheſnut,
Horſecheſnut,
Peas,
Beans,
Acorn,
And alſo in
Salop,
Sago.

SECT. III. *Of* GLUTEN.

25 Gluten, how obtained. WHEN wheat flour is waſhed in the manner deſcribed in the laſt ſection, in order to obtain ſtarch from it, the ſubſtance which remains, after every thing has been waſhed away which cold water can ſeparate, is called *gluten*. It was diſcovered by Beccaria an Italian philoſopher, to whom we are indebted for the firſt analyſis of wheat flour †.

26 Its properties. Gluten, when thus obtained, is of a grey colour, exceedingly tenacious, ductile, and elaſtic, and may be extended to twenty times its original length. When very thin, it is of a whitiſh colour, and has a good deal of reſemblance to animal tendon or membrane. In this ſtate it adheres very tenaciouſly to other bodies, and has often been uſed to cement together broken pieces of porcelain. Its ſmell is agreeable. It has ſcarce any taſte, and does not loſe its tenacity in the mouth.

27 Action of air. When expoſed to the air, it gradually dries; and, when completely dry, it is pretty hard, brittle, ſlightly tranſparent, of a dark brown colour, and has ſome reſemblance to *glue*. It breaks like a piece of glaſs, and the edges of the fracture reſemble in ſmoothneſs thoſe of broken glaſs; that is to ſay, it breaks with a *vitreous* fracture.

28 Water. When expoſed to the air, and kept moiſt, it ſoon putrifies; but when dry, it may be kept any length of time without alteration. It is inſoluble in water; tho' it imbibes and retains a certain quantity of it with great obſtinacy. To this water it owes its elaſticity and tenacity. When boiled in water, it loſes both theſe properties. It is ſoluble in alcohol, as Mr Vauquelin informs us ‡; and precipitated again, as Mr Fourcroy has obſerved, by pouring into the alcohol two parts of water §.

29 Acids. Gluten is ſoluble in the three mineral acids. When nitric acid is poured on it, and heat applied, there is a quantity of azotic gas emitted, as Berthollet diſcovered; and, by continuing the heat, a quantity of oxalic acid is formed ||.

30 Alkalies. Alkalies diſſolve gluten when they are aſſiſted by heat. The ſolution is never perfectly tranſparent. Acids precipitate the gluten from alkalies, but it is deſtitute of its elaſticity ¶.

31 Heat. When moiſt gluten is ſuddenly dried, it ſwells amazingly. Dry gluten, when expoſed to heat, cracks, ſwells, melts, blackens, exhales a fetid odour, and burns preciſely like feathers or horn. When diſtilled, there comes over water impregnated with ammonia and an empyreumatic oil; the charcoal which remains is with difficulty reduced to aſhes.

32 Its compoſition. From theſe phenomena, it is evident that gluten is compoſed of carbon, hydrogen, azot, and oxygen: perhaps alſo it contains a little lime. In what manner theſe ſubſtances are combined is unknown.

33 Subſtances containing it. The only vegetable ſubſtance which has been hitherto found to contain it abundantly, is wheat flour. Vauquelin alſo found it in the fruit of the *caſſia fiſtuloris* *, and Fourcroy in the bark of a ſpecies of quinquina from St Domingo †. It probably exiſts in many other plants.

SECT. IV. *Of* ALBUMEN.

IF the water in which wheat flour has been waſhed in order to obtain ſtarch and gluten, according to the directions laid down in the two laſt ſections, be filtrated, and afterwards boiled, a ſubſtance precipitates in white flakes; to which Mr Fourcroy, who firſt pointed it

---

* *Scheele, Crell's Jour.* ii. 14. Engliſh tranſlation.

† *Cruikſhank, Rollo on Diabetes.*

† *Collect. Acad.* x. 1.

‡ *Ann. de Chim.* vi. 278.

§ *Ibid.* viii. 135.

|| *Vauquelin Ibid* vi. 278.

¶ *Fourcroy.*

* *Ibid.*

† *Ibid.* viii. 135.

lly.

it out, has given the name of *albumen* (A), on account of its reſemblance to the *white* of an egg ‡.

‡ n. de Ch. iii.

34 erties umen.

It is evident, from the method of obtaining it, that albumen, in its natural ſtate, is ſoluble in water, and that heat precipitates it from that fluid in a concrete ſtate. While diſſolved in water, it has ſcarcely any taſte; but it has the property of changing vegetable blues, eſpecially that which is obtained from the flowers of the mallow (*malva ſylveſtris*), into a green §. When allowed to remain diſſolved in water, it putrifies without becoming previouſly acid ‖.

§ rcroy, 257.

‖ d.

After it has been precipitated from water in a concrete ſtate by boiling, it is no longer ſoluble in water as before. Alcohol alſo precipitates it from water preciſely in the ſame ſtate as when it is precipitated by heat.

When concrete albumen is dried it becomes ſomewhat tranſparent, and very like glue. In that ſtate it is ſoluble in alkalies, eſpecially ammonia*.

* d.

35 ompo- n.

When diſtilled it gives out carbonat of ammonia, a red fetid oil, and carbonated hydrogen gas; and a ſpongy charcoal remains behind †. From this, it is evident that albumen, like gluten, is compoſed of carbon, azot, hydrogen, and oxygen; but the proportions and combinations of theſe ſubſtances are altogether unknown.

† d.

Mr Fourcroy found albumen in the expreſſed juice of ſcurvy graſs, creſſes, cabbage, and almoſt all cruciform plants. He found it, too, in a great many young and ſucculent plants; but never a particle in thoſe parts of vegetables which contain an acid. He obſerved alſo that the quantity decreaſed conſtantly with the age of the plant.

SECT. V. *Of Jelly*.

If we preſs out the juice of ripe blackberries, currants, and many other fruits, and allow it to remain for ſome time in a ſtate of reſt, it partly coagulates into a tremulous ſoft ſubſtance, well known by the name of *jelly*. If we pour off the uncoagulated part, and waſh the coagulum with a ſmall quantity of water, we obtain *jelly* approaching to a ſtate of purity.

36 erties lly.

In this ſtate it is nearly colourleſs, unleſs tinged by the peculiar colouring matter of the fruit; it has a pleaſant taſte, and a tremulous conſiſtency. It is ſcarcely ſoluble in cold water, but very ſoluble in hot water; and, when the ſolution cools, it again coagulates into the form of a jelly †. When long boiled, it loſes the property of gelatiniſing by cooling, and becomes analagous to mucilage ‡. This is the reaſon that in making currant jelly, or any other jelly, when the quantity of ſugar added is not ſufficient to abſorb all the watery parts of the fruit, and conſequently it is neceſſary to concentrate the liquid by long boiling, the mixture often loſes the property of coagulating, and the jelly, of courſe, is ſpoiled §.

† uquelin, . de . vi.

‡ . Ibid. 00.

Gum.

§ Ann. de Chim. v. 102.

Jelly combines readily with alkalies; nitric acid converts it into oxalic acid, without ſeparating any azotic gas ‖. When dried it becomes tranſparent ¶. When diſtilled it affords a great deal of pyromucous acid, a ſmall quantity of oil, and ſcarcely any ammonia †.

‖ Ibid. vi. 282.

¶ Ibid. v. 100.

† Ibid. vi. 286.

Jelly exiſts in all acid fruits, as oranges, lemons, gooſeberries, &c. and no albumen is ever found in thoſe parts of vegetables which contain an acid. This circumſtance has induced Fourcroy to ſuppoſe that jelly is albumen combined with an acid *: but this conjecture has not been verified by experiment; nor indeed is it probable that it ever ſhall; as albumen evidently contains a quantity of azot, and jelly ſcarcely any. The products of jelly by diſtillation ſhew that it approaches nearer than any other vegetable ſubſtance to the nature of ſugar.

* Ibid. iii. 261.

SECT. VI. *Of Gum*.

There is a thick tranſparent taſteleſs fluid which ſometimes exſudes from certain ſpecies of trees. It is very adheſive, and gradually hardens without loſing its tranſparency; but eaſily ſoftens again when moiſtened with water. This exſudation is known by the name of *gum*. The gum moſt commonly uſed is that which exſudes from different ſpecies of the *mimoſa*, particularly the *nilotica* †. It is known by the name of *gum arabic*. Gum likewiſe exſudes abundantly from the *prunus avium*, or common wild cherry tree of this country.

37 Gum how obtained.

† Schouſboe, Philoſ. Mag. v. 241.

Gum is uſually obtained in ſmall pieces like tears, moderately hard, and ſomewhat brittle while cold, ſo that it can be reduced by pounding to a fine powder. Its colour is uſually yellowiſh, and it is not deſtitute of luſtre. It has no ſmell; its taſte is inſipid.

Gum undergoes no change from being expoſed to the atmoſphere; but the light of the ſun makes it aſſume a white colour. Water diſſolves it in large quantities. The ſolution which is known by the name of *mucilage* (B), is thick and adheſive: it is often uſed as a paſte, and to give ſtiffneſs and luſtre to linen. When ſpread out thin it ſoon dries, and has the appearance of a varniſh; but it readily attracts moiſture, and becomes glutinous. Water waſhes it away entirely. When mucilage is evaporated the gum is obtained unaltered.

38 Action of water.

Gum is inſoluble in alcohol. When alcohol is poured into mucilage, the gum immediately precipitates; becauſe the affinity between water and alcohol is greater than that between water and gum.

39 Alcohol.

The action of alkalies and earths upon gum has not been

(A) The exiſtence of albumen in vegetables was known to Scheele. He mentions it particularly in his paper on Milk, firſt publiſhed in the year 1780. See *Scheele's Works*, II. 55. Dijon edition.

(B) Hermſtadt uſes this word in a different ſenſe. He makes a diſtinction between *gum* and *mucilage*. The ſolution of *gum* in water is tranſparent and glutinous, and can be drawn out into threads; whereas that of *mucilage* is opake, does not feel glutinous, but ſlippery, and cannot be drawn into threads. Gum may be ſeparated from mucilage by the following proceſs:

Let the gum which is ſuppoſed to be mixed with mucilage, previouſly reduced to a dry maſs, be diſſolved in as ſmall a quantity of water as poſſible, and into the ſolution drop at intervals diluted ſulphuric acid. The mucilage coagulates while the gum remains diſſolved. When no more coagulation takes place, let the mixture remain at reſt for ſome time, and the mucilage will precipitate to the bottom, and aſſume the conſiſtence of jelly. Decant off the liquid part, and evaporate the mucilage to dryneſs by a gentle heat till it acquires the conſiſtence of horn. *Med. and Phyſ. Jour.* iii. 370.

been examined. Acids do not precipitate it from mucilage ‡. The concentrated mineral acids deſtroy it. Concentrated ſulphuric acid decompoſes it; water is formed, and perhaps alſo acetous acid; while charcoal is precipitated. Nitric acid converts it into oxalic acid; oxy-muriatic acid, on the contrary, into citric acid *.

40
Of heat.

When gum is expoſed to heat it ſoftens and ſwells, but does not melt; it emits air bubbles, blackens, and at laſt, when nearly reduced to charcoal, emits a low blue flame. This flame appears ſooner if a flaming ſubſtance be held juſt above the gum. After the gum is conſumed, there remains a ſmall quantity of white aſhes, compoſed chiefly of the carbonats of lime and potaſs.

When gum is diſtilled in a retort, the products are water impregnated with a conſiderable quantity of pyromucous acid, a little empyreumatic oil, carbonic acid gas, and carbonated hydrogen gas. When the pyromucous acid obtained by this proceſs is ſaturated with lime, a quantity of ammonia is diſengaged with which that acid had been combined. The charcoal which remained in the retort leaves behind it, after incineration, a little lime, and phoſphat of lime §.

41
Its compoſition.

Theſe experiments ſhew us that gum is compoſed of hydrogen, carbon, oxygen, azot, lime, and phoſphorus; but the proportions and combinations of theſe ſubſtances are unknown to us. Mr Cruickſhank has rendered it probable that the quantity of carbon is greater, and the quantity of oxygen leſs, in gum than in ſugar ||.

Gum, or mucilage, exiſts moſt abundantly in young plants, and gradually diſappears as they arrive at perfection. It forms a great proportion of the leaves and roots of many eatable plants.

SECT. VII. *Of Extract.*

42
Extract, how obtained.

THE word *extract* was at firſt applied to all thoſe ſubſtances which were extracted from plants by means of water, and conſequently included gum, jelly, and ſeveral other bodies. But of late it has been confined, by thoſe chemiſts who have paid attention to the uſe of language, to a ſubſtance which exiſts in many plants, and which may be obtained by infuſing *ſaffron* in water for ſome time, filtrating the infuſion, and evaporating it to dryneſs. The reſiduum, after evaporation, is *extract* nearly pure ¶. It poſſeſſes the following properties:

43
Its properties.

Water diſſolves it in conſiderable quantities, eſpecially hot water. Alcohol alſo diſſolves it with facility. This property of being ſoluble both in water and alcohol has induced ſome chemiſts to give *extract* the name of *ſoap*. It is inſoluble in ſulphuric ether. Theſe three properties are ſufficient to diſtinguiſh it from every other vegetable ſubſtance *.

When the ſolution of extract in water is expoſed for ſome time in the open air, the extract precipitates, and is now no longer ſoluble in water. This change is ſuppoſed to proceed from the addition of a quantity of oxygen which it imbibes from the atmoſphere †.

When oxy-muriatic acid is poured into a watery ſolution of extract, that ſubſtance precipitates in yellow flakes. Theſe flakes are inſoluble in water; they are inſoluble alſo in alcohol at the temperature of 97°; but that liquid diſſolves them at the temperature of 120°. They are ſoluble alſo in alkalies, and in boiling-hot water they melt into a yellow maſs ‡.

Extract is ſoluble in acids. Heat ſoftens but does not melt it §.

It is found in a great variety of plants; but as no method of obtaining it perfectly pure has hitherto been diſcovered, the extracts of different plants differ ſomewhat from each other both in their colour and ſmell.

SECT. VIII. *Of Tan.*

44
Preparation of tan

IF a quantity of nut galls, coarſely powdered, be kept for ſome time infuſed in cold water, if the water be filtered, and a ſolution of muriat of tin be dropt into it, a copious white precipitate falls to the bottom. This precipitate is to be carefully waſhed and diffuſed (for it will not diſſolve) thro' a large quantity of water, and this water is to be ſaturated with ſulphurated hydrogen gas ſo completely that it will not abſorb any more. By this treatment the white precipitate will gradually diſappear, and a brown precipitate will take its place. This brown precipitate muſt be ſeparated by filtration; and the water, which has now acquired the colour and the taſte of the infuſion of nut galls, muſt be evaporated to dryneſs. A ſubſtance remains behind, known by the name of *tan* or *tannine*.

It was firſt diſcovered by Seguin, who pointed out ſome of its properties, and the method of detecting it in plants ||. The above method of obtaining it in a ſtate of purity was contrived by Mr Prouſt. Tan exiſts in the ſolution of nut galls combined with gallic acid. The oxyd of tin has a ſtrong affinity for it. When muriat of tin is poured in, the tan combines with the oxyd, and the compound, being inſoluble, falls to the bottom. Sulphur has a ſtronger affinity for the oxyd than tan has. Hence when ſulphurated hydrogen gas is thrown upon this compound, the ſulphur leaves the gas and combines with the tin; and the compound, being inſoluble, falls to the bottom: The hydrogen gas eſcapes, and nothing remains in the water except the tan.

45
Its properties.

Tan is a brittle ſubſtance, of a brown colour. It breaks with a vitreous fracture, and does not attract moiſture from the air. Its taſte is exceedingly aſtringent. It is very ſoluble in water. The ſolution is of a deep brown colour, a very aſtringent and bitter taſte, and has the odour which diſtinguiſhes a ſolution of nut galls. It froths, when agitated, like a ſolution of ſoap; but does not feel unctuous. Acids precipitate the tan from this ſolution.

Tan is ſtill more ſoluble in alcohol than in water.

When the ſolution of tan is poured into a ſolution of the brown ſulphat of iron, a deep blue coloured precipitate immediately appears, conſiſting of the tan combined with the oxyd. This precipitate, when dried, aſſumes a black colour. It is decompoſed by acids. The green ſulphat of iron is not altered by tan.

When too great a proportion of brown ſulphat of iron is poured into a ſolution of tan, the ſulphuric acid, ſet at liberty by the combination of the iron and tan, is ſufficient to rediſſolve the precipitate as it appears; but the precipitate may eaſily be obtained by cautiouſly ſaturating this exceſs of acid with potaſs. When the experiment is performed in this manner, all the red ſulphat of iron which remains in the ſolution undecompoſed is converted into green ſulphat. Mr Prouſt, to whom we are indebted for almoſt every thing yet known concerning the properties of tan, ſuppoſes that this change is produced

---

‡ *Vauquelin.*

* *Id. Ann de Chim.* vi 278.

§ *Cruikſhank Rollo on Diabetes*

|| *Ibid.*

¶ *Hermſtadt.*

* *Hermſtadt.*

† *Fourcroy.*

‡ *Fourcroy.*

§ *Id. Ann. de Chim.* viii.

|| *Nicholſon's Jour.* i. 272.

ıphor.

produced by the tan abſorbing oxygen from the iron. This may very poſſibly be the caſe; but his experiments are inſufficient to prove that it is. The ſame change takes place if red oxyd be mixed with a conſiderable exceſs of ſulphuric acid, and diluted with water.

Tan combines readily with oxygen. When oxy muriatic acid is poured upon it, its colour deepens, and it loſes all its peculiar characters *.

46
ts con-
rg it.

Tan exiſts in almoſt all thoſe vegetable ſubſtances which have an aſtringent taſte. It is almoſt conſtantly combined with gallic acid. The following table, drawn up by Mr Biggin †, though the rule which the author followed in making his experiments precluded rigid accuracy, will ſerve to give ſome idea of the proportions of tan which exiſt in different plants:

	Prop. of Tan.		*Prop. of Tan.*
Elm	2,1	Sallow	4,6
Oak cut in winter	2,1	Mountain aſh	4,7
Horſe cheſnut	2,2	Poplar	6,0
Beech	2,4	Hazel	6,3
Willow (boughs)	2,4	Aſh	6,6
Elder	3,0	Spaniſh cheſnut	9,0
Plum tree	4,0	Smooth oak	9,2
Willow (trunk)	4,0	Oak cut in ſpring	9,6
Sycamore	4,1	Huntingdon or Leiceſter willow	10,1
Birch	4,1		
Cherry tree	4,2	Sumach	16,2

SECT. IX. *Of OILS.*

THERE are two ſpecies of oils; namely, *fixed* and *volatile*: both of which are found abundantly in plants.

1. Fixed oil is found in the ſeeds of many plants; eſpecially of the olive, beech, flax, almond, rape, &c.

2. Volatile oil is obtained by diſtillation from the leaves, flowers, or roots of aromatic plants, as lavender, roſes, roſemary, &c.

As an account of the properties of oils has been given already in the article CHEMISTRY, *Suppl.* it would be ſuperfluous to repeat it here.

SECT. X. *Of CAMPHOR.*

THE laurus camphorata is a tree which grows in China, Japan, and ſeveral parts of India. When the roots of this tree are put into an iron pot furniſhed with a capital, and a ſufficient heat is applied, a particular ſubſtance ſublimes into the capital, which is known by the name of *camphor*. The Dutch afterwards purify this camphor by a ſecond ſublimation.

Camphor is a white brittle ſubſtance, having a peculiar aromatic odour and a ſtrong taſte.

47
perties
mphor

It is not altered by atmoſpheric air; but it is ſo volatile, that if it be expoſed during warm weather in an open veſſel, it evaporates completely. When ſublimed in cloſe veſſels it cryſtalliſes in hexagonal plates or pyramids *.

It is inſoluble in water; but it communicates to that liquid a certain portion of its peculiar odour.

It diſſolves readily in alcohol, and is precipitated again by water. If the alcohol be diluted with water as much as poſſible, without cauſing the camphor to precipitate, ſmall cryſtals of camphor reſembling feathers gradually form †.

Camphor is ſoluble alſo in hot oils, both fixed and volatile; but as the ſolution cools the camphor precipitates, and aſſumes the form of plumoſe, or feather-like cryſtals ‡.

Camphor is not acted on by alkalies, either pure or in the ſtate of carbonats. Pure alkalies indeed ſeem to diſſolve a little camphor; but the quantity is too ſmall to be perceptible by any other quality than its odour §. Neither is it acted upon by any of the neutral ſalts which have hitherto been tried.

Acids diſſolve camphor, but it is precipitated again, unaltered, by alkalies, and even by water. The ſolution of camphor in ſulphuric acid is red; that in the nitric acid is yellow. This laſt ſolution has obtained the abſurd name of *oil of camphor*. When nitric acid is diſtilled repeatedly off camphor, it converts it into camphoric acid.

Muriatic, ſulphurous, and fluoric acids, in the ſtate of gas, diſſolve camphor. When water is added, the camphor appears unaltered in flakes, which ſwim on the ſurface of the water §.

When heat is applied to camphor it is volatilized. If the heat be ſudden and ſtrong, the camphor melts before it evaporates. It catches flame very readily, and emits a great deal of ſmoke as it burns, but it leaves no reſiduum. It is ſo inflammable that it continues to burn even on the ſurface of water. When camphor is ſet on fire in a large glaſs globe filled with oxygen gas, and containing a little water, it burns with a very bright flame, and produces a great deal of heat. The inner ſurface of the glaſs is ſoon covered with a black powder, which has all the properties of charcoal, a quantity of carbonic acid gas is evolved, the water in the globe acquires a ſtrong ſmell, and is impregnated with carbonic acid and camphoric acid ‖.

43
Its analyſis.

If two parts of alumina and one of camphor be formed into a paſte with water, and diſtilled in a glaſs retort, there comes over into the receiver (which ſhould contain a little water, and communicate with a pneumatic apparatus) a volatile oil of a golden yellow colour, a little camphoric acid which diſſolves in the water, and a quantity of carbonic acid gas, and carbonated hydrogen gas, which may be collected by means of a pneumatic apparatus. There remains in the retort a ſubſtance of a deep black colour, compoſed of alumina and charcoal. By this proceſs, from 122.284 parts of camphor, Mr Bouillon la Grange, to whom we are indebted for the whole of the analyſis of camphor, obtained 45.856 parts of volatile oil, and 30.571 parts of charcoal. The proportion of the other products was not aſcertained *.

From this analyſis, Mr Bouillon la Grange concludes, that camphor is compoſed of volatile oil, and charcoal or carbon, combined together. We learn, from his experiments, that the ultimate ingredients of camphor are carbon and hydrogen; and that the proportion of carbon is much greater than in oils.

49
Plants containing it.

Camphor exiſts in a great many plants. Neumann, Geoffroy, and Cartheuſer, extracted it from the roots of zedoary, thyme, ſage, &c. and rendered it probable that it is contained in almoſt all the labiated plants. It has been ſuppoſed to exiſt in theſe plants combined with volatile oil. Prouſt has ſhewn how it may be extracted, in conſiderable quantity, from many volatile oils †.

Camphor, which was unknown to the ancient Greeks and Romans, was introduced into Europe by the Arabians.

---

* ouſt, de . xxv. 3:

† ſ.

* mieu.

† mieu, . Par. , p. 41.

‡ Romieu, Mem. Par. 1756, p. 41.

§ Bouillon la Grange, Ann. de Chim. xxiii. 154.

§ Fourcroy.

‖ Bouillon la Grange, ibid, p. 168.

* Ibid, p. 157.

† Ann. de Chim. iv. 179.

bians. Ætius is the firſt perſon who mentions it. It ſeems, however, to have been very early known to the eaſtern nations.

It is much uſed in medicine. It is a powerful ſtimulant; it is conſidered as peculiarly efficacious in diſeaſes of the urinary organs; it is often ſerviceable in mania, and procures ſleep when every other medicine fails.

Sect. XI. *Of Resins.*

There is a yellowiſh white coloured ſubſtance which often exſudes from the *Abies Montana*, or *common Scotch fir*, and likewiſe from other fir trees. It is ſomewhat tranſparent, is hard and brittle, of a diſagreeable taſte, and may be collected in conſiderable quantities. This ſubſtance is known by the name of *reſin*; and the ſame name is alſo applied to all ſubſtances which poſſeſs nearly the ſame properties with it. Reſin may be diſtinguiſhed from every other ſubſtance by the following properties:

50 Properties of reſin.

It is more or leſs concrete, and has an acrid and hot taſte.

It is totally inſoluble in water. By this property it may eaſily be ſeparated from gum, if they happen to be mixed together.

It is ſoluble in alcohol, and in ſulphuric ether *. By the firſt of theſe properties we may ſeparate it from gum, and by the laſt from extract; for extract is inſoluble in ſulphuric ether. When theſe ſolutions are evaporated the reſin is obtained unaltered. If the ſolution be ſpread thin upon any body, it ſoon dries by the evaporation of the alcohol; the reſin remains behind, and covers the body with a ſmooth ſhining tranſparent coat, which cannot be waſhed off by water. This proceſs is called *varniſhing*.

Reſin is ſoluble alſo in volatile oils; and theſe ſolutions are often uſed likewiſe in varniſhing.

Reſin is ſcarcely acted upon by acids. Alkalies combine with it, but the combination is not eaſily effected.

When reſin is heated it readily melts; and if the heat be increaſed it is volatilized, and burns with a white flame and ſtrong ſmell. When diſtilled it yields much volatile oil, but ſcarcely any acid.

When volatile oils are expoſed for ſome time to the action of the atmoſphere they acquire conſiſtency, and aſſume the properties of reſins. During this change they abſorb a quantity of oxygen from the air. Weſtrum put 30 grains of oil of turpentine into 40 cubic inches of oxy-muriatic acid gas. Heat was evolved, the oil gradually evaporated, and aſſumed the form of yellow reſin †. Theſe facts render it probable that reſin is merely volatile oil combined with a quantity of oxygen.

To know whether any vegetable ſubſtance contains reſin, we have only to pour ſome ſulphuric ether upon it in powder, and expoſe the infuſion to the light. If any reſin be preſent the ether will aſſume a brown colour ‡.

51 Number of reſins.

The number of reſins is conſiderable. They differ from each other chiefly in colour, taſte, ſmell, and conſiſtency. Whether theſe reſins be really different combinations, or, as is moſt likely, owe theſe differences to foreign ingredients, either combined with the reſin, or mechanically mixed with it, is not at preſent known. To deſcribe each reſin ſeparately would be to little purpoſe, as ſcarcely any thing is known of them except their general properties as reſins. The following is a liſt of the principal. The reader will find an account of the manner of obtaining them, and of their uſes, by conſulting the name of each in the *Encyclopædia*.

1. Common reſin,
2. Turpentine,
3. Pitch,
4. Galipot,
5. Elemi,
6. Maſtic,
7. Sandarac,
8. Guaiacum,
9. Labdanum,
10. Dragon's blood,
11. Copaiba.

52 Balſams.

There are three vegetable ſubſtances which have been denominated *balſams* by ſome of the later French writers. They appear to conſiſt of reſin, or volatile oil combined with benzoic acid. Theſe ſubſtances are, benzoin, balſam of Tolu, and ſtorax. For an account of them we refer to the *Encyclopædia*.

53 Gum reſins.

Many vegetable ſubſtances occur in medicine which conſiſt chiefly of a mixture of gum and reſin. Theſe ſubſtances, of courſe, have a number of the properties both of gums and reſins. For this reaſon they have been denominated *gum reſins*. The following are the moſt important of theſe ſubſtances:

Olibanum,
Galbanum,
Scammony,
Aſafœtida,
Aloes,
Myrrh,
Ammoniac,
Opium.

For an account of them we refer to the *Encyclopædia*.

Sect. XII. *Of Caoutchouc.*

54 Diſcovery of caoutchouc.

About the beginning of the 18th century a ſubſtance, called *caoutchouc*, was brought as a curioſity from America. It was ſoft, wonderfully elaſtic, and very combuſtible. The pieces of it that came to Europe were uſually in the ſhape of bottles, birds, &c. This ſubſtance is very much uſed in rubbing out the marks made upon paper by a black lead pencil; and therefore in this country it is often called *Indian rubber*. Nothing was known of its production, except that it was obtained from a tree, till the French academicians went to South America in 1735 to meaſure a degree of the meridian. Mr de la Condamine ſent an account of it to the French Academy in the year 1736. He told them, that there grew in the province of Eſmeraldas, in Brazil, a tree, called by the natives *Hhevé*; that from this tree there flowed a milky juice, which, when inſpiſſated, was *caoutchouc*. Don Pedro Maldonado, who accompanied the French academicians, found the ſame tree on the banks of the Maragnon; but he died ſoon after, and his papers were never publiſhed. Mr Freſnau, after a very laborious ſearch, diſcovered the ſame tree in Cayenne. His account of it was read to the French Academy in 1751.

55 Plants containing it.

It is now known that there are at leaſt two trees in South America from which caoutchouc may be obtained, the Hævea Caoutchouc and the Jatropha Elaſtica; and it is exceedingly probable that it is extracted alſo from other ſpecies of Hævea and Jatropha. Several trees likewiſe which grow in the Eaſt Indies yield caoutchouc; the principal of theſe are, the Ficus Indica, the Artocarpus Integrifolia, and the Urceola Elaſtica; a plant diſcovered by Mr Howiſon, and firſt deſcribed and named by Dr Roxburgh *.

---

* *Hermſtadt.*

† *Crell's Annals*, i. 1790.

‡ *Hermſtadt.*

* *Aſiatic Reſearches* v. 167. London edition.

Caout-
chouc.

When any of theſe plants is punctured, there exſudes from it a milky juice, which, when expoſed to the air, gradually lets fall a concrete ſubſtance, which is caoutchouc.

If oxy-muriatic acid be poured into the milky juice, the caoutchouc precipitates immediately, and, at the ſame time, the acid loſes its peculiar odour. This renders it probable that the formation of the caoutchouc is owing to its baſis abſorbing oxygen *. If the milky juice be confined in a glaſs veſſel containing common air, it gradually abſorbs oxygen, and a pellicle of caoutchouc appears on its ſurface †.

* *Fourcroy*, *n. de* *im.* xi. 9.
† *Ibid.*

56
operties
caout-
ouc.

Caoutchouc was no ſooner known than it drew the attention of philoſophers. Its ſingular properties promiſed that it would be exceedingly uſeful in the arts, provided any method could be fallen upon to mould it into the various inſtruments for which it ſeemed peculiarly adapted. Meſſrs de la Condimine and Freſnau had mentioned ſome of its properties; but Macquer was the firſt perſon who undertook to examine it with attention. His experiments were publiſhed in the memoirs of the French Academy for the year 1768. They threw a good deal of light on the ſubject; but Macquer fell into ſome miſtakes, which were pointed out by Mr Berniard, who publiſhed an admirable paper on caoutchouc in the 17th volume of the *Journal de Phyſique*. To this paper we are indebted for the greater number of facts at preſent known reſpecting caoutchouc. Mr Groſſart and Mr Fourcroy have likewiſe added conſiderably to our knowledge of this ſingular ſubſtance; both of their treatiſes have been publiſhed in the 11th volume of the *Annales de Chimie*.

Caoutchouc, when pure, is of a white colour (c), and without either taſte or ſmell ‡. The blackiſh colour of the caoutchouc of commerce is owing to the method employed in drying it after it has been ſpread upon moulds. The uſual way is to ſpread a thin coat of the milky juice upon the mould, and then to dry it by expoſing it to ſmoke; afterwards another coat is ſpread on, which is dried in the ſame way. Thus the caoutchouc of commerce conſiſts of numerous layers of pure caoutchouc alternating with as many layers of ſoot.

‡ *ourcroy*, . 232.

Caoutchouc is ſoft and pliable like leather. It is exceedingly elaſtic and adheſive; ſo that it may be forcibly ſtretched out much beyond its uſual length, and inſtantly recover its former bulk when the force is withdrawn. It cannot be broken without very conſiderable force.

57
ion of
er,

It is not altered by expoſure to the air; it is perfectly inſoluble in water: but if boiled for ſome time its edges become ſomewhat tranſparent, owing undoubtedly to the water carrying off the ſoot; and ſo ſoft, that when two of them are preſſed and kept together for ſome time, they adhere as cloſely as if they formed one piece. By this contrivance pieces of caoutchouc may be ſoldered together, and thus made to aſſume whatever ſhape we pleaſe §.

§ *roſſart.* *. de* *n.* xi.

58
hol,

Caoutchouc is inſoluble in alcohol. This property was diſcovered very early, and fully confirmed by the experiments of Mr Macquer. The alcohol, however, renders it colourleſs.

59
ther,

Caoutchouc is ſoluble in ether. This property was firſt pointed out by Macquer. Berniard, on the contrary, found that caoutchouc was ſcarcely ſoluble at all in ſulphuric ether, which was the ether uſed by Macquer, and that even nitric ether was but an imperfect ſolvent. The difference in the reſults of theſe two chemiſts was very ſingular; both were remarkable for their accuracy, and both were too well acquainted with the ſubject to be eaſily miſled. The matter was firſt cleared up by Mr Cavallo. He found that ether, when newly prepared, ſeldom or never diſſolved caoutchouc completely; but if the precaution was taken to waſh the ether previouſly in water, it afterwards diſſolved caoutchouc with facility. Mr Groſſart tried this experiment, and found it accurate ‖. It is evident from this that theſe chemiſts had employed ether in different ſtates. The waſhing of ether has two effects. It deprives it of a little acid with which it is often impregnated, and it adds to it about one-tenth of water, which remains combined with it.

‖ *Ann. de Chim.* xi. 47.

When the ether is evaporated, the caoutchouc is obtained unaltered. Caoutchouc, therefore, diſſolved in ether, may be employed to make inſtruments of different kinds, juſt as the milky juice of the hævea; but this method would be a great deal too expenſive for common uſe.

60
Oils,

Caoutchouc is ſoluble in volatile oils *; but, in general, when theſe oils are evaporated, it remains ſomewhat glutinous, and therefore is ſcarcely proper for thoſe uſes to which, before its ſolution, it was ſo admirably adapted.

* *Berniard.*

61
Acids and
alkalies,

It is inſoluble in alkalies †. The acids act upon it with more or leſs violence according to their nature. Sulphuric acid decompoſes it completely, charcoal precipitates, and part of the acid is converted into ſulphurous acid. Nitric acid converts it into a yellow ſubſtance, analogous to ſuberic acid. Muriatic acid does not affect it ‡. The other acids have not been tried.

† *Id.*
‡ *Id.*

Fabroni has diſcovered, that rectified petroleum diſſolves it, and leaves it unaltered when evaporated ¶.

¶ *Ibid.* 155. and xii. 156.

62
Heat.

When expoſed to heat it readily melts; but it never afterwards recovers its properties, but continues always of the conſiſtence of tar. It burns very readily with a bright white flame, and diffuſes a fetid odour. In thoſe countries where it is produced, it is often uſed by way of candle.

When diſtilled, it gives out ammonia §. It is evident from this, and from the effect of ſulphuric and nitric acid upon it, that it is compoſed of carbon, hydrogen, azot, and oxygen; but the manner in which they are combined is unknown.

§ *Fourcroy*, *nn de* *Chim* xi. 232.

When treated with nitric acid, there came over azotic gas, carbonic acid gas, pruſſic acid gas; and oxalic acid was formed ‖.

‖ *Ibid.*

63
How to ſe-
parate it
from plants.

It ſeems to exiſt in a great variety of plants; but is uſually confounded with the other ingredients. It may be ſeparated from reſins by means of alcohol. It may be extracted from the different ſpecies of *miſletoe* by water, with which, in the fluid ſtate in which it exiſts in theſe plants, it readily combines. When mixed with gum or extract, it may be ſeparated by the following proceſs: Digeſt a part of the plant containing it firſt in water and then in alcohol, till all the ſubſtances ſo-

---

(c) Mr De Fourcroy ſays, that blackiſh brown is the natural colour of caoutchouc. But we have ſeen ſome pieces of it from the Eaſt Indies, which had been allowed to inſpiſſate in the open air: They were white, with a ſlight caſt of yellow, and had very much the appearance and feel of white ſoap.

luble in theſe liquids be extracted. Dry the reſiduum, and digeſt it in five times its weight of rectified petroleum. Expreſs the liquid part by ſqueezing the ſubſtance in a linen cloth. Let this liquid remain ſeveral days to ſettle, then decant off the clear liquid part, mix it with a third part of water and diſtil, the caoutchouc remains behind [*].

SECT. XIII. *Of Wax.*

THE upper ſurface of the leaves of many trees is covered with a varniſh of wax. This varniſh may be ſeparated and obtained in a ſtate of purity by the following proceſs.

64
Wax a vegetable production.

Digeſt the bruiſed leaves, firſt in water and then in alcohol, till every part of them which is ſoluble in theſe liquids be extracted. Then mix the reſiduum with ſix times its weight of a ſolution of pure ammonia, and, after ſufficient maceration, decant off the ſolution, filter it, and drop into it, while it is inceſſantly ſtirred, diluted ſulphuric acid, till more be added than is ſufficient to ſaturate the alkali. The wax precipitates in the form of a yellow powder. It ſhould be carefully waſhed with water, and then melted over a gentle fire [†].

Mr Tingry firſt diſcovered that this varniſh poſſeſſed all the properties of *bees wax* [‡]. Wax then is a vegetable product. The bees extract it unaltered from the leaves of trees and other vegetable ſubſtances which contain it. They ſeem, however, to mix it with ſome of the pollen of flowers.

65
Its properties.

Wax, when pure, is of a whitiſh colour, it is deſtitute of taſte, and has ſcarcely any ſmell. Bees wax indeed has a pretty ſtrong aromatic ſmell; but this ſeems chiefly owing to ſome ſubſtance with which it is mixed; for it diſappears almoſt completely by expoſing the wax, drawn out into thin ribands, for ſome time to the atmoſphere. By this proceſs alſo, which is called *bleaching*, the yellow colour of the wax diſappears, and it becomes very white. Bleached wax is not affected by the air [§].

Wax is inſoluble in water and in alcohol. It combines readily with alkalies, and forms with them a ſoap which is ſoluble in water [‖].

Punic wax, which the ancients employed in painting in encauſto, is a ſoap compoſed of twenty parts of wax and one of ſoda [*]. Its compoſition was aſcertained by Mr Lorgna [†].

Sulphuric and nitric acids decompoſe wax completely; oxy-muriatic acid bleaches it inſtantaneouſly.

Wax combines readily with oils, and forms with them a ſubſtance of greater or leſs conſiſtency according to the quantity of oil. This compoſition, which is known by the name of *cerate*, is much employed by ſurgeons.

When heat is applied to wax it becomes ſoft; and at the temperature of 142°, if unbleached, or of 155° if bleached [‡], it melts into a colourleſs tranſparent fluid, which concretes again, and reſumes its former appearance as the temperature diminiſhes. If the heat be ſtill farther increaſed, the wax boils and evaporates; and if a red heat be applied to the vapour, it takes fire and burns with a bright flame. It is this property which renders wax ſo uſeful for making candles.

66
Analyſis.

Mr Lavoiſier, by means of the apparatus deſcribed in the article CHEMISTRY, *Suppl.* n° 353. contrived to burn wax in oxygen gas. The quantity of wax conſumed was 21.9 grains. The oxygen gas employed in conſuming that quantity amounted to 66.55 grains. Conſequently the ſubſtances conſumed amounted to 88:45 grains. After the combuſtion, there were found in the glaſs veſſel 62.58 grains of carbonic acid, and a quantity of water, which was ſuppoſed to amount to 25 87 grains. Theſe were the only products.

Now 62.58 grains of carbonic acid gas contain
44 56 of oxy. and 18.02 of carb; and 25 87 gr. of water contain
21.99 of oxy. and 3.88 of hydro.

66.55	21.90

Conſequently 21.9 parts of wax are compoſed of 18.02 of carbon, and 3.88 of hydrogen. And 100 parts of wax are compoſed of 82.28 carbon,
17.72 hydrogen,

100.00 [*].

If wax be diſtilled with a heat greater than 212°, there comes over a little water, ſome ſebacic acid, a little very fluid and odorous oil: the oil, as the diſtillation advances, becomes thicker and thicker, till at laſt it is of the conſiſtency of butter, and for this reaſon has been called *butter of wax*. There remains in the retort a ſmall quantity of coal, which is not eaſily reduced to aſhes. When the butter of wax is repeatedly diſtilled it becomes very fluid, and aſſumes the properties of volatile oil [†].

SECT. XIV. *Of the WOODY FIBRE.*

ALL trees, and moſt other plants, contain a particular ſubſtance, well known by the name of *wood*. If a piece of wood be well dried, and digeſted, firſt in a ſufficient quantity of water, and then of alcohol, to extract from it all the ſubſtances ſoluble in theſe liquids, there remains behind only the *woody fibre*.

67
Properties of wood.

This ſubſtance, which conſtitutes the baſis of wood, is compoſed of longitudinal fibres, eaſily ſubdivided into a number of ſmaller fibres. It is ſomewhat tranſparent; is perfectly taſteleſs; has no ſmell; and is not altered by expoſure to the atmoſphere.

It is inſoluble in water and in alcohol; but ſoluble in alkalies. The mineral acids decompoſe it. When diſtilled it yields, in all probability, pyrolignous acid. When burnt with a ſmothered fire it leaves behind it a conſiderable quantity of charcoal.

It is precipitated from alkalies unaltered by acids [*].

68
Its analyſis.

By nitric acid Fourcroy converted the reſiduum of quinquina, which does not ſeem to differ from the woody fibre, into oxalic acid; at the ſame time there was a little citric acid formed, and a very ſmall quantity of malic and acetous acids. Some azotic gas alſo was diſengaged. By this proceſs he obtained from 100 parts of woody fibre

56.250	oxalic acid,
3.905	citric acid,
0.388	malic acid,
0.486	acetous acid,
0.867	azotic gas,
8.330	carbonat of lime,
70.226	
32.031	reſiduum.
102.257	

There was likewiſe a quantity of carbonic acid gas diſengaged, the weight of which was unknown. This increaſe

---

[*] Hermſtadt, Med. and Phyſ. Jour. iii. 372.

[†] Id. ibid. 373.

[‡] Enc. Meth. Forets et Bois, i. 100.

[§] Senebier, Ann. de Chim, xii. 60. and Jour. de Phyſ. xxxviii. 56.

[‖] Chaptal, iii 164.

[*] Plin. l. 21. c. 14.

[†] Jour. de Phyſ. Nov. 1785.

[‡] Nicholſon's Journal, i. 71.

[*] Lavoiſier, Jour. de Phyſ. xxxi. 59.

[†] Lemery, Mem. Par. 1708, p. 53.

[*] Fourcroy, Ann. de Chim. viii. 149.

increaſe of weight in the product was evidently owing to the oxygen derived from the nitric acid *.

When diſtilled in a retort, 100 parts yield the following products:

26.62 of a yellow liquid, containing alcohol, and acid which had the ſmell of pyromucous.
6.977 of concrete oil, moſtly ſoluble in alcohol.
22.995 charcoal } in the retort.
3.567 carbonat of lime } in the retort.

60.159
39.841 gas, half carbonic acid, half carbonated hydrogen.

100.000 *.

Theſe facts ſhew us, that the woody fibre is compoſed of oxygen, carbon, hydrogen, azot, and lime. Mr Chaptal ſuppoſes that mucilage differs from woody fibre merely in containing leſs oxygen. We are certain at leaſt that mucilage or gum is compoſed of the ſame ingredients; and Mr Chaptal has ſhewn, that the juices of plants are partly converted into woody fibre by oxy-muriatic acid, which imparts to them oxygen†. Theſe juices contain both gum and reſin: after the formation of the woody fibre the reſin is ſtill unaltered. This gives a good deal of probability to his opinion.

SECT. XV. *Of Acids.*

THE acids found ready formed in vegetables are the following:

1. Oxalic,
2. Tartarous,
3. Citric,
4. Malic,
5. Gallic,
6. Benzoic,
7. Phoſphoric.

Sometimes alſo the ſulphuric, nitric, and muriatic acids occur in vegetables, combined with alkalies or earths, but never except in very minute quantities.

69 1. Oxalic acid is eaſily detected and diſtinguiſhed by the following properties: It decompoſes all calcareous ſalts, and forms with lime a ſalt inſoluble in water. It readily cryſtallizes. Its cryſtals are quadrilateral priſms. It is totally deſtroyed by heat.

Oxalic acid was firſt detected in vegetables by Mr Scheele. It has been diſcovered in the following plants:

The leaves of the oxalis acetoſella †.
oxalis corniculata.
The root of rhubarb ‡.
The leaves of the geranium acidum §.

70 2. Tartarous acid is known by the following properties: When a little potaſs is cautiouſly dropt into a ſolution containing it, common tartar is formed, and precipitates to the bottom. Tartarous acid does not decompoſe the ſulphat, nitrat, or muriat of lime. Tartrite of lime is ſoluble in water. Tartarous acid cryſtallizes. Its cryſtals are long ſlender priſms. It is deſtroyed by heat.

Tartarous acid has been found in the following vegetable ſubſtances:

The pulp of the tamarind *.
The juice of grapes.
Mulberries †.
Rumex acetoſa, *ſorrel* †.
Rhus coriaria, *ſumach* †.
Rheum rhaponticum ‖.
Agave Americana ¶.
The roots of triticum repens †.
Leontodon taraxicum †.

71 Citric acid. 3. Citric acid is diſtinguiſhed by the following properties: It does not form tartar when potaſs is added to it. With lime it forms a ſalt inſoluble in water, which is decompoſed by ſulphuric, nitric, and muriatic acids. It readily cryſtallizes. It is deſtroyed by heat.

Citric acid has been found unmixed with other acids in the following vegetable ſubſtances*:

The juice of oranges and lemons.
The berries of vaccinium oxycoccos, *cranberry.*
——— vitis idæa, *red whortle berry.*
Prunus padus, *birdcherry.*
Solanum dulcamara, *nightſhade.*
Roſa canina, *hip.*

It occurs mixed with other acids in many other fruits.

72 Malic acid. 4. Malic acid is known by the following properties: It forms with lime a ſalt ſoluble in water, which is decompoſed by citric acid. It does not form tartar with potaſs. It is incryſtallizable. Heat deſtroys it.

Malic acid has been found, by Scheele †, in the fruits of the following plants, which contain no other acid:

Apples.
Berberis vulgaris, *barberry.*
Prunus domeſtica, *plum.*
——— ſpinoſa, *ſloe.*
Sambucus nigra, *elder.*
Sorbus aucuparia, *roan* or *ſervice.*

73 Malic and citric. In the following fruits he found nearly an equal quantity of malic and citric acids ‡.

Ribes groſſularia, *gooſeberry.*
——— rubrum, *currants.*
Vaccinium myrtillus, *bleaberry.*
Crategus aria, *beam.*
Prunus ceraſus, *cherry.*
Fragaria veſca, *ſtrawberry.*
Rubus chamæmorus, *cloudberries, evrochs.*
——— idæus, *raſpberry.*

Malic acid has alſo been found in the agave americana §, and in the pulp of tamarinds ‖. In the firſt of theſe it is mixed with tartarous acid; in the ſecond with tartarous and citric acids.

74 Gallic acid. 5. Gallic acid is known by the following properties: With the brown oxyd of iron it produces a black colour. It is cryſtallizable. Heat deſtroys it. It has been found in a great number of plants, chiefly in the bark.—The following table, drawn up by Mr Biggin *, will ſerve to ſhew the relative proportions of this acid in different plants:

Elm - - -	7	Sallow - -	8
Oak cut in winter -	8	Mountain aſh -	8
Horſe cheſnut -	6	Poplar - -	8
Beech - -	7	Hazel - - -	9
Willow (boughs) -	8	Aſh - -	10
Elder - -	4	Spaniſh cheſnut -	10
Plum tree - -	8	Smooth oak -	10
Willow (trunk) -	9	Oak cut in ſpring -	10
Sycamore - -	6	Huntingdon or Leiceſter willow	10
Birch - -	4		
Cherry tree -	8	Sumach - -	14

75 Benzoic acid. 6. Benzoic acid is diſtinguiſhed by its aromatic odour, and its volatility on the application of a very moderate heat. It has been found hitherto only in three vegetable ſubſtances, to which the French chemiſts have confined the term *balſam.* Theſe three are, *benzoin, balſam of tolu,* and *ſtorax.* In theſe ſubſtances it ſeems to be combined with a reſin, or ſomething which has nearly the properties of a reſin.

3 Y 2 7. Phoſ-

---

* *Scheele, Crell's Jour.* ii. 8. Eng. Tranſl.

† *Ibid.*

‡ *Ibid.*

§ *Hoffman of Weimar.*

‖ *Vauquelin, Ann. de Chim.* v. 92.

* *Nicholſon's Journal,* iii. 394.

76 Phoſphoric acid.

7. Phoſphoric acid is eaſily diſtinguiſhed from the former ſix, for it is very fixed, and a violent heat does not deſtroy it as it does the others.

Phoſphoric acid has been found in different plants, but only in very ſmall quantities; it is almoſt conſtantly combined with lime. Meyer found it in the leaves of many trees*; Thuren found phoſphat of lime in the Aconitus Napellus†; and Bergmann found it in all kinds of grain‡.

* *Enc. Meth Phyſiol Veget.* i. 100

† *Ann de Chim.* ii 308.

‡ *Bergman*, v. 96.

SECT. XVI. *Of ALKALIES.*

THE only alkalies found in plants are potaſs and ſoda. Ammonia may indeed be obtained by diſtilling many vegetable ſubſtances, but it is produced during the operation. One or other of theſe alkalies is found in every plant which has hitherto been examined. The quantity indeed is uſually very ſmall.

77 Proportion of potaſs in plants.

1. Potaſs is found in almoſt all plants which grow at a diſtance from the ſea. It may be extracted by burning the vegetable, waſhing the aſhes in water, filtrating the water, and evaporating it to dryneſs. It is in this manner that all the potaſh of commerce is procured.

The following table exhibits the quantity of aſhes and potaſs which may be extracted from 100 parts of various plants:

	Aſhes.	*Potaſs.*
Sallow - -	2.8	0.285*(c)
Elm - - -	2.36727	0.39*
Oak - - -	1.35185	0.15343
Poplar - -	1.23476	0.07481
Hornbeam - - -	1.1283	0.1254
Beech - - -	0.58432	0.14572
Fir - - -	0.34133	
Vine branches -	3 379	0.55*
Common nettle -	10.67186	2.5033
Common thiſtle -	4.04265	0.53734
Fern - -	5.00781	0.6259
Cow thiſtle - -	10.5	1.96603
Great river ruſh -	3.85395	0.72234
Feathered ruſh - -	4.33593	0.50811
Stalks of turkey wheat -	8.86	1.75*
Wormwood - -	9.744	7.3*
Fumitory - -	21.9	7.9*
Trifolium pratenſe - -		0.078*
Vetches - - - -		2.75*
Beans with their ſtalks - -		2.0*

In general, three times as much aſhes are obtained from ſhrubs, and five times as much from herbs, as from trees. Equal weights of the branches of trees produce more aſhes than the trunk, and the leaves more than the branches. Herbs arrived at maturity produce more aſhes than at any other time. Green vegetables produce more aſhes than dry†.

† *Ann. de Chim.* xix. 174.

The ſalt which is obtained from plants does not conſiſt wholly of potaſs, there are other ſalts mixed with it; theſe uſually are ſulphat of potaſs, muriat of potaſs, ſulphat of lime, phoſphat of lime, &c.; but theſe bear, in general, but a ſmall proportion to the potaſs. The aſhes conſiſt of potaſs mixed with earths.

Some judgment may be formed of the quantity of potaſs which a plant contains from the quantity of aſhes which it yields: but the above table is ſufficient to ſhew us, that were we to truſt to that we would often be miſled.

78 Soda.

2. Soda is found in almoſt all the plants which grow in the ſea, and in many of thoſe which grow on the ſhore. In general, the quantity of ſoda which plants contain bears a much greater proportion to their weight than the potaſs does which is found in inland vegetables. 100 parts of the *ſalſola ſoda*, for inſtance, yield 19.921 of aſhes; and theſe contain 1.992 parts of ſoda, ſome of which, however, is combined with muriatic acid*. The plants from which the greater part of the ſoda, or *barilba*, as it is called, which is imported from Spain, is extracted, are the *ſalſola ſativa*, and *vermiculata*.

* *Vauquelin, Ann. de Chim.* xviii. 77.

SECT. XVII. *Of EARTHS.*

THE only earths hitherto found in plants are the four following; *lime, ſilica, magneſia, alumina.*

79 Lime.

1. Lime is uſually the moſt abundant of the earths of plants, and the moſt generally diffuſed over the vegetable kingdom. Indeed, it is a very uncommon thing to find a plant entirely deſtitute of lime: ſalſola ſoda is almoſt the only one in which we know for certain that this earth does not exiſt*.

* *Id. ibid.*

80 Silica.

2. Silica exiſts alſo in many plants, particularly graſſes and equiſetums. Mr Davy has aſcertained, that it forms a part of the epidermis, or outermoſt bark of theſe plants; and that in ſome of them almoſt the whole epidermis is ſilica.

		Parts Silica.
100 parts of the epid. of bonnet-cane yielded		90
	bamboo	71.4
(arundo phragm.)	common reed	48.1
	ſtalks of corn	6.5

The concretions which are ſometimes found in the bamboo cane have been aſcertained by Mr Macie to be compoſed of pure ſilica.

81 Magneſia.

3. Magneſia does not exiſt ſo generally in the vegetable kingdom as the two preceding earths. It has been found, however, in conſiderable quantities in ſeveral ſea plants, eſpecially fuci†. But the ſalſola ſoda contains a greater proportion of magneſia than any plant hitherto examined. Mr Vauquelin found that 100 parts of it contained 17.929 of that earth‡.

† *Id. ibid.* 80. and i 94.

‡ *Ibid.* 78.

82 Alumina.

4. Alumina has only been found in very ſmall quantities in plants.

83 Proportio of earth i plants.

The following table will ſhew the quantity of theſe four earths which exiſt in ſeveral vegetables.

100 parts of oak contain of earths	1.03*
Beech - -	0.453†
Fir - -	0.003†
Turkey wheat -	7.11†
Sunflower -	3.72†
Vine branches -	2.85†
Box - -	2.674†
Willow - -	2.515†
Elm - -	1.96†
Aſpin - -	1.146†
Fern - -	3.221‡
Wormwood -	2.444§
Fumitory - -	14.000§

* *Watſon.*

† *Kirwan Iriſh Tran* iii. 35.

‡ *Home.*

§ *Wiegleb*

This

(c) Thoſe marked * are from *Kirwan, Iriſh Tranſ.* v. 164. The reſt from *Pertuis, Ann. de Chim.* 19. 178.

Metals.

This table ſhews us, that the quantity of earth is greater in herbs than in trees.

Bergman found all the four earths in every kind of grain which he analyſed*.

Vauquelin found, that 100 parts of oat grain left 3.1591 of reſiduum. This reſiduum is compoſed of

60 7 ſilica,
39 3 phoſphat.

100.0†.

When the whole of the avena ſativa, however, ſtalk and ſeed together, are burnt, they leave a reſiduum compoſed of

55 ſilica,
15 phóſphat of lime,
20 potaſs,
5 carbonat of lime.

95, and a little oxyd of iron‡.

This ſhews us that the ſtalk contains ſeveral ſubſtances not to be found in the grain.

Sect. XVIII. *Of Metals.*

Several metallic ſubſtances have alſo been found in vegetables, but their quantity is exceedingly ſmall; ſo ſmall, indeed, that without very delicate experiments their preſence cannot even be detected.

84 hree me- ls found plants.

The metals hitherto diſcovered are iron, which is by far the moſt common, manganeſe, and gold.

Scheele firſt detected manganeſe in vegetables*. Prouſt found it in the aſhes of the pine, calendula, vine, green oak, and fig-tree†. M. Sage has ſhewn, that gold exiſts in many plants. Iron exiſts in moſt plants. The aſhes of ſome ſpecies of ſalſola contain a conſiderable quantity of it.

85 nple ſub- ces con- ned in nts.

We have now taken a ſurvey of all the ſubſtances which have hitherto been obtained from vegetables: by analyſing each of theſe, we come at laſt to thoſe bodies which we are at preſent obliged to conſider as ſimple, becauſe they have not yet been decompoſed, and of which accordingly we muſt ſuppoſe that vegetables are ultimately compoſed. Theſe bodies amount ot 16, namely,

1. Oxygen,
2. Sulphur,
3. Phoſphorus
4. Carbon,
5. Hydrogen,
6. Azot,
7. Iron,
8. Manganeſe,
9. Gold,
10. Lime,
11. Magneſia,
12. Silica,
13. Alumina,
14. Potaſs,
15. Soda,
16. Muriatic acid.

But of theſe ſubſtances there are twelve which compoſe but a very ſmall proportion indeed of vegetables. Almoſt the whole of vegetable ſubſtances are compoſed of four ingredients, namely,

Carbon, Oxygen,
Hydrogen, Azot.

Of theſe the laſt, namely azot, forms but a ſmall proportion even of thoſe vegetable ſubſtances of which it is a conſtituent part, while into many it does not enter at all: So that, upon the whole, by far the greater part of vegetable ſubſtances is compoſed of carbon, hydrogen, and oxygen. We do not mention caloric and light, concerning the nature of which too little is known to enable us to determine with certainty into what ſubſtances they enter.

Vegetation.

The ſubſtances at preſent known to chemiſts, which they have not been hitherto able to decompoſe, amount (omitting caloric and light) to 40. Sixteen of theſe exiſt in plants; the other 24 belong excluſively to the mineral kingdom: for it is a fact, that no ſubſtance (we mean ſimple ſubſtance) has been hitherto found in the animal kingdom which does not exiſt alſo in vegetables.

On the contrary, all the ſimple ſubſtances at preſent known may be found in minerals. This indeed ought not to ſurpriſe us, if we recollect, that the ſpoils of animals and vegetables, after they have undergone decompoſition, are ultimately confounded with minerals, and conſequently arranged under the mineral kingdom. Beſides, as vegetables draw all their food from the mineral kingdom, it would be abſurd to ſuppoſe that they contain ſubſtances which they could not have procured from minerals. It muſt follow, therefore, of neceſſity, that minerals contain all the ſimple ſubſtances which exiſt in this globe of our's; and that plants owe their diverſity merely to different modifications of thoſe principles which they imbibe from the ſoil. But it is impoſſible to have any preciſe notions about a ſubject ſo intricate, without conſidering with ſome attention the ſtructure of vegetables, the food which they imbibe, and the changes which they produce on that food. Theſe enquiries ſhall form the ſubject of the next chapter; in which we propoſe to take a view of thoſe phenomena of vegetation which are connected with chemiſtry, or which may be elucidated by the application of the principles of that ſcience.

Chap. II. Of Vegetation.

We have now ſeen the different ſubſtances which are contained in plants; but we have ſtill to examine the manner in which theſe ſubſtances are produced, and to endeavour to trace the different proceſſes which conſtitute vegetation. We muſt warn our readers not to expect complete information in this chapter. The wonders of the vegetable kingdom are ſtill but very imperfectly explored; many of the organs of plants are too minute for our ſenſes; and ſcarcely a ſingle proceſs can be completely traced.

86 Phenomena of vegetation very numerous.

The multiplicity of operations continually going on in vegetables at the ſame time, and the variety of different, and even oppoſite ſubſtances, formed out of the ſame ingredients, and almoſt in the ſame place, aſtoniſh and confound us. The order, too, and the ſkill with which every thing is conducted, are no leſs ſurpriſing. No two operations claſh; there is no diſcord, no irregularity, no diſturbance; every object is gained, and every thing is ready for its intended purpoſe. This is too wonderful to eſcape our obſervation, and of too much importance not to claim our attention. Many philoſophers, accordingly, diſtinguiſhed equally by their induſtry and ſagacity, have dedicated a great part of their lives to the ſtudy of *vegetation*. But hitherto their ſucceſs has not been equal to their exertions. No perſon has been able to detect this *agent*, always ſo buſy, and performing ſuch wonders, or to diſcover him at his work; nor have philoſophers been much more fortu-

---

* *Opuſc.* v. 4.

† *Ann de Chim.* xxix. 7.

‡ *Ibid.* 19.

* *Opuſc* i. 6.

† *Phil. Mag* v.

Vegetation.

nate in their attempts to aſcertain the inſtruments which he employs in his operations. A great variety, however, of curious and intereſting facts, have been diſcovered. Theſe we ſhall attempt in this chapter to collect and arrange, to point out their dependence on each other, and perhaps to deduce ſuch conſequences as obviouſly reſult from this mutual dependence.

87 Plants ariſe from ſeed.

1. Natural hiſtorians have proved, by a very complete induction of facts, that all plants ariſe from *ſeeds*. The pretended exceptions have diſappeared, one after another, as our knowledge of vegetables increaſed: and now there remains ſcarcely a ſingle objection entitled to the ſmalleſt regard. The late attempt of Girtanner * to revive the doctrine of equivocal generation, deſerves no attention whatever; becauſe his concluſions are abſolutely incompatible with the *experiments* of Mr Senebier upon the very ſubſtance on which his theory is founded.

88 Seeds compoſed of three parts.

A SEED conſiſts of three parts; namely, the *cotyledons*, the *radicle*, and the *plumula*, which are uſually incloſed in a cover.

If we take a garden bean, we may perceive each of theſe three parts with great eaſe; for this ſeed is of ſo large a ſize, that all its organs are exceedingly diſtinct.

When we ſtrip off the external coats of the bean, which are two, and of different degrees of thickneſs in different parts, we find that it eaſily divides into two lobes, pretty nearly of the ſame ſize and figure. Each of theſe lobes is called a *cotyledon* (fig. 1. *a*). The cotyledons of the bean, then, are two in number.

Plate XLIII.

Near that part of the lobes which is contiguous to what is called the *eye* of the bean, there is a ſmall round white body *(b)*, which comes out between the two lobes. This body is called the *radicle*.

Attached to the radicle, there is another ſmall round body *(c)*, which lies between the cotyledons and wholly within them, ſo that it cannot be ſeen till they are ſeparated from each other. This body is called the *plumula*.

The appearance and ſhape of theſe three parts differ very much in different ſeeds, but there is no ſeed which wants them. The figure and ſize of the ſeed depend chiefly upon the cotyledons. This is evidently the caſe with the bean, and it is ſo with all other ſeeds. The number of cotyledons is different in different ſeeds. Some ſeeds have only one cotyledon, as the ſeeds of wheat, oats, barley, and the whole tribe of graſſes: ſome have three; others ſix, as the ſeeds of the garden graſs; but moſt ſeeds, like the bean, have two cotyledons.

89 Germination of ſeeds

2. When a ſeed is placed in a ſituation favourable to vegetation, it very ſoon changes its appearance. The radicle is converted into a root, and ſinks into the earth; the plumula, on the other hand, riſes above the earth, and becomes the trunk or ſtem. When theſe changes take place, the ſeed is ſaid to *germinate:* the proceſs itſelf has been called *germination*. Seeds do not germinate equally and indifferently in all places and ſeaſons. Germination, therefore, is a proceſs which does not depend upon the ſeed alone; ſomething external muſt alſo affect it.

90 Requires moiſture,

3. It is a well known fact, that ſeeds will not germinate unleſs *moiſture* have acceſs to them; for ſeeds, if they are kept perfectly dry, never vegetate at all, and yet their power of vegetating is not deſtroyed. There are indeed ſome apparent objections to this: potatoes, for inſtance, and other bulbous bodies, germinate, tho' kept ever ſo dry. But the reaſon of this is, that theſe bodies (which are not ſeeds, though they reſemble them in ſome particulars) have a ſufficient quantity of water within themſelves to give a beginning to germination. We may conclude, then, that no ſeed will germinate unleſs water has acceſs to it. *Water*, then, is eſſential to germination. Too much water, however, is no leſs prejudicial to moſt ſeeds than none at all. The ſeeds of water plants, indeed, germinate and vegetate extremely well in water; but moſt other ſeeds, if they are kept in water beyond a certain time, are rotted and deſtroyed altogether.

91 Heat,

4. It is well known alſo, that ſeeds will not germinate, even though ſupplied with water, provided the temperature be below a certain degree. No ſeed, for inſtance, on which the experiment has been tried, can be made to vegetate at or below the freezing point: yet this degree of cold does not injure the vegetating power of ſeeds; for many ſeeds will vegetate as well as ever after having been frozen, or after having been kept in frozen water. We may conclude, then, that a certain degree of heat is neceſſary for the germination of ſeeds. And every ſpecies of plants ſeems to have a degree peculiar to itſelf, at which its ſeeds begin to germinate; for we find that almoſt every ſeed has a peculiar ſeaſon at which it begins to germinate, and this ſeaſon varies always according to the temperature of the air. Mr Adanſon found that ſeeds, when ſown at the ſame time in France and in Senegal, always appeared ſooner above ground in the latter country, where the climate is hotter, than in France §.

92 And oxygen gas.

5. Seeds, although ſupplied with moiſture, and placed in a proper temperature, will not germinate, provided atmoſpherical air be completely excluded from them. Mr Ray found that grains of lettuce did not germinate in the vacuum of an air-pump, but they began to grow as ſoon as air was admitted to them †. Homberg made a number of experiments on the ſame ſubject, which were publiſhed in the Memoirs of the French Academy for the year 1693. He found, that the greater number of ſeeds which he tried refuſed to vegetate in the vacuum of an air-pump. Some, however, did germinate; but Boyle, Muſchenbroek, and Boerhaave, who made experiments on the ſame ſubject in ſucceſſion, proved beyond a doubt that no plant vegetates in the vacuum of an air-pump; and that in thoſe caſes in which Homberg's ſeeds germinated, the vacuum was far from perfect, a quantity of air ſtill remaining in the receiver. It follows, therefore, that no ſeed will germinate unleſs atmoſpherical air, or ſome air having the ſame properties, have acceſs to it. It is for this reaſon that ſeeds will not germinate at a certain depth below the ſurface of the earth.

Mr Scheele found that beans would not germinate except oxygen gas were preſent; Mr Achard afterwards proved, that oxygen gas is abſolutely neceſſary for the germination of all ſeeds, and that no ſeed will germinate in azotic gas, or hydrogen gas, or carbonic acid gas, unleſs theſe gaſes contain a mixture of oxygen gas. Theſe experiments have been confirmed by Mr

---

* Ann. de Chim. xxxiv. 35.

§ Enc. Meth. Phyſiol. Veget. 124.

† Phil. Tranſ. N° 53.

Mr Gough, Mr Cruickſhank, and many other philoſophers. It follows, therefore, that it is not the whole atmoſpheric air, but merely the oxygen gas which it contains, that is neceſſary for the germination of ſeeds.

93
jured by
e pre-
nce of
ght.

6. Seeds do not germinate equally well when they are expoſed to the light, and when they are kept in a dark place; light therefore has ſome effect on germination.

Mr Ingenhouſz found, that ſeeds always germinate faſter in the dark than when expoſed to the light *. His experiments were repeated by Mr Senebier with equal ſucceſs †; and it was concluded, in conſequence of their experiments, that light is injurious to germination. But the Abbé Bertholin, who diſtinguiſhed himſelf ſo much by his labours to demonſtrate the effect of electricity on vegetation, objected to the concluſions of theſe philoſophers, and affirmed, that the difference in the germination of ſeeds in the ſhade and in the light was owing, not to the light itſelf, but to the difference of the moiſture in the two ſituations; the moiſture evaporating much faſter from the ſeeds in the light than from thoſe in the ſhade; and he affirmed, that when precautions were taken to keep the ſeeds equally moiſt, thoſe in the ſun germinated ſooner than thoſe in the ſhade ‡. But when Mr Senebier repeated his former experiments, and employed every poſſible precaution to enſure the equality of moiſture in both ſituations, he conſtantly found the ſeeds in the ſhade germinate ſooner than thoſe in the light §. We may conclude, therefore, that light is injurious to germination; and hence one reaſon for covering ſeeds with the ſoil in which they are to grow.

7. Thus we have ſeen that ſeeds will not germinate unleſs *moiſture*, *heat*, and *oxygen gas*, be preſent; and that they do not germinate well if they are expoſed to the action of *light*. Now, in what manner do theſe ſubſtances affect the ſeed? What are the changes which they produce?

94
enome-
of ger-
nation.

We obſerved before, that all ſeeds have one or more cotyledons. Theſe cotyledons contain a quantity of farinaceous matter, laid up on purpoſe to ſupply the embryo plant with food as ſoon as it begins to require it. This food, however, muſt undergo ſome previous preparation, before it can be applied by the plant to the formation or completion of its organs. Now all the phenomena of germination which we can perceive conſiſt in the chemical changes which are produced in that food, and the conſequent developement of the organs of the plant.

95
e coty-
ons pre-
re food,

When a ſeed is placed in favourable circumſtances, it gradually imbibes moiſture, and very ſoon after emits a quantity of carbonic acid gas, even though no oxygen gas be preſent *. This ſeems to prove, as Mr Cruickſhank has ſuppoſed, that ſome of the water imbibed by the ſeed is decompoſed, that its oxygen combines with part of the carbon of the farina, and goes off in the form of carbonic acid gas, while the hydrogen remains behind, and combines with the ingredients contained in the cotyledon. The firſt part of germination, then, conſiſts in diminiſhing the quantity of carbon, and increaſing the hydrogen of the farina. If no oxygen gas be preſent, the proceſs ſtops here, and no germination takes place.

But if oxygen gas be preſent, it is gradually abſorbed and retained by the ſeed; and at the ſame time, the farina of the cotyledons aſſumes a ſweet taſte reſembling ſugar: it is therefore converted into ſugar, or ſome ſubſtance analogous to it †. Farina, then, is changed into ſugar, by diminiſhing its carbon, and augmenting the proportion of its hydrogen and oxygen. This is preciſely the proceſs of malting, or of converting grain into malt; during which it is well known that there is a conſiderable heat evolved; ſo much indeed, that in certain circumſtances grain improperly kept has even taken fire. We may conclude from this, that during the germination of ſeeds in the earth there is alſo an evolution of a conſiderable portion of heat. This indeed might have been expected, as it uſually happens when oxygen gas is abſorbed.

So far ſeems to be the work of chemiſtry alone; at leaſt we have no right to conclude that any other agent interferes; ſince *hay*, when it happens to imbibe moiſture, exhibits nearly the ſame proceſſes. Carbonic acid gas is evolved, oxygen gas is abſorbed, heat is produced ſo abundantly, that the hay often takes fire: at the ſame time a quantity of ſugar is formed. It is owing to a partial change of the ſame kind that old hay generally taſtes much ſweeter than new hay. Now we have no reaſon to ſuppoſe that any agents peculiar to the vegetable kingdom reſide in hay; as all vegetation, and all power of vegetating, are evidently deſtroyed.

96
Which paſſes into the radicle,

But when the farina in the ſeeds of vegetables is converted into ſugar, a number of veſſels make their appearance in the cotyledon. The reader will have a pretty diſtinct notion of their diſtribution, by inſpecting fig. 2. Theſe veſſels may indeed be detected in many ſeeds before germination commences, but they become much more diſtinct after it has made ſome progreſs. Branches from them have been demonſtrated by Grew, Malpighi, and Hedwig, paſſing into the radicle, and diſtributed through every part of it. Theſe evidently carry the nouriſhment prepared in the cotyledons to the radicle; for if the cotyledons be cut off even after the proceſſes above deſcribed are completed, germination, as Bonnet and Senebier aſcertained by experiment, immediately ſtops.

97
And converts it into a root.

The food therefore is conveyed from the cotyledons into the radicle, the radicle increaſes in ſize, aſſumes the form of a *root*, ſinks down into the earth, and ſoon becomes capable of extracting the nouriſhment neceſſary for the future growth of the plant. Even at this period, after the radicle has become a perfect root, the plant, as Senebier aſcertained by experiment, ceaſes to vegetate if the *cotyledons* be cut off. They are ſtill then abſolutely neceſſary for the vegetation of the plant.

98
Cotyledons become ſeminal leaves,

The cotyledons now aſſume the appearance of leaves, and appear above the ground, forming what are called the *ſeminal leaves* of the plant. After this the *plumula* gradually increaſes in ſize, riſes out of the earth, and expands itſelf into branches and leaves. The ſeminal leaves, ſoon after this, decay and drop off, and the plant carries on all the proceſſes of vegetation without their aſſiſtance.

Mr Eller attempted to ſhew, that there is a veſſel in ſeeds which paſſes from the cotyledons to the plumula; but later anatomiſts have not been able to perceive any ſuch veſſel. Even Mr Hedwig, one of the moſt patient, acute, and ſucceſsful philoſophers that ever turned their attention to the ſtructure of vegetables, could

never

---

* *Experi-ce ſur les Vegetaux*, ii.

† *Mem. byſico-imique*, iii 41.

‡ *Jour. de byſ.* 1789, ecemb.

§ *Enc Meth. byſiol. Ve-t.* 126.

* *Gough*, *ancb. Mem.* iv. 5. *Cruik-ank, Rollo Diabetes*, 452.

† *Ibid.*

never diſcover any ſuch veſſel, although he traced the veſſels of the cotyledons even through the radicle. As it does not appear, then, that there is any communication between the cotyledons and the plumula, it muſt follow that the nouriſhment paſſes into the plumula from the radicle: and accordingly we ſee, that the plumula does not begin to vegetate till the radicle has made ſome progreſs. Since the plant ceaſes to vegetate, even after the radicle has been converted into a root, if the cotyledons be removed before the plumula is developed, it follows, that the radicle is inſufficient of itſelf to carry on the proceſſes of vegetation, and that the cotyledons ſtill continue to perform a part. Now we have ſeen already what that part is: they prepare *food* for the nouriſhment of the plant. The root, then, is of itſelf inſufficient for this purpoſe. When the cotyledons aſſume the form of ſeminal leaves, it is evident that the nouriſhment which was originally laid up in them for the ſupport of the embryo plant is exhauſted, yet they ſtill continue as neceſſary as ever. They muſt therefore receive the nouriſhment which is imbibed by the root; they muſt produce ſome changes on it, render it ſuitable for the purpoſes of vegetation, and then ſend it back again to be tranſmitted to the plumula.

99
Which prepare the food ſent from the root.

After the plumula has acquired a certain ſize, which muſt be at leaſt a *line*, if the cotyledons be cut off, the plant, as Mr Bonnet aſcertained by a number of experiments, afterwards repeated with equal ſucceſs by Mr Senebier, does not ceaſe to vegetate, but it continues always a mere pigmy ; its ſize, when compared with that of a plant whoſe cotyledons are allowed to remain, being only as 2 to 7*.

100
Plumula forms the ſtem and leaves.

When the plumula has expanded completely into leaves, the cotyledons may be removed without injuring the plant, and they very ſoon decay of themſelves. It appears, then, that this new office of the cotyledons is afterwards performed by that part of the plant which is above ground.

Thus we have traced the phenomena of germination as far as they have been detected. The facts are obvious; but the *manner* in which they are produced is a profound ſecret. We can neither explain how the food enters into the veſſels, how it is conveyed to the different parts of the plant, how it is depoſited in every organ, nor how it is employed to increaſe the ſize of the old parts, or to form new parts. Theſe phenomena are analogous to nothing in mechanics or chemiſtry. He that attempts to explain them on the principles of theſe ſciences, merely ſubſtitutes new meanings of words inſtead of old ones, and gives us no aſſiſtance whatever in conceiving the proceſſes themſelves. As the ſubſtances employed in vegetation are all material, it is evident that they poſſeſs the properties of matter, and that they are arranged in the plant according to theſe laws. It follows, therefore, that all the changes which take place in the plant are produced according to the known laws of mechanics and chemiſtry. This cannot be diſputed: but it explains nothing; for what we want to know is the *agent* that brings every particle of matter to its proper place, and enables the laws of chemiſtry and mechanics to act only in order to accompliſh a certain end. Who is the agent that acts according to this end? To ſay that it is chemiſtry or mechanics is to pervert the uſe of words. For what are the laws of chemiſtry and mechanics? Are they not certain fixed and unalterable properties of matter? Now, to ſay that a property of matter has an end in view, or that it acts in order to accompliſh ſome deſign, is a downright abſurdity. There muſt therefore be ſome agent in all caſes of germination, which regulates and directs the mechanical and chemical proceſſes, and which therefore is neither a mechanical nor chemical property.

8. When the proceſs of germination is accompliſhed, the plant is complete in all its parts, and capable of vegetating in a proper ſoil, for a time and with a vigour proportional to its nature.

101
Plants compoſed of bark, wood, and pith.

Plants, as every body knows, are very various, and of courſe the ſtructure of each ſpecies muſt have many peculiarities. Trees have principally engaged the attention of anatomiſts, on account of their ſize and the diſtinctneſs which they expected to find in their parts. We ſhall therefore take a tree as an inſtance of the ſtructure of plants; and we ſhall do it the more readily, as the greater number of vegetables are provided with analogous organs, dedicated to ſimilar uſes.

A TREE is compoſed of a *root*, a *trunk*, and *branches*; the ſtructure of each of which is ſo ſimilar, that a general deſcription of their component parts will be ſufficient. Each of them conſiſts of three parts, the *bark*, the *wood*, and the *pith*.

102
Bark.

The BARK is the outermoſt part of the tree. It covers the whole plant from the extremity of the roots to the extremity of the branches. It is uſually of a green colour: if a branch of a tree be cut acroſs, the bark is eaſily diſtinguiſhed from the reſt of the branch by this colour. If we inſpect ſuch a horizontal ſection with attention, we ſhall perceive that the bark itſelf is compoſed of three diſtinct bodies, which, with a little care, may be ſeparated from each other. The outermoſt of theſe bodies is called the *epidermis*, the middlemoſt is called the *parenchyma*, and the innermoſt, or that next the wood, is called the *cortical layers*.

103
Compoſed of epidermis,

The *epidermis* is a thin tranſparent membrane, which covers all the outſide of the bark. It is pretty tough. When inſpected with a microſcope, it appears to be compoſed of a number of ſlender fibres croſſing each other, and forming a kind of network. It ſeems even to conſiſt of different thin retiform membranes, adhering cloſely together. This, at leaſt, is the caſe with the epidermis of the birch, which Mr Duhamel ſeparated into ſix layers. The epidermis, when rubbed off, is reproduced. In old trees it cracks and decays, and new epidermes are ſucceſſively formed. This is the reaſon that the trunks of many old trees have a rough ſurface.

104
Parenchyma,

The *parenchyma* lies immediately below the epidermis; it is of a deep green colour, very tender, and ſucculent. When viewed with a microſcope, it ſeems to be compoſed of fibres which croſs each other in every direction, like the fibres which compoſe a hat. Both in it and the epidermis there are numberleſs interſtices, which have been compared to ſo many ſmall bladders.

105
And cortical layer

The *cortical layers* form the innermoſt part of the bark, or that which is next to the wood. They conſiſt of ſeveral thin membranes, lying the one above the other; and their number appears to increaſe with the age of the plant. Each of theſe layers is compoſed of longitudinal fibres, which ſeparate and approach each other alternately, ſo as to form a kind of network. The meſhes of this network correſpond in each of the layers;

---

* Enc. Meth. Phyſiol Veget. 42.

egeta-
ion.

ers; and they become ſmaller and ſmaller in every layer as it approaches the wood. Theſe meſhes are filled with a green coloured cellular ſubſtance, which has been compared by anatomiſts to a number of bladders adhering together, and communicating with each other.

106
od com-
ed of

The WOOD lies immediately under the bark, and forms by far the greateſt part of the trunk and large branches of trees. It conſiſts of concentric layers, the number of which increaſes with the age of the part. Each of theſe layers, as Mr Du Hamel aſcertained, may be ſeparated into ſeveral thinner layers, and theſe are compoſed chiefly of longitudinal fibres. Hence the reaſon that wood may be much more eaſily ſplit aſunder than cut acroſs.

The *wood*, when we inſpect it with attention, is not, through its whole extent, the ſame; the part of it next the bark is much ſofter and whiter, and more juicy than the reſt, and has for that reaſon obtained a particular name: it has been called the *alburnum* or *aubier*. The *perfect wood* is browner, and harder, and denſer, than the alburnum, and the layers increaſe in denſity the nearer they are to the centre. Sir John Hill gave to the innermoſt layer of wood the name of *corona*, or rather he gave this name to a thin zone which, according to him, lies between the wood and the pith.

107
burnum
d perfect
ood.

108
th.

The PITH occupies the centre of the wood. It is a very ſpongy body, containing a prodigious number of cells, which anatomiſts have compared to bladders. In young ſhoots it is very ſucculent; but it becomes dry as the plant advances, and at laſt in the large trunks of many trees diſappears altogether.

109
eaves.

The LEAVES are attached to the branches of plants by ſhort footſtalks. From theſe footſtalks a number of fibres iſſue, which ramify and communicate with each other in every part of the leaf, and form a very curious network. Theſe fibres may be obtained ſeparately, by keeping the leaf long in moiſture. Every other part of it putrefies and falls off, or may eaſily be rubbed off, and only the fibres remain, conſtituting a ſkeleton of the leaf. In every leaf there are two layers of theſe fibres, forming two diſtinct ſkeletons, which had conſtituted the upper and under ſurface of the leaf.

The whole leaf is covered with the epidermis of the plant; and this epidermis, as Sauſſure has ſhewn, contains in it a great number of glands. The other parts of the bark may alſo be traced on many leaves; at leaſt Sauſſure has ſhewn, that the *bark* of leaves is compoſed of two different layers. The interſtices between the fibres of the leaf are filled up by a pulpy-like ſubſtance, to which the green colour of the leaf is owing.

Such is a ſhort deſcription of the moſt conſpicuous parts of plants. A more minute account would have been foreign to the ſubject of the preſent article.

110
lants in-
reaſe in
ze.

9. Plants, after they have germinated, do not remain ſtationary, but are continually increaſing in ſize. A tree, for inſtance, every ſeaſon, adds conſiderably to its former bulk. The root ſends forth new ſhoots, and the old ones become larger and thicker. The ſame increment takes place in the branches and the trunk. When we examine this increaſe more minutely, we find that a new layer of wood, or rather of alburnum, has been added to the tree in every part, and this addition has been made juſt under the bark. We find, too, that a layer of alburnum has aſſumed the appearance of perfect wood. Beſides this addition of vegetable fibre, a great number of leaves have been produced; and the tree puts forth flowers, and forms ſeeds.

Vegetation.

111
Therefore
require
food.

It is evident from all this, that a great deal of new matter is continually making its appearance in plants. Hence, ſince it would be abſurd to ſuppoſe that they *create* new matter, it muſt follow that they receive it by ſome channel or other. Plants, then, require food as well as animals. Now, what is this food, and whence do they derive it? Theſe queſtions can only be anſwered by an attentive ſurvey of the ſubſtances which are contained in vegetables, and an examination of thoſe ſubſtances which are neceſſary for their vegetation. If we could ſucceed completely, it would throw a great deal of light upon the nature of ſoils and of manures, and on ſome of the moſt important queſtions in agriculture. But we are far indeed at preſent from being able to examine the ſubject to the bottom.

112
Water neceſſary.

10. In the firſt place, it is certain that plants will not vegetate without water; for whenever they are deprived of it, they wither and die. Hence the well known uſe of rains and dews, and the artificial watering of ground. We may conclude, then, that water is at leaſt an eſſential part of the food of plants.

But many plants grow in pure water; and therefore it may be queſtioned whether water is not the only food of plants. This opinion was adopted very long ago, and numerous experiments have been made in order to demonſtrate it. Indeed, it was the general opinion of the 17th century; and ſome of the moſt ſucceſsful improvers of the phyſiology of plants, in the 18th century, have embraced it. The moſt zealous advocates for it were, Van Helmont, Boyle, Bonnet, Duhamel, and Tillet.

113
Suppoſed
the whole
food of
plants;

Van Helmont planted a willow which weighed five pounds, in an earthen veſſel filled with ſoil previouſly dried in an oven, and moiſtened with rain water. This veſſel he ſunk into the earth, and he watered his willow, ſometimes with rain, and ſometimes with diſtilled water. After five years it weighed 169½ lbs. and the earth in which it was planted, when again dried, was found to have loſt only two ounces of its original weight. Here, it has been ſaid, was an increaſe of 164 lb. and yet the only food of the willow was pure water; therefore it follows that pure water is ſufficient to afford nouriſhment to plants. The inſufficiency of this experiment to decide the queſtion was firſt pointed out by Bergman in 1773 *. He ſhewed, from the experiments of Margraff, that the rain water employed by Van Helmont contained in it as much earth as could exiſt in the willow at the end of five years. For, according to the experiments of Margraff, 1 lb. of rain water contains 1 gr. of earth †. The growth of the willow, therefore, by no means proves that the earth which plants contain has been formed out of water. Beſides, as Mr Kirwan has remarked ‡, the earthen veſſel muſt have often abſorbed moiſture, from the ſurrounding earth, impregnated with whatever ſubſtance that earth contained; for unglazed earthen veſſels, as Hales * and Tillet † have ſhewn, readily tranſmit moiſture.

Hence it is evident that no concluſion whatever can be drawn from this experiment; for all the ſubſtances which the willow contained, except water, may have been derived from the rain water, the earth in the pot, and the moiſture imbibed from the ſurrounding ſoil.

114
But without reaſon.

---

* *Opuſc.* v. 92.

† *Opuſc.* ii. 15. and 19.

‡ *Iriſh Tranſ.* v. 150.

* *Veget. Stat.* i. 5.

† *Mem. Par.* 1772. 298.

The experiments of Duhamel and Tillet are equally inconcluſive; ſo that it is impoſſible from them to decide the queſtion, Whether water be the ſole nouriſhment of plants or not? We owe the ſolution of this difficulty to the experiments of Mr Haſſenfratz, who pointed out the fallacy of thoſe juſt mentioned.

He analyſed the bulbous roots of hyacinths, in order to diſcover the quantity of water, carbon, and hydrogen, which they contained; and by repeating the analyſis on a number of bulbs, he diſcovered how much of theſe ingredients was contained in a given weight of the bulb. He analyſed alſo kidney beans and creſs ſeeds in the ſame manner. Then he made a number of each of theſe vegetate in pure water, taking the precaution to weigh them beforehand, in order to aſcertain the preciſe quantity of carbon which they contained. The plants being then placed, ſome within doors, and others in the open air, grew and flowered, but produced no ſeed. He afterwards dried them, collecting with care all their leaves and every other part which had dropt off during the courſe of the vegetation. On ſubmitting each plant to a chemical analyſis, he found that the quantity of carbon, which it contained, was ſomewhat leſs than the quantity which exiſted in the bulb or the ſeed from which the plant had ſprung *.

* *Ann. de Chim.* xiii. 188.

Hence it follows irreſiſtibly, that plants growing in pure water do not receive any increaſe of *carbon*; that the water merely ſerves as a vehicle for the carbonaceous matter already preſent, and diffuſes it thro' the plant. Water, then, is not the ſole food of plants; for all plants during vegetation receive an increaſe of carbonaceous matter, without which they cannot produce perfect ſeeds, nor even continue to vegetate beyond a certain time; and that time ſeems to be limited by the quantity of carbonaceous matter contained in the bulb or the ſeed from which they grow. For Duhamel found, that an oak which he had raiſed by water from an acorn, made leſs and leſs progreſs every year. We ſee, too, that thoſe bulbous roots, ſuch as hyacinths, tulips, &c. which are made to grow in water, unleſs they be planted in the earth every other year, refuſe at laſt to flower, and even to vegetate; eſpecially if they produce new bulbous roots annually, and the old ones decay.

115
A certain portion only proper.

So far, indeed, is water from being the ſole food of plants, that in general only a certain proportion of it is ſerviceable, too much being equally prejudicial to them as too little. Some plants, it is true, grow conſtantly in water, and will not vegetate in any other ſituation; but the reſt are entirely deſtroyed when kept immerſed in that fluid beyond a certain time. Moſt plants require a certain degree of moiſture, in order to vegetate well. This is one reaſon why different ſoils are required for different plants. Rice, for inſtance, requires a very wet ſoil: were we to ſow it in the ground on which wheat grows luxuriouſly, it would not ſucceed; and wheat, on the contrary, would rot in the rice ground.

We ſhould, therefore, in chooſing a ſoil proper for the plants which we mean to raiſe, conſider the quantity of moiſture which is beſt adapted for them, and chooſe our ſoil accordingly. Now, the dryneſs or moiſture of a ſoil depends upon two things; the nature and proportions of the earths which compoſe it, and the quantity of rain which falls upon it. Every ſoil contains at leaſt three earths, ſilica, lime, and alumina, and ſometimes alſo magneſia. The ſilica is always in the ſtate of ſand. Now ſoils retain moiſture longer or ſhorter according to the proportions of theſe earths. Thoſe which contain the greateſt quantity of ſand retain it the ſhorteſt, and thoſe which contain the greateſt quantity of alumina retain it longeſt. The firſt is a dry, the ſecond a wet ſoil. Lime and magneſia are intermediate between theſe two extremes: they render a ſandy ſoil more retentive of moiſture, and diminiſh the wetneſs of a clayey ſoil. It is evident, therefore, that, by mixing together proper proportions of theſe four earths, we may form a ſoil of any degree of dryneſs and moiſture that we pleaſe.

But whatever be the nature of the ſoil, its moiſture muſt depend in general upon the quantity of rain which falls. If no rain at all fell, a ſoil, however retentive of moiſture it be, muſt remain dry; and if rain were very frequently falling, the ſoil muſt be open indeed, if it be not conſtantly wet. The proportion of the different earths in a ſoil, therefore, muſt depend upon the quantity of rain which falls. In a rainy country, the ſoil ought to be open; in a dry country, it ought to be retentive of moiſture. In the firſt, there ought to be a greater proportion of ſand; in the ſecond, of clay.

116
Earth neceſſary;

11. Almoſt all plants grow in the earth, and every ſoil contains at leaſt ſilica, lime, alumina, and often magneſia. We have ſeen already, that one uſe of theſe earths is to adminiſter the proper quantity of water to the vegetables which grow in the ſoil. But as all plants contain earths as a part of their ingredients, is it not probable that earths alſo ſerve as a food for plants? It has not yet indeed been ſhewn, that thoſe plants which vegetate in pure water do not contain the uſual quantity of earth; but as earths are abſolutely neceſſary for the perfect vegetation of plants, as they are contained in all plants, and are even found in their juices, we can ſcarcely doubt that they are actually imbibed, though only in ſmall quantities (D).

117
And ſalts

12. We have ſeen in the laſt chapter, that all plants contain various ſaline ſubſtances; and if we analyſe the moſt fertile ſoils, and the richeſt manures, we never find them deſtitute of theſe ſubſtances. Hence it is probable that different ſalts enter as ingredients into the food of plants. It is probable alſo, that every plant abſorbs particular kinds of ſalts. Thus ſea plants yield ſoda by analyſis, while inland plants furniſh potaſs. The potaſs contained in plants has indeed been ſuppoſed to be the produce of vegetation; but this has not been proved in a ſatisfactory manner. We find potaſs in the very juices of plants, even more abundantly than in the vegetable fibres themſelves. But this ſubject is ſtill buried in obſcurity; and indeed it is extremely dif-

ficult

(D) Mr Tennant has aſcertained, that magneſia, when uncombined with carbonic acid gas, is injurious to corn when employed as a manure; and that lime, which contains a mixture of magneſia, likewiſe injures corn.—See *Phil. Tranſ.* 1799, p. 2. This important fact demonſtrates, that earths are not mere vehicles for conveying water to plants.

ficult to make deciſive experiments, on account of the very ſmall quantity of potaſs which moſt plants contain.

The phoſphorus, too, and the iron, and other metals which are found in plants, are no doubt abſorbed by them as a part of their food. We may ſuppoſe alſo, that the ſulphuric and muriatic acids, and perhaps even the nitric acid, when found in plants, are imbibed by them along with the reſt of their aliment.

Nothing is at preſent known concerning thoſe ſaline ſubſtances which form an eſſential part of the food of plants; though it has been long remarked that certain ſalts are uſeful as manures.

118 nd car-on.

13 Water, then, and earths, and perhaps alſo ſalts, form a part of the food of plants. But plants contain carbon, which cannot be derived from any of theſe ſubſtances; conſequently ſome ſubſtance or other beſides, which contains carbon, muſt conſtitute a part of the food of plants.

Mr Giobert mixed together the four earths, ſilica, alumina, lime, magneſia, in the proper proportions, to conſtitute a fertile ſoil; and after moiſtening them with water, planted ſeveral vegetables in them; but none of his plants grew well, till he moiſtened his artificial ſoil with water from a dunghill *. Now it is certain, from the experiments of Haſſenfratz, that this water contains carbon; for when evaporated, it conſtantly left behind it a reſiduum of charcoal † We know likewiſe, from a great variety of experiments, that all fertile ſoils contain a conſiderable quantity of carbonaceous matter; for all of them, when expoſed to heat, are ſuſceptible of partial combuſtion, during which a quantity of carbonic acid gas eſcapes. Thus Fourcroy and Haſſenfratz found, that 9216 parts of fertile ſoil contained 305 parts of carbon, beſides 279 parts of oil; which, from the analyſis of Lavoiſier, we may ſuppoſe to contain about 220 parts of carbon. It follows, therefore, from the experiments of theſe chemiſts ‡, that 9216 parts of ſoil contain 525 parts of carbon. But theſe 9216 parts of ſoil contained 806 parts of roots of vegetables which were excluded from the analyſis; conſequently a fertile ſoil contains (excluſive of the roots of vegetables) about one-ſixteenth of its weight of carbon.

119 Which muſt be in a particular ſtate;

But the carbon muſt exiſt in the ſoil in a particular ſtate of combination, otherwiſe it does not anſwer as food for plants: For inſtance, powdered pitcoal, mixed with earths, is not found to act, at leaſt immediately, as a manure; yet pitcoal contains a very great quantity of carbon. Farther, it appears, from the experiments of Mr Haſſenfratz, that ſubſtances employed as manures produce effects in times proportioned to their degree of putrefaction; thoſe ſubſtances which are moſt putrid producing the moſt ſpeedy effects, and of courſe ſooneſt loſing their efficacy. Having manured two pieces of the ſame kind of ſoil, the one with a mixture of dung and ſtraw highly putrefied, the other with the ſame mixture newly made, and the ſtraw almoſt freſh, he obſerved that, during the firſt year, the plants which grew on the land manured with the putrefied dung produced a much better crop than the other: but the ſecond year (no new dung being added), the ground which had been manured with the unputrified dung produced the beſt crop; the ſame thing took place the third year; after which, both ſeemed to be equally exhauſted *. Here it is evident that the putrified dung acted ſooneſt, and was ſooneſt exhauſted. It follows from this, that carbon only acts as a manure when in a particular ſtate of combination; and this ſtate, whatever it may be, is evidently produced by putrefaction. Another experiment of the ſame chemiſt renders this truth ſtill more evident. He allowed ſhavings of wood to remain for about ten months in a moiſt place till they began to putrefy, and then ſpread them over a piece of ground by way of manure. The firſt two years this piece of ground produced nothing more than others which had not been manured at all; the third year it was better, the fourth year ſtill better, the fifth year it reached its maximum of fertility; after which it declined conſtantly till the ninth, when it was quite exhauſted †. Here the effect of the manure evidently depended upon its progreſs in putrefaction.

120 And ſoluble in water.

Now what is the particular ſtate into which carbon muſt be reduced before it be fit for the food of plants? This ſubject has never been examined with attention; the different combinations of carbon having been in a great meaſure overlooked. And yet it is evident, that it is only by an accurate examination of theſe combinations, and a thorough analyſis of manures, in order to diſcover what particular combinations of carbon exiſt in them, and in what the moſt efficacious manures differ from the reſt, that we can expect to throw complete light upon the nature and uſe of manures, one of the moſt important ſubjects to which the farmer can direct his attention. We know, from the experiments of Mr Haſſenfratz, that all thoſe manures which act with efficacy and celerity contain carbon in ſuch a ſtate of combination, that it is ſoluble in water; and that the efficacy of the manure is proportional to the quantity of carbon ſo ſoluble. He found that all efficacious manures gave a brown colour to water, and that the water ſo coloured, when evaporated, left a reſiduum, which conſiſted in a great meaſure of carbon *. He obſerved, too, that the ſoil which gives the deepeſt colour to water, or which contains the greateſt quantity of carbon ſoluble in water, is, other things being the ſame, the moſt fertile.

This is not, however, to be underſtood without limitation; for it is well known that if we employ exceſſive quantities of manure, we injure vegetation inſtead of promoting it. This is the reaſon that plants will not, as Mr Duhamel found by experiment, vegetate in ſaturated ſolutions of dung †.

121 This ſtate not carbonic acid gas;

One of the combinations of carbon which is ſoluble in water, and with which we are beſt acquainted, is carbonic acid gas. It has been ſuppoſed by many philoſophers, particularly by Mr Senebier, that this gas, diſſolved in water, ſupplies plants with a great part of their carbon. But Mr Haſſenfratz, on making the experiment, found, that the plants which he raiſed in water, impregnated with carbonic acid gas, differed in no reſpect from thoſe which grew in pure water, and did not contain a particle of carbon which had not exiſted in the ſeeds from which they ſprung ‡. This experiment proves, that carbonic acid gas, diſſolved in water, does not ſerve as food for plants. It appears, however, from the experiments of Ruckert, that when plants growing in ſoil are watered daily with water impregnated with carbonic acid gas, they vegetate faſter than when this watering is omitted. He planted two beans

122 Though that gas is uſeful.

---

* Encyc. Meth. Phyſ. Veget. p. 275.

† Ann. de Chim. xiv. 56.

‡ Encyc. Meth. Phyſ. Veget. p. 277.

* Ann de Chim. xiv 57.

† Ibid. p. 58.

* Ibid. p. 56.

† Mem. Par. 1748.

‡ Ann de Chim. xiii. 320.

in pots of equal dimenſions, filled with garden mould. One of theſe was watered almoſt daily with diſtilled water, the other with water, every ounce of which was impregnated with half a cubic inch of carbonic acid gas. Both were placed in the open air, but in a ſituation where they were ſecure from rain. The bean treated with the water impregnated with carbonic acid gas appeared above ground nine days before the other, and produced 25 beans; whereas the other produced only 15. The ſame experiment was tried on other plants with equal ſucceſs [†]. This ſhews us that carbonic acid gas is ſomehow or other uſeful to plants when they vegetate in mould; but it gives us no information about its mode of acting. Some ſoils, we know, are capable of decompoſing it; for ſome ſoils contain the green oxyd of iron: and Gadolin has proved, that ſuch ſoils have the property of decompoſing carbonic acid gas [*]. Indeed almoſt all ſoils contain iron, either in the ſtate of the brown or the green oxyd; and Beaumé has ſhewn, that oils convert the brown oxyd of iron into the green [†]. Now dung contains a quantity of oily ſubſtance; and this is the caſe alſo with rich ſoils. One uſe of manures, therefore, may be, to reduce the brown oxyd of iron to the green, that it may be capable of decompoſing carbonic acid gas; and the carbon, thus precipitated, doubtleſs enters into ſome new combination, in which ſtate it ſerves as food for plants.

Mr Humbolt has lately proved, that ſoils have the property of abſorbing oxygen. It can ſcarcely be doubted that this abſorption has an influence on vegetation, eſpecially as watering plants with weak ſolutions of oxy-muriatic acid accelerates vegetation [*]. But we know too little of the ſubject at preſent to be able to ſpecify preciſely what that influence is.

123
Food abſorbed by the roots.

14. Since the only part of plants which is contiguous to the ſoil is the root, and ſince the plant periſhes when the root is pulled out of the ground, it is evident that the food of plants muſt be imbibed by the roots.

When we examine the roots, we do not find them to contain any large opening. The paſſages by which the food enters are too ſmall for the naked eye. This ſhews us, that the food can enter plants only in a fluid ſtate; and that conſequently every thing which can be rendered uſeful as food for plants muſt be previouſly in a ſtate of ſolution.

It ſeems moſt probable, that the whole, or the greateſt part of the food, enters at the extremities of the roots; for Duhamel obſerved, that the portion of the ſoil which is ſooneſt exhauſted, is preciſely that part in which the greateſt number of the extremities of roots lies [‡]. This ſhews us the reaſon why the roots of plants are continually increaſing in length. By this means they are enabled, in ſome meaſure, to go in queſt of nouriſhment. The extremities of the roots ſeem to have a peculiar ſtructure adapted for the imbibing of moiſture. If we cut off the extremity of a root, it never increaſes any more in length: therefore its uſe as a root has been in a great meaſure deſtroyed. But it ſends out fibres from its ſides which act the part of roots, and imbibe food by their extremity. Nay, in ſome caſes, when the extremity of a root is cut off, the whole decays, and a new one is formed in its place. This, as Dr Bell informs us, is the caſe with the hyacinth [†].

124
Diſſolved in water.

Since the food of plants muſt be in a fluid ſtate, and ſince no plant will live if it be deprived of moiſture, we may conclude that all its food is previouſly diſſolved in water. As for the carbon, we know, that in all active manures it is in ſuch a ſtate of combination, that it is ſoluble in water. We know, too, that all the ſalts which we can ſuppoſe to make a part of the food of plants, are more or leſs ſoluble in water. Lime alſo is ſoluble in water, whether it be pure or in the ſtate of a ſalt; magneſia and alumina may be rendered ſo by means of carbonic acid gas; and Bergman, Macie, and Klaproth, have ſhewn, that even ſilica may be diſſolved in water. We can ſee, therefore, in general, though we have no preciſe notions of the very combinations which are immediately imbibed by plants, that all the ſubſtances which form eſſential parts of that food *may* be diſſolved in water.

125
Therefore fluid.

15. Since the food of plants is imbibed by their roots in a fluid ſtate, it muſt exiſt in plants in a fluid ſtate; and unleſs it undergoes alterations in its compoſition juſt when imbibed, we may expect to find it in the plant unaltered. If there were any method of obtaining this fluid food from plants before it has been altered by them, we might analyſe it, and obtain by that means a much more accurate knowledge of the food of plants than we can by any other method. This plan indeed muſt fail, provided the food undergoes alteration juſt when it is abſorbed by the roots: but if we conſider, that when one ſpecies of tree is grafted upon another, each bears its own peculiar fruit, and produces its own peculiar ſubſtances, we can ſcarcely avoid thinking that the *great* changes, at leaſt which the food undergoes after abſorption, are produced, not in the roots, but in other parts of the plant.

126
Sap of plants.

If this concluſion be juſt, the food of plants, after being imbibed by the roots, muſt go directly to thoſe organs where it is to receive new modifications, and to be rendered fit for being aſſimilated to the different parts of the plant. There ought therefore to be certain juices continually aſcending from the roots of plants; and theſe juices, if we could get them pure and unmixed with the other juices or fluids which the plant muſt contain, and which have been ſecreted and formed from theſe primary juices, would be, very nearly at leaſt, the food as it was imbibed by the plant. Now during the vegetation of plants, there actually is a *juice* continually aſcending from their roots. This juice has been called the *ſap*, the *ſuccus communis*, the *lymph* of plants. We ſhall adopt the firſt of theſe names, becauſe it has been moſt generally received.

The firſt ſtep towards an accurate knowledge of the food, and of the changes which take place during vegetation, is an analyſis of the ſap. The ſap is moſt abundant during the ſpring. At that ſeaſon, if a cut be made through the bark and part of the wood of ſome trees, the ſap flows out very profuſely. The trees are then ſaid to *bleed*. By this contrivance any quantity of ſap we think proper may be collected. It is not probable, indeed, that by this method we obtain the aſcending ſap in all its purity: it is no doubt mixed with the peculiar juices of the plant; but the leſs progreſs vegetation has made, the purer we may expect to find it; both becauſe the peculiar juices muſt be in much ſmaller quantity, and becauſe its quantity may

---

[†] *Crell's Annals*, 1788. ii. 399.

[*] *Ibid.* 1791. i. 53.

[†] *Kirwan, Iriſh Tranſ.* v. 150.

[*] *Ingenhouſz.*

[‡] *Phyſique des Arbres*, ii. 239.

[†] *Manch. Mem.* ii. 412.

may be ſuppoſed to be greater. We ſhould therefore examine the ſap as early in the ſeaſon as poſſible, and at all events before the leaves have expanded.

127
lyſed.

For the moſt complete ſet of experiments hitherto made upon the ſap, we are indebted to Mr Vauquelin. An account of his experiments has been publiſhed in the 31ſt volume of the *Annales de Chimie*. He has neglected to inform us of the ſtate of the tree when the ſap which he analyſed was taken from it; ſo that we are left in a ſtate of uncertainty with reſpect to the purity of the ſap: but from the compariſon which he has put it in our power to draw between the ſtate of the ſap at different ſucceſſive periods, we may in ſome meaſure obviate this uncertainty.

He found that 1039 parts of the ſap of the ulmus campeſtris, or common elm, were compoſed of

1027.567 water and volatile matter,
9.553 acetite of potaſs,
1.062 vegetable matter,
0.818 carbonat of lime,

Beſides ſome ſlight traces of ſulphuric and muriatic acids.

On analyſing the ſame ſap ſomewhat later in the ſeaſon, Mr Vauquelin found the quantity of vegetable matter a little increaſed, and that of the carbonat of lime and acetite of potaſs diminiſhed. Still later in the ſeaſon the vegetable matter was farther increaſed, and the other two ingredients farther diminiſhed. The acetite of potaſs, in 1039 parts of this third ſap, amounted to 8.615 parts *.

If theſe experiments warrant any conſequence to be drawn from them, they would induce us to ſuppoſe that the carbonat of lime and acetite of potaſs were contained in the pure aſcending ſap, and that part at leaſt of the vegetable matter was derived from the peculiar juices altered by the ſecreting organs of the plant; for the two ſalts diminiſhed in quantity, and the vegetable matter increaſed as the vegetation of the tree advanced. Now this is preciſely what ought to have taken place, on the ſuppoſition that the ſap became more and more mixed with the peculiar juices of the tree, as we are ſuppoſing it to do. If theſe concluſions have any ſolidity, it follows from them, that carbonat of lime and acetite of potaſs are abſorbed by plants as a part of their food. Now theſe ſalts, before they are abſorbed, muſt be diſſolved in water. But the carbonat of lime may be diſſolved in water by the help of carbonic acid. This ſhews us how water ſaturated with carbonic acid may be uſeful to plants vegetating in a proper ſoil, while it is uſeleſs to thoſe that vegetate in pure water. In the pure water there is no carbonat of lime to be diſſolved; and therefore carbonic acid gas cannot enter into a combination which renders it proper for becoming the food of plants. Part of the vegetable matter was precipitated from the ſap by alcohol. This part ſeems to have been gummy. Now gums we know are produced by vegetation.

The ſap of the fagus ſylvatica, or beech, contained the following ingredients.

Water,
Acetite of lime with exceſs of acid,
Acetite of potaſs,
Gallic acid,
Tan,
A mucous and extractive matter,
Acetite of alumina.

Although Mr Vauquelin made two different analyſes of this ſap at different ſeaſons, it is impoſſible to draw any ſatisfactory concluſions from them, as he has not given us the proportions of the ingredients. It ſeems clear that the gallic acid and tan were combined together; for the ſap taſted like the infuſion of oak bark. The quantity of each of theſe ingredients increaſed as vegetation advanced; for the colour of the ſecond ſap collected later was much deeper than that of the firſt. This ſhews us that theſe ingredients were produced by vegetation, and that they did not form a part of the aſcending ſap. Probably they were derived from the bark of the tree. The preſence of alumina, and the abſence of carbonic acid gas, would ſeem to indicate that all plants do not imbibe the very ſame food.

The ſap of the carpinus ſylveſtris contains water, acetite of potaſs, acetite of lime, ſugar, mucilage, vegetable extract. It cannot be doubted that the ſugar and the mucilage are the produce of vegetation.

The ſap of the betula alba, or common birch, contains water, ſugar, vegetable extract, acetite of lime, acetite of alumina, and acetite of potaſs.

Theſe experiments are curious, and certainly add to the preciſion of our notions concerning the food of plants; but they are not deciſive enough to entitle us to draw concluſions. They would ſeem to ſhew, either that acetite of potaſs and lime are a part of the food of plants, or at leaſt ſome ſubſtances which have the property of aſſuming theſe combinations.

128
Whether the food is altered by the roots.

16. Theſe experiments lead to the concluſion that acetous acid forms a component part of the ſap. Now it is not eaſy to ſuppoſe that this ſubſtance is actually abſorbed by the roots in the ſtate of acetous acid. The thing might be determined by examining the mould in which plants grow. This examination indeed has been performed; but no chemiſt has ever found acetous acid, at leaſt in any ſenſible quantity. Is it not probable, then, that the food, after it is imbibed, is ſomewhat modified and altered by the roots? In what manner this is done we cannot ſay, as we know very little about the vaſcular ſtructure of the roots. We may conclude, however, that this modification is nearly the ſame in moſt plants: for one plant may be engrafted on another, and each continue to produce its own peculiar products; which could not be, unleſs the proper ſubſtances were conveyed to the digeſtive organs of all. There are ſeveral circumſtances, however, which render the modifying power of the roots ſomewhat probable. The ſtrongeſt of theſe is the nature of the ingredients found in the ſap. It is even poſſible that the roots may, by ſome means or other, throw out again ſome part of the food which they have imbibed as excrementitious. This has been ſuſpected by ſeveral phyſiologiſts; and there are ſeveral circumſtances which render it probable. It is well known that ſome plants will not vegetate well after others; and that ſome again vegetate unuſually well when planted in ground where certain plants had been growing. Theſe facts, without doubt, may be accounted for on other principles. If there be any excrementitious matter emitted by the roots, it is much more probable that this happens in the laſt ſtage of vegetation. That is to ſay, when the food, after digeſtion, is applied to the purpoſes which the root requires. But the fact ought to be ſupported by experiments, otherwiſe it cannot be admitted.

---

* Ann. de
m xxxi.

17. The ſap, as Dr Hales has ſhewn us, aſcends with a very conſiderable force. It iſſued during the bleeding ſeaſon with ſuch impetuoſity from the cut end of a vine branch, that it ſupported a column of mercury 32½ inches high*.

129 Sap aſcends

Now what is the particular channel through which the ſap aſcends, and what is the cauſe of the force with which it moves? Theſe are queſtions which have excited a great deal of the attention of thoſe philoſophers who have made the phyſiology of vegetables their particular ſtudy; but the examination of them is attended with ſo many difficulties that they are very far from being decided.

It is certain that the ſap flows from the roots towards the ſummit of the tree. For if in the bleeding ſeaſon a number of openings be made in the tree, the ſap begins firſt to flow from the loweſt opening, then from the loweſt but one, and ſo on ſucceſſively, till at laſt it makes its appearance at the higheſt of all. And when Duhamel and Bonnet made plants vegetate in coloured liquors, the colouring matter, which was depoſited in the wood, appeared firſt in the loweſt part of the tree, and gradually aſcended higher and higher, till at laſt it reached the top of the tree, and tinged the very leaves.

130 Through the wood.

It ſeems certain, too, that the ſap aſcends through the wood, and not through the bark of the tree: for a plant continues to grow even when ſtript of a great part of its bark; which could not happen if the ſap aſcended through the bark. When an inciſion, deep enough to penetrate the bark, and even part of the wood, is carried quite round a branch, provided the wound be covered up from the external air, the branch continues to vegetate as if nothing had happened; which could not be the caſe if the ſap aſcended between the bark and the wood. It is well known, too, that in the bleeding ſeaſon little or no ſap can be got from a tree unleſs our inciſion penetrate deeper than the bark.

131 Not by the parenchyma;

If the ſap aſcended thro' the parenchyma of plants, as ſome phyſiologiſts have ſuppoſed, ſince there is a communication between every part of that organ, it is evident that the tree ought to bleed whenever any part of the parenchyma is wounded. But this is not the caſe. Conſequently the ſap does not aſcend through the parenchyma. Beſides, if the ſuppoſition were true, the ſap, from the very ſtructure of the parenchyma, muſt aſcend in the ſame manner as water through a ſponge; and in that caſe could not poſſibly poſſeſs the force with which we know that it aſcends. But if the ſap is not found in the parenchyma, as is now well known to be the caſe, it muſt, of neceſſity, be confined in particular veſſels; for if it were not, it would undoubtedly make its appearance there. Now what are the veſſels through which the ſap aſcends?

132 But in veſſels.

Grew and Malpighi, the firſt philoſophers who examined the ſtructure of plants, took it for granted that the woody fibres were tubes, and that the ſap aſcended through them. For this reaſon they gave theſe fibres the name of *lymphatic* veſſels. But they were unable, even when aſſiſted by the beſt microſcopes, to detect any thing in theſe fibres which had the appearance of a tube; and ſucceeding obſervers have been equally unſucceſsful. The conjecture therefore of Malpighi and Grew, about the nature and uſe of theſe fibres, remains totally unſupported by any proof. Duhamel has even gone far to overturn it altogether. For he found that theſe woody fibres are diviſible into ſmaller fibres, and theſe again into ſtill ſmaller; and even, by the aſſiſtance of the beſt microſcopes, he could find no end of this ſubdiviſion*. Now granting theſe fibres to be veſſels, it is ſcarcely poſſible, after this, to ſuppoſe that the ſap really moves through tubes, whoſe diameters are almoſt infinitely ſmall. There are, however, veſſels in plants which may eaſily be diſtinguiſhed by the help of a ſmall microſcope, and even, in many caſes, by the naked eye. Theſe were ſeen, and diſtinctly deſcribed, by Grew and Malpighi. They conſiſt of a fibre twiſted round like a corkſcrew. If we take a ſmall cylinder of wood, and wrap round it a ſlender braſs wire, ſo cloſely that all the rings of the wire touch each other, and if, after this, we pull out the wooden cylinder altogether, the braſs wire thus twiſted will give us a very good repreſentation of theſe veſſels. If we take hold of the two ends of the braſs wire thus twiſted, and pull them, we can eaſily draw out the wire to a conſiderable length. In the ſame manner, when we lay hold of the two extremities of theſe veſſels, we can draw them out to a great length. Malpighi and Grew finding them always empty, concluded that they were intended for the circulation of the air through the plant, and therefore gave them the name of *tracheæ;* which word is uſed to denote the *windpipe* of animals. Theſe *tracheæ* are not found in the bark; but Hedwig has ſhewn that they are much more numerous in the wood than was ſuppoſed; and that they are of very different diameters; and Reichel has demonſtrated that they go to the minuteſt branches, and ſpread through every leaf. He has ſhewn, too, that they contain ſap; and Hedwig has proved that the notion which generally prevailed of their containing nothing but air, aroſe from this circumſtance, that the larger tracheæ, which alone were attended to, loſe their ſap as ſoon as they are cut; and, of courſe, unleſs they are inſpected the inſtant they are divided, they appear empty†. Is it not probable, then, or rather is it not certain, from the diſcoveries of that very ingenious phyſiologiſt, that the tracheæ are, in reality, the ſap veſſels of plants? Indeed it ſeems eſtabliſhed by the experiments both of Reichel and Hedwig, that all, or almoſt all the veſſels of plants may, if we attend only to their ſtructure, be denominated *tracheæ*.

133 Why it aſcends

But by what powers is the ſap made to aſcend in theſe veſſels? And not only to aſcend, but to move with very conſiderable force; a force, as Hales has ſhewn, ſufficient to overcome the preſſure of 43 feet perpendicular of water‡?

134 Hypot of Grew Malpig and De Hire.

Grew aſcribed this phenomenon to the levity of the ſap; which, according to him, entered the plant in the ſtate of a very light vapour. But this opinion will not bear the ſlighteſt examination. Malpighi ſuppoſed that the ſap was made to aſcend by the contraction and dilation of the air contained in the air veſſels. But even were we to grant that the tracheæ are air veſſels, the ſap, according to this hypotheſis, could only aſcend when a change of temperature takes place; which is contrary to fact. And even if we were to wave every objection of that kind, the hypotheſis would not account for the circulation of the ſap, unleſs the ſap veſſels be provided with valves. Now the experiments of Hales and Duhamel ſhew that no valves can poſſibly exiſt in them. For branches imbibe moiſture nearly equally

---

* *Veg. Stat.* i. 105.

* *Phyſiqu des Arbres* i. 57.

† *Fundament. H Nat M cor. Fro* Part i. 54.

‡ *Veget Stat.* i.

equally by either end ; and conſequently the ſap moves with equal facility both upwards and downwards, which it could not do were there valves in the veſſels. Beſides, it is known, from many experiments, that we may convert the roots of a tree into the branches, and the branches into the roots, by covering the branches with earth, and expoſing the roots to the air. Now this would be impoſſible if the ſap veſſels were provided with valves. The ſame remarks overturn the hypotheſis of Mr de la Hire, which is merely that of Malpighi, expreſſed with greater preciſion, and with a greater parade of mechanical knowledge. Like Borelli, he placed the aſcending power of the ſap in the parenchyma. But his very experiments, had he attended to them with care, would have been ſufficient to ſhew the imperfection of his theory.

The greater number of philoſophers (for it is needleſs to mention thoſe who, like Perrault, had recourſe to fermentation, nor thoſe who introduced the weight of the atmoſphere) have aſcribed the motion of the ſap to *capillary attraction*.

135 cribed to pillary raction.

There exiſts a certain attraction between many ſolid bodies and liquids ; in conſequence of which, if theſe ſolid bodies be formed into ſmall tubes, the liquid enters them, and riſes in them to a certain height. But this is perceptible only when the diameter of the tube is very ſmall. Hence the attraction has been denominated *capillary*. We know that there is ſuch an attraction between vegetable fibres and watery liquids. For ſuch liquids will aſcend through dead vegetable matter. It is highly probable, therefore, that the food of plants enters the roots, in conſequence of the capillary attraction which ſubſiſts between the ſap veſſels and the liquid imbibed. This ſpecies of attraction then, will account perfectly well for the entrance of moiſture into the mouths of the ſap veſſels. But will it account alſo, as ſome have ſuppoſed, for the aſcent of the ſap, and for the great force with which it aſcends ?

136 is opi- n exa- ed;

The nature and laws of capillary attraction have been very much overlooked by philoſophers. But we know enough concerning it to enable us to decide the preſent queſtion. It conſiſts in a certain attraction between the particles of the liquid and of the tube. It has been demonſtrated, that it does not extend, or at leaſt that it produces no ſenſible effect, at greater diſtances than $\frac{1}{1000}$ part of an inch. It has been demonſtrated, that the water aſcends, not by the capillary attraction of the whole tube, but of a ſlender film of it ; and Clairaut has ſhewn that this film is ſituated at the lowermoſt extremity of the tube (G). This film attracts the liquid with a certain force ; and if this force be greater than the coheſion between the particles of the liquid, part enters the tube, and continues to enter, till the quantity above the attracting film of the tube juſt equals, by its weight, the exceſs of the capillary attraction between the tube and the liquid, above the cohesion of the liquid. The quantity of water therefore in the tube is pretty nearly the meaſure of this exceſs ; for the attracting film is probably very minute.

It has been demonſtrated, that the heights to which liquids riſe in capillary tubes, are inverſely as the diameter of the tube. Conſequently the ſmaller the diameter of the tube, the greater is the height to which the liquid will riſe. But the particles of water are not infinitely ſmall ; therefore whenever the diameter of the tube is diminiſhed beyond a certain ſize, water cannot aſcend in it, becauſe its particles are now larger than the bore of the tube. Conſequently the riſe of water in capillary tubes muſt have a limit : if they exceed a certain length, how ſmall ſoever their bore may be, water will either not riſe to the top of them, or it will not enter them at all. We have no method of aſcertaining the preciſe height to which water would riſe in a capillary tube, whoſe bore is juſt large enough to admit a ſingle particle of water. Therefore we do not know the limit of the height to which water may be raiſed by capillary attraction. But whenever the bore is diminiſhed beyond a certain ſize, the quantity of water which riſes in it is too ſmall to be ſenſible. We can eaſily aſcertain the height which water cannot exceed in capillary tubes before this happens ; and if any perſon calculate, he will find that this height is not nearly equal to the length of the ſap veſſels of many plants. But beſides all this, we ſee in many plants very long ſap veſſels, of a diameter too large for a liquid to riſe in them a ſingle foot by capillary attraction, and yet the ſap riſes in them to very great heights.

If any perſon ſays that the ſap veſſels of plants gradually diminiſh in diameter as they aſcend ; and that, in conſequence of this contrivance, they act preciſely as an indefinite number of capillary tubes, one ſtanding upon another, the inferior ſerving as a reſervoir for the ſuperior : we anſwer, that the ſap may aſcend by that means to a conſiderable height ; but certainly not in any greater quantity than if the whole ſap veſſel had been preciſely of the bore of its upper extremity. For the quantity of ſap raiſed muſt depend upon the bore of the upper extremity, becauſe it muſt all paſs through that extremity. The quantity of ſap, too, on that ſuppoſition, muſt diminiſh the farther we go from the root, becauſe the bore of the ſap veſſels is conſtantly diminiſhing ; the aſcending force muſt alſo diminiſh, becauſe it is, in all caſes, proportional to the quantity of water raiſed. Now neither of theſe, as Dr Hales has demonſtrated, is true.

137 And refuted.

But farther, if the ſap moved only in the veſſels of plants by capillary attraction, it would be ſo far from flowing out at the extremity of a branch, with a force ſufficient to overcome the preſſure of a column of water 43 feet high, that it could not flow out at all. It would be impoſſible in that caſe for any ſuch thing as the bleeding of trees ever to happen.

If we take a capillary tube, of ſuch a bore that a liquid will riſe in it ſix inches, and after the liquid has riſen to its greateſt height, break it ſhort three inches from the bottom, none of the liquid in the under half flows over. The tube, thus ſhortened, continues indeed full, but not a ſingle particle of liquid ever eſcapes from it. And how is it poſſible for it to eſcape ? The film,

---

(G) The action of all the other films, of which the tube is compoſed, on the water, as far as it is meaſured by its effect, is nothing at all. For every particle of water in the tube (except thoſe attracted by the undermoſt film) is attracted upwards and downwards by the ſame number of films : it is therefore preciſely in the ſame ſtate as if it were not attracted at all.

film, at the *upper* extremity of the tube, muſt certainly have as ſtrong an attraction for the liquid as the film at the *lower* extremity. As part of the liquid is within its attracting diſtance, and as there is no part of the tube above to counterbalance this attraction, it muſt of neceſſity attract the liquid neareſt it, and with a force ſufficient to counterbalance the attraction of the undermoſt film, how great ſoever we may ſuppoſe it. Of courſe no liquid can be forced up, and conſequently none can flow out of the tube. Since then the ſap *flows out* at the upper extremity of the ſap veſſels of plants, we are abſolutely certain that it does not aſcend in them merely by its capillary attraction, but that there is ſome other cauſe.

It is impoſſible therefore to account for the motion of the ſap in plants by any mechanical or chemical principles whatever; and he who aſcribes it to theſe principles has not formed to himſelf any clear or accurate conception of the ſubject. We know indeed that heat is an agent; for Dr Walker found that the aſcent of the ſap is much promoted by heat, and that after it had begun to flow from ſeveral inciſions, cold made it give over flowing from the higher orifices while it continued to flow at the lower*. But this cannot be owing to the dilating power of heat; for unleſs the ſap veſſels of plants were furniſhed with valves (and they have no valves), dilatation would rather retard than promote the aſcent of the ſap. Conſequently the effect of heat can give us no aſſiſtance in explaining the aſcent of the ſap upon mechanical and chemical principles.

138
The veſſels muſt contract,

We muſt therefore aſcribe it to ſome other cauſe: the veſſels themſelves muſt certainly act. Many philoſophers have ſeen the neceſſity of this, and have accordingly aſcribed the aſcent of the ſap to *irritability*. But the firſt perſon who gave a preciſe view of the manner in which the veſſels probably act was Sauſſure. He ſuppoſes that the ſap enters the open mouths of the veſſels, at the extremity of the roots; that theſe mouths then contract, and by that contraction propel the ſap upwards; that this contraction gradually follows the ſap, puſhing it up from the extremity of the root to the ſummit of the plant. In the mean time the mouths are receiving new ſap, which in the ſame manner is puſhed upwards†. Whether we ſuppoſe the contraction to take place preciſely in this manner or not, we can ſcarcely deny that it muſt take place; but by what means it is impoſſible to ſay. The agents cannot preciſely reſemble the muſcles of animals; becauſe the whole tube, however cut or maimed, ſtill retains its contracting power, and becauſe the contraction is performed with equal readineſs in every direction. It is evident, however, that they muſt be the ſame in kind. Perhaps the particular ſtructure of the veſſels may fit them for their office. Does ring after ring contract its diameter? The contracting agents, whatever they are, ſeem to be excited to act by ſome ſtimulus communicated to them by the ſap. This capacity of being excited to action is known in phyſiology by the name of *irritability*; and there are not wanting proofs that plants are poſſeſſed of it. It is well known that different parts of plants move when certain ſubſtances act upon them. Thus the flowers of many plants open at ſunriſe, and cloſe again at night. Linnæus has given us a liſt of theſe plants. Des Fontaines has ſhewn that the ſtamina and antheræ of many plants exhibit diſtinct motions‡. Dr Smith has obſerved, that the ſtamina of the barberries are thrown into motions when touched §. Roth has aſcertained that the leaves of the droſera longifolia and rotundifolia have the ſame property. Mr Coulon, too, who has adopted the opinion that the motion of the ſap in plants is produced by the contraction of veſſels, has even made a number of experiments in order to ſhew this contraction. But the fact is, that every one has it in his power to make a deciſive experiment. Simply cutting a plant, the *euphorbia peplis* for inſtance, in two places, ſo as to ſeparate a portion of the ſtem from the reſt, is a complete demonſtration that the veſſels actually do contract. For whoever makes the experiment, will find that the milky juice of that plant flows out at both ends ſo completely, that if afterwards we cut the portion of the ſtem in the middle, no juice whatever appears. Now it is impoſſible that theſe phenomena could take place without a contraction of the veſſels; for the veſſels in that part of the ſtem which has been detached cannot have been *more* than full; and their diameter is ſo ſmall, that if it were to continue unaltered, the capillary attraction would be more than ſufficient to retain their contents, and conſequently not a drop could flow out. Since, therefore, the whole liquid eſcapes, it muſt be driven out forcibly, and conſequently the veſſels muſt contract.

139
In conſequence of ſtimuli.

It ſeems pretty plain, too, that the veſſels are excited to contract by various ſtimuli; the experiments of Coulon and Sauſſure render this probable, and an obſervation of Dr Smith Barton makes it pretty certain. He found that plants growing in water vegetated with much greater vigour, provided a little camphor was thrown into the water *.

140
Peculiar juice formed from the ſap;

18. Beſides the ſap which aſcends upwards towards the leaves, they contain alſo another fluid, known by the name of *ſuccus proprius*, or *peculiar juice*. This juice differs very conſiderably in different plants. It ſeems to be the ſap altered by ſome proceſs or other, and fitted for the various purpoſes of vegetation. That it flows from the leaves of the plant towards the roots, appears from this circumſtance, that when we make an inciſion into a plant, into whatever poſition we put it, much more of the ſuccus proprius flows from that ſide of the wound which is next the leaves and branches, than from the other ſide: and this happens even though the leaves and branches be held undermoſt †. When a ligature is tied about a plant, a ſwelling appears above, but not below the ligature.

The veſſels containing the peculiar juice are found in all the parts of the plant. Hedwig, who has examined the veſſels of plants with very great care, ſeems to conſider them as of the ſame ſtructure with the tracheæ. The peculiar juice is eaſily known by its colour and its conſiſtence. In ſome plants it is green, in ſome red, in many milky. It cannot be doubted that its motion in the veſſels is performed in the ſame way as that of the ſap.

141
In the leaves.

19. It appears, then, that the ſap aſcends to the leaves, that there it undergoes certain alterations, and is converted into the peculiar juices; which, like the blood in animals, are afterwards employed in forming the various ſubſtances found in plants. Now the changes which the ſap undergoes in the leaves, provided we can trace them, muſt throw a great deal of light upon the nature of vegetation.

---

* Edin. Tranſ. i.

† Encyc. Meth. Phyſ. Veget. p. 267.

‡ Mem. Par. 1787.

§ Phil. Tranſ. lxxviii.

* Ann. de Chim. xxxi 63.

† Bell. Manch. Mem. ii 402.

142
rt of the
per-
res thro'
: leaves.

No ſooner has the ſap arrived at the leaves, than a great part of it is thrown off by evaporation. The quantity thus perſpired bears a very great proportion to the moiſture imbibed. Mr Woodward found that a ſprig of mint in 77 days imbibed 2558 grains of water, and yet its weight was only increaſed 15 grains * ; therefore it muſt have given out 2543 grains. Another branch, which weighed 127 grains, increaſed in weight 128, and it had imbibed 14190 grains. Another ſprig, weighing 76 grains, growing in water mixed with earth, increaſed in weight 168 grains, and had imbibed 10731 grains of water. Theſe experiments demonſtrate the great quantity of matter which is conſtantly leaving the plant. Dr Hales found that a cabbage tranſmitted daily a quantity of moiſture equal to about half its weight ; and that a ſun flower, three feet high, tranſmitted in a day 1 lb. 14 oz. avoirdupois †. He ſhewed, that the quantity of tranſpiration in the ſame plant was proportional to the ſurface of the leaves, and that when the leaves were taken off, the tranſpiration nearly ceaſed ‡. By theſe obſervations, he demonſtrated that the leaves are the organs of tranſpiration. He found, too, that the tranſpiration was nearly confined to the day, very little taking place during the night § ; that it was much promoted by heat, and ſtopped by rain and froſt ||. And Millar ¶, Guettard *, and Senebier, have ſhewn that the tranſpiration is alſo very much promoted by ſunſhine.

* Phil.
anſ.
253.

† Veget.
at. i. 5.
d 15.

‡ Ibid. 30.

§ Ibid. 5.

|| Ibid 27.
d 48.

¶ Ibid. 22.

* Mem.
ir. 1748.

The quantity of moiſture imbibed by plants depends very much upon what they tranſpire : the reaſon is evident : when the veſſels are once filled with ſap, if none be carried off, no more can enter ; and, of courſe, the quantity which enters muſt depend upon the quantity emitted.

In order to diſcover the nature of the tranſpired matter, Hales placed plants in large glaſs veſſels, and by that means collected a quantity of it †. He found that it reſembled pure water in every particular, excepting only that it ſometimes had the odour of the plant. He remarked, too, as Guettard and Du Hamel did after him, that when kept for ſome time it putrefied, or at leaſt acquired a ſtinking ſmell. Senebier ſubjected a quantity of this liquid to a chemical analyſis.

† Ibid. 49.

143
s nature,

He collected 13030 grains of it from a vine during the months of May and June. After filtration he gradually evaporated the whole to dryneſs. There remained behind two grains of reſiduum. Theſe two grains conſiſted of nearly $\frac{1}{2}$ grain of carbonat of lime, $\frac{1}{12}$ grain of ſulphat of lime, $\frac{1}{2}$ grain of matter ſoluble in water, and having the appearance of gum, and $\frac{1}{2}$ grain of matter which was ſoluble in alcohol, and apparently reſinous. He analyzed 60768 grains of the ſame liquid, collected from the vine during the months of July and Auguſt. On evaporation he obtained $2\frac{1}{8}$ grains of reſiduum, compoſed of $\frac{3}{4}$ grain of carbonat of lime, $\frac{1}{4}$ grain of ſulphat of lime, $\frac{1}{2}$ grain of mucilage, and $\frac{1}{2}$ grain of reſin. The liquid tranſpired by the *aſter novæ Angliæ* afforded preciſely the ſame ingredients ‡.

‡ Enc. Me-
od. Phyſ.
eget. 287.

144
nd quan-
y.

Senebier attempted to aſcertain the proportion which the liquid tranſpired bore to the quantity of moiſture imbibed by the plant. But it is eaſy to ſee that ſuch experiments are liable to too great uncertainties to be depended on. His method was as follows : He plunged the thick end of the branch on which he made the experiment into a bottle of water, while the other end, containing all its leaves, was thruſt into a very large glaſs globe. The apparatus was then expoſed to the ſunſhine. The quantity imbibed was known exactly by the water which diſappeared from the bottle, and the quantity tranſpired was judged of by the liquid which condenſed and trickled down the ſides of the glaſs globe. The following table exhibits the reſult of his experiments :

Plants.	*Imbibed.*	*Perſpired.*	*Time.*
Peach	100 gr.	35 gr.	
Ditto	210	90	
Ditto	220	120	
Mint	200	90	2 days.
Ditto	575	120	10
Raſp	725	560	2
Ditto	1232	765	2
Peach	710	295	1
Apricot	210	180	1

In ſome of his experiments no liquid at all was condenſed. Hence it is evident that the quantity of matter tranſpired cannot be deduced from theſe experiments. The mouth of the glaſs globe does not ſeem to have been accurately cloſed ; the air within it communicated with the external air : conſequently the quantity condenſed muſt have depended entirely upon the ſtate of the external air, the heat, &c.

The firſt great change, then, which takes place upon the ſap after it arrives at the leaves, is the evaporation of a great part of it ; conſequently what remains muſt be very different in its proportions from the ſap. The leaves ſeem to have particular organs adapted for throwing off part of the ſap by tranſpiration. For the experiments of Guettard *, Duhamel †, and Bonnet ‡, ſhew that it is performed chiefly by the upper ſurfaces of leaves, and may be nearly ſtopped altogether by varniſhing the upper ſurface.

* Mem.
Par. 1749.
† Phyſique
des Arbres,
i. 158.
‡ Traité des
Feuilles,
1. Mem.

145
Why the
leaves fall
off.

The leaves of plants become gradually leſs and leſs fit for this tranſpiration ; for Senebier found, that when all other things are equal, the tranſpiration is much greater in May than in September *. Hence the reaſon that the leaves are renewed annually. Their organs become gradually unfit for performing their functions, and therefore it is neceſſary to renew them. Thoſe trees which retain their leaves during the winter, were found by Hales and ſucceeding phyſiologiſts to tranſpire leſs than others. It is now well known that theſe trees alſo renew their leaves.

* Enc. Method. Veget.
285.

20. Leaves have alſo the property of abſorbing carbonic acid gas from the atmoſphere.

146
Leaves abſorb carbonic acid
gas.

We are indebted for this very ſingular diſcovery to the experiments of Dr Prieſtley, though he himſelf did not diſcover the truth, and though he even refuſed to acknowledge it when it was pointed out by others. It has been long known, that when a candle has been allowed to burn out in any quantity of air, no candle can afterwards be made to burn in it. In the year 1771 Dr Prieſtley made a ſprig of mint vegetate for ten days in contact with a quantity of ſuch air; after which he found that a candle would burn in it perfectly well ¶. This experiment he repeated frequently, and found that it was always attended with the ſame reſult. According to the opinion at that time univerſally received, that the

¶ On Air,
iii. 251.

the burning of candles rendered air impure by communicating phlogiſton to it, he concluded from it, that plants, while they vegetate, abſorb phlogiſton.

Carbonic acid gas was at that time ſuppoſed to contain phlogiſton. It was natural, therefore, to ſuppoſe that it would afford nouriſhment to plants, ſince they had the property of abſorbing phlogiſton from the atmoſphere. Dr Percival had publiſhed a ſet of experiments; by which he endeavoured to ſhew that this was actually the caſe.

Theſe experiments induced Dr Prieſtley, in 1776, to conſider the ſubject with more attention. But as, in all the experiments which he made, the plants confined in carbonic acid gas very ſoon died, he concluded, that carbonic acid gas was not a food, but a poiſon to plants[*]. Mr Henry of Mancheſter was led, in 1784, probably by the contrariety of theſe reſults, to examine the ſubject. His experiments, which were publiſhed in the Mancheſter Tranſactions[†], perfectly coincided with thoſe of Dr Percival. For he found, that carbonic acid gas, ſo far from killing plants, conſtantly promoted their growth and vigour. Meanwhile Mr Senebier was occupied at Geneva with the ſame ſubject; and he publiſhed the reſult of his reſearches in his *Memoires Phyſico-chymique* about the year 1780. His experiments ſhewed, in the cleareſt manner, that carbonic acid gas is uſed by plants as food. The ſame thing was ſupported by Ingenhouſz in his ſecond volume. The experiments of Sauſſure the Son, publiſhed in 1797, have at laſt put the ſubject beyond the reach of diſpute. From a careful compariſon of the experiments of theſe philoſophers, it will not be difficult for us to diſcover the various phenomena, and to reconcile all the ſeeming contradictions which occur in them. The facts are as follows:

Mr Sauſſure has ſhewn, that plants will not vegetate when totally deprived of carbonic acid gas. They vegetate indeed well enough in air which has been previouſly deprived of carbonic acid gas; but when a quantity of lime was put into the glaſs veſſel which contained them, they no longer continued to grow, and the leaves in a few days fell off[‡]. The air, when examined, was found to contain no carbonic acid gas. The reaſon of this phenomenon is, that plants (as we ſhall ſee afterwards) have the power of forming and giving out carbonic acid in certain circumſtances; and this quantity is ſufficient to continue their vegetation for a certain time. But if this new formed gas be alſo withdrawn, by quicklime, for inſtance, which abſorbs it the inſtant it appears, the leaves droop, and refuſe to perform their functions. Carbonic acid gas, then, applied to the leaves of plants, is *eſſential* to vegetation.

147
Decompoſe it and emit the oxygen;

Dr Prieſtley, to whom we are indebted for many of the moſt important facts relative to vegetation, obſerved, in the year 1778, that plants, in certain circumſtances, emitted oxygen gas[||]; and Ingenhouſz very ſoon after diſcovered that this gas is emitted by the *leaves* of plants, and only when they are expoſed to the bright light of day. His method was to plunge the leaves of different plants into veſſels full of water, and then expoſe them to the ſun, as Bonnet, who had obſerved the ſame phenomenon, though he had given a wrong explanation of it, had done before him. Bubbles of oxygen gas very ſoon detached themſelves from the leaves, and were collected in an inverted glaſs veſſel[*]. He obſerved, too, that it was not a matter of indifference what kind of water was uſed. If the water, for inſtance, had been previouſly boiled, little or no oxygen gas eſcaped from the leaves; river water afforded but little gas; but pump water was the moſt productive of all[†].

Senebier proved, that if the water be previouſly deprived of all its air by boiling, the leaves do not emit a particle of air; that thoſe kinds of water which yield moſt air, contain in them the greateſt quantity of carbonic acid gas; that leaves do not yield any oxygen when plunged in water totally deſtitute of carbonic acid gas; that they emit it abundantly when the water, rendered unproductive by boiling, is impregnated with carbonic acid gas; that the quantity of oxygen emitted, and even its purity, is proportional to the quantity of carbonic acid gas which the water contains; that water impregnated with carbonic acid gas gradually loſes the property of affording oxygen gas with leaves; and that whenever this happens, all the carbonic acid gas has diſappeared; and on adding more carbonic acid gas the property is renewed[‡]. Theſe experiments prove, in a moſt ſatisfactory manner, that the oxygen gas which the leaves of plants emit depends upon the preſence of carbonic acid gas; that the leaves abſorb carbonic acid gas, decompoſe it, give out the oxygen, and retain the carbon.

148
But durin the day only.

We now ſee why plants will not vegetate without carbonic acid gas. They abſorb it and decompoſe it; but this proceſs goes on only when the plants are expoſed to the light of day. Therefore we may conclude, that the abſorption and decompoſition of carbonic acid gas is confined to the day, and that light is an eſſential agent in the decompoſition. Probably it is by its agency, or by its entering into combination with the oxygen, that this ſubſtance is enabled to aſſume the gaſeous form, and to ſeparate from the carbon.

If we reaſon from analogy, we ſhall conclude, that during this proceſs a quantity of caloric is neceſſary; and that therefore no increaſe of temperature takes place, but rather the contrary. This may be one reaſon why the operation takes place only during the day.

149
In this w plants ma acquire much carbon.

It is extremely probable that plants by this proceſs acquire the greateſt part of the carbonaceous matter which they contain; for if we compare the quantity of carbon contained in plants vegetating in the dark, where this proceſs cannot go on, with the quantity which thoſe plants contain which vegetate in the uſual manner, we ſhall perceive a very conſpicuous difference. Chaptal found that a byſſus, which was vegetating in the dark, contained only $\frac{1}{35}$ of its weight of carbonaceous matter; but the ſame plant, after being made to vegetate in the light for 30 days, contained $\frac{1}{13}$th of its weight of carbonaceous matter[*]. Haſſenfratz aſcertained, that plants growing in the dark contain much more water, and much leſs carbon and hydrogen, than plants growing in the light. Senebier analyſed both with the ſame reſult. Plants growing in the dark yielded leſs hydrogen gas and oil: their reſinous matter was to that of plants growing in the light as 2 to 5,5, and their moiſture as 13 to 6; they contain even one-half leſs of fixed matters.

It is evident, however, that this abſorption and decompoſition of carbonic acid gas does not depend upon the

---

[*] *On Air*, i. 100.

[†] ii. 341.

[‡] *Ann. de Chim* xxiv 145. 148.

[||] *On Air*, iii 284.

[*] *Ingenhouſz on Veget.* i. 15. &c.

[†] *Ibid.* 83.

[‡] *Enc. Method. Phyſ. Veget.* 181

[*] *Mem. Par.* 178

Vegetation.

the light alone. The nature of the ſap has alſo its influence; for Haſſenfratz found, that the quantity of carbon did not increaſe when plants vegetated in pure water. Here the ſap ſeems to have wanted that part which combines with and retains the carbon; and which therefore is by far the moſt important part of the food of plants. Upon the diſcovery and mode of applying this ſubſtance, whatever it is, the improvements in agriculture muſt in a great meaſure depend.

If we conſider the difference in the proportion of carbonaceous matter in plants vegetating in the dark and in the uſual manner, we can ſcarcely avoid concluding that the quantity of carbonic acid gas abſorbed by plants is conſiderable. To form an eſtimate of it, would require a ſet of experiments performed in a very different manner from any hitherto made. The ſtems and branches of plants vegetating in a rich ſoil ſhould be confined within a large glaſs globe, the inſide of which ought to have no communication with the external air. A very ſmall ſtream of carbonic acid gas ſhould be made occaſionally to flow into this globe, ſo as to ſupply the quantity that may appear neceſſary; and there ſhould be a contrivance to carry off and examine the air within the globe when it increaſes beyond a certain quantity. Experiments conducted in this manner would probably throw a great deal of light upon this part of vegetation, and enable us to calculate the quantity of carbonic acid decompoſed, and the quantity of oxygen emitted by plants; to compare theſe with the waſte of oxygen by the reſpiration of animals and combuſtion, and to ſee whether or not they balance each other.

150
he decompoſi-
ion per-
ormed by
he paren
hyma.

Senebier has aſcertained, that the decompoſition of the carbonic acid takes place in the parenchyma. He found, that the epidermis of a leaf would, when ſeparated, give out no air, neither would the nerves in the ſame circumſtances; but upon trying the parenchyma, thus ſeparated from its epidermis and part of its nerves, it continued to give out oxygen as before †. He remarked alſo, that every thing elſe being equal, the quantity of oxygen emitted, and conſequently of carbonic acid decompoſed, is proportional to the thickneſs of the leaf; and this thickneſs depends upon the quantity of parenchyma.

That the decompoſition is performed by peculiar organs, is evident from an experiment of Ingenhouſz. Leaves cut into ſmall pieces continued to give out oxygen as before; but leaves pounded in a mortar loſt the property entirely. In the firſt ſtate, the peculiar ſtructure remained; in the other, it was deſtroyed. Certain experiments of Count Rumford, indeed, are totally incompatible with this concluſion; and they will naturally occur to the reader as an unſurmountable objection. He found, that dried leaves, black poplar, fibres of raw ſilk, and even glaſs, when plunged into water, gave out oxygen gas by the light of the ſun. But when Senebier repeated theſe experiments, not one of them would ſucceed ‡; and we have attempted them with the ſame bad ſucceſs. The Count muſt have been miſled by ſomething which he has not mentioned.

Thus we have ſeen, that when the ſap arrives at the leaves, great part is thrown off by evaporation, and that the nature of the remainder is conſiderably altered by the addition of a quantity of carbon: but theſe are by no means all the alterations produced upon the ſap in the leaves.

Vegetation.

151
Leaves abſorb oxygen,

21. Plants will not vegetate unleſs atmoſpheric air or oxygen gas have acceſs to their leaves. This was rendered probable by thoſe philoſophers who, about the end of the 17th century, turned their attention particularly towards the phyſical properties of the air: But Mr Ingenhouſz was perhaps the firſt of the modern chemiſts who put it beyond doubt. He found that carbonic acid gas, azot, and hydrogen gas, deſtroyed plants altogether, unleſs they were mixed with atmoſpheric air or oxygen gas. He found alſo, that plants grew very well in oxygen gas and in atmoſpheric air *. Theſe experiments are ſufficient to ſhew, that oxygen gas is neceſſary to vegetation. The leaves of plants ſeem to abſorb it; and moſt probably this abſorption takes place only in the night. We know, at leaſt, that in germination light is injurious to the abſorption of oxygen gas; and therefore it is probable that this is the caſe alſo in vegetation.

152
And water,

22. The leaves of plants not only abſorb carbonic acid gas and oxygen gas, but water alſo. This had been ſuſpected in all ages: the great effect which dew, ſlight ſhowers, and even wetting the leaves of plants, have in recruiting their ſtrength, and making them vegetate with vigour, are ſo many proofs that the leaves imbibe moiſture from the atmoſphere. Hales rendered this ſtill more probable, by obſerving, that plants increaſe conſiderably in weight when the atmoſphere is moiſt; and Mr Bonnet put the matter beyond doubt in his *Reſearches concerning the Uſe of the Leaves.* He ſhewed, that leaves continue to live for weeks when one of their ſurfaces is applied to water; and that they not only vegetate themſelves, but even imbibe enough of water to ſupport the vegetation of a whole branch, and the leaves belonging to it. He diſcovered alſo, that the two ſurfaces of leaves differ very conſiderably in their power of imbibing moiſture; that in trees and ſhrubs, the under ſurface poſſeſſes almoſt the whole of the property, while the contrary holds in many of the other plants; the kidney bean for inſtance.

Theſe facts prove, not only that the leaves of plants have the power of abſorbing moiſture, but alſo that the abſorption is performed by very different organs from thoſe which emit moiſture; for theſe organs lie on different ſides of the leaf. If we conſider that it is only during the night that the leaves of plants are moiſtened with dew, we can ſcarcely avoid concluding, that, except in particular caſes, it is during the night that plants imbibe almoſt all the moiſture which they do imbibe.

153
And emit carbonic acid gas.

23. During the night the leaves of plants emit carbonic acid gas. This fact was firſt demonſtrated by Mr Ingenhouſz †, and it has been ſince confirmed by every philoſopher who has attended to the ſubject.

Thus we have ſeen that the leaves of plants perform very different operations at different times. During the day they are giving out moiſture, abſorbing carbonic acid gas, and emitting oxygen gas; during the night, on the contrary, they are abſorbing moiſture, giving out carbonic acid gas, and abſorbing oxygen gas.

The emiſſion of the carbonic acid gas ſeems to be the conſequence of the decompoſition of water; either of the water which is already contained in the ſap, or

---

Enc. Method. Phyſ. Veget. 180.

Ann. de Chim. i. 15.

* *Ingenhouſz* ii. paſſim.

† *On Vegetables*, i. 47. and ii. paſſim.

Vegetation.

of that which the leaves imbibe during the night; but which of the two, it is impoſſible to determine, nor is it of much conſequence. We may conclude that this is the caſe, becauſe it takes place during the germination of the ſeed, where all the circumſtances ſeem to be perfectly analogous. The water is decompoſed, its oxygen is combined with part of the carbon which had been abſorbed during the day, and the hydrogen enters into new combinations in the ſap. It appears, alſo, that this decompoſition of water depends in a good meaſure upon the quantity of oxygen gas abſorbed; for Dr Ingenhouſz found, that when plants are confined in oxygen gas, they emit more carbonic acid gas than when they are confined in common air †.

154 Sap converted by theſe proceſſes into the peculiar juice.

To deſcribe in what manner theſe decompoſitions take place, is impoſſible; becauſe we neither know preciſely the ſubſtances into which the ſap has been converted by the operations performed during the day, nor the new ſubſtances formed by the operations of the night. We only ſee the elementary ſubſtances which are added and ſubtracted; which is far from being ſufficient to give us preciſe notions concerning the chemical changes and the affinities by which theſe changes are produced. We have reaſon, however, to conclude, that during the day the carbon of the ſap is increaſed, and that during the night the hydrogen and oxygen are increaſed; but the preciſe new ſubſtances formed are unknown to us. Nor let any one ſuppoſe that the increaſe of the hydrogen, and of the oxygen of the ſap, is the ſame thing as the addition of a quantity of water. Far from it. The ſubſtances into which the ſap is converted have been enumerated in the laſt chapter; almoſt all of them conſiſt chiefly of carbon, hydrogen, and oxygen, and yet none of them has the ſmalleſt reſemblance to water. In water, oxygen and hydrogen are already combined together in a certain proportion; and this combination muſt be broken before theſe elementary bodies can enter into thoſe triple compounds with carbon, of which a great part of the vegetable products conſiſt. We have not the ſmalleſt conception of the manner in which theſe triple combinations are formed, and as little of the manner in which the bodies which compoſe vegetable ſubſtances are combined together. The combination may, for any thing we know to the contrary, be very complicated, though it conſiſts only of three ingredients; and analogy leads us to ſuppoſe, that it actually is very complicated: for in chemiſtry it may be conſidered as a truth, to which at preſent few or no exceptions are known, that bodies are decompoſed with a facility inverſely as the ſimplicity of their compoſition; that is to ſay, that thoſe bodies which conſiſt of the feweſt ingredients are moſt difficultly decompoſed, and that thoſe which are formed of many ingredients are decompoſed with the greateſt facility.

Neither let any one ſuppoſe, that the abſorption of carbonic acid gas, during the day, is balanced by the quantity emitted during the night, and that therefore there is no increaſe of carbon: for Ingenhouſz has ſhewn, that the quantity of oxygen gas emitted during the day is much greater than the carbonic acid gas emitted during the night; and that in favourable circumſtances, the quantity of oxygen gas in the air ſurrounding plants is very much increaſed, and the carbonic acid gas diminiſhed; ſo much ſo, that both Dr Prieſtley and Dr Ingenhouſz found, that air which had been ſpoiled by a lighted candle, or by animals, was rendered as good as ever by plants. Now we know, that combuſtion and reſpiration diminiſh the oxygen gas, and add carbonic acid gas to air; therefore vegetation, which reſtores the purity of air altered by theſe proceſſes, muſt increaſe the oxygen, and diminiſh the carbonic acid gas of that air; conſequently the quantity of carbonic acid gas abſorbed by plants during the day is greater than the quantity emitted by them during the night, and of courſe the carbon of the ſap is increaſed in the leaves.

It is true, that when plants are made to vegetate for a number of days in a given quantity of air, its ingredients are not found to be altered. Thus Haſſenfratz aſcertained, that the air in which young cheſnuts vegetated for a number of days together, was not altered in its properties, whether the cheſnuts were vegetating in water or in earth *. And Sauſſure the Younger proved, that peaſe growing for ten days in water did not alter the ſurrounding air †. But this is preciſely what ought to be the caſe, and what muſt take place, provided the concluſions which we have drawn be juſt. For if plants only emit oxygen gas, by abſorbing and decompoſing carbonic acid gas, it is evident, that unleſs carbonic acid gas be preſent, they can emit no oxygen gas; and whenever they have decompoſed all the carbonic acid gas contained in a given quantity of air, we have no longer any reaſon to look for their emitting any more oxygen gas; and if the quantity of carbonic acid gas emitted during the night be ſmaller than that abſorbed during the day, it is evident, that during the day the plant will conſtantly decompoſe all the acid which had been formed during the night. By theſe proceſſes, the mutual changes of day and night compenſate each other; and they are prevented from more than compenſating each other by the forced ſtate of the plant. It is probable, that when only part of a plant is made to vegetate in this forced ſtate, ſome *carbonated ſap* (if we may be allowed the expreſſion) is ſupplied by the reſt of the plant; and that therefore the quantity of carbonic acid gas emitted during the night may bear a nearer proportion to that emitted in a ſtate of nature, than that of the abſorption of fixed air can poſſibly do. And probably, even when the whole plant is thus confined, the nightly proceſs goes on for a certain time at the expence of the carbon already in the ſap; for Haſſenfratz found, that in theſe caſes the quantity of carbon in the plant, after it had vegetated for ſome time in the dark, was leſs than it had been when it began to vegetate *. This is the reaſon that plants growing in the dark, when confined, abſorb all the oxygen gas, and emit an equal quantity of carbonic acid gas: and whenever this has happened, they die; becauſe then neither the daily nor nightly proceſſes can go on.

24. Certain changes are alſo produced on the ſap in the leaves by the action of light; and theſe changes ſeem to be in ſome meaſure independent, or at leaſt different from the abſorption and decompoſition of carbonic acid gas, in which light, as we have ſeen, acts an important part.

155 Green colour of plants pr duced b light.

The green colour of plants is owing entirely to their vegetating in the light; for when they vegetate in the dark they are white; and when expoſed to the light, they acquire a green colour in a very ſhort time, in what-

---

† Ingenhouſz ii.

* Ann. de Chim. xiii. 325.

† Ibid xxiv 139.

* Ann de Chim. xii 188.

egeta-tion.

whatſoever ſituation they are placed, even though plunged in water, provided always that oxygen be preſent; for Mr Gough has ſhewn, that light without oxygen has not the power of producing the green colour *. In what manner this change is operated, cannot, in the preſent limited ſtate of our knowledge, be aſcertained. We know too little about the properties of light to be able even to conjecture with any plauſibility. We know indeed, that part of the light is abſorbed by green plants; but this will not account for the phenomenon. When dilated, it amounts to no more than this, that plants which have grown in the dark reflect all the rays of light; while thoſe which vegetate in the light reflect the green and abſorb the others. The very mention of this phenomenon is enough to ſhew us, that we have not advanced far enough to be able to explain it.

* anch. noirs, i 501.

Etiolated (E) plants want ſomething, or poſſeſs ſomething peculiar; and it is on this ſomething that the phenomenon depends. But what is this ſomething? The ſudden appearance of the green colour is rather againſt the ſuppoſition, that it is owing to any ſpecific change in the qualities of the ſap.

Senebier has obſerved, that when plants are made to vegetate in the dark, their etiolation is much diminiſhed by mixing a little hydrogen gas with the air that ſurrounds them *. Ingenhouſz had already remarked, that when a little hydrogen gas is added to the air in which plants vegetate, even in the light, it renders their verdure deeper †: and he ſeems to think alſo, that he has proved by experiments, that plants abſorb hydrogen gas in theſe circumſtances‡. Mr Humbolt has obſerved, that the poa annua and compreſſa, plantago lanceolata, trifolium arvenſe, cheiranthus cheiri, lichen verticillatus, and ſeveral other plants which grow in the galleries of mines, retain their green colour even in the dark, and that in theſe caſes the air around them contains a quantity of hydrogen gas. Theſe facts are ſufficient to ſhew that there is ſome connection between the green colour of plants and the action of hydrogen gas on them; but what that connection is, it is impoſſible at preſent to ſay.

* Enc. Me- l. Phyſ. get. 77.

† Ann. de im. iii.

‡ Ibid. 61.

25. By theſe different changes which go on in the leaves, the nature of the ſap is altogether changed. It is now converted into what is called the *peculiar juice*, and is fit for being aſſimilated to the different parts of the plant, and for being employed in the formation of thoſe ſecretions which are neceſſary for the purpoſes of the vegetable economy.

156 eaves the geſting gans of ants.

The leaves, therefore, may be conſidered as the digeſting organs of plants, and as equivalent in ſome meaſure to the ſtomach and lungs of animals. The leaves conſequently are not mere ornaments; they are the moſt important parts of the plant. Accordingly we find, that whenever we ſtrip a plant of its leaves, we ſtrip it entirely of its vegetating powers till new leaves are formed. It is well known, that when the leaves of plants are deſtroyed by inſects, they vegetate no longer, and that their fruit never makes any farther progreſs in ripening, but decays and dries up. Even in germination no progreſs is made in the growth of the ſtem till the ſeed leaves appear. As much food indeed is laid up in the cotyledons as advances the plant to a certain ſtate, the root is prepared, and made ready to perform its functions; but the ſap which it imbibes muſt be firſt carried to the ſeed leaves, and digeſted there, before it be proper for forming the plumula into a ſtem. Accordingly if the ſeed leaves are cut off, the plant refuſes to vegetate.

157 How they are produced.

It will be very natural to aſk, If this be true, how come the leaves themſelves to be produced? Even if no anſwer could be given to this queſtion, it could not overturn a ſingle fact which has been formerly mentioned, nor affect a ſingle concluſion as far as it has been fairly deduced from theſe facts. We know that the leaves exiſt long before they appear; they have been traced even five years back. They are completely formed in the bud, and fairly rolled up for evolution, many months before that ſpring in which they expand. We know, too, that if we take a bud, and plant it properly, it vegetates, forms to itſelf a root, and becomes a complete plant. It will not be ſaid, ſurely, that in this caſe the bud imbibes nouriſhment from the earth; for it has to form a root before it can obtain nouriſhment in that manner; and this root cannot be formed without nouriſhment. Is not this a demonſtration that the bud contains, already laid up in itſelf, a ſufficient quantity of nouriſhment, not only to develope its own organs, but alſo to form new ones. This we conſider as a ſufficient anſwer to the objection. During the ſummer, the plant lays up a ſufficient quantity of nouriſhment in each bud, and this nouriſhment is afterwards employed in developing the leaves. This is the reaſon that the leaves make their appearance, and that they grow during the winter, when the plant is deprived of its organs of digeſtion.

Hence we ſee why the branch of a vine, if it be introduced into a hothouſe during the winter, puts forth leaves and vegetates with vigour, while every other part of the plant gives no ſigns of life. Hence alſo the reaſon that the inoculation of plants ſucceeds (F).

If a tree be deprived of its leaves, new leaves make their appearance, becauſe they are already prepared for that purpoſe: but what would be the conſequence if a tree were deprived of its leaves and of all its buds for five

---

(E) Plants of a white colour, from vegetating in the dark, are called *etiolated*, from a French word which ſignifies a *ſtar*, as if they grew by *ſtar light*.

(F) Hence alſo the cauſe of another well known phenomenon. The ſap flows out of trees very readily in ſpring before the leaves appear, but after that the bleeding ceaſes altogether. It is evident that there can be ſcarcely any circulation of ſap before the leaves appear; for as there is no outlet, when the veſſels are once full, they can admit no more. It appears, however, from the bleeding, that the roots are capable of imbibing, and the veſſels of circulating, the ſap with vigour. Accordingly, whenever there is an outlet, they perform their functions as uſual, and the tree bleeds; that is, they ſend up a quantity of ſap to be digeſted as uſual: but as there are no digeſting organs, it flows out, and the tree receives no injury, becauſe the ſap that flows out would not have been imbibed at all, had it not been for the artificial opening. But when the digeſtive organs appear, the tree will not bleed; becauſe theſe organs require all the ſap, and it is conſtantly flowing to them.

five years back? That plants do not vegetate without leaves, is evident from an experiment of Duhamel. He ſtript the bark off a tree in ringlets, ſo as to leave five or ſix rings of it at ſome diſtance from each other, with no bark in the intervals. Some of theſe rings had buds and leaves; theſe increaſed conſiderably in ſize; but one ring which had none of theſe remained for years unaltered.

158 Nature of the peculiar juices.

26. The peculiar juice thus formed in the leaves is carried by veſſels intended for that uſe to all the parts of the plant, in order to be employed for the purpoſes of vegetation;—to increaſe the wood, the bark, the roots; to prepare the ſeeds, lay up nouriſhment for the buds, and to repair the decayed parts of the ſyſtem, or form new ones.

If we had any method of obtaining this peculiar juice in a ſtate of purity, the analyſis of it would throw a great deal of light upon vegetation; but this is ſcarce poſſible, as we cannot extract it without dividing at the ſame time the veſſels which contain the ſap. In many caſes, however, the peculiar juice may be known by its colour; and then its analyſis may be performed with an approach towards accuracy. The experiments made on ſuch juices have proved, as might have been expected, that they differ very conſiderably from each other, and that every plant has a juice peculiar to itſelf. Hence it follows, that the proceſſes which go on in the leaves of plants muſt differ at leaſt in degree, and that we have no right to transfer the concluſions deduced from experiments on one ſpecies of plants to thoſe of another ſpecies. It is even probable, that the proceſſes in different plants are not the ſame in kind; for it is not reaſonable to ſuppoſe, that the phenomena of vegetation in an agaric or a boletus are preciſely the ſame as thoſe which take place in trees and in larger vegetables, on which alone experiments have hitherto been made.

To attempt any general account of the ingredients of the peculiar juice of plants, is at preſent impoſſible. We may conclude, however, from the experiments of Chaptal, that it contains the *vegetable fibre* of wood, either ready formed, or very nearly ſo; juſt as the blood in animals contains a ſubſtance which bears a ſtrong reſemblance to the muſcular fibres.

When oxy-muriatic acid was poured into the peculiar juice of the euphorbia, which in all the ſpecies of that ſingular genus is of a milky colour and conſiſtency, a very copious white precipitate fell down. This powder, when waſhed and dried, had the appearance of fine ſtarch, and was not altered by keeping. It was neither affected by water nor alkalies. Alcohol, aſſiſted by heat, diſſolved two thirds of it; which were again precipitated by water, and had all the properties of reſin. The remaining third part poſſeſſed the properties of the *woody fibre*. Mr Chaptal tried the ſame experiment on the juices of a great number of other plants, and he conſtantly found that oxy-muriatic acid precipitated from them *woody fibre*. The ſeeds of plants exhibited exactly the ſame phenomenon; and a greater quantity of woody fibre was obtained from them than from an equal portion of the juices of plants *. Theſe experiments are ſufficient to ſhew, that the proper juices of plants contain their nouriſhment ready prepared, nearly in the ſtate in which it exiſts in the ſeed for the uſe of the young embryo.

159 Its uſes.

The peculiar juices of plants, then, contain more carbon, hydrogen, and oxygen, and leſs water, and probably lime alſo, than the ſap. They are conveyed to every part of the plant; and all the ſubſtances which we find in plants, and even the organs themſelves, by which they perform their functions, are formed from them. But the thickeſt veil covers the whole of theſe proceſſes; and ſo far have philoſophers hitherto been from removing this veil, that they have not even been able to approach it. All theſe operations, indeed, are evidently chemical decompoſitions and combinations; but we neither know what theſe decompoſitions and combinations are, nor the inſtruments in which they take place, nor the agents by which they are regulated.

160 Plants decay and die.

27. Such, as far as we are acquainted with them, are the changes produced by vegetation. But plants do not continue to vegetate for ever; ſooner or later they decay, and wither, and rot, and are totally decompoſed. This change indeed does not happen to all plants at the end of the ſame time. Some live only for a ſingle ſeaſon, or even for a ſhorter period; others live two ſeaſons, others three, others a hundred or more; and there are ſome plants which continue to vegetate for a thouſand years. But ſooner or later they all ceaſe to live; and then thoſe very chemical and mechanical powers which had promoted vegetation combine to deſtroy the remains of the plant. Now, What is the cauſe of this change? Why do plants die?

This queſtion can only be anſwered by examining with ſome care what it is which conſtitutes the *life* of plants; for it is evident, that if we can diſcover what that is which conſtitutes the life of a plant, it cannot be difficult to diſcover what conſtitutes its death.

161 Phenomena of vegetable life.

Now the phenomena of vegetable life are in general *vegetation*. As long as a plant continues to vegetate, we ſay that it lives; when it ceaſes to vegetate, we conclude that it is dead.

The life of vegetables, however, is not ſo intimately connected with the phenomena of vegetation that they cannot be ſeparated. Many ſeeds may be kept for years without giving any ſymptom of vegetation; yet if they vegetate when put into the earth, we ſay that they poſſeſs life: and if we would ſpeak accurately, we muſt ſay alſo, that they poſſeſſed life even before they were put into the earth; for it would be abſurd to ſuppoſe that the ſeed *obtained* life merely by being put into the earth. In like manner, many plants decay, and give no ſymptoms of vegetation during winter; yet if they vegetate when the mild temperature of ſpring affects them, we conſider them as having lived all winter. The life of plants, then, and the phenomena of vegetation, are not preciſely the ſame thing; for the one may be ſeparated from the other, and we can even ſuppoſe the one to exiſt without the other. Nay, what is more, we can, in many caſes, *decide*, without heſitation, that a vegetable is not dead, even when no vegetation appears; and the proof which we have for its life is, that it *remains unaltered*; for we know that when a vegetable is dead, it ſoon changes its appearance, and falls into decay.

Thus it appears that the *life* of a vegetable conſiſts in two things. 1. In remaining unaltered, when circumſtances are unfavourable to vegetation; 2. In exhibiting

---

* *Ann. de Chim.* xxi. 285.

ta- on. hibiting the phenomena of vegetation when circumſtances are favourable. When neither of theſe two things happens, we ſay that a vegetable is dead.

The phenomena of vegetation have been enumerated above. They conſiſt in the formation or expanſion of the organs of the plant, in the taking in of nouriſhment, in carrying it to the leaves, in digeſting it, in diſtributing it through the plant, in augmenting the bulk of the plant, in repairing decayed parts, in forming new organs when they are neceſſary, in producing ſeeds capable of being converted into plants ſimilar to the parent. The *cauſe* of theſe phenomena, whatever it may be, is the *cauſe* alſo of *vegetable life*.

All the ſubſtances which have been enumerated in the firſt part of the article CHEMISTRY, *Suppl.* together with their compounds and component parts, poſſeſs certain qualities in common; in conſequence of which, a term has been invented which includes them all This term is *matter*. Now theſe common qualities may all ultimately be reſolved into certain attractions and repulſions which theſe ſubſtances exert. Theſe qualities may be ſaid, without any impropriety, to be *eſſential to matter*; becauſe every body to which we give the name of *matter* poſſeſſes them; and if any body were to be deprived of theſe qualities, it could no longer be included under the denomination *matter*. In ſhort, the word *matter* comprehends under it certain qualities; every ſubſtance which poſſeſſes theſe qualities is called *matter*; and no other ſubſtance except theſe can receive the name of *matter* without altering the meaning of the word.

162 relu- e to the s of tter;

The attractions and repulſions of matter have been examined with care; and the changes which they produce have been aſcertained with conſiderable accuracy. They have even been reduced to general principles under the name of *mechanical and chemical laws*. Whenever any change is obſerved, if that change be a caſe of a mechanical or chemical law, we ſay that the agent is *matter*; but if the change cannot be reduced under theſe laws, or if it be incompatible with theſe laws, we muſt ſay, unleſs we would pervert the meaning of words altogether, that the agent is not *matter*.

Now it cannot be diſputed that ſeveral of the phenomena of life in vegetables are incompatible with the laws of mechanics and chemiſtry. The motion of the ſap, for inſtance, muſt be produced by the contraction of the veſſels; and the contraction of veſſels, on the application of ſtimuli, is incompatible with the laws of chemiſtry, becauſe no decompoſition takes place; and of mechanics, becauſe a much greater force is generated than the generating body itſelf poſſeſſed. The evolution of the organs of vegetables, the reparation of decayed organs, the formation of new ones to ſupply the place of the old, the production of ſeeds capable of producing new plants, the conſtant ſimilarity of individuals of the ſame ſpecies;—theſe, and many other well known phenomena, cannot be reduced under mechanical and chemical laws.

163 ſe- ntly ng to mma- al cauſe.

The cauſe of life, then, in plants, is a *ſubſtance* (for we can form no conception of an agent which is not a ſubſtance) which does not act according to the laws of mechanics and chemiſtry, and which conſequently is *not matter*. We ſhall therefore, till a better name be choſen, denominate it the *vegetative principle* (G).

Vegetation.

164 Nature of the vegetative principle.

The nature of the *vegetative principle* can only be deduced from the phenomena of vegetation. It evidently follows a fixed plan, and its actions are directed to promote the good of the plant. It has a power over matter, and is capable of directing its attractions and repulſions, in ſuch a manner as to render them the inſtruments of the formation, and improvement, and preſervation of the plant. It is capable alſo of generating ſubſtances endowed with powers ſimilar to itſelf. The plan according to which it acts, diſplays the moſt conſummate wiſdom and foreſight, and a knowledge of the properties of matter infinitely beyond what man can boaſt.

165 Whether endowed with conſciouſneſs.

Metaphyſicians have thought proper to divide all ſubſtances into two claſſes, *matter* and *mind*. If we follow this diviſion, the vegetative principle, as it is not *material*, muſt undoubtedly be ranked under *mind*. But if *conſciouſneſs* and *intelligence* be conſidered as eſſential to mind, which is the caſe according to their definition, we cannot give the vegetative principle the name of *mind*, becauſe it has not been proved that it poſſeſſes conſciouſneſs and intelligence. It acts indeed according to a fixed plan, which diſplays the higheſt degree of intelligence; but this plan may belong, not to the vegetative principle itſelf, but to the Being who formed that principle We can conceive it to have been endowed by the Author of Nature with peculiar powers, which it muſt always exert according to certain fixed laws; and the phenomena of vegetation *may be* the reſult of this mode of acting. This, as far as we can ſee, is not impoſſible. It muſt be ſhewn to be impoſſible by every perſon who wiſhes to prove that plants poſſeſs conſciouſneſs and intelligence; for the proofs of this conſciouſneſs can only be deduced from the deſign which the actions of plants manifeſt. Thoſe philoſophers who have aſcribed conſciouſneſs and intelligence to plants, have founded their belief principally on certain actions which plants perform on the application of ſtimuli. But theſe actions prove nothing more than what cannot be denied, that there exiſts a vegetative principle, which is not material, and which has certain properties in common with the living principles of animals; but whether or not this vegetative principle poſſeſſes conſciouſneſs and intelligence, is a very different queſtion, and muſt be decided by very different proofs. We do not ſay that the heart of an animal is conſcious, becauſe it continues to beat on the application of proper ſtimuli for ſome time after it has been ſeparated from the reſt of the body.

166 Death of plants.

The death of plants, if we can judge from the phenomena, is owing, not to the vegetative principle leaving them, but to the organs becoming at laſt altogether unfit for performing their functions, and incapable of being repaired by any of the powers which that principle poſſeſſes. The changes which vegetable ſubſtances undergo after death come now to be examined. They ſhall form the ſubject of the enſuing chapter.

CHAP.

(G) Phyſiologiſts have uſually given it the name of *living principle*. We would have adopted that name, if it had not been too general for our purpoſe.

CHAP. III. OF THE DECOMPOSITION OF VEGETABLE SUBSTANCES.

NOT only entire plants undergo decompoſition after death, but certain vegetable ſubſtances alſo, whenever they are mixed together, and placed in proper circumſtances, mutually decompoſe each other, and new compound ſubſtances are produced.

167 Vegetable decompoſitions,

Theſe mutual decompoſitions, indeed, are naturally to be expected: for as all vegetable ſubſtances are compoſed of ſeveral ingredients, differing in the ſtrength of their affinity for each other, it is to be ſuppoſed that, when two ſuch ſubſtances are mixed together, the divellent affinities will, in many caſes, prove ſtronger than the quieſcent; and therefore decompoſition, and the formation of new compounds, muſt take place: juſt as happens when the acetite of lead and ſulphat of potaſs are mixed together.

Theſe mutual decompoſitions of vegetable ſubſtances are by no means ſo eaſily traced, or ſo readily explained, as the mutual decompoſitions of neutral ſalts; partly on account of the number of ſubſtances, whoſe affinities for each other are brought into action, and partly becauſe we are ignorant of the manner in which the ingredients of vegetable ſubſtances are mutually combined.

168 Called FERMENTATION.

Chemiſts have agreed to give theſe mutual decompoſitions which take place in vegetable ſubſtances the name of *fermentation*; a word firſt introduced into chemiſtry by Van Helmont*; and the new ſubſtances produced they have called the *products* of fermentation. All the phenomena of fermentation lay for many years concealed in the completeſt darkneſs, and no chemiſt was bold enough to hazard even an attempt to explain them. They were employed, however, and without heſitation too, in the explanation of other phenomena; as if giving to one proceſs, the name of another of which we are equally ignorant, could, in reality, add any thing to our knowledge. The darkneſs which enveloped theſe phenomena, has lately begun to diſperſe; but they are ſtill ſurrounded with a very thick miſt; and we muſt be much better acquainted with the compoſition of vegetable ſubſtances, and the mutual affinities of their ingredients, than we are at preſent, before we can explain them in a ſatisfactory manner.

169 Diviſion of them.

The vegetable fermentations or decompoſitions may be arranged under five heads; namely, that which produces *bread*, that which produces *wine*, that which produces *beer*, that which produces *acetous acid* or *vinegar*, and the *putrefactive* fermentation, or that which produces the ſpontaneous decompoſition of decayed vegetables. Theſe ſhall be the ſubject of the five following ſections. In order to avoid long titles, we ſhall give to the firſt three ſections the name of the new ſubſtances produced by the fermentation.

SECT. I. *Of BREAD.*

170 Diſcovery of bread.

SIMPLE as the manufacture of bread may appear to us who have been always accuſtomed to conſider it as a common proceſs, its diſcovery was probably the work of ages, and the reſult of the united efforts of men, whoſe ſagacity, had they lived in a more fortunate period of ſociety, would have rendered them the rivals of Ariſtotle or of Newton.

The method of making bread ſimilar to ours was known in the Eaſt at a very early period; but neither the preciſe time of the diſcovery, nor the name of the perſon who publiſhed it to the world, has been preſerved. We are certain that the Jews were acquainted with it in the time of Moſes: for in Exodus* we find a prohibition to uſe leavened bread during the celebration of the paſſover. It does not appear, however, to have been known to Abraham; for we hear in his hiſtory of cakes frequently, but nothing of leaven. Egypt, both from the nature of the ſoil and the early period at which it was civilized, bids faireſt for the diſcovery of making bread. It can ſcarcely be doubted, that the Jews learned the art from the Egyptians The Greeks aſſure us, that they were taught the art of making bread by the god Pan. We learn from Homer that it was known during the Trojan war †. The Romans were ignorant of the method of making bread till the year 580, after the building of Rome, or 200 years before the commencement of the Chriſtian era ‡. Since that period the art has never been unknown in the ſouth of Europe; but it made its way to the north very ſlowly, and even at preſent in many northern countries fermented bread is but very ſeldom uſed.

171 Subſtance which make bread.

The only ſubſtance well adapted for making bread, we mean *loaf bread*, is wheat flour, which is compoſed of four ingredients; namely, gluten, ſtarch, albumen, and a *ſweet mucous matter*, which poſſeſſes nearly the properties of ſugar, and which is probably a mixture of ſugar and mucilage. It is to the gluten that wheat flour owes its ſuperiority to every other as the baſis of bread. Indeed, there are only two other ſubſtances at preſent known of which good loaf bread can be made; theſe are *rye* and *potatoes*. The rye loaf is by no means ſo well raiſed as the wheat loaf; and potatoes will not make bread at all without particular management. Potatoes, previouſly boiled and reduced to a very fine tough paſte by a rolling pin, muſt be mixed with an equal weight of potato ſtarch. This mixture, baked in the uſual way, makes a very white, well raiſed, pleaſant bread. We are indebted for the proceſs to Mr Permentier. Barley-meal perhaps might be ſubſtituted for ſtarch.

172 Baking bread.

The baking of bread conſiſts in mixing wheat flour with water, and forming it into a paſte. The average proportion of theſe is two parts of water to three of flour. But this proportion varies conſiderably, according to the age and the quality of the flour. In general, the older and the better the flour is, the greater is the quantity of water required. If the paſte, after being thus formed, be allowed to remain for ſome time, its ingredients gradually act upon each other, and the paſte acquires new properties. It gets a diſagreeable ſour taſte, and a quantity of gas (probably carbonic acid gas) is evolved. In ſhort, the paſte ferments (H). Theſe changes do not take place without water; that liquid, therefore, is a neceſſary agent. Poſſibly it is decompoſed by the action of the ſtarch upon it; for when ſtarch is diluted with water, it gradually becomes ſour. The gluten, too, is altered, either by the action of the water on it, or of the ſtarch; for if we examine the paſte after

---

* *Stahl, Fundament. Chem.* i. 124.

* Ch. xii. v. 15.

† *Iliad*, ix 216.

‡ *Plin.* l. 1 cap. 11.

(H) It was from this proceſs that Van Helmont transferred the word *fermentation* into chemiſtry.

ead. after it has undergone fermentation, the gluten is no longer to be found. If paſte, after ſtanding for a ſufficient time to ferment, be baked in the uſual way, it forms a loaf full of eyes like our bread, but of a taſte ſo ſour and unpleaſant that it cannot be eaten. If a ſmall quantity of this old paſte, or *leaven* as it is called, be mixed with new made paſte, the whole begins to ferment in a ſhort time; a quantity of gas is evolved; but the glutinous part of the flour renders the paſte ſo tough, that the gas cannot eſcape; it therefore cauſes the paſte to ſwell in every direction: and if it be now baked into loaves, the immenſe number of air bubbles impriſoned in every part renders the bread quite full of eyes, and very light. If the preciſe quantity of leaven neceſſary to produce the fermentation, and no more, has been uſed, the bread is ſufficiently light, and has no unpleaſant taſte; but if too much leaven be employed, the bread has a bad taſte; if too little, the fermentation does not come on, and the bread is too compact and heavy. To make good bread with leaven, therefore, is very difficult.

The ancient Gauls had another method of fermenting bread. They formed their paſte in the uſual way; and inſtead of leaven, mixed with it a little of the *barm* which collects on the ſurface of fermenting beer *. This mixture produced as complete and as ſpeedy a fermentation as leaven; and it had the great advantage of not being apt to ſpoil the taſte of the bread. About the end of the 17th century, the bakers in Paris began to introduce this practice into their proceſſes. The practice was diſcovered, and exclaimed againſt; the faculty of medicine, in 1688, declared it prejudicial to health; and it was not till after a long time that the bakers ſucceeded in convincing the public that bread baked with *barm* is ſuperior to bread baked with leaven. In this country the bread has for theſe many years been fermented with barm.

* *lin.* 7.

173 n. What is this *barm* which produces theſe effects? The queſtion is curious and important; but we are not able to anſwer it completely. Mr Henry of Mancheſter has concluded, from a number of very intereſting experiments, that the only uſeful part of barm is carbonic acid gas, and that this gas therefore is the real fermenter of paſte †.

† *anch.* v. ii.

That the barm of beer, in its uſual ſtate, contains carbonic acid gas, cannot be doubted; and that carbonic acid gas acts as a ferment, the experiments of Mr Henry prove deciſively. But that the only active part of barm is carbonic acid gas, and nothing but carbonic gas, is extremely doubtful, or rather we are certain that it is not true. It has been cuſtomary with the bakers of Paris to bring their barm from Flanders and Picardy in a ſtate of dryneſs. When ſkimmed off the beer, it is put into ſacks, and the moiſture allowed to drop out; then theſe ſacks are ſubjected to a ſtrong preſſure, and when the barm is dry it is made up into balls †. Now, in this ſtate, it is not to be ſuppoſed that bubbles of carbonic acid can remain entangled in the barm; they muſt have been ſqueezed out by the preſs, and by the ſubſequent formation of the barm into balls: yet this barm, when moiſtened with water, ferments the bread as well as new barm.

† *Meth.* 249.

174 Heat of the oven. After the bread has fermented, and is properly raiſed, it is put into the oven previouſly heated, and allowed to remain till it be baked. The mean heat of an oven, as aſcertained by Mr Tillet, is 448° *. The bakers do not uſe a thermometer; but they judge that the oven is arrived at the proper heat when flour thrown on the floor of it becomes black very ſoon without taking fire. We ſee, from Tillet's experiment, that this happens at the heat of 448°.

* *Enc. Meth.* art. i. 275.

175 Loſs of weight ſuſtained in it. When the bread is taken out of the oven, it is found to be lighter than when put in; as might naturally have been expected, from the evaporation of moiſture, which muſt have taken place at that temperature. Mr Tillet, and the other commiſſioners who were appointed to examine this ſubject in conſequence of a petition from the bakers of Paris, found that a loaf, which weighed before it was put into the oven 4.625 lbs. after being taken out baked, weighed, at an average, only 3.813 lbs. or 0.812 lb. leſs than the paſte. Conſequently 100 parts of paſte loſe, at an average, 17.34 parts, or ſomewhat more than $\frac{1}{5}$th by baking *. They found, however, that this loſs of weight was by no means uniform, even with reſpect to thoſe loaves which were in the oven at the ſame time, of the ſame form, and in the ſame place, and which were put in and taken out at the ſame inſtant. The greateſt difference in theſe circumſtances amounted to .2889, or 7.5 parts in the hundred, which is about $\frac{1}{13}$th of the whole. This difference is very conſiderable, and it is not eaſy to ſay to what it is owing. It is evident, that if the paſte has not all the ſame degree of moiſture, and if the barm be not accurately mixed through the whole, if the fermentation of the whole be not preciſely the ſame, that theſe differences muſt take place. Now it is needleſs to obſerve how difficult it is to perform all this completely. The French commiſſioners found, as might indeed have been expected, that other things being equal, the loſs of weight ſuſtained is proportional to the extent of ſurface of the loaf, and to the length of time that it remains in the oven; that is to ſay, the ſmaller the extent of the external ſurface, or, which is the ſame thing, the nearer the loaf approaches to a globular figure, the ſmaller is the loſs of weight which it ſuſtains; and the longer it continues in the oven, the greater is the loſs of weight which it ſuſtains. Thus a loaf which weighed exactly 4 lbs. when newly taken out of the oven, being replaced as ſoon as weighed, loſt, in ten minutes, .125 lb. of its weight, and in ten minutes more it again loſt .0625 lb †.

* *Ibid.* 275.

† *Ibid.* p. 270.

Loaves are heavieſt when juſt taken out of the oven; they gradually loſe part of their weight, at leaſt if not kept in a damp place, or wrapt round with a wet cloth (K). Thus Mr Tillet found that a loaf of 4 lbs. after being kept for a week, wanted .3125, or nearly $\frac{1}{13}$th of its original weight ‡.

‡ *Ibid.*

176 Properties of bread. When bread is newly taken out of the oven, it has a peculiar, and rather pleaſant ſmell, which it loſes by keeping; as it does alſo the peculiar taſte by which new bread is diſtinguiſhed. This ſhews us, that the bread undergoes chemical changes; but what theſe changes are, or what the peculiar ſubſtance is to which the odour of bread is owing, is not known.

(K) This is an excellent method of preſerving bread freſh, and free from mould, for a long time.

Bread differs very completely from the flour of which it is made, for none of the ingredients of the flour can now be diſcovered in it. The only chemiſt who has attempted an analyſis of bread is Mr Geoffroy. He found that 100 parts of bread contained the following ingredients :

24.735 water.
32.030 gelatinous matter, extracted by boiling water.
39.843 reſiduum inſoluble in water.

96.608
3.392 loſs.

100.

But this analyſis, which was publiſhed in the Memoirs of the French Academy for the year 1732, was made at a time when the infant ſtate of the ſcience of chemiſtry did not admit of any thing like accuracy.

Sect. II. *Of Wine.*

177
Fruits affording wine

There is a conſiderable number of ripe fruits from which a ſweet liquor may be expreſſed, having at the ſame time a certain degree of acidity. Of ſuch fruits we have in this country the apple, the cherry, the gooſeberry, the currant, &c. but by far the moſt valuable of theſe fruits is the *grape*, which grows luxuriantly in the ſouthern parts of Europe. From grapes, fully ripe, may be expreſſed a liquid of a ſweet taſte, to which the name of *muſt* has been given. This liquid is compoſed almoſt entirely of five ingredients ; namely, *water*, *ſugar*, *jelly*, *mucilage*, and *tartarous* acid partly ſaturated with potaſs. The quantity of ſugar which grapes fully ripe contain is very conſiderable ; it may be obtained in cryſtals by evaporating muſt to the conſiſtence of ſyrup, ſeparating the tartar which precipitates during the evaporation, and then ſetting the muſt aſide for ſome months. The cryſtals of ſugar are gradually formed.

178
Undergo the vinous fermentation ;

When muſt is put into the temperature of about 70°, the different ingredients begin to act upon each other, and what is called *vinous fermentation* commences. The phenomena of this fermentation are an inteſtine motion in the liquid, its becoming thick and muddy, a temperature equal to 72.5°, and an evolution of carbonic acid gas. In a few days the fermentation ceaſes, the thick part ſubſides to the bottom, the liquid becomes clear, it has loſt much of its ſaccharine taſte, and aſſumed a new one, its ſpecific gravity is diminiſhed ; and, in ſhort, it has become the liquid well known under the name of *wine*.

Now what is the cauſe of this fermentation ; what are the ſubſtances which mutually decompoſe each other ; and what is the nature of the new ſubſtance formed ?

Theſe changes are produced altogether by the mutual action of the ſubſtances contained in muſt ; for they take place equally well, and wine is formed equally well in cloſe veſſels as in the open air §.

179
For which water,

If the *muſt* be evaporated to the conſiſtency of a thick ſyrup, or to a *rob*, as the elder chemiſts termed it, the fermentation will not commence, though the proper temperature, and every thing elſe neceſſary to produce fermentation, be preſent ||. But if this ſyrup be again diluted with water, and placed in favourable circumſtances, it will ferment. Therefore the preſence of *water* is abſolutely neceſſary for the exiſtence of vinous fermentation.

180
Sugar,

If the juice of thoſe fruits which contain but little ſugar, as currants, be put into a favourable ſituation, fermentation indeed takes place, but ſo ſlowly, that the product is not *wine*, but *vinegar* : but if a ſufficient quantity of ſugar be added to theſe very juices, wine is readily produced. No ſubſtance whatever can be made to undergo vinous fermentation, and to produce wine, unleſs ſugar be preſent. *Sugar* therefore is abſolutely neceſſary for the exiſtence of vinous fermentation ; and we are certain that it is decompoſed during the proceſs ; for no ſugar can be obtained from properly fermented wine.

181
An acid,

All thoſe juices of fruits which undergo the vinous fermentation, either with or without the addition of ſugar, contain an acid. We have ſeen already in the firſt chapter that the vegetable acids are obtained chiefly from fruits. The apple, for inſtance, contains malic acid ; the lemon, citric acid ; the grape, tartarous acid. The Marquis de Bullion has aſcertained, that *muſt* will not ferment if all the tartarous acid which it contains be ſeparated from it*. We may conclude from this, that the preſence of a vegetable acid is abſolutely neceſſary for the commencement of the vinous fermentation. This renders it probable that the eſſential part of barm is a vegetable acid, or ſomething equivalent ; for if ſugar be diſſolved in four times its weight of water, mixed with the yeaſt of beer, and placed in a proper temperature, it undergoes the vinous fermentation †.

182
And jelly are nece ſary.

All the juices of fruits which undergo the vinous fermentation contain a quantity of jelly, or mucilage, or of both. Theſe two ſubſtances reſemble each other in ſo many particulars, and it is ſo difficult to ſeparate them, that we ſhall ſuppoſe they have the ſame effect in the mixture. The preſence of theſe ſubſtances renders it probable that they alſo are neceſſary for the vinous fermentation. Perhaps they act chiefly by their tendency to become acid.

Thus we ſee, that for the production of wine a certain temperature, a certain portion of water, ſugar, a vegetable acid, and, in all probability, jelly alſo, is neceſſary. Mr Lavoiſier found that ſugar would not ferment unleſs diſſolved in at leaſt four times its weight of water. This ſeems to indicate that the particles of ſugar muſt be removed to a certain diſtance from each other before the other ingredients can decompoſe them. The evolution and ſeparation of carbonic acid gas in ſuch quantity, ſhews us that the proportion of the carbon and the oxygen of the ſugar is diminiſhed. It is not certain that the mucilage of the wine is decompoſed ſo completely as the ſugar ; for it has been obſerved, that when the muſt abounds in mucilage, the wine is apt to become ſour.

183
Decomp ſition of wine.

When wine is diſtilled by means of a low heat, there comes over a quantity of *alcohol*, and the remainder is a ſolution of acetous acid. From this fact, it has been concluded that wine is compoſed of acetous acid and alcohol. But that the diſtillation occaſions a chemical change in the ingredients of wine is evident from this, that if we again mix the alcohol and acetous acid, we do not reproduce the wine.

Fourcroy has attempted to ſhew that alcohol exiſted ready formed ; but his proofs are not concluſive. Fabroni

---

§ *Fabroni, Ann. de Chim.* xxxi. 302.

|| *Stahl*, i.

* *Chapta*

† *Bergma*

roni has ſhewn, that alcohol cannot be obtained from new made wine by any other method than diſtillation. When wine is ſatured with very dry carbonat of potaſs, no alcohol makes its appearance on the ſurface of the mixture, yet a very ſmall quantity of alcohol, artificially mixed with wine, may be detected by this method. It is certain, however, that alcohol exiſts ready formed in old wine.

SECT. III. *Of Beer.*

THE method of making beer was known in the moſt remote ages; we are ignorant to whom the world is indebted for the diſcovery of it. Beer is uſually made from *barley*.

184 hod of ing

The barley is ſteeped in water for about ſixty hours, in order to ſaturate it with that liquid. It ought then to be removed as ſpeedily as poſſible, otherwiſe the water diſſolves, and carries off the moſt valuable part of the grain. The barley is then to be laid in a heap for twenty-four hours; heat is evolved, oxygen gas abſorbed, carbonic acid gas emitted, and germination commences with the ſhooting forth of the radicle. It is then ſpread upon a cool floor, dried ſlowly, and is afterwards known by the name of *malt* *.

185 t,

Malt, previouſly ground to a coarſe powder, is to be infuſed in a ſufficient quantity of pure water, of the temperature of 160°, for an hour. The infuſion is then to be drawn off, and more water may be added, at a higher temperature, till all the ſoluble part of the malt is extracted. This infuſion is known by the name of *wort*. It has a ſweet taſte, and contains a quantity of ſaccharine, and doubtleſs alſo of gelatinous matter.

186 l beer.

When *wort* is placed in the temperature of about 60°, fermentation gradually takes place in it, and the very ſame phenomena appear which diſtinguiſh the production of wine. The fermentation of wort, then, is nothing but a particular caſe of the vinous fermentation. But wort does not ferment ſo well, nor ſo ſoon, nor does it produce nearly ſo great a quantity of good fermented liquor, as when *yeaſt* is added to it. The reaſon of which is, probably, that the fermentation does not commence till an acid is generated in the wort, and before that happens part of the ſaccharine contents are decompoſed; whereas the yeaſt adds an acid, or, at leaſt, ſomething equivalent to it, at once.

Wort ferments in cloſe veſſels, as Mr Collier aſcertained by experiment, equally well as in the open air. Therefore the decompoſition is produced entirely by the ſubſtances contained in the wort, without the addition of any thing from the air. The quantity of beer produced in cloſe veſſels is much greater than when the proceſs takes place in the open air. The reaſon of which is, that in the open air the beer gradually evaporates during the fermentation. Thus Mr Collier found that 11 quarts, $3\frac{1}{2}$ oz. fermented in open veſſels, loſt, in 12 days, 40 oz.; whereas an equal weight, fermented in cloſe veſſels, loſt only 8 oz. in the ſame time. Yet the quality of the *beer* was the ſame in each; for equal quantities of both, when diſtilled, yielded preciſely the ſame portion of alcohol †.

During the fermentation, a quantity of carbonic acid gas is conſtantly diſengaged, not in a ſtate of purity, but containing, combined with it, a portion of the wort; and if this gas be made to paſs through water, it will depoſite wort, which may be fermented in the uſual manner *.

When beer is diſtilled, alcohol is obtained, and the reſiduum is an acid liquor †. The theory of beer is ſo obviouſly the ſame with that of wine that it requires no additional explanation.

SECT. IV. *Of the Acetous Fermentation.*

187 Subſtances which undergo the acetous fermentation.

IF wine or beer be kept at a temperature between 70° and 90°, it gradually loſes its properties, and is converted into *acetous acid*.

During this change, a quantity of oxygen gas is abſorbed, and the whole of the ſpirituous part of the wine or beer diſappears. Conſequently its ingredients have mutually decompoſed each other.

Neither pure alcohol, nor alcohol diluted with water, are capable of undergoing this change, neither do they abſorb any oxygen. This abſorption, then, is made by the mucilaginous matter which always exiſts in theſe liquids. No acetous acid is ever produced, unleſs ſome acid be preſent in the liquid. We may conclude, then, that the mucilage acquires the properties of an acid before it begins to act upon the ſpirituous part of the beer or the wine.

As the acetous acid has been already treated of in the article CHEMISTRY, *Suppl.* it is unneceſſary to dwell any longer on this ſubject here.

SECT. V. *Of Putrefaction.*

188 Nature of putrefaction.

ALL vegetable ſubſtances, both complete plants and their component parts ſeparately, when left entirely to themſelves, are gradually decompoſed and deſtroyed, provided moiſture be preſent, and the temperature be not much under 45°, nor too high to evaporate ſuddenly all the moiſture. This decompoſition has obtained the name of *putrefaction*.

It proceeds with moſt rapidity in the open air; but the contact of air is not abſolutely neceſſary. Water is, in all caſes, eſſential to the proceſs, and therefore is moſt probably decompoſed.

Putrefaction is conſtantly attended with a fetid odour, owing to the emiſſion of certain gaſeous matters, which differ according to the putrefying ſubſtance. Some vegetable ſubſtances, as gluten, and cruciform plants, emit ammonia; others, as onions, ſeem to emit phoſphorated hydrogen gas. Carbonic acid gas, and hydrogen gas, impregnated with unknown vegetable matters, are almoſt conſtantly emitted in abundance. When the whole proceſs is finiſhed, ſcarcely any thing remains but the earths, the ſalts, and the metals, which formed a conſtituent part of the vegetable. But our chemical knowledge of vegetable compounds is by far too limited to enable us to follow this very complicated proceſs with any chance of ſucceſs.

---

* llier, nch. n. v.

† id, p.

* *Collier, Manch. Mem.*

† *Henry, Manch. Mem.* ii. 257.

Part II. Of Animal SUBSTANCES.

Ingredients of Animals, Fibrina.

189 Claſſes of animals and vegetables

WHEN we compare animals and vegetables together, each in their moſt perfect ſtate, nothing can be eaſier than to diſtinguiſh them. The plant is confined to a particular ſpot, and exhibits no marks of conſciouſneſs or intelligence; the animal, on the contrary, can remove at pleaſure from one place to another, is poſſeſſed of conſciouſneſs, and a high degree of intelligence. But on approaching the contiguous extremities of the animal and vegetable kingdom, theſe ſtriking differences gradually diſappear, the objects acquire a greater degree of reſemblance, and at laſt approach each other ſo nearly, that it is ſcarcely poſſible to decide whether ſome of thoſe ſituated on the very boundary belong to the animal or vegetable kingdom.

190 Difficultly diſtinguiſhed.

To draw a line of diſtinction, then, between animals and vegetables, would be a very difficult taſk; but it is not neceſſary for us, in this place at leaſt, to attempt it; for almoſt the only animals whoſe bodies have been hitherto examined with any degree of chemical accuracy, belong to the moſt perfect claſſes, and conſequently are in no danger of being confounded with plants. Indeed the greater number of facts which we have to relate, apply only to the human body, and to thoſe of a few domeſtic animals. The taſk of analyſing all animal bodies is immenſe, and muſt be the work of ages of indefatigable induſtry.

191 Diviſion of this part.

We ſhall divide this part of the article into four chapters. In the firſt chapter, we ſhall give an account of the different ingredients hitherto found in animals, ſuch of them at leaſt as have been examined with any degree of accuracy: in the ſecond, we ſhall treat of the different members of which animal bodies are compoſed; which muſt conſiſt each of various combinations of the ingredients deſcribed in the firſt chapter: in the third, we ſhall treat of thoſe animal functions which may be elucidated by chemiſtry: and, in the fourth, of the changes which animal bodies undergo after death.

Chap. I. Of the Ingredients of Animals.

The ſubſtances which have been hitherto detected in the animal kingdom, and of which the different parts of animals, as far as theſe parts have been analyſed, are found to be compoſed, may be arranged under the following heads:

1. Fibrina,
2. Albumen,
3. Gelatine,
4. Mucilage,
5. Baſis of bile,
6. Urea,
7. Sugar,
8. Sulphur,
9. Oils,
10. Acids,
11. Alkalies,
12. Earths,
13. Metals.

Theſe ſhall form the ſubject of the following ſections:

Sect. I. *Of Fibrina.*

192 Fibrina how obtained.

If a quantity of blood, newly drawn from an animal, be allowed to remain at reſt for ſome time, a thick red clot gradually forms in it, and ſubſides. Separate this clot from the reſt of the blood, waſh it repeatedly in water till it ceaſes to give out any colour or taſte to the liquid; the ſubſtance which remains after this proceſs is denominated *fibrina*. It has been long known to phyſicians under the name of the *fibrous part of the blood*, but has not till lately been accurately deſcribed.

193 Its properties.

Fibrina is of a white colour, has no taſte, and is inſoluble in water and in alcohol. It is ſoft and ductile, has a conſiderable degree of elaſticity, and reſembles very much the gluten of vegetables.

Pure fixed alkalies do not act upon it, unleſs they be very much concentrated, and then they decompoſe it. All the acids combine with it readily, and diſſolve it. Water and alkalies ſeparate it again; but it has loſt entirely its former properties. With muriatic acid it forms a green coloured jelly.

When nitric acid is poured upon fibrina, azotic gas is diſengaged, as Berthollet firſt diſcovered. The quantity of this gas is greater than can be obtained from the ſame quantity of other animal ſubſtances by the ſame proceſs [*]. After this, pruſſic acid and carbonic acid gas are exhaled. By the aſſiſtance of heat the fibrina is diſſolved; much nitrous gas is diſengaged; the liquid, when concentrated, yields oxalic and malic acids; and white flakes are depoſited, conſiſting of an oily ſubſtance, and of phoſphat of lime [†].

When fibrina is diſtilled, it yields a very large quantity of ammonia [‡].

Theſe properties are ſufficient to ſhew us that this ſubſtance is compoſed of azot, hydrogen, and carbon; but neither the preciſe proportion of theſe ingredients, nor the manner of their combination, are at preſent known.

Sect. II. *Of Albumen.*

194 Albumen contained in eggs.

The eggs of fowls contain two very different ſubſtances: a yellow oily like matter, called the *yolk*; and a colourleſs gloſſy viſcid liquid, diſtinguiſhed by the name of *white*. This laſt is the ſubſtance which chemiſts have agreed to denominate *albumen* (L). The white of an egg, however, is not pure albumen. It contains, mixed with it, ſome carbonat of ſoda, and ſome ſulphur; but the quantity of theſe ſubſtances is ſo ſmall that they do not much influence its properties. We ſhall therefore conſider it as *albumen*.

195 Coagulated by heat.

On the application of a heat of 165 [§] it *coagulates*, as is well known, into a white ſolid maſs; the conſiſtency of which, when other things are equal, depends, in ſome meaſure, on the time during which the heat was applied. The coagulated maſs has preciſely the ſame weight that it had while fluid.

The taſte of coagulated albumen is quite different from that of liquid albumen: its appearance, too, and its

[*] *Fourcroy Ann. de Chim.* i. 41

[†] *Fourcroy.*

[‡] *Fourcroy Ann. de Chim.* i. 43

[§] *Cullen.*

(L) This is merely the Latin term for the white of an egg. It was firſt introduced into chemiſtry by the phyſiologiſts.

umen.

its properties, are entirely changed ; for it is no longer ſoluble, as before, either in hot or in cold water.

96
ome-
f this
ula-

The coagulation of albumen takes place even though air be completely excluded ; and even when air is preſent there is no abſorption of it, nor does albumen in coagulating change its volume *. Acids have the property of coagulating albumen, as Scheele aſcertained †. Alcohol alſo produces, in ſome meaſure, the ſame effect. *Heat*, then, *acids* and *alcohol*, are the agents which may be employed to coagulate albumen.

It is remarkable, that if albumen be diluted with a ſufficient quantity of water, it can no longer be coagulated by any of theſe agents. Scheele mixed the white of an egg with ten times its weight of water, and then, though he even *boiled* the liquid, no coagulum appeared. Acids indeed, and alcohol, even then coagulated it ; but they alſo loſe their power, if the albumen be diluted with a much greater quantity of water, as has been aſcertained by many experiments. Now we know, that when water is poured into albumen, not only a mechanical mixture takes place, but a chemical combination ; for the albumen is equally diſtributed through every part of the liquid. Conſequently its integrant particles muſt be farther ſeparated from each other, and their diſtance muſt increaſe with the quantity of water with which they are diluted. We ſee, therefore, that albumen ceaſes to coagulate whenever its particles are ſeparated from each other beyond a certain diſtance. That no other change is produced, appears evident from this circumſtance, that whenever the watery ſolution of albumen is ſufficiently concentrated by evaporation, coagulation takes place, upon the application of the proper agents, preciſely as formerly.

It does not appear that the diſtance of the particles of albumen is changed by coagulation ; for coagulated albumen occupies preciſely the ſame ſenſible ſpace as liquid albumen *.

197
uiry
its
ſe.

Thus two things ſeem certain reſpecting the coagulation of albumen : 1. That its particles muſt not be beyond a certain diſtance ; 2. That the coagulation does not produce any ſenſible change in their diſtance. To what, then, is the coagulation of albumen owing ? We can conceive no change to take place from a ſtate of liquidity to that of ſolidity, without ſome change in the figure of the particles of the body which has undergone that change : for if the figure and the diſtance of the particles of bodies continue the ſame, it is impoſſible to conceive any change at all to take place. Since, then, the diſtance of the particles of albumen does not, as far at leaſt as we can perceive, change, we muſt conclude, that the figure of the particles actually does change. Now ſuch a change may take place three ways: 1. The figure may be changed by the addition of ſome new molecules to each of the molecules of the body. 2. Some molecules may be abſtracted from every integrant particle of the body. 3. Or the molecules, of which the integrant particles are compoſed, may enter into new combinations, and form new integrant particles, whoſe form is different from that of the old integrant particles. Some one or other of theſe three things muſt take place during the coagulation of albumen.

1. Scheele and Fourcroy have aſcribed the coagulation of albumen to the firſt of theſe cauſes, namely, to the addition of a new ſubſtance. According to Scheele, *caloric* is the ſubſtance which is added. Fourcroy, on the contrary, affirms that it is *oxygen*.

Albumen.

Scheele ſupported his opinion with that wonderful ingenuity which ſhone ſo eminently in every thing which he did. He mixed together one part of white of egg and four parts of water, added a little pure alkali, and then dropt in as much muriatic acid as was ſufficient to ſaturate the alkali. The albumen coagulated : but when he repeated the experiment, and uſed carbonat of alkali inſtead of pure alkali, no coagulation enſued. In the firſt caſe, ſays he, there was a double decompoſition: the muriatic acid ſeparated from a quantity of caloric with which it was combined, and united with the alkali ; while, at the ſame inſtant, the caloric of the acid united with the albumen, and cauſed it to coagulate. The ſame combination could not take place when the alkaline carbonat was uſed, becauſe the carbonic acid gas carried off the caloric, for which it has a ſtrong affinity *.

This explanation is plauſible ; but it is contrary to every other known fact in chemiſtry, to ſuppoſe that caloric can combine with a ſubſtance without occaſioning any alteration in its bulk, and cannot therefore be admitted without the moſt rigid proof.

Fourcroy obſerves, in ſupport of his opinion, that the white of an egg is not at firſt capable of forming a hard coagulum, and that it only acquires that property by expoſure to the atmoſphere. It is well known that the white of a new laid egg is milky after boiling ; and that if the ſhell be covered over with greaſe, to exclude the external air, it continues long in that ſtate ; whereas the white of an old egg, which has not been preſerved in that manner, forms a very hard tough coagulum. Theſe facts are undoubted ; and they render it exceedingly probable, that albumen acquires the property of forming a hard coagulum only by abſorbing oxygen : but they by no means prove that coagulation itſelf is owing to ſuch an abſorption. And ſince coagulation takes place without the preſence of air, and ſince no air, even when it is preſent, is abſorbed, this opinion cannot be maintained without inconſiſtency.

2. The only ſubſtance which can be ſuppoſed to leave albumen during coagulation, ſince it does not loſe weight, is *caloric*. We know that in moſt caſes where a fluid is converted into a ſolid, caloric is actually diſengaged. It is extremely probable, then, that the ſame diſengagement takes place here. But the opinion has not been confirmed by any proof. Fourcroy indeed ſays, that in an experiment made by him, the thermometer roſe a great number of degrees. But as no other perſon has ever been able to obſerve any ſuch thing, it cannot be doubted that this philoſopher has been miſled by ſome circumſtance or other to which he did not attend †. It is uſual, in many caſes, for bodies to loſe bulk when they give out caloric ; but that there are exceptions to this rule, is well known.

3. Even if the ſecond opinion were true, it is ſcarcely poſſible to conceive the coagulation of albumen to take place without ſome change in its integrant particles. We can ſee how all the ſubſtances which coagulate albumen might produce ſuch a change ; and the inſolubility of coagulated albumen in water, and its other different properties, render it more than probable that ſome ſuch change actually takes place. But what that change is, cannot even be conjectured.

The-

---

* rradori, de .xxix. 9

† *Scheele*, 3.

* rradori.

* *Scheele*, ii 58.

† *Thomſon's Fourcroy*, iii. 271.

198
Properties of albumen

The coagulation of albumen is intimately connected with one of the moſt important problems in chemiſtry, namely, the cauſe of fluidity and ſolidity. But this problem can only be reſolved, with any proſpect of ſucceſs, by a geometrical inveſtigation of the phenomena of heat.

Coagulated albumen is diſſolved by the mineral acids, greatly diluted with water; and if a concentrated acid be added to the ſolution, the albumen is again precipitated [*]. Alkalies, however, do not precipitate it from its ſolution in acids [†]. But if a ſolution of tan be poured into the acid ſolution of albumen, a very copious precipitate appears [‡].

If the ſolution of tan be poured into an aqueous ſolution of uncoagulated albumen, it forms with it a very copious precipitate, which is inſoluble in water. This precipitate is a combination of tan and albumen. This property which albumen has of precipitating with tan, was diſcovered by Seguin [§]: it furniſhes us with a method of detecting the preſence of albumen in any liquid in which we ſuſpect it.

Pure alkalies and lime water alſo diſſolve albumen; at the ſame time ammonia is diſengaged, owing to the decompoſition of part of the albumen. Acids precipitate the albumen from alkalies, but its properties are changed [*].

Nitric acid, when aſſiſted by heat, diſengages azotic gas from albumen [†]; but the quantity is not ſo great as may be obtained from fibrina [‡]. The albumen is gradually diſſolved, nitrous gas is emitted, oxalic and malic acids are formed, and a thick oily matter makes its appearance on the ſurface [§]. When diſtilled, it furniſhes the ſame products as fibrina, only the quantity of ammonia is not ſo great [||].

Hence it follows, that albumen is compoſed of azot, hydrogen, and carbon, as well as fibrina; but the proportion of azot is not ſo great in the firſt ſubſtance as in the ſecond.

SECT. III. *Of Gelatine.*

199
Gelatine how obtained.

If a piece of the freſh ſkin of an animal, an ox for inſtance, after the hair and every impurity is carefully ſeparated, be waſhed repeatedly in cold water, till the liquid ceaſes to be coloured, or to abſtract any thing; if the ſkin, thus purified, be put into a quantity of pure water, and boiled for ſome time, part of it will be diſſolved. Let the decoction be ſlowly evaporated till it is reduced to a ſmall quantity, and then put aſide to cool. When cold, it will be found to have aſſumed a ſolid form, and to reſemble preciſely that tremulous ſubſtance well known to every body under the name of *gelly*. This is the ſubſtance called in chemiſtry *gelatine*. If the evaporation be ſtill farther continued, by expoſing the gelly to dry air, it becomes hard, ſemitranſparent, breaks with a glaſſy fracture, and is in ſhort the ſubſtance ſo much employed in different arts under the name of *glue*. Gelatine, then, is preciſely the ſame with glue; only that it muſt be ſuppoſed always free from thoſe impurities with which glue is ſo often contaminated.

200
Its properties.

Gelatine is tranſparent and colourleſs; when thrown into water, it very ſoon ſwells, and aſſumes a gelatinous form, and gradually diſſolves completely. By evaporating the water, it may be obtained again unaltered in the form of gelly.

When an infuſion of tan is dropt into a ſolution of gelatine in water, there is inſtantly formed a copious white precipitate, which has all the properties of leather. This precipitate is compoſed of tan and gelatine. Theſe two ſubſtances, therefore, when combined, form leather. Albumen and gelatine are the only animal ſubſtances known which have the property of combining with tan, and forming with it an inſoluble compound. They may be always eaſily detected, therefore, by means of tan; and they may be readily diſtinguiſhed from each other, as albumen alone coagulates by heat, and gelatine alone concretes into a gelly.

Gelatine is inſoluble in alcohol, and is even precipitated from water by it; but both acids and alkalies diſſolve it. Nitric acid diſengages from it a ſmall quantity of azotic gas; diſſolves it, when aſſiſted by heat, excepting an oily matter, which appears on the ſurface of the ſolution; and converts it, partly into oxalic and malic acids [*].

When diſtilled, there comes over firſt water, containing ſome animal matter; the gelatine then ſwells, becomes black, emits a fetid odour, accompanied with acrid fumes: Some empyreumatic oil then comes over, and a very ſmall quantity of carbonat of ammonia: its coaly reſiduum remains behind. Theſe phenomena ſhew, that gelatine is compoſed of carbon, hydrogen, and azot; but the proportion of azot is evidently much ſmaller than in either fibrina or albumen [†].

SECT. IV. *Of Animal Mucilage.*

No word in chemiſtry is uſed with leſs accuracy than *mucilage*. It ſerves as a common name for almoſt every animal ſubſtance which cannot be referred to any other claſs.

None of the ſubſtances to which the name of *animal mucilage* has been given, have been examined with care; of courſe it is unknown whether theſe ſubſtances be the ſame or different.

201
Properties of mucilage.

Whenever an animal ſubſtance poſſeſſes the following properties, it is at preſent denominated an animal mucilage by chemiſts

1. Soluble in water.
2. Inſoluble in alcohol.
3. Neither coagulable by heat, nor concreting into a gelly by evaporation.
4. Not precipitated by the ſolution of tan.

Moſt of the ſubſtances called *mucilage* have alſo the property of abſorbing oxygen, and of becoming by that means inſoluble in water

The mucilaginous ſubſtances ſhall be pointed out in the next chapter. In the preſent ſtate of our knowledge, any account of them here would merely be a repetition of the properties juſt mentioned.

SECT. V. *Of the Baſis of Bile.*

202
Baſis of bile how obtained.

Into 32 parts of freſh ox bile pour one part of concentrated muriatic acid. After the mixture has ſtood for ſome hours, paſs it through a filter, in order to ſeparate a white coagulated ſubſtance. Pour the filtrated liquor, which has a fine green colour, into a glaſs veſſel, and evaporate it by a moderate heat. When it has arrived at a certain degree of concentration, a green coloured ſubſtance precipitates. Decant off the clear liquid, and waſh the precipitate in a ſmall quantity of pure

---

[*] Scheele, ii. 57.

[†] Vauquelin, Ann. de Chim. xxix. 15.

[‡] Ibid.

[§] Nicholſon's Journal, i. 271.

[*] Scheele, ii. 57.

[†] Scheele and Bertholl.t.

[‡] Fourcroy, Ann. de Chim. i. 41.

[§] Scheele, Crell's Annals, ii. 17. Eng. Tranſl.

[||] Fourcroy, Ann. de Chim. i. 43.

[*] Scheele, Crell's Ann. ii. 17. Eng. Tranſl.

[†] Fourcroy, Ann de Chim. i. 41

pure water. This precipitate is the *baſis of bile*, or the *reſin of bile*, as it is ſometimes called *.

203 ...roper The baſis of bile is of a black colour; but when ſpread out upon paper or on wood, it is green: its taſte is intenſely bitter †.

When heated to about 122°, it melts; and if the heat be ſtill farther increaſed, it takes fire, and burns with rapidity. It is ſoluble in water, both cold and hot, and ſtill more ſoluble in alcohol; but water precipitates it from that liquid ‡.

It is ſoluble alſo in alkalies, and forms with them a compound which has been compared to a ſoap. Acids, when ſufficiently diluted, precipitate it both from water and alkalies without any change; but if they be concentrated, the precipitate is rediſſolved §.

When diſtilled, it furniſhes ſome ſebacic acid ||.

204 ...bines oxy- From theſe properties, it is clear that the baſis of bile has a conſiderable reſemblance to oils; but it differs from them entirely in ſeveral of its properties. The addition of oxygen, with which it combines readily, alters it ſomewhat, and brings it ſtill nearer to the claſs of oils.

In this altered ſtate, the baſis of bile may be obtained by the following proceſs. Pour oxy-muriatic acid cautiouſly into bile till that liquid loſes its green colour; then paſs it through a filter to ſeparate ſome albumen which coagulates. Pour more oxy muriatic acid into the filtered liquid, and allow the mixture to repoſe for ſome time. The oxy-muriatic acid is gradually converted into common muriatic acid; and in the mean time the baſis of bile abſorbs oxygen, and acquires new properties. Pour into the liquid, after it has remained a ſufficient time, a little common muriatic acid, a white precipitate immediately appears, which may be ſeparated from the fluid. This precipitate is the baſis of bile combined with oxygen.

It has the colour and the conſiſtence of tallow, but ſtill retains its bitter taſte. It melts at the temperature of 104°. It diſſolves readily in alcohol, and even in water, provided it be aſſiſted by heat. Acids precipitate it from theſe ſolutions ¶.

SECT. VI. *Of UREA.*

205 ...a low ...ines. EVAPORATE, by a gentle heat, a quantity of human urine voided ſix or eight hours after a meal, till it be reduced to the conſiſtence of a thick ſyrup. In this ſtate, when put by to cool, it concretes into a cryſtalline maſs. Pour, at different times, upon this maſs four times its weight of alcohol, and apply a gentle heat; a great part of the maſs will be diſſolved, and there will remain only a number of ſaline ſubſtances. Pour the alcohol ſolution into a retort, and diſtil by the heat of a ſand bath till the liquid, after boiling ſome time, is reduced to the conſiſtence of a thick ſyrup. The whole of the alcohol is now ſeparated, and what remains in the retort cryſtallizes as it cools. Theſe cryſtals conſiſt of the ſubſtance known by the name of *urea* *.

This ſubſtance was firſt deſcribed by Rouelle the Younger in 1773, under the name of the *ſaponaceous extract of urine*. He mentioned ſeveral of its properties; but very little was known concerning its nature till Fourcroy and Vauquelin publiſhed their experiments on it in 1799. Theſe celebrated chemiſts have given it the name of *urea*, which we have adopted.

Urea.

206 Its properties. Urea, obtained in this manner, has the form of cryſtalline plates croſſing each other in different directions. Its colour is yellowiſh white; it has a fetid ſmell, ſomewhat reſembling that of garlic or arſenic; its taſte is ſtrong and acrid, reſembling that of ammoniacal ſalts; it is very viſcid and difficult to cut, and has a good deal of reſemblance to thick honey †. When expoſed to the open air, it very ſoon attracts moiſture, and is converted into a thick brown liquid. It is extremely ſoluble in water; and during its ſolution, a conſiderable degree of cold is produced ‡. Alcohol diſſolves it with facility, but ſcarcely in ſo large a proportion as water. The alcohol ſolution yields cryſtals much more readily on evaporation than the ſolution in water.

When nitric acid is dropt into a concentrated ſolution of urea in water, a great number of bright pearl coloured cryſtals are depoſited, compoſed of urea and nitric acid. No other acid produces this ſingular effect. The concentrated ſolution of urea in water is brown, but it becomes yellow when diluted with a large quantity of water. The infuſion of nut galls gives it a yellowiſh brown colour, but cauſes no precipitate. Neither does the infuſion of tan produce any precipitate ||.

207 Its component parts. When heat is applied to urea, it very ſoon melts, ſwells up, and evaporates, with an inſupportably fetid odour. When diſtilled, there comes over firſt benzoic acid, then carbonat of ammonia in cryſtals, ſome carbonated hydrogen gas, with traces of pruſſic acid and oil; and there remains behind a large reſiduum, compoſed of charcoal, muriat of ammonia, and muriat of ſoda. The diſtillation is accompanied with an almoſt inſupportably fetid alliaceous odour. Two hundred and eighty-eight parts of urea yield by diſtillation 200 parts of carbonat of ammonia, 10 parts of carbonated hydrogen gas, 7 parts of charcoal, and 68 parts of benzoic acid, muriat of ſoda, and muriat of ammonia. Theſe three laſt ingredients Fourcroy and Vauquelin conſider as foreign ſubſtances, ſeparated from the urine by the alcohol at the ſame time with the urea. Hence it follows, that 100 parts of urea, when diſtilled, yield

92.027	carbonat of ammonia,
4.608	carbonated hydrogen gas,
3.225	charcoal.
99.860	

Now 200 parts of carbonat of ammonia are compoſed of 86 ammonia, 90 carbonic acid gas, and 24 water. Hence it follows, that 100 parts of urea are compoſed of

39.5	oxygen,
32.5	azot,
14.7	carbon,
13.3	hydrogen.
100.0	

But it can ſcarcely be doubted, that the water which was found in the carbonat of ammonia exiſted ready formed in the urea before the diſtillation ¶.

When the ſolution of urea in water is kept in a boiling heat, and new water is added as it evaporates, the urea is gradually decompoſed, a very great quantity of carbonat of ammonia is diſengaged, and at the ſame time acetous acid is formed, and ſome charcoal precipitates *.

208 Spontaneous decompoſition. When a ſolution of urea in water is left to itſelf for ſome time, it is gradually decompoſed. A froth col-

---

¶ ...ourcroy, ...de ...n. v.i.

* ...ourcroy ...Vau- ...n, Ann. ...him. ...i. 86.

† Fourcroy and Vauquelin, Ann. de Chim xxxii. p. 87.

‡ Ibid, p. 88.

|| Ibid.

¶ Ibid.

* Ibid, p. 96.

lects on its ſurface ; air bubbles are emitted which have a ſtrong diſagreeable ſmell, in which ammonia and acetous acid are diſtinguiſhable. The liquid contains a quantity of acetous acid. The decompoſition is much more rapid if a little gelatine be added to the ſolution. In that caſe more ammonia is diſengaged, and the proportion of acetous acid is not ſo great*

209 Action of acids.

When the ſolution of urea is mixed with one-fourth of its weight of diluted ſulphuric acid, no efferveſcence takes place ; but, on the application of heat, a quantity of oil appears on the ſurface, which concretes upon cooling ; the liquid, which comes over into the receiver, contains acetous acid, and a quantity of ſulphat of ammonia remained in the retort diſſolved in the undiſtilled maſs. By repeated diſtillations, the whole of the urea is converted into acetous acid and ammonia †.

When nitric acid is poured upon cryſtallized urea, a violent efferveſcence takes place, the mixture froths, aſſumes the form of a dark red liquid, great quantities of nitrous gas, azotic gas, and carbonic acid gas, are diſengaged. When the efferveſcence is over, there remains only a concrete white matter, with ſome drops of reddiſh liquid. When heat is applied to this reſiduum, it detonates like nitrat of ammonia. Into a ſolution of urea, formed by its attracting moiſture from the atmoſphere, an equal quantity of nitric acid, of the ſpecific gravity 1.460, diluted with twice its weight of water, was added ; a gentle efferveſcence enſued : very gentle heat was applied, which ſupported the efferveſcence for two days. There was diſengaged the firſt day a great quantity of azotic gas and carbonic acid gas ; the ſecond day, carbonic acid gas, and at laſt nitrous gas. At the ſame time with the nitrous gas an odour was perceivable of the oxygenated pruſſic acid of Berthollet. At the end of the ſecond day, the matter in the retort, which was become thick, took fire, and burnt with a violent exploſion. The reſiduum contained traces of pruſſic acid and ammonia. The receiver contained a yellowiſh acid liquor, on the ſurface of which ſome drops of oil ſwam ‡.

Muriatic acid diſſolves urea, but does not alter it. Oxy-muriatic acid gas is abſorbed very rapidly by a diluted ſolution of urea ; ſmall whitiſh flakes appear, which ſoon become brown, and adhere to the ſides of the veſſel like a concrete oil. After a conſiderable quantity of oxy-muriatic acid had been abſorbed, the ſolution, left to itſelf, continued to efferveſce exceeding ſlowly, and to emit carbonic acid and azotic gas. After this efferveſcence was over, the liquid contained muriat and carbonat of ammonia.

210 Of alkalies.

Urea is diſſolved very rapidly by a ſolution of potaſs or ſoda; and at the ſame time a quantity of ammonia is diſengaged, the ſame ſubſtance is diſengaged when urea is treated with barytes, lime, or even magneſia. Hence it is evident, that this appearance muſt be aſcribed to the muriat of ammonia, with which it is conſtantly mixed. When pure ſolid potaſs is triturated with urea, heat is produced, a great quantity of ammonia is diſengaged. The mixture becomes brown, and a ſubſtance is depoſited, having the appearance of an empyreumatic oil. One part of urea and two of potaſs, diſſolved in four times its weight of water, when diſtilled give out a great quantity of ammoniacal water; the reſiduum contained acetite and carbonat of potaſs ||.

When muriat of ſoda is diſſolved in a ſolution of urea in water, it is obtained by evaporation, not in cubic cryſtals, its uſual form, but in regular octohedrons. Muriat of ammonia, on the contrary, which cryſtallizes naturally in octohedrons, is converted into cubes, by diſſolving and cryſtallizing it in the ſolution of urea.

Such are the properties of this ſingular ſubſtance, as far as they have been aſcertained by the experiments of Fourcroy and Vauquelin. It differs from all animal ſubſtances hitherto examined, in the great proportion of azot which enters into its compoſition, and in the facility with which it is decompoſed, even by the heat of boiling water.

SECT. VII. *Of Sugar.*

SUGAR has been already deſcribed in the former part of this article as a vegetable ſubſtance ; nothing therefore is neceſſary here but to point out the different ſtates in which it is found in animals. It has never indeed been found in animals in every reſpect ſimilar to the ſugar of vegetables ; but there are certain animal ſubſtances which have ſo many properties in common with ſugar, that they can ſcarcely be arranged under any other name. Theſe ſubſtances are,

1. Sugar of milk,
2. Honey,
3. Sugar of diabetic urine.

211 Sugar of milk.

1. The method of obtaining ſugar of milk has been already detailed in the article CHEMISTRY, n° 488. to which we refer the reader. For an account of its properties, we are indebted to the obſervations of Mr Lichtenſtein.

When pure, it has a white colour, a ſweetiſh taſte, and no ſmell. Its cryſtals are ſemitranſparent regular parallelopipeds, terminated by four-ſided pyramids. Its ſpecific gravity, at the temperature of 55°, is 1.543. At that temperature, it is ſoluble in ſeven times its weight of water ; but is perfectly inſoluble in alcohol. When burnt, it emits the odour of caromel, and exhibits preciſely the appearance of burning ſugar. When diſtilled, it yields the ſame products as ſugar, only the empyreumatic oil obtained has the odour of benzoic acid §.

212 Honey.

2. Honey is prepared by bees, and perhaps rather belongs to the vegetable than the animal kingdom. It has a white or yellowiſh colour, a ſoft and grained conſiſtence, a ſaccharine and aromatic ſmell ; by means of alcohol, and even by water, with peculiar management, a true ſugar is obtained ; by diſtillation it affords an acid phlegm and an oil, and its coal is light and ſpongy like that of the mucilages of plants. Nitric acid extracts the oxalic acid, which is entirely ſimilar to that of ſugar ; it is very ſoluble in water, with which it forms a ſyrup, and like ſugar paſſes to the vinous fermentation *.

3. The urine of perſons labouring under the diſeaſe known to phyſicians by the name of *diabetes*, yields, when evaporated, a conſiderable quantity of matter, which poſſeſſes the properties of ſugar.

SECT. VIII. *Of Oils.*

213 Fixed oi

THE oily ſubſtances found in animals may be arranged under three heads: 1. Fixed oils; 2. Fat; 3. Spermaceti.

1. The fixed oils are obtained chiefly from different kinds of fiſh, as the whale, &c. ; and they are diſtinguiſhed

---

* *Fourcroy and Vauquelin, Ann. de Chim.* xxxii. p. 96

† *Ibid*, p. 204.

‡ *Ibid*, p. 207.

|| *Ibid.*

§ *Scheele*, ii. 70.

* *Fourcro*

guiſhed by the name of the animal from which they are obtained, as *whale oil*, &c. Theſe oils agree in their properties with other fixed oils; which have been already deſcribed in the article CHEMISTRY, Part II. Chap. iii. *Suppl.*

2. *Fat*, or rather tallow, is a well-known animal ſubſtance, much employed in the manufacture of candles and ſoap.

14 perties at.

It has a white colour, often with a ſhade of yellow. When freſh, it has no ſmell, and but little taſte. While cold, it is hard and brittle; but when expoſed to the heat of 92°, it melts, and aſſumes the appearance of oil. The fat, however, which is extracted from fleſh by boiling, does not melt till it reach the temperature of 127°*. Tallow and fat, in other reſpects, have the properties of fixed oils. They ſeem to be compoſed of a fixed oil combined with ſebacic acid. When ſtrongly heated, with contact of air, it emits a ſmoke of a penetrating ſmell, which excites tears and coughing, and takes fire when ſufficiently heated to be volatilized: the charcoal it affords is not abundant. If fat be diſtilled on a water-bath, an inſipid water, of a ſlight animal ſmell, is obtained, which is neither acid nor alkaline, but which ſoon acquires a putrid ſmell, and depoſites filaments of a mucilaginous nature. This phenomenon, which takes place with the water obtained by diſtillation on the water bath from any animal ſubſtance, proves, that this fluid carries up with it a mucilaginous principle, which is the cauſe of its alteration. Fat, diſtilled in a retort, affords phlegm, at firſt aqueous, and afterwards ſtrongly acid; an oil, partly liquid, and partly concrete; and a very ſmall quantity of charcoal, exceedingly difficult to incinerate, in which Crell found a ſmall quantity of phoſphat of lime. Theſe products have an acid and penetrating ſmell, as ſtrong as that of ſulphurous acid. The acid is the ſebacic.

215 perties ſperma-

3. *Spermaceti*, is an oily, concrete, cryſtalline, ſemitranſparent matter, of a peculiar ſmell, which is taken out of the cavity of the cranium of the cachalot; it is purified by liquefaction, and the ſeparation of another fluid and inconcreſcible oil, with which it is mixed. This ſubſtance exhibits very ſingular chemical properties; for it reſembles fixed oils in ſome reſpects, and volatile oils in others.

When heated to the temperature of 133°†, it melts; and if the heat be increaſed, it evaporates without much alteration. When repeatedly diſtilled, however, it loſes its ſolid form, and becomes like oil. When heated in contact with air, it takes fire, and burns uniformly without any diſagreeable odour: hence its uſe in making candles.

By long expoſure in hot air it becomes yellow and rancid. Pure alkali combines with it, and forms a ſoap. Nitric and muriatic acids do not affect it, but ſulphuric acid diſſolves it and alters its colour.

SECT. IX. *Of Acids.*

THE acids hitherto diſcovered in the animal kingdom are the nine following.

1. Sulphuric,
2. Muriatic,
3. Phoſphoric,
4. Carbonic,
5. Benzoic,
6. Sebacic,
7. Formic,
8. Bombyc,
9. Uric.

The firſt eight of theſe have been already deſcribed in the article CHEMISTRY, *Suppl.* it is unneceſſary therefore to deſcribe them here.

216 Diſcovery of uric acid.

Few perſons are ignorant that concretions ſometimes form in the human urinary bladder, and produce that very formidable diſeaſe known by the names of the *ſtone* and the *gravel*. Theſe concretions are often extracted by a ſurgical operation: they are called *urinary calculi*.

The moſt common of theſe calculi is of a brown colour, and very ſoluble in pure potaſs or ſoda ley.

If into an alkaline ſolution of one of theſe calculi a quantity of acetous acid be poured, a copious brown coloured precipitate immediately appears, which may be ſeparated and edulcorated in a ſmall quantity of water. This ſubſtance is *uric acid**.

It was diſcovered by Scheele in 1776, and the French chemiſts afterwards called it *lithic acid*: but this name, in conſequence chiefly of ſome remarks of Dr Pearſon on its impropriety, has been lately given up, and that of *uric* (L) acid ſubſtituted in its place. We have adopted the new name, becauſe we think it preferable to the old; which indeed conveyed a kind of inconſiſtency to thoſe who attended to the etymological meaning of the word.

217 Its properties.

Uric acid poſſeſſes the following properties: it cryſtallizes in thin plates; has a brown colour, and ſcarcely any taſte. Cold water ſcarcely diſſolves any part of it; but it is ſoluble in 360 parts of boiling water. The ſolution reddens vegetable blues, eſpecially the tincture of turnſol. A great part of the acid precipitates again as the water cools. It combines readily with alkalies and earths; but the compound is decompoſed by every other acid. Sulphuric acid, when concentrated, decompoſes it entirely*. Nitric acid diſſolves it readily: the ſolution is of a pink colour, and has the property of tinging animal ſubſtances, the ſkin for inſtance, of the ſame colour†. When this ſolution is boiled, a quantity of azotic gas, carbonic acid gas, and of pruſſic acid, is diſengaged‡. Oxy-muriatic acid converts it in a few minutes into oxalic acid §.

When diſtilled, about a fourth of the acid paſſes over a little altered, and is found in the receiver cryſtallized in plates; a few drops of thick oil make their appearance; $\frac{1}{8}$th of the acid of concrete carbonat of ammonia, ſome pruſſiat of ammonia, ſome water, and carbonic acid; and there remains in the retort charcoal, amounting to about $\frac{1}{80}$th of the weight of the acid diſtilled ||.

Theſe facts are ſufficient to ſhew us, that uric acid is compoſed of carbon, azot, hydrogen, and oxygen; and that the proportion of the two laſt ingredients is much ſmaller than of the other two.

The different ſalts which uric acid forms with alkaline and earthy baſes have not been examined with attention; but urat of potaſs, of ſoda, and of lime, have been formed both by Scheele and Fourcroy; and urat of

---

[*] chol- Jour- i. 71.

[†] bid.

[*] Fourcroy, Ann. de Chim. xvi. 116.

[*] Scheele, i. 200.

[†] Ibid. and Pearſon.

[‡] Fourcroy, Ann. de Chim. xxvii. 267.

[§] Brugnatelli, ibid. xxxii. 184.

[||] Fourcroy, ibid. xvi. 116.

(L) From *urine*; becauſe this acid is always found in human urine.

of ammonia is not unfrequently found cryſtallized in urinary calculi.

The order of the affinities of the different baſes for uric acids is entirely unknown; but it has been aſcertained, that its affinity for theſe baſes is much weaker than that of any other acid. Its ſalts are decompoſed even by pruſſic and carbonic acid.

SECT. X. *Of* ALKALIES, EARTHS, *and* METALS.

1. ALL the three alkalies have been found in the animal kingdom, as we ſhall ſhew in the next chapter.

2. The only earths which have been found in animals are,

1. Lime,
2. Magneſia,
3. Silica.

The firſt in great abundance, almoſt in every large animal; the other two very rarely, and only as it were by accident.

3. The metals hitherto found in animals are,

1. Iron,
2. Manganeſe.

The firſt exiſts in all the larger animals in ſome conſiderable quantity; the ſecond has ſcarce ever been found in any quantity ſo great as to admit of being weighed.

218 Subſtances found in animals.

Such are the ſubſtances hitherto found in animals. The ſimple bodies of which all of them conſiſt are the following:

1. Azot,
2. Carbon,
3. Hydrogen,
4. Oxygen,
5. Lime,
6. Phoſphorus,
7. Muriatic acid,
8. Potaſs,
9. Soda,
10. Sulphur,
11. Magneſia,
12. Silica,
13. Iron,
14. Manganeſe.

Of theſe, magneſia and ſilica may in a great meaſure be conſidered as foreign bodies; for they are only found in exceedingly minute quantities, and the laſt not unleſs in caſes of diſeaſe. The principal elementary ingredients are the firſt ſix: animal ſubſtances may be conſidered as in a great meaſure compoſed of them. The firſt four conſtitute almoſt entirely the ſoft parts, and the other two form the baſis of the hard parts. But we will be able to judge of this much better, after we have taken a view of the various parts of animals as they exiſt ready formed in the body. This ſhall be the ſubject of the next chapter.

CHAP. II. OF THE PARTS OF ANIMALS.

THE different ſubſtances which compoſe the bodies of animals have been deſcribed with ſufficient minuteneſs in the article ANATOMY, *Encycl.* to which we beg leave to refer the reader. Any repetition in this place would be improper. Theſe ſubſtances are the following:

1. Bones and ſhells,
2. Muſcles,
3. Tendons,
4. Ligaments,
5. Membranes,
6. Cartilages,
7. Skin,
8. Brain and nerves,
9. Horns and nails,
10. Hair and feathers.

Beſides theſe ſubſtances which conſtitute the ſolid part of the bodies of animals, there are a number of fluids, the moſt important of which is the *blood*, which pervades every part of the ſyſtem in all the larger animals: The reſt are known by the name of *ſecretions*, becauſe they are formed or *ſecreted*, as the anatomiſts term it, from the blood. The principal animal ſecretions are the following:

1. Milk,
2. Saliva,
3. Pancreatic juice,
4. Bile and biliary calculi,
5. Tears,
6. Mucus of the noſe,
7. Sinovia,
8. Semen,
9. Liquor of the amnios,
10. Urine and urinary calculi.

Theſe ſubſtances ſhall form the ſubject of the following ſections.

SECT. I. *Of* BONES.

BY *bones*, we mean thoſe hard, ſolid, well known ſubſtances, to which the firmneſs, ſhape, and ſtrength of animal bodies, are owing; which, in the larger animals, form, as it were, the ground-work upon which all the reſt is built. In man, in quadrupeds, and many other animals, the bones are ſituated below the other parts, and ſcarcely any of them are expoſed to view; but ſhell-fiſh and ſnails have a hard covering on the outſide of their bodies, evidently intended for defence. As theſe coverings, though known by the name of *ſhells*, are undoubtedly of a bony nature, we ſhall include them alſo in this ſection. For the very ſame reaſons, it would be improper to exclude *egg-ſhells*, and thoſe coverings of certain animals, the tortoiſe for inſtance, known by the name of *cruſts*.

It had been long known, that bones may be rendered ſoft and cartilaginous by keeping them in diluted acid ſolutions, and that ſome acids even diſſolve them altogether; that when expoſed to a violent heat, they become white, opaque, and brittle; and Dr Lewis had obſerved, that a ſudden and violent heat rendered them hard, ſemitranſparent, and ſonorous. But their component parts remained unknown till Scheele mentioned, in his diſſertation on Fluor Spar, publiſhed in the Stockholm Tranſactions for 1771, that the earthy part of bones is *phoſphat of lime* (M). Since that time conſiderable additions have been made to the chemical analyſis of theſe ſubſtances by Berniard, Bouillon, and Rouelle. Mr Hatchett has publiſhed a very valuable paper on the ſubject in the Philoſophical Tranſactions for 1799; and in the 34th volume of the *Annales de Chimie*, Mr Merat-Guillot has given us a table of the component parts of the bones of a conſiderable number of animals.

The *bony parts* of animals may be divided into three claſſes; namely, *bones*, *cruſts*, and *ſhells*.

219 Properties of bones.

1. Bones have a conſiderable degree of hardneſs; when recent, they contain a quantity of marrow, which may be partly ſeparated from them. When the water in which bones have been for ſome time boiled is evaporated to a proper conſiſtence, it aſſumes the form of a *gelly*; bones therefore contain *gelatine*.

220 Their component parts.

If a piece of bone be kept for ſome time in diluted muriatic, or even acetous acid, it gradually loſes a conſiderable part of its weight, becomes ſoft, and acquires a

---

(M) The diſcoverer of this has not been completely aſcertained: Scheele does not claim it in that paper; Bergman gives it to Gahn; but Crell affirms that it was made by Scheele.

ones.

a certain degree of tranſparency; and, in ſhort, acquires all the properties of *cartilage*. Bone therefore conſiſts of *cartilage*, combined with ſome ſubſtance which theſe acids are capable of diſſolving and carrying off.

If pure ammonia be dropt into the acid which has reduced the bone to this ſtate, a quantity of white powder precipitates, which poſſeſſes all the properties of *phoſphat of lime*. The ſubſtance, then, which was combined with the cartilage is *phoſphat of lime*.

After the phoſphat of lime has precipitated, the addition of carbonat of ammonia occaſions a farther precipitate, which conſiſts of carbonat of lime: but the quantity of this precipitate is inconſiderable *. When concentrated acids are poured on bones, whether recent or calcined, an effervescence is perceptible; the gas which eſcapes renders lime water turbid, and is therefore *carbonic acid*. Now ſince bones contain carbonic acid, and ſince they contain lime alſo uncombined with any acid ſtronger than carbonic—it is evident that they contain a little *carbonat of lime*. Mr Hatchett found this ſubſtance in all the bones of quadrupeds and of fiſh which he examined †.

When bones are calcined, and the reſiduum is diſſolved in nitric acid, nitrat of barytes cauſes a ſmall precipitate, which is inſoluble in muriatic acid, and is therefore ſulphat of barytes‡. Conſequently bones contain ſulphuric acid. It has been aſcertained, that this acid is combined with lime. The proportion of *ſulphat of lime* in bones is very inconſiderable.

Thus we have ſeen, that bones are compoſed of cartilage, which conſiſts almoſt entirely of gelatine, of phoſphat of lime, carbonat of lime, and ſulphat of lime. The following table, drawn up by Merat-Guillot ||, exhibits a comparative view of the relative proportion of theſe ingredients in a variety of bones. The ſulphat of lime, which occurs only in a very ſmall quantity, has been confounded with phoſphat of lime.

One hundred parts contain	Gelatine.	Phoſp. of lime	Carb. of lime	Loſs.
Human bones from a burying ground,	16	67	1.5	15.5
Do. dry, but not from under the earth,	23	63	2	2
Bone of ox, - - -	3	93	2	2
calf, - - -	25	54	trace	21
horſe, - - -	9	67.5	1.25	22.25
ſheep, - - -	16	70	0.5	13.5
elk, - - -	1.5	90	1	7.5
hog, - - -	17	52	1	30
hare, - - -	9	85	1	5
pullet, - -	6	72	1.5	20.5
pike, - - -	12	64	1	23
carp, - - -	6	45	0.5	48.5
Horſe tooth, - - -	12	85.5	0.25	2.25
Ivory, - - - - -	24	64	0.1	11.15
Hartſhorn, - - - -	27	57.5	1	14.5

The enamel of the teeth is compoſed of the ſame earthy ingredients as other bones; but it is totally deſtitute of cartilage *.

221
mponent
rts of
ſts.

2. The cruſtaceous coverings of animals, as of echini, crabs, lobſters, prawns, and cray-fiſh, and alſo the ſhells of eggs, are compoſed of the ſame ingredients as bones; but in them the proportion of carbonat of lime far exceeds that of phoſphat *.

Bones.

Thus 100 parts of lobſter cruſt contain
60 carbonat of lime,
14 phoſphat,
26 cartilage,
———
100 †.

One hundred parts of crawfiſh cruſt contain
60 carbonat of lime,
12 phoſphat of lime,
28 cartilage.
———
100 ‡.

One hundred parts of hens egg-ſhells contain
89.6 carbonat of lime,
5.7 phoſphat of lime,
4.7 animal matter.
———
100.0 ||.

Mr Hatchett found traces of phoſphat of lime alſo in the ſhells of ſnails.

223
Component parts of ſhells.

3. The ſhells of ſea animals may be divided into two claſſes: The firſt has the appearance of porcelain; their ſurface is enamelled, and their texture is often ſlightly fibrous. Mr Hatchett has given them the name of *porcellaneous* ſhells. The ſecond kind of ſhell is known by the name of *mother of pearl*. It is covered with a ſtrong epidermis, and below it lies the ſhelly matter in layers *. The ſhell of the freſh water muſcle, mother of pearl, heliotis iris, and turbo olearius, are inſtances of theſe ſhells.

Porcellaneous ſhells are compoſed of carbonat of lime cemented together by a very ſmall quantity of animal matter †.

Mother of pearl ſhells are compoſed of alternate layers of carbonat of lime and a thin membranaceous or cartilaginous ſubſtance. This cartilage ſtill retains the figure of the ſhell, after all the carbonat of lime has been ſeparated by acids ‡.

Mother of pearl contains 66 carbonat of lime,
34 cartilage.
———
100 ||.

Coral, which is a bony ſubſtance formed by certain ſea inſects, has a nearer relation to mother of pearl ſhells in its ſtructure than to any other bony ſubſtance, as the following table ¶ will ſhew.

	White coral.	Red coral.	Articulated coraline.
Carbonat of lime,	50	53.5	49
Animal matter,	50	46.5	51
	100	100.0	100

SECT. II. *Of the* MUSCLES *of* ANIMALS.

THE muſcular parts of animals are known in common language by the name of *fleſh*. They conſtitute a conſiderable proportion of the food of man.

Muſcular fleſh is compoſed of a great number of fibres or threads, commonly of a reddiſh or whitiſh colour; but its appearance is too well known to require any deſcription. Hitherto it has not been ſubjected to any accurate chemical analyſis. Mr Thouvenel, indeed, has publiſhed a very valuable diſſertation on the ſubject;

---

* Haicl ett, il. Tranſ 99, p. 7.

† Ibid.

‡ Ibid.

|| Ann. de im. xiv. 71.

* Hatchett, bil. Tranſ. 99, p. 8

* Hatchett, *Phil Tranſ.* 1799, p. 321. and 324.

† *Merat-Guillot, Ann. de Chim.* xxxiv. 71.

‡ *Ibid.*

|| *Vauquelin, ibid.* xxix. 6.

* *Heriſſant, Mem. Par.* 1766, p. 22. *Hatchett, ibid* 317.

† *Hatchett, ibid.*

‡ *Ibid* 318.

|| *Merat-Guillot, ibid.*

¶ *Merat-Guillot, ibid.*

ſubject; but his analyſis was made before the method of examining animal ſubſtances was ſo well underſtood as it is at preſent. It is to him, however, that we are indebted for almoſt all the facts known concerning the compoſition of muſcle.

It is ſcarcely poſſible to ſeparate the muſcle from all the other ſubſtances with which it is mixed. A quantity of fat often adheres to it cloſely; blood pervades the whole of it; and every fibre is enveloped in a particular thin membranous matter, which anatomiſts diſtinguiſh by the name of *cellular ſubſtance*. The analyſis of the muſcle, then, cannot be ſuppoſed to exhibit an accurate view of the compoſition of pure muſcular fibres, but only of muſcular fibre not perfectly ſeparated from other ſubſtances.

223 Analyſis of muſcles. 1. When a muſcle is well waſhed in cold water, ſeveral of its parts are diſſolved, and may be obtained by the uſual chemical methods. When the water is evaporated ſlowly, it at laſt coagulates, and the coagulum may be ſeparated by means of a filter. It poſſeſes the properties of *albumen*.

2. The water is then to be evaporated gently to dryneſs, and alcohol poured upon the dry maſs: part of it is diſſolved by digeſtion, and there remains a ſaline ſubſtance, which has not been examined; but which Fourcroy conjectures to be a *phoſphat*.

3. When the alcohol is evaporated to dryneſs, it leaves a peculiar mucous ſubſtance, ſoluble both in water and alcohol; and when its watery ſolution is very much concentrated, it aſſumes an acid and bitter taſte. It ſwells upon hot coals, and melts, emitting an acid and penetrating ſmell. It attracts moiſture from the air, and forms a ſaline efflorеſcence. In a hot atmoſphere it becomes ſour and putrefies. All theſe properties render it probable that this ſubſtance of Mr Thouvenel is that which is converted into *zoonic* acid during the roaſting of meat.

4. The muſcle is now to be boiled in water for ſome time. A quantity of fat appears on its ſurface in the form of oil, which may be taken off.

5. The water, when evaporated ſufficiently, aſſumes the form of a jelly on cooling, and therefore contains a portion of *gelatine*. It contains alſo a little of the ſaline ſubſtance, and of the mucous ſubſtance mentioned above.

6. The reſiduum of the muſcle is now white and inſipid, of a fibrous ſtructure, and inſoluble in water, and has all the properties of *fibrina*.

Thus it appears that muſcle is compoſed of

Albumen,
Mucous matter,
Gelatine,
Fibrina,
A ſalt.

The French chemiſts have diſcovered, that when a piece of muſcle is allowed to remain a ſufficient time in diluted ſulphuric acid, it is converted into a ſubſtance reſembling tallow: weak nitric acid, on the other hand, converts it into a ſubſtance reſembling *wax* [*].

SECT. III. *Of the Soft and White Parts of Animals.*

THOSE parts of animals to which anatomiſts have given the names of cartilage, tendon, ligament, membrane, differ altogether in their appearance from the muſcles. They have never been analyſed. We know only that they are compoſed, in a great meaſure, of *gelatine*; for it is partly from them that *glue* is made; which does not differ from gelatine, except in not being perfectly pure.

Mr Hatchett has aſcertained that they contain no phoſphat of lime as a conſtituent part, and ſcarcely any ſaline ingredients; for when calcined they leave but a very inconſiderable reſiduum. Thus 250 grains of hog's bladder left only 0.02 grain of reſiduum [†].

SECT. IV. *Of the Skin.*

THE ſkin is that ſtrong thick covering which envelopes the whole external ſurface of animals. It is compoſed chiefly of two parts: a thin white elaſtic layer on the outſide, which is called *epidermis*, or *cuticle*; and a much thicker layer, compoſed of a great many fibres, cloſely interwoven, and diſpoſed in different directions; this is called the *cutis*, or *true ſkin*. The *epidermis* is that part of the ſkin which is raiſed in bliſters.

224 Epidermis. 1. The epidermis is eaſily ſeparated from the cutis by maceration in hot water. It poſſeſſes a very great degree of elaſticity.

225 Its properties. It is totally inſoluble in water and in alcohol. Pure fixed alkalies diſſolve it completely, as does lime likewiſe, though ſlowly [‡]. Sulphuric and muriatic acids do not diſſolve it, at leaſt they have no ſenſible action on it for a conſiderable time; but nitric acid ſoon deprives it of its elaſticity, cauſes it to fall to pieces, and probably ſoon decompoſes it [§].

It is well known that the living epidermis is tinged yellow almoſt inſtantaneouſly by nitric acid; but this effect does not take place, at leaſt ſo ſpeedily, when the dead cuticle is plunged in nitric acid altogether [||].

226 Cutis. 2. When a portion of cutis is macerated for ſome hours in water, and agitation and preſſure is employed to accelerate the effect, the blood, and all the extraneous matter with which it was loaded, are ſeparated from it, but its texture remains unaltered. On evaporating the water employed, a ſmall quantity of gelatine may be obtained. No ſubſequent maceration in cold water has any farther effect; the weight of the cutis is not diminiſhed, and its texture is not altered: but if it be boiled in a ſufficient quantity of water, it may be completely diſſolved, and the whole of it, by evaporating the water, obtained in the ſtate of *gelatine* [*].

227 Compoſed of gelatine. Seguin informs us that he has aſcertained, by a great variety of experiments, that the cutis differs from gelatine merely in containing an additional quantity of oxygen. Hot water (he ſays) expels this oxygen, and thus converts cutis into gelatine [†]. As theſe experiments have not been publiſhed, it is impoſſible to form any judgment of their weight.

228 Nature of tanning. It is the ſkin or cutis of animals of which leather is formed. The proceſs of converting ſkin into leather is called *tanning*. This proceſs, though practiſed in the earlieſt ages, was merely empyrical, till the happy ingenuity of Mr Seguin led him to diſcover its real nature. After the epidermis and all the impurities of the ſkin have been ſeparated, and its pores have been ſo far opened as to admit of being completely penetrated, it is ſteeped in an infuſion of oak-bark, which conſiſts of gallic acid and tan. The gallic acid (if we believe Seguin) deprives the ſkin gradually of oxygen, and thus converts it into gelatine, and the tan combines with this gelatine the inſtant it is formed; and this proceſs goes

---

[*] *Humbolt on Galvaniſm*, 170.

[†] *Phil. Tranſ.* 1799, p. 333.

[‡] *Chaptal, Ann. de Chim.* xxii. 221.

[§] *Cruikſhank on Inſenſible Perſpiration*, p. 32.

[||] *Ibid.*

[*] *Seguin, Nicholſon's Journal*, i. 271.

[†] *Ibid.* 277.

Br and N ves.

goes on ſo ſlowly that the texture of the ſkin is not altered. Leather, therefore, is merely a combination of gelatine and tan ‡.

‡ N olſon's Jou il, i. 271

SECT. V. *Of the Brain and Nerves.*

The brain and nerves are the inſtruments of ſenſation, and even of motion; for an animal loſes the power of moving a part the inſtant that the nerves which enter it are cut.

The brain and nerves have a ſtrong reſemblance to each other; and it is probable that they agree alſo in their compoſition. But hitherto no attempt has been made to analyſe the nerves. The only chemiſts who have examined the nature of *brain* are Mr Thouret * and Mr Fourcroy ‡.

* r. de Pl xx i 329

‡ de Ch xvi. 28

The brain conſiſts of two ſubſtances, which differ from each other ſomewhat in colour, but which, in other reſpects, ſeem to be of the ſame nature. The outermoſt matter, having ſome ſmall reſemblance in colour to wood-aſhes, has been called the *cineritious* part; the innermoſt part has been called the *medullary* part.

9 Pr ties of in.

Brain has a ſoft feel, not unlike that of ſoap; its texture appears to be very cloſe; its ſpecific gravity is greater than that of water.

When brain is kept in cloſe veſſels ſo that the external air is excluded, it remains for a long time unaltered. Fourcroy filled a glaſs veſſel almoſt completely with pieces of brain, and attached it to a pneumatic apparatus; a few bubbles of carbonic acid gas appeared at firſt, but it remained above a year without undergoing any farther change ‡.

‡ .297.

This is very far from being the caſe with brain expoſed to the atmoſphere. In a few days (at the temperature of 60°) it exhales a moſt deteſtible odour, becomes acid, aſſumes a green colour, and very ſoon a great quantity of ammonia makes its appearance in it.

Cold water does not diſſolve any part of the brain; but by trituration in a mortar, it forms, with water, a whitiſh coloured emulſion, which appears homogeneous, may be paſſed through a filter, and the brain does not precipitate by reſt. When this emulſion is heated to 145°, a white coagulum is formed. The addition of a great quantity of water alſo cauſes a coagulum to appear, which ſwims on the ſurface, but the water ſtill retains a milky colour. When ſulphuric acid is dropt into the watery emulſion of brain, white flakes ſeparate and ſwim on the ſurface, and the liquid becomes red. Nitric acid produces the ſame effects, only the liquid becomes yellow. Alcohol alſo ſeparates a white coagulum from the emulſion, after it has been mixed with it for ſome hours. When nitric acid is added to the emulſion till it becomes ſlightly acid, a coagulum is alſo ſeparated. This coagulum is of a white colour; it is inſoluble in water and in alcohol. Heat ſoftens, but does not melt it. When dried, it becomes tranſparent, and breaks with a glaſſy fracture. It has therefore ſome reſemblance to *albumen* §.

§ 1. 288.

When brain is triturated in a mortar with diluted ſulphuric acid, part is diſſolved, the reſt may be ſeparated, by filtration, in the form of a coagulum. The acid liquor is colourleſs. By evaporation, the liquid becomes black, ſulphurous acid is exhaled, and cryſtals appear; and when evaporated to dryneſs, a black maſs remains behind. When this maſs is diluted with water, a quantity of charcoal ſeparates, and the water remains clear. The brain is completely decompoſed, a quantity of ammonia combines with the acid and forms ſulphat of ammonia, while charcoal is precipitated. The water, by evaporation and treatment with alcohol, yields ſulphats of ammonia and lime, phoſphoric acid, and phoſphats of ſoda and ammonia. Brain therefore contains

Brain and Nerves.

230 Its analyſis.

Phoſphat of lime,
——— -- ſoda,
——— -- ammonia.

Traces alſo of ſulphat of lime can be diſcovered in it. The quantity of theſe ſalts is very ſmall; altogether they do not amount to $\frac{1}{230}$th part ‖.

‖ Ann. de Chim. xvi. 288.

Diluted nitric acid, when triturated with brain, likewiſe diſſolves a part, and coagulates the reſt. The ſolution is tranſparent. When evaporated till the acid becomes concentrated, carbonic acid gas and nitrous gas are diſengaged; an efferveſcence takes place, white fumes appear, an immenſe quantity of ammonia is diſengaged, a bulky charcoal remains mixed with a conſiderable quantity of oxalic acid *.

* Ibid 307.

When brain is gradually evaporated to dryneſs by the heat of a water bath, a portion of tranſparent liquid ſeparates at firſt from the reſt, and the reſiduum, when nearly dry, acquires a brown colour; its weight amounts to about one-fourth of the freſh brain. It may ſtill be formed into an emulſion with water, but very ſoon ſeparates again ſpontaneouſly.

When alcohol is repeatedly boiled upon this dried reſiduum till it ceaſes to have any more action, it diſſolves about five-eighths of the whole. When this alcohol cools, it depoſits a yellowiſh white ſubſtance, compoſed of brilliant plates. When kneaded together by the fingers, it aſſumes the appearance of a ductile paſte: at the temperature of boiling water it becomes ſoft, and when the heat is increaſed it blackens, exhales empyreumatic and ammoniacal fumes, and leaves behind it a charry matter †. When the alcohol is evaporated, it depoſites a yellowiſh black matter, which reddens paper tinged with turnſol, and readily diffuſes itſelf through water ‡.

† Ibid. 313.

‡ Ibid. 317.

Pure concentrated potaſs diſſolves brain, diſengaging a great quantity of ammonia.

Theſe facts are ſufficient to ſhew us, that, excluſive of the ſmall proportion of ſaline ingredients, brain is compoſed of a peculiar matter, differing in many particulars from all other animal ſubſtances, but having a conſiderable reſemblance in many of its properties to albumen. Brain has been compared to a ſoap; but it is plain that the reſemblance is very faint, as ſcarcely any oily matter could be extricated from brain by Fourcroy, though he attempted it by all the contrivances which the preſent ſtate of chemiſtry ſuggeſted; and the alkaline proportion of it is a great deal too ſmall to merit any attention.

SECT. VI. *Of Nails, Horns, Hair, Feathers.*

These ſubſtances have not hitherto been analyſed. We know only that they have a great reſemblance to each other. They give out the ſame ſmell, and exhibit the ſame phenomena when burnt, and they yield the ſame products when diſtilled.

Pure fixed alkali has the property of decompoſing theſe ſubſtances, and of converting them into ammonia and oil. The ammonia is diſengaged in great abundance, and the oil combines with the alkali, and forms a ſpecies of ſoap. When muriatic acid is poured into the ſolution of theſe ſubſtances in pure ſoda, a quantity of ſulphurated hydrogen gas is diſengaged, and a black ſubſtance, doubtleſs charcoal, precipitates. Hence it follows that theſe ſubſtances contain in their compoſition a quantity of ſulphur. Accordingly, if a bit of ſilver is put into the ſolution, it inſtantly aſſumes a black colour §.

Theſe ſubſtances ſcarcely contain any earthy ingredients. One hundred grains of ox horn, after calcination, left only 0.04 grain of reſiduum, half of which was phoſphat of lime. Seventy-eight grains of chamois horn left five grains of reſiduum ||.

Such is a very imperfect account of the ſolids which compoſe animal bodies. We proceed next to the fluid which circulates through living bodies, namely *blood;* and to the various *ſecretions* formed from the blood, either in order to anſwer ſome important purpoſe to the animal, or to be evacuated as uſeleſs, that the blood thus purified may be more proper for anſwering the ends for which it is deſtined. Many of theſe ſubſtances have been examined with more care by chemiſts than the animal ſolids.

SECT. VII. *Of Blood.*

231 Properties of blood.

BLOOD is a well known fluid, which circulates in the veins and arteries of the more perfect animals. It is of a red colour, has a conſiderable degree of conſiſtency, and an unctuous feel, as if it contained a quantity of ſoap. Its taſte is ſlightly ſaline, and it has a peculiar ſmell.

The ſpecific gravity of human blood is, at a medium, 1.0527 *. Mr Fourcroy found the ſpecific gravity of bullock's blood, at the temperature of 60°, to be 1.056 †. The blood does not uniformly retain the ſame conſiſtence in the ſame animal, and its conſiſtence in different animals is very various. It is eaſy to ſee that its ſpecific gravity muſt be equally various.

232 Compoſed of red globules,

When the blood is viewed through a microſcope, a great many globules, of a red colour, are ſeen floating in it. It is to theſe globules that the red colour of the blood is owing. They were firſt examined with attention by Leuwenhoeck. Their form, their proportion, and the changes which they undergo from the addition of various ſubſtances, have been examined with the greateſt care; but hitherto without adding much to our knowledge. We neither know the ingredients of which the red globules are compoſed, nor the changes to which they are ſubjected, nor the uſeful purpoſes which they ſerve; nor has any accurate method been diſcovered of ſeparating them from the reſt of the blood, and of obtaining them in a ſtate of purity.

When blood, after being drawn from an animal, is allowed to remain for ſome time at reſt, it very ſoon coagulates into a ſolid maſs, of the conſiſtence of curdled milk. This maſs gradually ſeparates into two parts: one of which is fluid, and is called *ſerum;* the other, the coagulum, has been called *cruor,* becauſe it alone retains the red colour which diſtinguiſhes blood. This ſeparation is very ſimilar to the ſeparation of curdled milk into curds and whey. The cruor uſually ſinks to the bottom of the veſſel, and, of courſe, is covered by the ſerum.

233 Cruor,

The cruor, or *clot* as it is ſometimes called, is of a red colour, and poſſeſſes conſiderable conſiſtence. Its mean ſpecific gravity is about 1.245 ‡. If we waſh the cruor in a ſufficient quantity of water, it gradually loſes its red colour, and aſſumes the appearance of a whitiſh, fibrous, elaſtic maſs, which poſſeſſes all the properties of *fibrina.* The cruor therefore is compoſed chiefly of fibrina. The water in which it has been waſhed aſſumes a red colour, but continues tranſparent. It is evident from this that it contains, diſſolved in it, the red globules; not, however, in a ſtate of purity, for it is impoſſible to ſeparate the cruor completely from the ſerum: conſequently the water muſt contain both ſerum and red globules. We know, however, from this, that the red globules are ſoluble in water. The cruor of the blood, then, is compoſed of red globules and fibrina.

If the cruor of the blood be expoſed to a gentle heat, it becomes gradually dry and brittle. If this dry maſs be ſubmitted to diſtillation, it yields water, ammonia, a thick empyreumatic oil, and much carbonat of ammonia: there remains a ſpongy coal of a brilliant appearance, from which ſulphuric acid extracts *ſoda* and *iron;* there remains behind a mixture of phoſphat of lime and charcoal ||.

When the fibrina is diſtilled, it yields preciſely the ſame products; but the reſiduum contains neither iron nor ſoda. The red water, on the contrary, which had been employed to waſh the cruor, contains both of theſe ſubſtances, eſpecially iron; which may be obtained in the ſtate of oxyd by evaporating this water to dryneſs, and calcining the reſiduum ¶. Theſe facts are ſufficient to demonſtrate that the red globules contain iron; conſequently the opinion that their colour depends upon that metal is at leaſt poſſible. It is probably owing to the ſoda which it contains, that the preſence of iron cannot be aſcertained in the ſolution of theſe globules by the uſual teſts. The pruſſian alkali cauſes no precipitate; the infuſion of nut galls gives it no blue or purpliſh tinge *.

234 And ſerum

The ſerum is of a light greeniſh yellow colour; it has the taſte, ſmell, and feel of the blood, but its conſiſtence is not ſo great. Its mean ſpecific gravity is about 1.0287 †. It converts ſyrup of violets to a green, and therefore contains an alkali. On examination, it is found that it owes this property to a portion of ſoda. When heated to the temperature of 156° §, the ſerum coagulates, as Harvey firſt diſcovered †. It coagulates alſo when boiling water is mixed with it; but if ſerum be mixed with ſix parts of cold water, it does not coagulate by heat ‡. When thus coagulated, it has a greyiſh white colour, and is not unlike the boiled white of an egg §. If the coagulum be cut into ſmall pieces, a muddy fluid may be ſqueezed from it, which has been termed the *ſeroſity.* After the ſeparation of this fluid, if the reſiduum be carefully waſhed in boiling water and examined, it will be found to poſſeſs all the properties of *albumen.* The ſerum, therefore, contains a conſiderable proportion of albumen. Hence its coagulation by heat, and the other phenomena which albumen uſually exhibits.

If the ſeroſity be gently evaporated till it becomes concentrated, and then be allowed to cool, it aſſumes the form of a jelly, as was firſt obſerved by De Haen ||. Conſequently it contains *gelatine.*

If ſerum be mixed with twice its weight of water, and, after coagulation by heat, the albumen be ſeparated

---

§ *Merat-Guillot, Ann de Chim.* xxxiv. 70.

|| *Hatchett, Phil. Tranſ.* 1799, p. 332.

* *Haller's Phyſiology,* ii. 41.

† *Ann. de Chim.* vii. 147.

‡ *Jurin, Haller's Phyſiology* ii. 41.

|| *Fourcr* iii. 267.

¶ *Ibid.*

* *Well's Phil. Tr* 1797.

† *Jurin, Haller's Phyſiology* ii. 41

§ *Cullen.*

† *De Ge Anim.* p. 161.

‡ *Fourcr Ann de Chim* vi 157

§ *Ibid.* 1

|| *Ibid. Tr*

ted by filtration, and the liquid be ſlowly evaporated till it is conſiderably concentrated, a number of cryſtals are depoſited when the liquid is left ſtanding in a cool place. Theſe cryſtals conſiſt of muriat of ſoda and carbonat of ſoda [¶].

Thus it appears that the ſerum of the blood contains albumen, gelatine, ſoda, muriat of ſoda, and carbonat of ſoda, beſides a portion of water.

Gelatine may be precipitated from the ſeroſity by the three mineral acids. Mr Hunter obſerved, that Goulard's extract, or, which is the ſame thing, acetite of lead diſſolved in acetous acid, produces with gelatine a copious precipitate [¶]. When nitric acid is diſtilled off ſerum, it converts it partly into pruſſic acid [*]. Acids, alcohol, and tan, precipitate the albumen in different ſtates; but this, after what has been ſaid in the laſt chapter, ſection ii. requires no farther explanation.

The proportion between the cruor and ſerum of the blood varies much in different animals, and even in the ſame animal in different circumſtances. The moſt common proportion is about one part of cruor to three parts of ſerum; but in many caſes the cruor exceeds and falls ſhort of this quantity: the limits of the ratios of theſe ſubſtances to each other appear, from a compariſon of the concluſions of moſt of thoſe who have written accurately on the ſubject, to be 1 : 1 and 1 : 4; but the firſt caſe muſt be very rare indeed [*].

When new-drawn blood is ſtirred briſkly round with a ſtick, or the hand, the whole of the fibrina collects together upon the ſtick, and in this manner may be ſeparated altogether from the reſt of the blood. The red globules, in this caſe, remain behind in the ſerum. It is in this manner that the blood is prepared for the different purpoſes to which it is put: as clarifying ſugar, making puddings, &c. After the fibrina is thus ſeparated, the blood no longer coagulates when allowed to remain at reſt, but a ſpongy flaky matter ſeparates from it and ſwims on the ſurface [†].

When blood is dried by a gentle heat, water exhales from it, retaining a very ſmall quantity of animal matter in ſolution, and conſequently having the odour of blood. Blood dried in this manner being introduced into a retort and diſtilled, there comes over, firſt a clear watery liquor, then carbonic acid gas, and carbonat of ammonia, which cryſtallizes in the neck of the retort; after theſe products there comes over a fluid oil, carbonated hydrogen gas, and an oily ſubſtance of the conſiſtence of butter. The watery liquor poſſeſſes the property of precipitating from ſulphat of iron a green powder: muriatic acid diſſolves part of this powder, and there remains behind a little pruſſian blue. Conſequently this watery liquor contains both an alkali and pruſſic acid [‡].

9216 grains of dried blood being put into a large crucible, and gradually heated, at firſt became nearly fluid, and ſwelled up conſiderably, emitted a great many fetid fumes of a yellowiſh colour, and at laſt took fire and burned with a white flame, evidently owing to the preſence of oil. After the flame and the fumes had diſappeared, a light ſmoke was emitted, which affected the eyes and the noſe, which had the odour of pruſſic acid, and reddened moiſt papers ſtained with vegetable blues. At the end of ſix hours, when the matter had loſt five-ſixths of its ſubſtance, it melted anew, exhibited a purple flame on its ſurface, and emitted a thick ſmoke. This ſmoke affected the eyes and noſtrils, and reddened blue paper, but it had not the ſmell of pruſſic acid. When a quantity of it was collected and examined, it was found to poſſeſs the properties of phoſphoric acid. The reſiduum amounted to 181 grains; it had a deep black colour, and a metallic brilliancy, and its particles were attracted by the magnet. It contained no uncombined ſoda, though the blood itſelf, before combuſtion, contains it abundantly; but water extracted from it muriat of ſoda, part of the reſt was diſſolved by muriatic acid, and, of courſe, was lime; there was beſides a little ſilica, which had evidently been ſeparated from the crucible. The iron had been reduced during the combuſtion [‡].

235
Component parts of blood.

Such are the properties of blood, as far as they have been hitherto aſcertained by experiment. We have ſeen that it contains the following ingredients:

1. Water,
2. Fibrina,
3. Albumen,
4. Gelatine,
5. Iron,
6. Soda,
7. Muriat of ſoda,
8. Phoſphat of lime.

But our knowledge of this ſingular fluid is by no means ſo complete as it ought to be; a more accurate analyſis would probably diſcover the preſence of other ſubſtances, and enable us to account for many of the properties of blood which at preſent are inexplicable.

It would be of great conſequence alſo to compare together the blood of different animals, and of the ſame animal at different ages, and to aſcertain in what particulars they differ from each other. This would probably throw light on ſome of the obſcureſt parts of the animal economy. Very little progreſs has hitherto been made in theſe reſearches: if we except the labours of Rouelle, who obtained nearly the ſame ingredients, though in different proportions, from the blood of a great variety of animals, the experiments of Fourcroy on the blood of the human fœtus are almoſt the only ones of that kind with which we are acquainted.

236
Blood of the fœtus.

He found that it differs from the blood of the adult in three things: *1ſt*, Its colouring matter is darker, and ſeems to be more abundant; *2d*, It contains no fibrina, but probably a greater proportion of gelatine than blood of adults; *3d*, It contains no phoſphoric acid [§].

237
Diſeaſed blood.

The examination of diſeaſed blood, too, would be of great conſequence; becauſe the difference of its properties from the blood of people in health might throw much light on the nature of the diſeaſe. It is well known, that when a perſon labours under inflammation, his blood is not ſuſceptible of coagulating ſo ſoon as healthy blood. This longer time allows the red globules to ſink to the bottom, and the coagulated fibrina appears at the top, of its natural whitiſh colour. Hence the appearance of the *buffy coat*, as it is called, which characterizes blood during inflammation.

During that diſeaſe which is known by the name of *diabetes*, in which the urine is exceſſive in quantity, and contains ſugar, the ſerum of blood often, as appears from the experiments of Dr Dobſon and Dr Rollo, aſſumes the appearance of whey; and, like it, ſeems to contain ſugar, or, at leaſt, it has loſt its uſual ſalt taſte.

Fourcroy mentions a caſe of extreme feebleneſs, in which all the parts of the body were in an unuſual relaxed ſtate. In that patient a quantity of blood oozed

---

[‡] *Fourcroy, Ann. de Chim.* vii. 151.

[§] *Ibid.* 161.

out from the eye-lids, which tinged linen blue, as if it had been ſtained with pruſſian blue. Here pruſſic alkali ſeems to have been formed in the blood.

SECT. VIII. *Of Milk.*

MILK is a fluid ſecreted by the female of all thoſe animals denominated *mammalia*, and intended evidently for the nouriſhment of her offspring.

The milk of every animal has certain peculiarities which diſtinguiſh it from every other milk. But the animal whoſe milk is moſt made uſe of by man as an article of food, and with which, conſequently, we are beſt acquainted, is the *cow*. Chemiſts, therefore, have made choice of cow's milk for their experiments. We ſhall at firſt confine ourſelves to the properties and analyſis of cow's milk, and afterwards point out in what reſpect the milk of other animals differs from it, as far at leaſt as theſe differences have hitherto been aſcertained.

238 Properties of milk.

Milk is an opaque fluid, of a white colour, a ſlight peculiar ſmell, and a pleaſant ſweetiſh taſte. When newly drawn from the cow, it has a taſte very different from that which it acquires after it has been kept for ſome hours.

It is liquid, and wets all thoſe ſubſtances which can be moiſtened by water; but its conſiſtence is greater than that of water, and it is ſlightly unctuous. Like water, it freezes when cooled down to about 30°; but Parmentier and Deyeux, to whom we are indebted for by far the completeſt account of milk hitherto publiſhed, found that its freezing point varies conſiderably in the milk of different cows, and even of the ſame cow at different times *. Milk boils alſo when ſufficiently heated; but the ſame variation takes place in the boiling point of different milks, though it never deviates very far from the boiling point of water. Milk is ſpecifically heavier than water, and lighter than blood; but the preciſe degree cannot be aſcertained, becauſe almoſt every particular milk has a ſpecific gravity peculiar to itſelf.

When milk is allowed to remain for ſome time at reſt, there collects on its ſurface a thick unctuous yellowiſh coloured ſubſtance, known by the name of *cream*. The cream appears ſooner in milk in ſummer than in winter, evidently owing to the difference of temperature. In ſummer, about four days of repoſe are neceſſary before the whole of the cream collects on the ſurface of the liquid; but in winter it requires at leaſt double the time †.

After the cream is ſeparated, the milk which remains is much thinner than before, and it has a bluiſh white colour. If it be heated to the temperature of 100°, and a little *rennet*, which is water digeſted with the inner coat of a calf's ſtomach, and preſerved with ſalt, be poured into it, coagulation enſues; and if the coagulum be broken, the milk very ſoon ſeparates into two ſubſtances: a ſolid white part, known by the name of *curd*; and a fluid part, called *whey*.

Thus we ſee that milk may be eaſily ſeparated into three parts; namely, *cream*, *curd*, and *whey*.

239 Cream

CREAM is of a yellow colour, and its conſiſtence increaſes gradually by expoſure to the atmoſphere. In three or four days, it becomes ſo thick that the veſſel which contains it may be inverted without riſking any loſs. In eight or ten days more its ſurface is covered over with mucors and byſſi, and it has no longer the flavour of cream, but of very fat cheeſe *. This is the proceſs for making what in this country is called a *cream cheeſe*.

Cream poſſeſſes many of the properties of an oil. It is ſpecifically lighter than water, it has an unctuous feel, ſtains clothes preciſely in the manner of oil; and if it be kept fluid, it contracts at laſt a taſte which is very analogous to the rancidity of oils †. When kept boiling for ſome time, a little oil makes its appearance, and floats upon its ſurface ‡. Cream is neither ſoluble in alcohol nor oils §. Theſe properties are ſufficient to ſhew us that it contains a quantity of oil; but this oil is combined with a part of the curd, and mixed with ſome ſerum. Cream, then, is compoſed of a peculiar oil, curd, and ſerum. The oil may be eaſily obtained ſeparate by agitating the cream for a conſiderable time. This proceſs, known to every body, is called *churning*. After a certain time, the cream ſeparates into two portions: one fluid, and reſembling creamed milk; the other ſolid, and called *butter*.

240 Converte into butt

Butter is of a yellow colour, poſſeſſes the properties of an oil, and mixes readily with other oily bodies. When heated to the temperature of 96°, it melts, and becomes tranſparent; if it be kept for ſome time melted, ſome curd and water or whey ſeparate from it, and it aſſumes exactly the appearance of oil ‖. But this proceſs deprives it in a great meaſure of its peculiar flavour.

When butter is kept for a certain time, it becomes rancid, owing in a good meaſure to the preſence of theſe foreign ingredients; for if butter be well waſhed, and a great portion of theſe matters ſeparated, it does not become rancid nearly ſo ſoon as when it is not treated in this manner. It was formerly ſuppoſed that this rancidity was owing to the developement of a peculiar acid; but Parmentier and Deyeux have ſhewn, that no acid is preſent in rancid butter *. When butter is diſtilled, there comes over water, ſebacic acid, and oil, at firſt fluid, but afterwards concrete. The carbonaceous reſiduum is but ſmall

241 And h

Butter may be obtained by agitating cream newly taken from milk, or even by agitating milk newly drawn from the cow. But it is uſual to allow cream to remain for ſome time before it is churned. Now cream, by ſtanding, acquires a ſour taſte; butter therefore is commonly made from ſour cream. Freſh cream requires at leaſt four times as much churning before it yields its butter as ſour cream does †; conſequently cream acquires, by being kept for ſome time, new properties, in conſequence of which it is more eaſily converted into butter. When very ſour cream is churned, every one who has paid the ſmalleſt attention muſt have perceived, that the butter-milk, after the churning, is not nearly ſo ſour as the cream had been. The butter, in all caſes, is perfectly ſweet; conſequently the acid which had been evolved has in a great meaſure diſappeared during the proceſs of churning. It has been aſcertained, that cream may be churned, and butter obtained, though the contact of atmoſpheric air be excluded ‡. We have no doubt, that in all caſes where ſuch an experiment ſucceeded, the cream on which it was made had previouſly become ſour. On the other hand, it has been aſcertained, that when cream is churned in contact with air, it abſorbs a conſiderable quantity of it §; and it cannot

---

* Jour. de Phyſ. xxxvii. 362.

† Fourcroy, Ann. de Chim. vii. 167.

* Parmentier and Deyeux, Ann. de Chim. vii. 372.

† Ibid. 37

‡ Ibid. 37

§ Ibid.

‖ Fourcr Ann. de Chim. vi 170.

* Ibid.

† Fourc ibid. 16

‡ Youn Lacte,

§ Mid thian port fo 1795.

cannot be doubted, that the portion abſorbed is oxygen.

Theſe facts are ſufficient to afford us a key to explain what takes place during the proceſs of churning. There is a peculiar oil in milk, which has ſo ſtrong an affinity for the other ingredients, that it will not ſeparate from them ſpontaneouſly; but it has an affinity for oxygen, and when combined with it, forms the concrete body called *butter*. Agitation produces this combination of the oil with oxygen; either by cauſing it to abſorb oxygen from the air, or, if that be impoſſible, by ſeparating it from the acid which exiſts in ſour cream. Hence the abſorption of air during churning; hence alſo the increaſe of temperature of the cream, which Dr Young found to amount conſtantly to 4°; and hence the ſweetneſs of the butter milk compared with the cream from which it was obtained.

The affinity of the oil of cream for the other ingredients is ſuch, that it never ſeparates completely from them. Not only is curd and whey always found in the cream, but ſome of this oil is conſtantly found in creamed milk and even in whey: for it has been aſcertained by actual experiment, that butter may be obtained by churning whey; 27 Scotch pints of whey yield at an average about a pound of butter ‖. This accounts for a fact well known to thoſe who ſuperintend dairies, that a good deal more butter may be obtained from the ſame quantity of milk, provided it be churned as drawn from the cow, than when the cream alone is collected and churned.

The butter-milk, as Parmentier and Deyeux aſcertained by experiment, poſſeſſes preciſely the properties of milk deprived of cream ¶.

272
perties
urd.

Curd, which may be ſeparated from creamed milk by rennet, has all the properties of coagulated albumen. It is white and ſolid; and when all the moiſture is ſqueezed out, it has a good deal of brittleneſs. It is inſoluble in water; but pure alkalies and lime diſſolve it readily, eſpecially when aſſiſted by heat; and when fixed alkali is uſed, a great quantity of ammonia is emitted during the ſolution. The ſolution of curd in ſoda is of a red colour, at leaſt if heat be employed; owing probably to the ſeparation of charcoal from the curd by the action of the alkali *. Indeed, when a ſtrong heat has been uſed, charcoal precipitates as the ſolution cools †. The matter diſſolved by the alkali may be ſeparated from it by means of any acid; but it has loſt all the properties of curd. It is of a black colour, melts like tallow by the application of heat, leaves oily ſtains on paper, and never acquires the conſiſtence of curd ‡. Hence it appears that curd, by the action of a fixed alkali, is decompoſed, and converted into two new ſubſtances, ammonia, and oil or rather fat.

Curd is ſoluble alſo in acids. If, over curd newly precipitated from milk, and not dried, there be poured eight parts of water, containing as much of any of the mineral acids as gives it a ſenſibly acid taſte, the whole is diſſolved after a little boiling §. Acetous acid and lactic acid do not diſſolve curd when very much diluted ‖. But theſe acids, when concentrated, diſſolve it readily, and in conſiderable quantity ¶. It is remarkable enough, that concentrated vegetable acids diſſolve curd readily, but have very little action on it when they are very much diluted: whereas the mineral diſſolve it when much diluted; but when concentrated, have either very little effect on it, as ſulphuric acid *; or decompoſe it, as nitric acid. By means of this laſt acid, as Berthollet diſcovered, a quantity of azotic gas may be obtained from curd.

273
Of cheeſe.

Curd, as is well known, is uſed in making *cheeſe*; and the cheeſe is the better the more it contains of cream, or of that oily matter which conſtitutes cream. It is well known to cheeſemakers, that the goodneſs of it depends in a great meaſure on the manner of ſeparating the whey from the curd. If the milk be much heated, the coagulum broken in pieces, and the whey forcibly ſeparated, as is the practice in many parts of Scotland, the cheeſe is ſcarce good for any thing; but the whey is delicious, eſpecially the laſt ſqueezed-out whey, and butter may be obtained from it in conſiderable quantity. A full proof that nearly the whole creamy part of the milk has been ſeparated with the whey. Whereas if the milk be not too much heated (about 100° is ſufficient), if the coagulum be allowed to remain unbroken, and the whey be ſeparated by very ſlow and gentle preſſure, the cheeſe is excellent; but the whey is almoſt tranſparent, and nearly colourleſs.

Good cheeſe melts at a moderate heat; but bad cheeſe, when heated, dries, curls, and exhibits all the phenomena of burning horn. Hence it is evident, that all the properties in which curd differs from albumen are owing to its containing combined with it a quantity of the peculiar oil which conſtitutes the diſtinguiſhing characteriſtic of cream; hence its flavour and ſmell; and hence alſo the white colour of milk.

274
Coagulation of milk.

This ſameneſs of curd and albumen ſhews us, that the coagulation of milk and of albumen depend upon the ſame cauſe. Heat, indeed, does not coagulate milk, becauſe the albumen in it is diluted with too large a quantity of water. But if milk be boiled in contact with air, a pellicle ſoon forms on its ſurface, which has the properties of coagulated albumen: if this pellicle be removed, another ſucceeds; and by continuing the boiling, the whole of the albuminous or curdy matter may be ſeparated from milk *. When this pellicle is allowed to remain, it falls at laſt to the bottom of the veſſel, where, being expoſed to a greater heat, it becomes brown, and communicates to milk that diſagreeable taſte which, in this country is called a *ſinged* taſte. It happens more readily when milk is boiled along with rice, flour, &c.

If to boiling milk there be added as much of any neutral ſalt as it is capable of diſſolving, or of ſugar, or of gum arabic, the milk coagulates, and the curd ſeparates †. Alcohol alſo coagulates milk ‡; as do all acids, rennet, and the infuſion of the flowers of artichoke, and of the thiſtle ‖. If milk be diluted with ten times its weight of water, it cannot be made to coagulate at all ¶.

275
Properties of whey.

Whey, after being filtered, to ſeparate a quantity of curd which ſtill continues to float through it, is a thin pellucid fluid, of a yellowiſh green colour and pleaſant ſweetiſh taſte, in which the flavour of milk may be diſtinguiſhed. It always contains ſome curd; but nearly the whole may be ſeparated by keeping the whey for ſome time boiling; a thick white ſcum gathers on the ſurface, which in Scotland is known by the name of *float whey*. When this ſcum, which conſiſts of the curdy part, is carefully ſeparated, the whey, after being allowed to remain at reſt for ſome hours, to give the

---

‖ *Vid-Lo-* *Report,* 5.

¶ *nn. de* *n.* VII. 3.

* *bid.*

† *urcroy,* p 175.

‡ *id.*

§ *beele,* ii.

‖ *id.*

¶ *armen-* *and* *eux,* 417 *rcroy,* p. 173.

* *Parmentier, ibid.*

* *Parmentier, ibid.* p. 415.

† *Scheele,* ii. 52.

‡ *Parmentier, ibid* p. 416.

‖ *Ibid.*

¶ *Scheele,* ii. 54.

remainder of the curd time to precipitate, is decanted off, almoſt as colourleſs as water, and ſcarcely any of the peculiar taſte of milk can be diſtinguiſhed in it. If it be now ſlowly evaporated, it depoſites at laſt a number of white coloured cryſtals, which are *ſugar of milk*. Towards the end of the evaporation, ſome cryſtals of muriat of potaſs and of muriat of lime make their appearance [*]. According to Scheele, it contains alſo a little phoſphat of lime[†].

After the ſalts have been obtained from whey, what remains concretes into a jelly on cooling [‡]. Hence it follows, that whey alſo contains *gelatine*. Whey, then, is compoſed of water, ſugar of milk, gelatine, muriat of potaſs, and muriat of lime. The other ſalts, which are ſometimes found in it, are only accidentally preſent.

If whey be allowed to remain for ſome time, it becomes ſour, owing to the formation of a peculiar acid known by the name of *lactic acid*. It is to this property of whey that we are to aſcribe the acidity which milk contracts; for neither curd nor cream, perfectly freed from ſerum, ſeem ſuſceptible of acquiring acid properties. Hence the reaſon, alſo, that milk, after it becomes ſour, always coagulates. Boiled milk has the property of continuing longer ſweet; but it is ſingular enough, that it runs ſooner to putrefaction than ordinary milk [*].

276 Vinegar obtained from milk.

The acid of milk differs conſiderably from the acetous; yet vinegar may be obtained from milk by a very ſimple proceſs. If to ſomewhat more than 8 lbs. troy of milk, ſix ſpoonfuls of alcohol be added, and the mixture well corked be expoſed to a heat ſufficient to ſupport fermentation (provided attention be paid to allow the carbonic acid gas to eſcape from time to time), the whey, in about a month, will be found converted into vinegar [†].

277 Milk undergoes fermentation.

Milk is almoſt the only animal ſubſtance which may be made to undergo the vinous fermentation, and to afford a liquor reſembling wine or beer, from which alcohol may be ſeparated by diſtillation. This ſingular fact ſeems to have been firſt diſcovered by the Tartars; they obtain all their ſpirituous liquors from mares milk. It has been aſcertained, that milk is incapable of being converted into wine till it has become ſour; after this, nothing is neceſſary but to place it in the proper temperature, the fermentation begins of its own accord, and continues till the formation of wine be completed [‡]. Scheele had obſerved, that milk was capable of fermenting, and that a great quantity of carbonic acid gas was extricated from it during this fermentation [||]. But he did not ſuſpect, that the reſult of this fermentation was the formation of an intoxicating liquor ſimilar to wine.

When milk is diſtilled by the heat of a water bath, there comes over water, having the peculiar odour of milk; which putrifies, and conſequently contains, beſides mere water, ſome of the other conſtituent parts of milk. After ſome time, the milk coagulates [¶], as always happens when hot albumen acquires a certain degree of concentration. There remains behind a thick unctuous yellowiſh white ſubſtance, to which Hoffman gave the name of *franchipann*. This ſubſtance, when the fire is increaſed, yields at firſt a tranſparent liquid, which becomes gradually more coloured; ſome very fluid oil comes over, then ammonia, an acid, and at laſt a very thick black oil. Towards the end of the proceſs carbonated hydrogen gas is diſengaged [*]. There remains in the retort a coal which contains carbonat of potaſs, muriat of potaſs, and phoſphat of lime, and ſometimes magneſia, iron, and muriat of ſoda [†].

278 Its component parts.

Thus we ſee, that cows milk is compoſed of the following ingredients.

1. Water,
2. Oil,
3. Albumen,
4. Gelatine,
5. Sugar of milk,
6. Muriat of lime,
7 Muriat of potaſs,
8. Sulphur.

The milk of all other animals, as far as it has hitherto been examined, conſiſts nearly of the ſame ingredients; but there is a very great difference in their proportion.

279 Woman's milk.

WOMAN'S MILK has a much ſweeter taſte than cows milk. When allowed to remain at reſt for a ſufficient time, a cream gathers on its ſurface. This cream is more abundant than in cows milk, and its colour is uſually much whiter. After it is ſeparated, the milk is exceedingly thin, and has the appearance rather of whey, with a bluiſh white colour, than of creamed milk. None of the methods by which cows milk is coagulated ſucceed in producing the coagulation of woman's milk [*]. It is certain, however, that it contains curd; for if it be boiled, pellicles form on its ſurface, which have all the properties of curd [†]. Its not coagulating, therefore, muſt be attributed to the great quantity of water with which the curd is diluted.

Though the cream be churned ever ſo long, no butter can be obtained from it; but if, after being agitated for ſome hours, it be allowed to remain at reſt for a day or two, it ſeparates into two parts; a fluid which occupies the inferior part of the veſſel, pellucid, and colourleſs, like water and a thick white unctuous fluid, which ſwims on the ſurface. The lowermoſt fluid contains ſugar of milk and ſome curd; the uppermoſt does not differ from cream except in conſiſtence. The oily part of the cream, then, cannot be ſeparated by agitation from the curd [‡]. This cream contains a greater portion of curd than the cream of cows milk [*].

When this milk, after the curd is ſeparated from it, is ſlowly evaporated, it yields cryſtals of ſugar of milk, and of muriat of ſoda. The quantity of ſugar is rather greater than in cow's milk. According to Haller, the ſugar obtained from cow's milk is to that obtained from an equal quantity of woman's milk as 35 : 58, and ſometimes as 37 : 67, and in all the intermediate ratios.

280 Its peculiarities.

Thus it appears, that woman's milk differs from that of cows in three particulars.

1. It contains a much ſmaller quantity of curd.
2. Its oil is ſo intimately combined with its curd, that it does not yield butter.
3. It contains rather more ſugar of milk.

Parmentier and Deyeux aſcertained, that the quantity of curd in woman's milk increaſes in proportion to the time after delivery [||]. Nearly the ſame thing has been obſerved with reſpect to cow's milk.

281 Aſſes milk.

ASSES MILK has a very ſtrong reſemblance to human milk: it has nearly the ſame colour, ſmell, and conſiſtence. When left at reſt for a ſufficient time, a cream forms upon its ſurface, but by no means in ſuch abundance as in woman's milk. This cream, by very long agitation, yields a butter, which is always ſoft, white, and taſteleſs; and, what is ſingular, very readily mixes again with the butter-milk; but it may be again ſeparated

---

[*] *Parmentier*, p. 417.

[†] *Scheele*, ii. 61.

[‡] *Rouelle.*

[*] *Parmentier, ibid* p. 343.

[†] *Scheele*, ii. 68.

[‡] *Parmentier, ibid.* p. 365.

[||] *Scheele*, ii. 66.

[¶] *Bouquet.*

[*] *Parmentier, ibid.* p. 368

[†] *Mem. Med. Par.* 1767. p. 607.

[*] *Clarke, Iriſh Tranſ.* ii. 175.

[†] *Parmentier, ibid.* p. 419.

[‡] *Ibid.*

[*] *Ibid.*

[||] *Ibid.* p. 420.

ilk, liva.

rated by agitation, while the veſſel, which contains it, is plunged in cold water. Creamed aſſes milk is thin, and has an agreeable ſweetiſh taſte. Alcohol and acids ſeparate from it a little curd, which has but a ſmall degree of conſiſtence. The ſerum yields ſugar of milk and muriat of lime *.

282 I ecu- li ies.

Aſſes milk therefore differs from cows milk in three particulars.

1. Its cream is leſs abundant and more inſipid.
2. It contains leſs curd.
3. It contains more ſugar of milk: the proportion is 35 : 80.

283 ts milk

Goats milk, if we except its conſiſtence, which is greater, does not differ much from cows milk. Like that milk, it throws up abundance of cream, from which butter is eaſily obtained. The creamed milk coagulates juſt as cows milk, and yields a greater quantity of curd. Its whey contains ſugar of milk, muriat of lime, and muriat of ſoda †.

284 es milk

Ewes milk reſembles almoſt preciſely that of the cow. Its cream is rather more abundant, and yields a butter which never acquires the conſiſtence of butter from cows milk. Its curd has a fat and viſcid appearance, and is not without difficulty made to aſſume the conſiſtence of the curd of cows milk. It makes excellent cheeſe ‡.

285 res k

Mares milk is thinner than that of the cow, but ſcarcely ſo thin as human milk. Its cream cannot be converted into butter by agitation. The creamed milk coagulates preciſely as cows milk, but the curd is not ſo abundant. The ſerum contains ſugar of milk, ſulphat of lime, and muriat of lime ‖.

Sect IX. *Of Saliva.*

The fluid ſecreted in the mouth, which flows in conſiderable quantity during a repaſt, is known by the name of *ſaliva*. No accurate analyſis has hitherto been made of it, though it poſſeſſes ſome very ſingular properties.

286 pe tie- ſaliva.

It is a limpid fluid like water, but much more viſcid: it has neither ſmell nor taſte.

Its ſpecific gravity, according to Hamberger, is 1.0167 *. When agitated it froths like all other adheſive liquids; indeed it is uſually mixed with air, and has the appearance of froth.

It neither mixes readily with water nor oil †; but by trituration in a mortar, it may be mixed ſo with water as to paſs through a filter ‡ It has a great affinity for oxygen, abſorbs it readily from the air, and gives it out again to other bodies §. Hence the reaſon why gold or ſilver, triturated with ſaliva in a mortar, is oxydated, as Dutenner has obſerved; and why the killing of mercury by oils is much facilitated by ſpitting into the mixture ¶ Hence alſo, in all probability, the reaſon that ſaliva is a uſeful application to ſores of the ſkin. Dogs, and ſeveral other animals, have conſtantly recourſe to this remedy, and with much advantage.

Saliva is coagulated by oxy muriat of mercury, by alcohol, and by nitre *. Therefore, in all probability, it contains albumen and gelatine, or ſome analogous ſubſtances.

When 100 parts of ſaliva are diſtilled, there come over 80 parts of water nearly pure, then a little carbonat of ammonia, ſome oil, and an acid, which perhaps is the pruſſic. The reſiduum amounts to about 1.56 parts, and is compoſed of muriat of ſoda and phoſphat of lime †.

Bile.

287 Tartar of the teeth.

The *tartar* of the teeth, which is a cruſt depoſited from ſaliva, conſiſts, as Fourcroy has aſcertained, of phoſphat of lime.

288 Pa creatic j ice.

The pancreatic juice has never been examined with much attention; but it does not appear, from the experiments that have been made, to differ much from ſaliva.

Sect. X. *Of Bile.*

Bile is a liquid of a yellowiſh green colour, an unctuous feel, and bitter taſte, is ſecreted by the liver; and in moſt animals conſiderable quantities of it are uſually found collected in the gall bladder.

Great attention has been paid to this liquid by phyſicians; becauſe the ancients were accuſtomed to aſcribe a very great number of diſeaſes, and even affections of the mind, to its agency. The moſt accurate chemical analyſis of it which has hitherto appeared is that of Mr Cadet, which was publiſhed in the Memoirs of the French Academy of Sciences for the year 1767. Several important obſervations had been previouſly made on it by Boyle, Boerhaave, Verheyen, Ramſay, and Baglivi: and ſome facts have ſince been added to our chemical knowledge of bile by Maclurg and Fourcroy. The experiments have chiefly been confined to the bile of oxen, known in this country by the name of *gall*; becauſe it is moſt eaſily procured in large quantities.

289 Properties of bile.

The ſpecific gravity of bile ſeems to vary, like that of all other animal fluids. According to Hartmann, it is 1.027 *. When ſtrongly agitated, it lathers like ſoap; and for this reaſon, as well as from a medical theory concerning its uſe, it has been often called an *animal ſoap*.

It mixes readily with water in any proportion, and aſſumes a yellow colour: but it refuſes to unite with oil when the two fluids are agitated together; the inſtant that they are left at reſt, the oil ſeparates and ſwims on the ſurface †.

When muriatic acid is poured upon bile, let it be ever ſo freſh, an odour of ſulphurated hydrogen gas is conſtantly exhaled ‡. When on 100 parts of ox-bile four parts of ſtrong muriatic acid are poured, the whole inſtantly coagulates; but in ſome hours the greater part becomes again fluid; and when paſſed through the filter it leaves 0.26 of a white matter, which has all the properties of albumen §. This matter was detected by Ramſay; who found that it could be precipitated from bile by alcohol, acetous acid, ſulphat of potaſs, and muriat of ſoda *. Cadet aſcertained, that 100 parts of ox bile contain about 0.52 of albumen. It is precipitated in a ſtate of purity by oxy-muriatic acid, provided that acid be not employed in exceſs †.

290 Its component parts.

The muriatic acid ſolution, after the ſeparation of the albumen, has a fine graſs-green colour. When concentrated by ſome hours evaporation in a glaſs cucurbit on hot coals, it depoſites a very copious precipitate, and loſes almoſt the whole of its green colour. By longer evaporation, a new precipitate, ſimilar to the firſt, appears, and the remaining liquid aſſumes the colour of beer. This precipitate poſſeſſes all the properties of the *reſin of bile*. In its moiſt ſtate it amounts to 10.8 parts ‡. The ſame ſubſtances may be obtained from bile by nitric acid; but the reſin in that

---

* armen ti p. 423.

il p.

id p.

iid. p

* Haller's yſ. vi.

Narceſſus. aller. ibid 54

Fordyce on gſt p.

Fourcroy, in de im. viii. 261

Ibid

* Haller's yſ. vi.

† *Verheyen, Textor, Nuck* &c. as quoted by Haller, *Phyſiol.* vi. 55.

* *Haller's Phyſ.* vi. 546.

† *Ramſay, Theſaur. Med. Edin.* ii 459.

‡ *Maclurg,* p 10.

§ *Cadet, Mem. Par.* 1767. p. 340.

* *Ibid.*

* *Theſaur. Edin.* ii. 400.

† *Fourcroy, Ann. de Chim.* vii. 176.

‡ *Cadet, ibid.*

caſe has a yellow colour, and its properties are ſomewhat altered *.

If 100 parts of bile be gently evaporated to dryneſs by a very moderate heat, the dry maſs only weighs 10 parts, and has a browniſh black colour. When expoſed to a ſtrong heat in a crucible, this matter ſwells up, takes fire, and emits very thick fumes. The reſiduum amounts to 1.09. By lixiviation with water, 1.87 of cryſtallized ſoda may be obtained †; conſequently 100 parts of bile contain, according to Mr Kirwan's table, 0.403546 of pure ſoda. But it is evident that, by this method, part of the ſoda muſt have been evaporated; therefore 100 parts of bile contain more than 0.403546 of ſoda. Beſides the ſoda, there is found alſo a ſmall portion of muriat of ſoda ‡.

Cadet found the reſiduum, after the ſeparation of the ſalts, of a black colour: it gave ſome traces of iron. He alſo obtained a calcareous ſalt from bile, which he conſidered as a ſulphat; but it is more than probable that it was phoſphat of lime.

Cadet alſo obtained from bile, by evaporating the muriatic acid ſolution after the ſeparation of the reſin, a ſalt which cryſtallized in trapeziums; it had a ſweetiſh taſte, and was conſidered by him as analogous to ſugar of milk *.

Thus we ſee that bile contains the following ingredients:

1. Water,
2. Reſin,
3. Albumen,
4. Soda,
5. A ſweetiſh ſalt,
6. Muriat of ſoda,
7. Phoſphat of lime,
8. Iron.

The proportion of theſe ingredients has by no means been aſcertained. The preſence of iron has been denied in bile, becauſe it gives no blue precipitate with pruſſic alkali, and becauſe tincture of nut-galls does not give it a black colour †. But theſe reaſons are inſufficient to overturn the experiment of Cadet, who actually found it in bile.

When four parts of vinegar and five of bile are mixed together, the mixture has a ſweet taſte, and does not coagulate milk. The lactic acid has preciſely the ſame effect as vinegar ‡.

When bile is diſtilled in a water bath, it affords a tranſparent watery liquor, which contracts a pretty ſtrong odour, not unlike that of muſk or amber, eſpecially if the bile has been kept for ſome days before it is ſubmitted to diſtillation §. The reſiduum is of a deep browniſh green; it attracts moiſture from the air, and diſſolves readily in water. When diſtilled in a retort, it affords a watery liquor of a yellowiſh colour, and impregnated with alkali, oil, carbonat of ammonia, carbonic acid, and hydrogen gas. The coaly reſiduum is eaſily incinerated *. Bile, expoſed to a temperature between 65° and 85°, ſoon loſes its colour and viſcidity, acquires a nauſeous ſmell, and depoſites whitiſh mucilaginous flakes. After the putrefaction has made conſiderable progreſs, its ſmell becomes ſweet, and reſembles amber †. If bile be heated, and ſlightly concentrated by evaporation, it may be kept for many months without alteration ‡.

Sect. XI. *Of Biliary Calculi.*

Hard bodies ſometimes form in the gall bladder, or in the duct through which the bile paſſes into the inteſtinal canal, and ſtop up the paſſage altogether. Theſe concretions have got the name of *biliary calculi* or *gall-ſtones*. As they are formed in the midſt of bile, and as the ſubſtances of which they are compoſed muſt be derived from the bile, it is proper to give an account of them here, becauſe their properties cannot fail to throw ſome additional light on the nature of bile itſelf.

291 Biliary calculi of three kinds.

Biliary calculi, all of them at leaſt which have been hitherto examined with attention, may be divided into three claſſes.

1. The firſt kind comprehends thoſe which have a white colour, and a cryſtallized, ſhining, lamellated ſtructure.

2. The ſecond is dark coloured, and has preciſely the appearance of inſpiſſated bile. Both theſe kinds are combuſtible.

3. The third kind comprehends thoſe gall ſtones which do not flame, but gradually waſte away at a red heat.

We ſhall take a view of each of theſe kinds of biliary calculi in their order. For the greater part of the chemical knowledge which has been hitherto acquired of them, the world is chiefly indebted to Mr Fourcroy.

292 Properties of the firſt.

1. The firſt ſpecies of biliary calculi was pointed out for the firſt time by Haller, in a diſſertation publiſhed in 1749. Walther afterwards added ſeveral new facts; and at laſt it was accurately deſcribed by Vicq d'Azyr *. It is almoſt always of an oval ſhape, ſometimes as large as a pigeon's egg, but commonly about the ſize of a ſparrow's; and for the moſt part only one calculus (when of this ſpecies) is found in the gall bladder at a time. It has a white colour; and when broken, preſents cryſtalline plates or ſtriæ, brilliant and white like mica, and having a ſoft greaſy feel. Sometimes its colour is yellow or greeniſh; and it has conſtantly a nucleus of inſpiſſated bile †.

Its ſpecific gravity is lower than that of water: Gren found the ſpecific gravity of one 0.803 ‡.

When expoſed to a heat conſiderably greater than that of boiling water, this cryſtallized calculus ſoftens and melts, and cryſtallizes again when the temperature is lowered §. It is altogether inſoluble in water; but hot alcohol diſſolves it with facility. Alcohol, of the temperature of 167°, diſſolves $\frac{1}{10}$ of its weight of this ſubſtance; but alcohol, at the temperature of 60°, ſcarcely diſſolves any of it *. As the alcohol cools, the matter is depoſited in brilliant plates reſembling talc or boracic acid †. It is ſoluble in oil of turpentine ‡. When melted, it has the appearance of oil, and exhales the odour of melted wax: when ſuddenly heated, it evaporates altogether in a thick ſmoke. It is ſoluble in pure alkalies, and the ſolution has all the properties of a ſoap. Nitric acid alſo diſſolves it; but it is precipitated unaltered by water ‡.

This matter, which is evidently the ſame with the cryſtals which Cadet obtained from bile, and which he conſidered as analogous to ſugar of milk, has a ſtrong reſemblance to ſpermaceti. Like that ſubſtance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars.

Since it is contained in bile, it is not difficult to ſee how it may cryſtallize in the gall-bladder if it happens to be more abundant than uſual; and the conſequence muſt

---

* *Cadet, ibid.* p. 343.

† *Ibid* p. 350.

‡ *Ibid.*

* *Ibid.* p. 342.

† *Maclurg,* p. 56.

‡ *Ramſay, ibid.* p. 462.

§ *Fourcroy,* iii. 292.

* *Ibid.*

† *Ibid.*

‡ *Vauquelin.*

* *Ibid.* p. 180.

† *Fourcroy, Ann. de Chim.* iii. 249.

‡ *Ann. de Chim.* v. 186.

§ *Fourcroy, ibid.* ii. 123.

* *Ibid.* p. 180.

† *Ibid* iii. 250.

‡ *Gren, ibid.* v. 187.

‡ *Fourcroy, ibid.* iii. 247.

Bil y Calli, ars.

muſt be a gall-ſtone of this ſpecies. Fourcroy found a quantity of the ſame ſubſtance in the dried human liver *.

2. The ſecond ſpecies of biliary calculus is of a round or polygonal ſhape, of a grey colour exteriorly, and brown within. It is formed of concentric layers of a matter which ſeems to be inſpiſſated bile; and there is uſually a nucleus of the white cryſtalline matter at the centre. For the moſt part there are many of this ſpecies of calculus in the gall-bladder together: indeed it is frequently filled with them. Their ſize is uſually much ſmaller than that of the laſt ſpecies.

13 Of e fe- co

This is the moſt common kind of gall ſtone. It may be conſidered as a mixture of inſpiſſated bile, and of the cryſtalline matter which forms the firſt ſpecies: and the appearance of calculi of this kind muſt vary conſiderably, according to the proportion of theſe ingredients.

94 Of e th

3. Concerning the third ſpecies of gall-ſtone, very little is known with accuracy. Dr Saunders tells us, that he has met with ſome gall-ſtones inſoluble both in alcohol and oil of turpentine; ſome which do not flame, but become red, and conſume to an aſh like a charcoal † Haller quotes ſeveral examples of ſimilar calculi ‡.

Gall-ſtones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of theſe animals have not hitherto been examined with attention.

SECT. XII. *Of Tears.*

THAT peculiar fluid which is employed in lubricating the eye, and which is emitted in conſiderable quantities when we expreſs grief by weeping, is known by the name of *tears*. For an accurate analyſis of this fluid, chemiſtry is indebted to Meſſrs Fourcroy and Vauquelin. Before their diſſertation, which was publiſhed in 1791, appeared, ſcarcely any thing was known about the nature of tears.

95 P erties of ars.

The liquid called tears is tranſparent and colourleſs like water; it has ſcarcely any ſmell, but its taſte is always perceptibly ſalt. Its ſpecific gravity is ſomewhat greater than that of diſtilled water. It gives to paper, ſtained with the juice of the petals of mallows or violet, a permanently green colour, and therefore contains a fixed alkali *. It unites with water, whether cold or hot, in all proportions. Alkalies unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it †. Expoſed to the air, this liquid gradually evaporates, and becomes thicker. When nearly reduced to a ſtate of dryneſs, a number of cubic cryſtals form in the midſt of a kind of mucilage. Theſe cryſtals poſſeſs the properties of muriat of ſoda; only they tinge vegetable blues green, and therefore contain an exceſs of ſoda. The mucilaginous matter acquires a yellowiſh colour as it dries ‡.

This liquid boils like water, excepting that a conſiderable froth collects on its ſurface. If it be kept a ſufficient time at the boiling temperature, $\frac{96}{100}$ parts of it evaporate in water; and there remain about .04 parts of a yellowiſh matter, which by diſtillation in a ſtrong heat yield water and a little oil: the reſiduum conſiſts of different ſaline matters §.

When alcohol is poured into this liquid, a mucilaginous matter is precipitated in the form of large white flakes. The alcohol leaves behind it, when evaporated, traces of muriat of ſoda and ſoda. The reſiduum which remains behind, when inſpiſſated tears are burnt in the open air, exhibits ſome traces of phoſphat of lime and phoſphat of ſoda ||.

296 Component parts.

Thus it appears that tears are compoſed of the following ingredients:

1. Water,	4. Soda,
2. Mucilage,	5. Phoſphat of lime,
3. Muriat of ſoda,	6. Phoſphat of ſoda,

The ſaline parts amount only to about 0.01 of the whole, or probably not ſo much.

The *mucilage* contained in the tears has the property of abſorbing oxygen gradually from the atmoſphere, and of becoming thick and viſcid, and of a yellow colour. It is then inſoluble in water, and remains long ſuſpended in it without alteration. When a ſufficient quantity of oxy muriatic acid is poured into tears, a yellow flaky precipitate appears abſolutely ſimilar to this inſpiſſated mucilage The oxy muriatic acid loſes its peculiar odour; hence it is evident that it has given out oxygen to the mucilage. The property which this mucilage has of abſorbing oxygen, and of acquiring new qualities, explains the changes which take place in tears which are expoſed for a long time to the action of the atmoſphere, as is the caſe in thoſe perſons who labour under a fiſtula lachrymalis *.

297 Mucus of the noſe.

The MUCUS of the noſe has alſo been examined by Fourcroy and Vauquelin. They found it compoſed of preciſely the ſame ingredients with the tears. As this fluid is more expoſed to the action of the air than the tears, in moſt caſes its mucilage has undergone leſs or more of that change which is the conſequence of the abſorption of oxygen. Hence the reaſon of the greater viſcidity and conſiſtence of the mucus of the noſe; hence alſo the great conſiſtence which it acquires during colds, where the action of the atmoſphere is aſſiſted by the increaſed action of the parts †.

SECT. XIII. *Of Sinovia.*

WITHIN the capſular ligament of the different joints of the body, there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomiſts by the name of *ſinovia*.

Whether it be the ſame in different animals, or even in all the different joints of the ſame animal, has not been determined; as no accurate analyſis of the ſinovia of different animals has been attempted. The only analyſis of ſinovia which has hitherto appeared is that by Mr Margueron, which was publiſhed in the 14th volume of the *Annales de Chimie*. He made uſe of ſinovia obtained from the joints of the lower extremities of oxen.

298 Sinovia of the ox.

The ſinovia of the ox, when it has juſt flowed from the joint, is a viſcid ſemi-tranſparent fluid, of a greeniſh white colour, and a ſmell not unlike frog ſpawn. It very ſoon acquires the conſiſtence of jelly; and this happens equally whether it be kept in a cold or a hot temperature, whether it be expoſed to the air or excluded from it. This conſiſtence does not continue long; the ſinovia ſoon recovers again its fluidity, and at the ſame time depoſites a thready like matter *.

299 Its properties.

Sinovia mixes readily with water, and imparts to that liquid a great deal of viſcidity. The mixture frothes when agitated; becomes milky when boiled, and

---

* rcroy, ibi . 126.

† the Li , p. 11

‡ ſiol. vi 7.

* urcroy Vau- q , Jour. de yſ. x 256.

† d, p. 2

‡ d, p. 2

§ d.

|| Fourcroy and Vauquelin, Jour. de Phyſ. p. 259.

* Ibid p. 257.

† Ibid. p. 259.

* Margueron, Ann. de Chim. xiv. 124.

and depoſites ſome pellicles on the ſides of the diſh; but its viſcidity is not diminiſhed †.

300 Its component parts

When alcohol is poured into ſinovia, a white ſubſtance precipitates, which has all the properties of albumen. One hundred parts of ſinovia contain 4.52 of albumen. The liquid ſtill continues as viſcid as ever; but if acetous acid be poured into it, the viſcidity diſappears altogether, the liquid becomes tranſparent, and depoſites a quantity of matter in white threads, which poſſeſſes the following properties:

1. It has the colour, ſmell, taſte, and elaſticity of vegetable gluten.

2. It is ſoluble in concentrated acids and pure alkalies.

3. It is ſoluble in cold water, the ſolution frothes; acids and alcohol precipitate the fibrous matter in flakes One hundred parts of ſinovia contain 11.86 of this matter ‡.

When the liquid, after theſe ſubſtances have been ſeparated from it, is concentrated by evaporation, it depoſites cryſtals of acetite of ſoda Sinovia, therefore, contains *ſoda*. Margueron found that 100 parts of ſinovia contained about 0.71 of ſoda.

When ſtrong ſulphuric, muriatic, nitric, acetic, or ſulphurous acid is poured into ſinovia, a number of white flakes precipitate at firſt, but they are ſoon rediſſolved, and the viſcidity of the liquid continues. When theſe acids are diluted with five times their weight of water, they diminiſh the tranſparency of ſinovia, but not its viſcidity; but when they are ſo much diluted that their acid taſte is juſt perceptible, they precipitate the peculiar thready matter, and the viſcidity of the ſinovia diſappears §.

When ſinovia is expoſed to a dry atmoſphere it gradually evaporates, and a ſcaly reſiduum remains, in which cubic cryſtals, and a white ſaline efflореſcence, are apparent. The cubic cryſtals are muriat of ſoda. One hundred parts of ſinovia contain about 1.75 of this ſalt. The ſaline effloreſcence is carbonat of ſoda ‖.

Sinovia ſoon putrefies in a moiſt atmoſphere, and during the putrefaction ammonia is exhaled When ſinovia is diſtilled in a retort there comes over, firſt water, which ſoon putrefies; then water containing ammonia; then empyreumatic oil and carbonat of ammonia. From the reſiduum muriat and carbonat of ſoda may be extracted by lixiviation. The coal contains ſome phoſphat of lime ¶.

From the analyſis of Mr Margueron it appears that ſinovia is compoſed of the following ingredients:

11.86	fibrous matter,
4.52	albumen,
1.75	muriat of ſoda,
.71	ſoda,
.70	phoſphat of lime (N),
80.57	water,
100.00.	

SECT. XIV. *Of SEMEN.*

THE peculiar liquid ſecreted in the teſtes of males, and deſtined for the impregnation of females, is known by the name of *ſemen*. The human ſemen alone has hitherto been ſubjected to chemical analyſis. Nothing is known concerning the ſeminal fluid of other animals. Vauquelin publiſhed an analyſis of the human ſemen in 1791.

301 Properties of ſemen.

Semen, when newly ejected, is evidently a mixture of two different ſubſtances: the one, fluid and milky, which is ſuppoſed to be ſecreted by the proſtate gland; the other, which is conſidered as the true ſecretion of the teſtes, is a thick mucilaginous ſubſtance, in which numerous white ſhining filaments may be diſcovered *. It has a ſlight diſagreeable odour, an acrid irritating taſte, and its ſpecific gravity is greater than that of water. When rubbed in a mortar it becomes frothy, and of the conſiſtence of pomatum, in conſequence of its enveloping a great number of air bubbles. It converts paper ſtained with the bloſſoms of mallows or violets to a green colour, and conſequently contains an alkali †

As the liquid cools, the mucilaginous part becomes tranſparent, and acquires greater conſiſtency; but in about twenty minutes after its emiſſion, the whole becomes perfectly liquid. This liquefaction is not owing to the abſorption of moiſture from the air, for it loſes inſtead of acquiring weight during its expoſure to the atmoſphere; nor is it owing to the action of the air, for it takes place equally in cloſe veſſels ‡.

Semen is inſoluble in water before this ſpontaneous liquefaction, but afterwards it diſſolves readily in it. When alcohol or oxy muriatic acid is poured into this ſolution, a number of white flakes are precipitated §. Concentrated alkalies facilitate its combination with water. Acids readily diſſolve the ſemen, and the ſolution is not decompoſed by alkalies; neither indeed is the alkaline ſolution decompoſed by acids ‖.

Lime diſengages no ammonia from freſh ſemen; but after that fluid has remained for ſome time in a moiſt and warm atmoſphere, lime ſeparates a great quantity from it Conſequently ammonia is formed during the expoſure of ſemen to air ¶.

302 Its comp nent par

When oxy-muriatic acid is poured into ſemen, a number of white flakes precipitate, and the acid loſes its peculiar odour. Theſe flakes are inſoluble in water, and even in acids. If the quantity of acid be ſufficient, the ſemen acquires a yellow colour. Thus it appears that ſemen contains a mucilaginous ſubſtance, analogous to that of the tears, which coagulates by abſorbing oxygen. Mr Vauquelin obtained from 100 parts of ſemen ſix parts of this mucilage.

When ſemen is expoſed to the air about the temperature of 60°, it becomes gradually covered with a tranſparent pellicle, and in three or four days depoſites ſmall tranſparent cryſtals, often croſſing each other in ſuch a manner as to repreſent the ſpokes of a wheel. Theſe cryſtals, when viewed through a microſcope, appear to be four ſided priſms, terminated by very long four-ſided pyramids. They may be ſeparated by diluting the liquid with water, and decanting it off. They have all the properties of phoſphat of lime *. If, after the appearance of theſe cryſtals, the ſemen be ſtill allowed to remain expoſed to the atmoſphere, the pellicle on

---

(N) Mr Hatchett found only 0.268 of phoſphat of lime in the ſinovia which he examined. He found, however, traces of ſome other phoſphat; probably phoſphat of ſoda. *Phil. Tranſ.* 1799, p. 246.

† *Margueron, Ann. de Chim.* xiv. 126.

‡ *Ibid.* p 126—130.

§ *Ibid.* p. 127.

‖ *Ibid.* 125.

¶ *Ibid* 128

* *Vauquelin Ann de Chim.* ix 64.

† *Ibid.* p. 65.

‡ *Ibid.* p. 66.

§ *Ibid.* p. 70.

‖ *Ibid.* p. 71.

¶ *Ibid.* p. 71.

* *Ibid.* 67, and

on its ſurface gradually thickens, and a number of white round bodies appear on different parts of it. Theſe bodies alſo are phoſphat of lime, prevented from cryſtallizing regularly by the too rapid abſtraction of moiſture. Mr Vauquelin found that 100 parts of ſemen contain three parts of phoſphat of lime †. If at this period of the evaporation the air becomes moiſt, other cryſtals appear in the ſemen, which have the properties of carbonat of ſoda. The evaporation does not go on to complete exſiccation, unleſs at the temperature of 77°, and when the air is very dry. When all the moiſture is evaporated, the ſemen has loſt 0.9 of its weight, the reſiduum is ſemi-tranſparent like horn, and brittle ‡.

When ſemen is kept in very moiſt air, at the temperature of about 77°, it acquires a yellow colour, like that of the yolk of an egg; its taſte becomes acid, it exhales the odour of putrid fiſh, and its ſurface is covered with abundance of the byſſus ſeptica §

When dried ſemen is expoſed to heat in a crucible, it melts, acquires a brown colour, and exhales a yellow fume, having the odour of burnt horn. When the heat is raiſed, the matter ſwells, becomes black, and gives out a ſtrong odour of ammonia. When the odour of ammonia diſappears, if the matter be lixiviated with water, an alkaline ſolution may be obtained, which, by evaporation, yields cryſtals of carbonat of ſoda. Mr Vauquelin found that 100 parts of ſemen contain one part of ſoda ¶. If the reſiduum be incinerated, there will remain only a quantity of white aſhes, conſiſting of phoſphat of lime.

Thus it appears that ſemen is compoſed of the following ingredients:

90 water,
6 mucilage,
3 phoſphat of lime,
1 ſoda,

100

SECT. XV. *Liquor of the Amnios.*

The fœtus in the uterus is enveloped in a peculiar membranous covering, to which anatomiſts have given the name of *amnios*. Within this amnios there is a liquid, diſtinguiſhed by the name of the *liquor of the amnios*, which ſurrounds the fœtus on every part. This liquid, as might have been expected, is very different in different animals, at leaſt the liquor amnii in women and in cows, which alone have hitherto been analyſed, have not the ſmalleſt reſemblance to each other. Theſe two liquids have been lately analyſed by Vauquelin and Buniva, and the reſult of their analyſis has been publiſhed in the 33d volume of the *Annales de Chimie*.

1. The liquor of the amnios of women is a fluid of a ſlightly milky colour, a weak but pleaſant odour, and a ſaltiſh taſte. The white colour is owing to a curdy matter ſuſpended in it, for it may be obtained quite tranſparent by filtration *.

Its ſpecific gravity is 1.005. It gives a green colour to the tincture of violets and yet it reddens very decidedly the tincture of turnſol. Theſe two properties would indicate at once the preſence of an acid and of an alkali. It froths conſiderably when agitated. On the application of heat it becomes opaque, and has then a great reſemblance to milk diluted with a large quantity of water. At the ſame time it exhales the odour of boiled white of egg †.

Liquor of the Amnios.

Acids render it more tranſparent. Alkalies precipitate an animal matter in ſmall flakes. Alcohol likewiſe produces a flaky precipitate, which, when collected and dried, becomes tranſparent, and very like glue. The infuſion of nut galls produces a very copious brown coloured precipitate. Nitrat of ſilver occaſions a white precipitate, which is inſoluble in nitric acid, and conſequently is muriat of ſilver †.

When ſlowly evaporated it becomes ſlightly milky, a tranſparent pellicle forms on its ſurface, and it leaves a reſiduum which does not exceed 0.012 of the whole. By lixiviating this reſiduum, and evaporating the ley, cryſtals of muriat and carbonat of ſoda, may be obtained. The remainder, when incinerated, exhales a fetid and ammoniacal odour, reſembling that of burning horn; the aſhes conſiſt of a ſmall quantity of carbonat of ſoda, and of phoſphat and carbonat of lime ‡.

Thus we ſee that the liquor of the human amnios is compoſed of about

98.8 water,

$$1.2\left\{\begin{array}{l}\text{albumen,}\\ \text{muriat of ſoda, ſoda,}\\ \text{phoſphat of lime, lime,}\end{array}\right.$$

100.0

304
Curdy matter depoſited on the fœtus.

While the fœtus is in the uterus, a curdy-like matter is depoſited on the ſurface of its ſkin, and in particular parts of its body. This matter is often found collected in conſiderable quantities. It is evidently depoſited from the liquor of the amnios; and conſequently the knowledge of its peculiar nature muſt throw conſiderable light upon the properties and uſe of that liquor. For an analyſis of this ſubſtance we are alſo indebted to Vauquelin and Buniva.

Its colour is white and brilliant; it has a ſoft feel, and very much reſembles newly prepared ſoap. It is inſoluble in water, alcohol, and oils. Pure alkalies diſſolve part of it, and form with it a kind of ſoap. On burning coals it decrepitates like a ſalt, becomes dry and black, exhales vapours which have the odour of empyreumatic oil, and leaves a reſiduum which is very difficultly reduced to aſhes. When heated in a platinum crucible it decrepitates, lets an oil exſude, curls up like horn, and leaves a reſiduum, conſiſting chiefly of carbonat of lime ‡.

Theſe properties ſhew that this matter is different from every one of the component parts of the liquor of the amnios, and that it has a great reſemblance to the *fat*. It is probable, as Vauquelin and Buniva have conjectured, that it is formed from the albumen of that liquid, which has undergone ſome unknown changes. It has been long known, that the parts of a fœtus which has lain for ſome time after it has been deprived of life in the uterus, are ſometimes converted into a kind of fatty matter. It is evident that this ſubſtance, after it is depoſited upon the ſkin of the fœtus, muſt preſerve it in a great meaſure from being acted upon by the liquor of the amnios.

305
Liquor of the amnios of the cow.

2. The liquor of the amnios of the cow has a viſcidity ſimilar to mucilage of gum arabic, a browniſh red colour, an acid and bitter taſte, and a peculiar odour, not unlike that of ſome vegetable extracts. Its ſpecific gravity is 1.028. It reddens the tincture of turnſol, and

---

† Ann. de Chim. xxxiii. 271.

† Ibid.

‡ Ibid. p. 272.

‡ Ibid p. 274.

and therefore contains an acid. Muriat of barytes cauſes a very abundant precipitate, which renders it probable that it contains ſulphuric acid. Alcohol ſeparates from it a great quantity of a reddiſh coloured matter §.

306 Its component parts. When this liquid is evaporated, a thick frothy ſcum gathers on the ſurface, which is eaſily ſeparated, and in which ſome white acid-taſted cryſtals may be diſcovered. By continuing the evaporation, the matter becomes thick, and viſcid, and has very much the look of honey. Alcohol boiled upon this thick matter, and filtered off, depoſites upon cooling brilliant needle-formed cryſtals nearly an inch in length. Theſe cryſtals may be obtained in abundance by evaporating the liquor of the amnios to a fourth part of its bulk, and then allowing it to cool. The cryſtals ſoon make their appearance. They may be ſeparated and purified by waſhing them in a ſmall quantity of cold water. Theſe cryſtals have the properties of an acid §.

If after the ſeparation of this acid the liquor of the amnios be evaporated to the conſiſtence of a ſyrup, large tranſparent cryſtals appear in it, which have all the properties of ſulphat of ſoda. The liquid of the amnios of cows contains a conſiderable quantity of this ſalt.

Thus it appears that the liquor of the amnios of cows contains the following ingredients:

1. Water,
2. A peculiar animal matter,
3. A peculiar acid,
4. Sulphat of ſoda.

307 Nature of the animal matter. The animal matter poſſeſſes the following properties: It has a reddiſh brown colour, and a peculiar taſte; it is very ſoluble in water, but inſoluble in alcohol, which has the property of ſeparating it from water. When expoſed to a ſtrong heat it ſwells, exhales firſt the odour of burning gum, then of empyreumatic oil and of ammonia, and at laſt the peculiar odour of pruſſic acid becomes very conſpicuous. It differs from gelatine in the viſcidity which it communicates to water, in not forming a jelly when concentrated, and in not being precipitated by tan. It muſt be therefore ranked among the very undefined and inaccurate claſs of *animal mucilages*.

When burnt, it leaves a very large coal, which is readily incinerated, and leaves a little white aſhes, compoſed of phoſphat of magneſia, and a very ſmall proportion of phoſphat of lime ‖.

308 Amniotic acid. The acid ſubſtance is of a white and brilliant colour; its taſte has a very ſlight degree of ſourneſs; it reddens the tincture of turnſol; it is ſcarcely ſoluble in cold water, but very readily in hot water, from which it ſeparates in long needles as the ſolution cools. It is ſoluble alſo in alcohol, eſpecially when aſſiſted by heat. It combines readily with pure alkalies, and forms a ſubſtance which is very ſoluble in water. The other acids decompoſe this compound; and the acid of the liquor of the amnios is precipitated in a white cryſtalline powder. This acid does not decompoſe the alkaline carbonats at the temperature of the atmoſphere, but it does ſo when aſſiſted by heat. It does not alter ſolutions of ſilver, lead, or mercury, in nitric acid. When expoſed to a ſtrong heat, it froths and exhales an odour of ammonia and of pruſſic acid. The properties are ſufficient to ſhew that it is different from every other acid. Vauquelin and Boniva have given it the name of *amniotic acid*. It approaches neareſt to the ſaccholactic and the *uric* acids; but the ſachlactic acid does not furniſh ammonia by diſtillation like the amniotic. The uric acid is not ſo ſoluble in hot water as the amniotic, it does not cryſtallize in white brilliant needles, and it is inſoluble in boiling alcohol; in both which reſpects it differs completely from amniotic acid *.

SECT. XVI. *Of URINE.*

309 Urine, No animal ſubſtance has attracted more attention than urine, both on account of its ſuppoſed connection with various diſeaſes, and on account of the very ſingular products which have been obtained from it. Mr Boyle, and the other chemiſts who were his contemporaries, were induced to attend particularly to this liquid, by the diſcovery of a method of obtaining phoſphorus from it. Boerhaave, Haller, Haupt, Margraf, Pott, Rouelle, Prouſt, and Klaproth, ſucceſſively improved the method of obtaining the phoſphoric ſalts from urine, or added ſomething to our knowledge of the component parts of theſe ſalts. Scheele added greatly to our knowledge of urine by detecting ſeveral new ſubſtances in it which had not been ſuſpected. Cruickſhank has given us a very valuable paper on urine in the ſecond edition of *Rollo's Diabetes*; and Fourcroy and Vauquelin have lately publiſhed the moſt complete analyſis of it which has hitherto appeared.

Freſh urine is a liquid of a peculiar aromatic odour, an orange colour, of greater or leſs intenſity, and an acrid ſaline taſte.

Its ſpecific gravity varies from 1.005 to 1.033 *.

1. It reddens paper ſtained with turnſol and with the juice of radiſhes, and therefore contains an acid.

310 Contains phoſphat of lime, 2. If a ſolution of ammonia be poured into freſh urine, a white powder precipitates, which has the properties of phoſphat of lime. The preſence of this ſubſtance in urine was firſt diſcovered by Scheele †. If lime water be poured into urine, phoſphat of lime precipitates in greater abundance than when ammonia is uſed; conſequently the acid which urine contains is the phoſphoric. Thus we ſee that the phoſphat of lime is kept diſſolved in urine by an exceſs of acid. This alſo was firſt diſcovered by Scheele ‡. This ſubſtance is moſt abundant in the urine of the ſick. Berthollet has obſerved, that the urine of gouty people is leſs acid than that of people in perfect health. The average quantity of phoſphat of lime in healthy urine is, as Cruickſhank has aſcertained, about $\frac{1}{965}$ of the weight of the urine §.

311 Phoſphat of magneſia, 3. If the phoſphat of lime precipitated from urine be examined, a little magneſia will be found mixed with it. Fourcroy and Vauquelin have aſcertained that this is owing to a little phoſphat of magneſia which urine contains, and which is decompoſed by the alkali or lime employed to precipitate the phoſphat of lime ¶.

312 Uric acid, 4. When freſh urine cools, it often lets fall a brick coloured precipitate, which Scheele firſt aſcertained to be cryſtals of uric acid. All urine contains this acid, even when no ſenſible precipitate appears when it cools. For if a ſufficient quantity of clear and freſh urine be evaporated to $\frac{1}{178}$ of its weight, a ſubtle powder precipitates to the bottom, and attaches itſelf in part very firmly to the veſſel. This part may be diſſolved in pure alkali, and precipitated again by acetous acid. It exhibits all the properties of uric acid *. The quantity of uric acid in urine is very various. During intermittent

---

§ *Ann de Chim* xxxiii p. 275.

§ *Ibid* p. 276.

‖ *Ibid.* p. 278.

* *Ann. de Chim.* xxxiii. p. 279.

* *Cruickſhank, Phil. Mag.* ii. 240.

† *Scheele*, i. 208.

‡ *Ibid.*

§ *Phil Mag.* ii. 241.

¶ *Ann. de Chim* xxxi. 66.

* *Scheele*, i. 207.

termittent fevers it is depoſited very copiouſly, and has been long known to phyſicians under the name of *lateritious ſediment*. This ſediment always makes its appearance at the criſis of fevers. In gouty people, the ſame ſediment appears in equal abundance towards the end of a paroxyſm of the diſeaſe (P). And if this ſediment ſuddenly diſappears after it has begun to be depoſited, a freſh attack may be expected *.

13 5. If freſh urine be evaporated to the conſiſtence of a ſyrup, and muriatic acid be then poured into it, a precipitate appears which poſſeſſes the properties of benzoic acid. Scheele firſt diſcovered the preſence of benzoic acid in urine. He evaporated it to dryneſs, ſeparated the ſaline part, and applied heat to the reſiduum. The benzoic acid was ſublimed, and found cryſtallized in the receiver. The method which we have given is much eaſier; it was firſt propoſed by Fourcroy and Vauquelin †. By it very conſiderable quantities of benzoic acid may be obtained from the urine of horſes and cows, where it is much more abundant than in human urine. In human urine it varies from $\frac{1}{1000}$ to $\frac{1}{10000}$ of the whole §.

14 6. When an infuſion of tan is dropt into urine, a white precipitate appears, having the properties of the combination of tan and albumen, or gelatine. Urine, therefore, contains albumen and gelatine. Theſe ſubſtances had been ſuſpected to be in urine, but their preſence was firſt demonſtrated by Seguin, who diſcovered the above method of detecting them. Their quantity in healthy urine is very ſmall. Cruikſhank found that the precipitate afforded by tan in healthy urine amounted to $\frac{1}{240}$th part of the weight of the urine ‡. It is to theſe ſubſtances that the appearance of the *cloud*, as it is called, or the mucilaginous matter, which is ſometimes depoſited as the urine cools, is owing. It is probable that healthy urine contains only gelatine and not albumen, though the quantity is too ſmall to admit of accurate examination; but in many diſeaſes the quantity of theſe matters is very much increaſed. The urine of dropſical people often contains ſo much albumen, that it coagulates not only on the addition of acids, but even on the application of heat §. In all caſes of impaired digeſtion, the albuminous and gelatinous part of urine is much increaſed. This forms one of the moſt conſpicuous and important diſtinctions between the urine of thoſe who enjoy good and bad health ‖.

15 7. If urine be evaporated by a ſlow fire to the conſiſtence of a thick ſyrup, it aſſumes a deep brown colour, and exhales a fetid ammoniacal odour. When allowed to cool, it concretes into a maſs of cryſtals, compoſed of all the component parts of urine. If four times its weight of alcohol be poured upon this maſs, at intervals, and a ſlight heat be applied, the greateſt part of it is diſſolved. The alcohol, which has acquired a brown colour, is to be decanted off, and diſtilled in a crucible in a ſand heat, till the mixture has boiled for ſome time, and acquired the conſiſtence of a ſyrup. By this time the whole of the alcohol has paſſed off, and the matter, on cooling, cryſtallizes in quadrangular plates which interſect each other. This ſubſtance is *urea*, which compoſes $\frac{19}{20}$ of the urine, provided the watery part be excluded. To this ſubſtance the taſte, ſmell, and colour of urine are owing. It is a ſubſtance which characterizes urine, and conſtitutes it what it is, and to which the greater part of the very ſingular phenomena of urine are to be aſcribed.

The colour of urine depends upon the urea; the greater the quantity, the deeper is the colour. It may be detected by evaporating urine to the conſiſtence of a ſyrup, and pouring into it concentrated nitric acid. Immediately a great number of white ſhining cryſtals appear in the form of plates, very much reſembling cryſtallized boracic acid. Theſe cryſtals are urea combined with nitric acid.

The quantity of urea varies exceedingly in different urines. In the urine voided ſoon after a meal, very little of it is to be found, and ſcarcely any at all in that which hyſterical patients void during a paroxyſm.

316 Muriat of ſoda, 8. If urine be ſlowly evaporated to the conſiſtence of a ſyrup, a number of cryſtals make their appearance in it. Two of theſe are remarkable by their form: one of them conſiſts of ſmall regular octahedrons; which, when examined, are found to poſſeſs the properties of muriat of ſoda. Urine, therefore, contains muriat of ſoda. It is well known that muriat of ſoda cryſtallizes in cubes; the ſingular modification of its form in urine is owing to the action of urea. It has been long known that urine ſaturated with muriat of ſoda depoſites that ſalt in regular octahedrons.

317 Muriat of ammonia, 9. Another of the ſalts which appear during the evaporation of urine has the form of regular cubes. This ſalt has the properties of muriat of ammonia. Now the uſual form of the cryſtals of muriat of ammonia is the octahedron. The change of its form in urine is produced alſo by urea.

318 Phoſphat of ammonia and of ſoda, 10. The ſaline reſiduum which remains after the ſeparation of urea from cryſtallized urine by means of alcohol, has been long known under the names of fuſible ſalt of urine and microcoſmic ſalt. Various methods of obtaining it have been given by chemiſts from Boerhaave, who firſt publiſhed a proceſs, to Rouelle and Chaulnes, who gave the method juſt mentioned. If this ſaline maſs be diſſolved in a ſufficient quantity of hot water, and allowed to cryſtallize ſpontaneouſly in a cloſe veſſel, two ſets of cryſtals are gradually depoſited. The lowermoſt ſet has the figure of flat rhomboidal priſms; the uppermoſt, on the contrary, has the form of rectangular tables. Theſe two may be eaſily ſeparated by expoſing them for ſome time to a dry atmoſphere. The rectangular tables effloreſce and fall to powder, but the rhomboidal priſms remain unaltered.

When theſe ſalts are examined, they are found to have the properties of phoſphats. The rhomboidal priſms conſiſt of phoſphat of ammonia united to a little phoſphat of ſoda; the rectangular tables, on the contrary,

* uik- ſh, Phil. M. ii. 2

† n. de C. xxxi. 6

§ d. p. 6

‡ l. Mag. i. 3.

§ uik- ſh, ibid. 2

‖ urcroy Vau- , Ann. de im. x. 61.

(P) The concretions which ſometimes make their appearance in gouty joints have been found to conſiſt chiefly of uric acid. This ſingular coincidence deſerves the attention of phyſiologiſts: it cannot fail, ſooner or later, to throw light, not only upon gout, but upon ſome of the animal functions.

trary, are phoſphat of ſoda united to a ſmall quantity of phoſphat of ammonia. Urine, then, contains phoſphat of ſoda and phoſphat of ammonia.

Thus we have found that urine contains the twelve following ſubſtances:

1. Water,
2. Phoſphoric acid,
3. Phoſphat of lime,
4. Phoſphat of magneſia,
5. Uric acid,
6. Benzoic acid,
7. Gelatine and albumen,
8. Urea,
9. Muriat of ſoda,
10. Muriat of ammonia,
11. Phoſphat of ſoda,
12. Phoſphat of ammonia.

319 Sometimes other ſalts.

Theſe are the only ſubſtances which are conſtantly found in healthy urine [*]; but it contains alſo occaſionally other ſubſtances. Very often muriat of potaſs may be diſtinguiſhed among the cryſtals which form during its evaporation. The preſence of this ſalt may always be detected by dropping cautiouſly ſome tartarous acid into urine. If it contains muriat of potaſs, there will precipitate a little tartar, which may eaſily be recogniſed by its properties [*].

Urine ſometimes alſo contains ſulphat of ſoda, and even ſulphat of lime. The preſence of theſe ſalts may be aſcertained by pouring into urine a ſolution of muriat of barytes, a copious white precipitate appears, conſiſting of the barytes combined with phoſphoric acid, and with ſulphuric acid, if any be preſent. This precipitate muſt be treated with a ſufficient quantity of muriatic acid. The phoſphat of barytes is diſſolved, but the ſulphat of barytes remains unaltered [†].

320 Putrefaction of urine.

No ſubſtance putrefies ſooner, or exhales a more deteſtable odour during its ſpontaneous decompoſition, than urine; but there is a very great difference in this reſpect in different urines. In ſome, putrefaction takes place almoſt inſtantaneouſly as ſoon as it is voided; in others, ſcarcely any change appears for a number of days. Fourcroy and Vauquelin have aſcertained that this difference depends on the quantity of gelatine and albumen which urine contains. When there is very little of theſe ſubſtances preſent, urine remains long unchanged; on the contrary, the greater the quantity of gelatine or albumen, the ſooner does putrefaction commence. The putrefaction of urine, therefore, is, in ſome degree, the teſt of the health of the perſon who has voided it; for a ſuperabundance of gelatine in urine always indicates ſome defect in the power of digeſtion [*].

The rapid putrefaction of urine, then, is owing to the action of gelatine on urea. We have ſeen already the facility with which that ſingular ſubſtance is decompoſed, and that the new products into which it is changed are, ammonia, carbonic acid, and acetous acid. Accordingly, the putrefaction of urine is announced by an ammoniacal ſmell. Mucilaginous flakes are depoſited, conſiſting of part of the gelatinous matter. The phoſphoric acid is ſaturated with ammonia, and the phoſphat of lime, in conſequence, is precipitated. Ammonia combines with the phoſphat of magneſia, forms with it a triple ſalt, which cryſtallizes upon the ſides of the veſſel in the form of white cryſtals, compoſed of ſix-ſided priſms, terminated by ſix-ſided pyramids. The uric and benzoic acids are ſaturated with ammonia; the acetous acid, and the carbonic acid, which are the products of the decompoſition of the urea, are alſo ſaturated with ammonia, and notwithſtanding the quantity which exhales, the production of this ſubſtance is ſo abundant, that there is a quantity of unſaturated alkali in the liquid. Putrefied urine, therefore, contains chiefly the following ſubſtances, moſt of which are the products of putrefaction:

Ammonia,
Carbonat of ammonia,
Phoſphat of ammonia,
Phoſphat of magneſia and ammonia,
Urat of ammonia,
Acetite of ammonia,
Benzoat of ammonia,
Muriat of ſoda,
Muriat of ammonia;

Beſides the precipitated gelatine and phoſphat of lime [*].

The diſtillation of urine produces almoſt the ſame changes; for the heat of boiling water is ſufficient to decompoſe urea, and to convert it into ammonia, carbonic and acetous acids. Accordingly, when urine is diſtilled, there comes over water, containing ammonia diſſolved in it, and carbonat of ammonia in cryſtals. The acids contained in urine are ſaturated with ammonia, and the gelatine and phoſphat of lime precipitate [†].

Such are the properties of the human urine. The urine of other animals has not hitherto been examined with equal care; but it is certain that it differs very conſiderably from that of men. The urine of cows and horſes, and of all ruminating animals, for inſtance, contains carbonat of lime, without any mixture of phoſphat of lime [‡]. It contains alſo a much greater proportion of benzoic acid than that of man.

SECT. XVII. *Of the URINARY CALCULUS.*

It is well known that concretions not unfrequently form in the bladder, or the other urinary organs, and occaſion one of the moſt diſmal diſeaſes to which the human ſpecies is liable.

321 Urinary calculi

Theſe concretions were diſtinguiſhed by the name of *calculi*, from a ſuppoſition that they are of a ſtony nature. They have long attracted the attention of phyſicians. Chemiſtry had no ſooner made its way into medicine than it began to exerciſe its ingenuity upon the urinary calculus; and various theories were given of their nature and origin. According to Paracelſus, who gave them the ridiculous name of *duelech*, urinary calculi were intermediate between tartar and ſtone, and compoſed of an *animal reſin*. Van Helmont pronounced them anomalous coagulations, the offspring of the ſalts of urine, and of a volatile earthy ſpirit, produced at once, and deſtitute of any viſcid matter [§]. Boyle extracted from them, by diſtillation, oil, and a great quantity of volatile ſalt. Boerhaave ſuppoſed them compounds of oil and volatile ſalts. Hales extracted from them a prodigious quantity of air. He gave them the name of *animal tartar*, pointed out ſeveral circumſtances in which they reſemble common tartar, and made many experiments to find a ſolvent of them [*]. Drs Whytt and Alſton pointed out alkalies as ſolvents of calculi. It was an attempt to diſcover a more perfect ſolvent that induced Dr Black to make thoſe experiments which terminated in the diſcovery of the nature of the alkaline carbonats.

322 Analyſed by Scheele

Such was the ſtate of the chemical analyſis of calculus, when, in 1776, Scheele publiſhed a diſſertation on the ſubject in the *Stockholm Tranſactions*; which was ſucceeded by ſome remarks of Mr Bergmann. Theſe illuſtrious

---

[*] Fourcroy and Vauquelin, *Ann. de Chim.* xxxi. 69.

[*] Cruikſhank, *Phil. Mag.* ii, 241.

[†] Fourcroy, *Ann. de Chim.* vii. 183.

[*] *Ann de Chim.* xxxi. 61.

[*] *Ann. de Chim.* xxxi. 70.

[†] *Ibid*, 55.

[‡] *Vauquelin, ibid.* xxix. 4.

[§] *De Lithiaſi*, c. 3.

[*] *Veget. Stat.* ii. 189.

inary culus

illuſtrious chemiſts completely removed the uncertainty which had hitherto hung over the ſubject, and aſcertained the nature of the calculi which they examined. Since that time conſiderable additional light has been thrown upon the nature of theſe concretions by the labours of Auſtin, Pearſon, and, above all, of Fourcroy and Vauquelin, who have lately analyſed above 300 calculi, and aſcertained the preſence of ſeveral new ſubſtances which had not been ſuſpected. The ſubſtances hitherto diſcovered in urinary calculi are the following:

23 ir com ent s.

1. Uric acid,
2. Urat of ammonia,
3. Phoſphat of lime (q),
4. Phoſphat of magneſia-and-ammonia,
5. Oxalat of lime,
6. Silica,
7. An animal matter.

24 acid.

1. The greater number of calculi conſiſt of uric acid. All thoſe analyſed by Scheele were compoſed of it entirely. Of 300 calculi analyſed by Dr Pearſon, ſcarcely one was found which did not contain a conſiderable quantity of it, and the greater number manifeſtly were formed chiefly of it. Fourcroy and Vauquelin found it alſo in the greater number of the 300 calculi which they analyſed.

The preſence of this acid may eaſily be aſcertained by the following properties: A ſolution of potaſs or ſoda diſſolves it readily, and it is precipitated by the weakeſt acids. The precipitate is ſoluble in nitric acid, the ſolution is of a pink colour, and tinges the ſkin red *.

* ourcroy, . de n. xxxii.

325 at of ammonia.

2. Urat of ammonia is eaſily detected by its rapid ſolubility in fixed alkaline leys, and the odour of ammonia which is perceived during the ſolution. It is not ſo often preſent in urinary calculi as the laſt mentioned ſubſtance. No calculus has hitherto been found compoſed of it alone, except the very ſmall polygonal calculi, ſeveral of which ſometimes exiſt in the bladder together.

It is moſt uſually in thin layers, alternating with ſome other ſubſtance, very eaſily reduced to powder, and of the colour of ground coffee †.

† bid. 218.

326 ſphat ime.

3 Phoſphat of lime is white, without luſtre, fiery, friable, ſtains the hands, paper, and cloth. It has very much the appearance of chalk, breaks under the forceps, is inſipid, and inſoluble in water. It is ſoluble in nitric, muriatic, and acetous acids, and is again precipitated by ammonia, fixed alkalies, and oxalic acid.

It is never alone in calculi. It is intimately mixed with a gelatinous matter, which remains under the form of a membrane when the earthy part is diſſolved by very diluted acids ‡.

‡ bid.

327 ſphat magne- and-am- nia.

4. Phoſphat of magneſia-and-ammonia occurs in white, ſemitranſparent, lameller layers; ſometimes it is cryſtallized on the ſurface of the calculi in priſms, or what are called *dog tooth* cryſtals. It has a weak ſweetiſh taſte, it is ſomewhat ſoluble in water, and very ſoluble in acids, though greatly diluted. Fixed alkalies decompoſe it.

It never forms entire calculi. Sometimes it is mixed with phoſphat of lime, and ſometimes layers of it cover uric acid or oxalat of lime. It is mixed with the ſame gelatinous matter as phoſphat of lime ‡.

‡ Fourcroy, Ann. de Chim. xxxii. 219.

328 Oxalat of lime.

5. Oxalat of lime is found in certain calculi, which, from the inequality of their ſurface, have got the name of *moriform* or *mulberry ſhaped* calculi. It is never alone, but combined with a peculiar animal matter, and forming with it a very hard calculus, of a grey colour, difficult to ſaw aſunder, admitting a poliſh like ivory, exhaling, when ſawed, an odour like that of ſemen. Inſoluble and indecompoſible by alkalies; ſoluble in very diluted nitric acid, but ſlowly, and with difficulty. It may be decompoſed by the carbonats of potaſs and ſoda. When burnt, it leaves behind a quantity of pure lime, which may be eaſily recogniſed by its properties *.

* Ibid. 220.

329 Silica.

6. Silica has only been found in two inſtances by Fourcroy and Vauquelin, though they analyſed 300 calculi. No other chemiſt has obſerved it. It muſt therefore be conſidered as a very uncommon ingredient of theſe concretions. In the two inſtances in which it occurred, it was mixed with uric acid and the two phoſphats above mentioned †.

† Ibid. 221.

330 Animal matters.

7. *Animal matter* appears to compoſe the cement which binds the different particles of the calculus together, and in all probability it is the cauſe which influences its formation. It is different in different calculi. Sometimes it has the appearance of gelatine or albumen, at other times it reſembles urea. It deſerves a more accurate inveſtigation ‡.

‡ Ibid.

No general deſcription of the different calculi has hitherto appeared; but Fourcroy and Vauquelin are at preſent occupied with that ſubject. They propoſe to claſſify them according to their compoſition; to point out their different ſpecies and varieties; to give a method of detecting them by their appearance; to analyſe the animal matter by which they are cemented; and to apply all the preſent chemical knowledge of the ſubject in the inveſtigation of the cauſe, the ſymptoms, and the cure, of that dreadful diſeaſe which the urinary calculi produce. As their labour is already very far advanced, it would be unneceſſary for us to attempt any claſſification of calculi. Indeed every attempt of that kind, by any perſon who has not had an opportunity of analyſing a very great number of calculi, muſt be ſo exceedingly imperfect as ſcarcely to be of any uſe.

We ſhall ſatisfy ourſelves with the following remarks, deduced almoſt entirely from the obſervations which theſe celebrated chemiſts have already publiſhed.

331 Method of diſſolving the calculi.

Many calculi conſiſt entirely, or almoſt entirely, of uric acid. The animal matter, which ſerves as a cement to theſe calculi, appears to be urea. Calculi of this kind may be diſſolved by injecting into the bladder ſolutions of pure potaſs or ſoda, ſo much diluted as not to act upon the bladder itſelf. The gritty ſubſtance, which many perſons threatened with the ſtone diſcharge along with their urine, which has been called *gravel*, conſiſts almoſt conſtantly of uric acid. It may therefore ſerve as an indication that the ſubſequent ſtone, if any ſuch form, is probably compoſed of uric acid.

The two phoſphats, mixed together, ſometimes compoſe calculi. Theſe calculi are very brittle, and generally

---

(q) Brugnatelli found alſo phoſphat of lime, with exceſs of acid, in calculi. See *Ann. de Chim.* xxxii. 183.

rally break in pieces during the extraction. Such calculi may be diſſolved by injecting into the bladder muriatic acid, ſo much diluted as ſcarcely to have any taſte of acid.

The phoſphats never form the nucleus of a calculus. They have never been found covered with a layer of uric acid, but they often cover that acid. Hence it would ſeem that the exiſtence of any extraneous matter in the bladder diſpoſes theſe phoſphats to cryſtallize. When extraneous bodies are accidentally introduced into the bladder, and allowed to lodge there, they are conſtantly covered with a coat of phoſphat of ammonia and magneſia, or of the two phoſphats mixed.

As the phoſphat of ammonia and magneſia is not an ingredient of freſh urine, but formed during its putrefaction, when it exiſts in calculi, it would ſeem to indicate a commencement of putrefaction during the time that the urine lodges in the bladder. But putrefaction does not take place ſpeedily in urine, unleſs where there is an exceſs of albumen and gelatine; conſequently we have reaſon to ſuppoſe, that theſe ſubſtances are morbidly abundant in the urine of thoſe patients who are afflicted with calculi conſiſting of the phoſphats: hence alſo we may conclude, that their digeſtion is imperfect. It will no doubt be objected, that dropſical people are not peculiarly ſubject to calculi; but their urine is only morbidly albuminous when the diſeaſe is beginning to diſappear, and then there ſeems to be a deficiency of urea; at leaſt their urine has not been obſerved to putrefy with uncommon rapidity. Beſides, there ſeems to be ſome animal matter preſent, which ſerves as a cement to the phoſphat in all caſes where calculi form.

Urat of ammonia is only found alone in the very ſmall polygonous calculi which exiſt, ſeveral together, in the bladder. In other caſes it is mixed with uric acid. It ſometimes alternates with uric acid or with the phoſphats. It is diſſolved by the ſame ſubſtance that acts as a ſolvent of uric acid.

Oxalat of lime often forms the nucleus of calculi compoſed of layers of uric acid or of the phoſphats. It forms thoſe irregular calculi which are called *moriform*. Theſe calculi are the hardeſt and the moſt difficult of ſolution. A very much diluted nitric acid diſſolves them but very ſlowly. As oxalic acid does not exiſt in urine, ſome morbid change muſt take place in the urine when ſuch calculi are depoſited. Brugnatelli's diſcovery of the inſtantaneous converſion of uric acid into oxalic acid by oxy-muriatic acid, which has been confirmed by the experiments of Fourcroy and Vauquelin, throws conſiderable light upon the formation of oxalic acid in urine, by ſhewing us that uric acid is probably the baſis of it; but in what manner the change is actually produced, it is not ſo eaſy to ſay.

The calculi found in the bladder of other animals have not been examined with the ſame care. Some of them, however, have been ſubjected to an accurate analyſis. No uric acid has ever been found in any of them.

332
Calculi of inferior animals.

Fourcroy found a calculus extracted from the kidney of a horſe compoſed of three parts of carbonat of lime, and one part phoſphat of lime *. Dr Pearſon examined a urinary calculus of a horſe; it was compoſed of phoſphat of lime and phoſphat of ammonia. Brugnatelli found a calculus extracted from the bladder of a ſow, which was exceedingly hard, compoſed of pure carbonat of lime, incloſing a ſoft nucleus of a fœtid and urinous odour †. Bartholdi examined another calculus of a pig, the ſpecific gravity of which was 1.9200. It conſiſted of phoſphat of lime ‡. Dr Pearſon found a calculus taken from the bladder of a dog compoſed of phoſphat of lime, phoſphat of ammonia, and an animal matter. He found the urinary calculus of a rabbit, of the ſpecific gravity 2, compoſed of carbonat of lime and ſome animal matter ||.

The compoſition of the different animal concretions hitherto examined may be ſeen in the following table.

Horſe.	1. Carbonat of lime and phoſphat of lime *.	* Fourcroy.
	2. Phoſph. of lime and phoſph. of ammonia †.	† Pearſon.
	3. Carbon. of lime and animal matter †.	
Sow.	1. Carbon. of lime and an animal nucleus ‡.	‡ Brugnatelli
	2. Phoſphat of lime ¶.	¶ Bartholdi.
Dog.	Phoſphat of lime, and of ammonia, and animal matter †.	† Pearſon.
Rabbit.	Carbonat of lime and animal matter †.	

We have now given an account of all thoſe ſecretions which have been attentively examined by chemiſts. The remainder have been hitherto neglected; partly owing to the difficulty of procuring them, and partly on account of the multiplicity of other objects which occupied the attention of chemical philoſophers (R). It remains for us now to examine by what proceſſes theſe different ſecretions are formed, how the conſtant waſte of living bodies is repaired, and how the organs themſelves are nouriſhed and preſerved. This ſhall form the ſubject of the following chapter.

CHAP. III. OF THE FUNCTIONS OF ANIMALS.

The intention of the two laſt chapters was to exhibit a view of the different ſubſtances which enter into the compoſition of animals, as far as the preſent limited ſtate of our knowledge puts it in our power. But were our enquiries concerning animals confined to the mere ingredients of which their bodies are compoſed, even ſuppoſing the analyſis as complete as poſſible, our knowledge of the nature and properties of animals would be imperfect indeed.

How are theſe ſubſtances arranged? How are they produced?

---

* Ann. de Chim. xvi, 95.

† Ibid. xxxii. 184.

‡ Ibid. 185.

|| Phil. Mag. ii. 134.

(R) The chief of theſe ſecretions are the following:

1. Cerumen, or ear-wax, is at firſt nearly liquid, and of a whitiſh colour. It gradually acquires conſiſtence. Its taſte is very bitter. Said to be inſoluble in alcohol; but ſoluble in hot water. Does not become rancid by keeping.
2. The humours of the eye.
3. The milky liquor, ſecreted by the thyroid gland.
4. Mucus of the lungs, inteſtinal canal, &c.
5. Smegma of the areola of the breaſts, glans penis, vagina, ſubcutaneous glands, &c.
6. Marrow.

Fu ions of A mals.

produced? What purpoſes do they ſerve? What are the diſtinguiſhing properties of animals, and the laws by which they are regulated?

3
Ani ls reſe le veg bles

Animals reſemble vegetables in the complexneſs of their ſtructure. Like them, they are machines nicely adapted for particular purpoſes, conſtituting one whole, and continually performing an infinite number of the moſt delicate proceſſes. But neither an account of the ſtructure of animals, nor of the properties which diſtinguiſh them from other beings, will be expected here. Theſe have been already treated of ſufficiently in the articles ANATOMY and PHYSIOLOGY (*Encycl.*), to which we beg leave to refer the reader. We mean only, in the preſent chapter, to take a view of thoſe proceſſes which are concerned in the *production* of animal ſubſtances, which alone properly belong to chemiſtry. The other functions are regulated by laws of a very different nature, which have no reſemblance or analogy to the laws of chemiſtry or mechanics.

4
Re ire foc

1. Every body knows that animals require food, and that they die ſooner or later if food be withheld from them. There is indeed a very great difference in different animals, with regard to the quantity of food which they require, and the time which they can paſs without it. In general, this difference depends upon the activity of the animal. Thoſe which are moſt active require moſt, and thoſe which move leaſt require leaſt food.

The cauſe of this is alſo well known; the bodies of animals do not remain ſtationary, they are conſtantly waſting; and the waſte is generally proportional to the activity of the animal. It is evident, then, that the body muſt receive, from time to time, new ſupplies, in place of what has been carried off. Hence the uſe of food, which anſwers this purpoſe.

5
Iti ture.

2. We are much better acquainted with the food of animals than of vegetables. It conſiſts of almoſt all the animal and vegetable ſubſtances which have been treated of in the former part of this article; for there are but very few of them which ſome animal or other does not uſe as food. Man uſes as food chiefly the muſcles of animals, the feeds of certain graſſes, and a variety of vegetable fruits. Almoſt all the inferior animals have particular ſubſtances on which they feed excluſively. Some of them feed on animals, others on vegetables. Man has a greater range; he can feed on a very great number of ſubſtances. To enumerate theſe ſubſtances would be uſeleſs; as we are not able to point out with accuracy what it is which renders one ſubſtance more nouriſhing than another.

Many ſubſtances do not ſerve as nouriſhment at all; and not a few, inſtead of nouriſhing, deſtroy life. Theſe laſt are called *poiſons*. Some poiſons act chemically, by decompoſing the animal body. The action of others is not ſo well underſtood.

36
C verted i chyme

3. The food is introduced into the body by the mouth, and almoſt all animals reduce it to a kind of pulpy conſiſtence. In man and many other animals this is done in the mouth by means of teeth, and the ſaliva with which it is there mixed; but many other animals grind their food in a different manner. See PHYSIOLOGY, (*Encycl.*) After the food has been thus ground, it is introduced into the ſtomach, where it is ſubjected to new changes. The ſtomach is a ſtrong ſoft bag, of different forms in different animals: in man it has ſome reſemblance to the bag of a *bag-pipe*. In this organ the food is converted into a ſoft pap, which has no reſemblance to the food when firſt introduced. This pap has been called *chyme*.

Functions of Animals.

4. Since chyme poſſeſſes new properties, it is evident that the food has undergone ſome changes in the ſtomach, and that the ingredients of which it was compoſed have entered into new combinations. Now, in what manner have theſe changes been produced?

At firſt they were aſcribed to the mechanical action of the ſtomach. The food, it was ſaid, was ſtill farther triturated in that organ; and being long agitated backwards and forwards in it, was at laſt reduced to a pulp. But this opinion, upon examination, was found not to be true. The experiments of Stevens, Reaumur, and Spallanzani, demonſtrated, that the formation of chyme is not owing to trituration; for on incloſing different kinds of food in metallic tubes and balls full of holes, in ſuch a manner as to ſcreen them from the mechanical action of the ſtomach, they found, that theſe ſubſtances, after having remained a ſufficient time in the ſtomach, were converted into chyme, juſt as if they had not been incloſed in ſuch tubes. Indeed, the opinion was untenable, even independent of theſe deciſive experiments, the moment it was perceived that chyme differed entirely from the food which had been taken: that is to ſay, that if the ſame food were triturated mechanically out of the body, and reduced to pap of preciſely the ſame conſiſtence with chyme, it would not poſſeſs the ſame properties with chyme; for whenever this fact was known, it could not but be evident that the food had undergone changes in its compoſition.

The change of food into chyme, therefore, was aſcribed by many to *fermentation*. This opinion is indeed very ancient, and it has had many zealous ſupporters among the moderns. When the word *fermentation* was applied to the change produced on the food in the ſtomach, the nature of the proceſs called fermentation was altogether unknown. The appearances, indeed, which take place during that proceſs, had been deſcribed, and the progreſs and the reſult of it were known. Chemiſts had even divided fermentations into different claſſes; but no attempt had been made to explain the cauſe of fermentation, or to trace the changes which take place during its continuance. All that could be meant, then, by ſaying that the converſion of food into chyme in the ſtomach was owing to fermentation, was merely, that the unknown cauſe which acted during the converſion of vegetable ſubſtances into wine or acid, or during their putrefaction, acted alſo during the converſion of the food into chyme, and that the reſult in both caſes was preciſely the ſame. Accordingly, the advocates for this opinion attempted to prove, that air was conſtantly generated in the ſtomach, and that an acid was conſtantly produced: for it was the vinous and acetous fermentations which were aſſigned by the greater number of phyſiologiſts as the cauſe of the formation of chyme. Some indeed attempted to prove, that it was produced by the putrefactive fermentation; but their number was inconſiderable, compared with thoſe who adopted the other opinion.

Our ideas reſpecting fermentation are now ſomewhat more preciſe. It ſignifies a ſlow decompoſition, which takes place when certain animal or vegetable ſubſtances are mixed together at a given temperature; and the

conſequent

conſequent production of particular compounds. If therefore the converſion of the food into chyme be owing to fermentation, it is evident that it is totally independent of the ſtomach any farther than as it ſupplies temperature; and that the food would be converted into chyme exactly in the ſame manner, if it were reduced to the ſame conſiſtence, and placed in the ſame temperature out of the body. But this is by no means the caſe; ſubſtances are reduced to the ſtate of chyme in a ſhort time in the ſtomach, which would remain unaltered for weeks in the ſame temperature out of the body. This is the caſe with bones; which the experiments of Stevens and Spallanzani have ſhewn to be ſoon digeſted in the ſtomach of the dog. Further, if the converſion of food into chyme were owing to fermentation, it ought to go on equally well in the ſtomach and œſophagus. Now, it was obſerved long ago by Ray and Boyle, that when voracious fiſh had ſwallowed animals too large to be contained in the ſtomach, that part only which was in the ſtomach was converted into chyme, while what was in the œſophagus remained entire; and this has been fully confirmed by ſubſequent obſervations.

Still farther, if the converſion were owing to fermentation, it ought always to take place equally well, provided the temperature be the ſame, whether the ſtomach be in a healthy ſtate or not. But it is well known, that this is not the caſe. The formation of chyme depends very much on the ſtate of the ſtomach. When that organ is diſeaſed, digeſtion is conſtantly ill performed. In theſe caſes, indeed, fermentation ſometimes appears, and produces flatulence, acid eructations, &c. which are the well-known ſymptoms of indigeſtion. Theſe facts have been long known; they are totally incompatible with the ſuppoſition, that the formation of chyme is owing to fermentation Accordingly that opinion has been for ſome time abandoned, by all thoſe at leaſt who have taken the trouble to examine the ſubject.

337 By the action of the gaſtric juice.

The formation of chyme, then, is owing to the ſtomach; and it has been concluded, from the experiments of Stevens, Reaumur, Spallanzani, Scopoli, Brugnatelli, Carimini, &c. that its formation is brought about by the action of a particular liquid ſecreted by the ſtomach, and for that reaſon called *gaſtric juice*.

That it is owing to the action of a liquid, is evident; becauſe if pieces of food be incloſed in cloſe tubes, they paſs through the ſtomach without any farther alteration than would have taken place at the ſame temperature out of the body: but if the tubes be perforated with ſmall holes, the food is converted into chyme.

This liquid does not act indiſcriminately upon all ſubſtances: For if grains of corn be put into a perforated tube, and a granivorous bird be made to ſwallow it, the corn will remain the uſual time in the ſtomach without alteration; whereas if the huſk of the grain be previouſly taken off, the whole of it will be converted into chyme. It is well known, too, that many ſubſtances paſs unaltered through the inteſtines of animals, and conſequently are not acted upon by the gaſtric juice. This is the caſe frequently with grains of oats when they have been ſwallowed by horſes entire with their huſks on. This is the caſe alſo with the ſeeds of apples, &c. when ſwallowed entire by men; yet theſe very ſubſtances, if they have been previouſly ground ſufficiently by the teeth, are digeſted. It appears, therefore, that it is chiefly the huſk or outſide of theſe ſubſtances which reſiſts the action of the gaſtric juice. We ſee alſo, that trituration greatly facilitates the converſion of food into chyme

338 Nature of gaſtric juice.

The gaſtric juice is not the ſame in all animals; for many animals cannot digeſt the food on which others live. The *conium maculatum* (hemlock), for inſtance, is a poiſon to man inſtead of food, yet the goat often feeds upon it. Many animals, as ſheep, live wholly upon vegetables; and if they are made to feed on animals, their ſtomachs will not digeſt them: others, again, as the eagle, feed wholly on animal ſubſtances, and cannot digeſt vegetables.

The gaſtric juice does not continue always of the ſame nature, even in the ſame animal: it changes gradually, according to circumſtances. Graminivorous animals may be brought to live on animal food; and after they have been accuſtomed to this for ſome time, their ſtomachs become incapable of digeſting vegetables. On the other hand, thoſe animals which naturally digeſt nothing but animal food may be brought to digeſt vegetables.

What is the nature of the gaſtric juice, which poſſeſſes theſe ſingular properties? It is evidently different in different animals; but it is a very difficult taſk, if not an impoſſible one, to obtain it in a ſtate of purity. Various attempts have indeed been made by very ingenious philoſophers to procure it; but their analyſis of it is ſufficient to ſhew us, that they have never obtained it in a ſtate of purity.

The methods which have been uſed to procure gaſtric juice are, *firſt*, to kill the animal whoſe gaſtric juice is to be examined after it has faſted for ſome time. By this method, Spallanzani collected 37 ſpoonfuls from the two firſt ſtomachs of a ſheep. It was of a green colour, undoubtedly owing to the graſs which the animal had eaten. He found alſo half a ſpoonful in the ſtomach of ſome young crows which he killed before they had left their neſt.

Small tubes of metal, pierced with holes, and containing a dry ſponge, have been ſwallowed by animals; and when vomited up, the liquid imbibed by the ſponge is ſqueezed out. By this method, Spallanzani collected 481 grains of gaſtric juice from the ſtomachs of five crows.

A *third* method conſiſts in exciting vomiting in the morning, when the ſtomach is without food. Spallanzani tried this method twice upon himſelf, and collected one of the times 1 oz. 32 gr. of liquid; but the pain was ſo great, that he did not think proper to try the experiment a third time. Mr Goſſe, however, who could excite vomiting whenever he thought proper by ſwallowing air, has employed that method to collect gaſtric juice.

Spallanzani has obſerved, that eagles throw up every morning a quantity of liquid, which he conſiders as gaſtric juice; and he has availed himſelf of this to collect it in conſiderable quantities.

It is almoſt unneceſſary to remark how imperfect theſe different methods are, and how far every concluſion drawn from the examination of ſuch juices muſt deviate from the truth. It is impoſſible that the gaſtric juice, obtained by any one of theſe proceſſes, can be pure; becauſe in the ſtomach it muſt be conſtantly

mixed

mixed with large quantities of ſaliva, mucus, bile, food, &c. It may be queſtioned, indeed, whether any gaſtric juice at all can be obtained by theſe methods: for as the intention of the gaſtric juice is to convert the food into chyme, in all probability it is only ſecreted, or at leaſt thrown into the ſtomach when food is preſent.

We need not be ſurpriſed, then, at the contradictory accounts concerning its nature, given us by thoſe philoſophers who have attempted to examine it; as theſe relate not ſo much to the gaſtric juice, as to the different ſubſtances found in the ſtomach. The idea that the gaſtric juice can be obtained by vomiting, or that it is thrown up ſpontaneouſly by ſome animals, is, to ſay the leaſt of it, very far from being probable.

According to Brugnatelli, the gaſtric juice of carnivorous animals, as hawks, kites, &c. has an acid and reſinous odour, is very bitter, and not at all watery; and is compoſed of an uncombined acid, a reſin, an animal ſubſtance, and a ſmall quantity of muriat of ſoda *. The gaſtric juice of herbivorous animals, on the contrary, as goats, ſheep, &c. is very watery, a little muddy, has a bitter ſaltiſh taſte, and contains ammonia, an animal extract, and a pretty large quantity of muriat of ſoda †. Mr Carminati found the ſame ingredients; but he ſuppoſes that the ammonia had been formed by the putrefaction of a part of their food, and that in reality the gaſtric juice of theſe animals is of an acid nature ‡.

The accounts which have been given of the gaſtric juice of man are ſo various, that it is not worth while to tranſcribe them. Sometimes it has been found of an acid nature, at other times not. The experiments of Spallanzani are ſufficient to ſhew, that this acidity is not owing to the gaſtric juice, but to the food. He never found any acidity in the gaſtric juice of birds of prey, nor of ſerpents, frogs, and fiſhes. Crows gave an acidulous gaſtric juice only when fed on grain; and he found that the ſame obſervation holds with reſpect to dogs, herbiverous animals, and domeſtic fowls. Carnivorous birds threw up pieces of ſhells and coral without alteration; but theſe ſubſtances were ſenſibly diminiſhed in the ſtomachs of hens, even when incloſed in perforated tubes. Spallanzani himſelf ſwallowed calcareous ſubſtances incloſed in tubes; and when he fed on vegetables and fruits, they were ſometimes altered and a little diminiſhed in weight, juſt as if they had been put into weak vinegar; but when he uſed only animal food, they came out untouched. According to this philoſopher, whoſe experiments have been by far the moſt numerous, the gaſtric juice is naturally neither acid nor alkaline. When poured on the carbonat of potaſs, it cauſes no efferveſcence.

Such are the reſults of the experiments on the juices taken from the ſtomach of animals. No concluſion can be drawn from them reſpecting the nature of the gaſtric juice. But from the experiments which have been made on the digeſtion of the ſtomach, eſpecially by Spallanzani, the following facts are eſtabliſhed.

The gaſtric juice attacks the ſurfaces of bodies, unites to the particles of them which it carries off, and cannot be ſeparated from them by filtration. It operates with more energy and rapidity the more the food is divided, and its action is increaſed by a warm temperature. The food is not merely reduced to very minute parts; its taſte and ſmell are quite changed; its ſenſible properties are deſtroyed, and it acquires new and very different ones. This juice does not act as a ferment; ſo far from it, that it is a powerful antiſeptic, and even reſtores fleſh already putrefied. There is not the ſmalleſt appearance of ſuch a proceſs; indeed, when the juice is renewed frequently, as in the ſtomach, ſubſtances diſſolve in it with a rapidity which excludes all idea of fermentation. Only a few air bubbles make their eſcape, which adhere to the alimentary matter, and buoy it up to the top, and which are probably extricated by the heat of the ſolution.

With reſpect to the ſubſtances contained in the ſtomach, only two facts have been perfectly aſcertained: The firſt is, that the juice contained in the ſtomach of oxen, calves, ſheep, invariably contains uncombined phoſphoric acid, as Macquart and Vauquelin have demonſtrated: The ſecond, that the juice contained in the ſtomach, and even the inner coat of the ſtomach itſelf, has the property of coagulating milk and the ſerum of blood. Dr Young found, that ſeven grains of the inner coat of a calf's ſtomach, infuſed in water, gave a liquid which coagulated more than 100 ounces of milk; that is to ſay, more than 6857 times its own weight; and yet, in all probability, its weight was not much diminiſhed.

What the ſubſtance is which poſſeſſes this coagulating property, has not yet been aſcertained; but it is evidently not very ſoluble in water: for the inſide of a calf's ſtomach, after being ſteeped in water for ſix hours, and then well waſhed with water, ſtill furniſhes a liquor on infuſion which coagulates milk *: And Dr Young found, that a piece of the inner coat of the ſtomach, after being previouſly waſhed with water, and then with a diluted ſolution of carbonat of potaſs, ſtill afforded a liquid which coagulated milk and ſerum.

It is evident, from theſe facts, that this coagulating ſubſtance, whatever it is, acts very powerfully; and that it is ſcarcely poſſible to ſeparate it completely from the ſtomach. But we know at preſent too little of the nature of coagulation to be able to draw any inference from theſe facts. An almoſt imperceptible quantity of ſome ſubſtances ſeems to be ſufficient to coagulate milk. For Mr Vaillant mentions in his Travels in Africa, that a porcelain diſh which he procured, and which had lain for ſome years at the bottom of the ſea, poſſeſſed, in conſequence, the property of coagulating milk when put into it; yet it communicated no taſte to the milk, and did not differ in appearance from other cups.

It is probable that the ſaliva is of ſervice in the converſion of food into chyme as well as the gaſtric juice. It evidently ſerves to dilute the food; and probably it may be ſerviceable alſo, by communicating oxygen.

339. Chyme converted into chyle and excrement.

5. The chyme, thus formed, paſſes from the ſtomach into the inteſtines, where it is ſubjected to new changes, and at laſt converted into two very different ſubſtances; chyle and excrementitious matter.

6. The *chyle* is a white coloured liquid, very much reſembling milk. It is exceedingly difficult to collect it in any conſiderable quantity, and for that reaſon it has never been accurately analyſed. We know only in general that it reſembles milk; containing, like it, an albuminous part capable of being coagulated, a ſerum, and globules which have a reſemblance to cream †. It contains alſo different ſalts; and, according to ſome, a ſubſtance ſcarcely differing from the ſugar of milk. It is probable alſo that it contains iron; but if ſo, it muſt be

---

* opoli's quer's D

† d.

‡ rebier's rvat. aſtric j e.

* *Young.*

† *Fordyce on Digeſtion*, 121.

be in the ſtate of a white oxyd; for an infuſion of nut galls does not alter the colour of chyle ‡.

6. Concerning the proceſs by which chyle is formed from chyme, ſcarcely any thing is known. It does not appear that the chyme is preciſely the ſame in all animals; for thoſe which are herbivorous have a greater length of inteſtine than thoſe which are carnivorous. It is certain that the formation of the chyle is brought about by a chemical change, although we cannot ſay preciſely what that change is, or what the agents are by which it is produced. But that the change is chemical, is evident, becauſe the chyle is entirely different, both in its properties and appearance, from the chyme. The chyme, by the action of the inteſtines, is ſeparated into two parts, chyle and excrement: the firſt of which is abſorbed by a number of ſmall veſſels called *lacteals*; the ſecond is puſhed along the inteſtinal canal, and at laſt thrown out of the body altogether.

After the chyme has been converted into chyle and excrement, although theſe two ſubſtances remain mixed together, it does not appear that they are able to decompoſe each other; for perſons have been known ſeldom or never to emit any excrementitious matter *per anum* for years. In theſe, not only the chyle, but the excrementitious matter alſo, was abſorbed by the lacteals; and the excrement was afterwards thrown out of the body by other outlets, particularly by the ſkin; in conſequence of which, thoſe perſons have conſtantly that particular odour about them which diſtinguiſhes excrement. Now in theſe perſons, it is evident that the chyle and excrement, though mixed together, and even abſorbed together, did not act on each other; becauſe theſe perſons have been known to enjoy good health for years, which could not have been the caſe had the chyle been deſtroyed.

340
Uſe of bile.

7. It has been ſuppoſed by ſome that the decompoſition of the chyme, and the formation of chyle, is produced by the agency of the bile, which is poured out abundantly, and mixed with the chyme, ſoon after its entrance into the inteſtines. If this theory were true, no chyle could be formed whenever any accident prevented the bile from paſſing into the inteſtinal canal: but this is obviouſly not true; for frequent inſtances have occurred of perſons labouring under jaundice from the bile ducts being ſtopped, either by gallſtones or ſome other cauſe, ſo completely, that no bile could paſs into the inteſtines; yet theſe perſons have lived for a conſiderable time in that ſtate. Conſequently digeſtion, and therefore the formation of chyle, muſt be poſſible, independent of bile.

The principal uſe of the bile ſeems to be to ſeparate the excrement from the chyle, after both have been formed, and to produce the evacuation of the excrement out of the body. It is probable that theſe ſubſtances would remain mixed together, and that they would perhaps even be partly abſorbed together, were it not for the bile, which ſeems to combine with the excrement, and by this combination to facilitate its ſeparation from the chyle, and thus to prevent its abſorption. It alſo ſtimulates the inteſtinal canal, and cauſes it to evacuate its contents ſooner than it otherwiſe would do; for when there is a deficiency of bile, the body is conſtantly coſtive.

341
Of the excrementitious matter.

8. The excrement, then, which is evacuated *per anum*, conſiſts of all that part of the food and chyme which was not converted into chyle, entirely altered however from its original ſtate, partly by the decompoſition which it underwent in the ſtomach and inteſtines, and partly by its combination with bile. Accordingly we find in it many ſubſtances which did not exiſt at all in the food. Thus in the dung of cows and horſes there is found a very conſiderable quantity of benzoic acid. The excrements of animals have not yet been ſubjected to an accurate analyſis, though ſuch an analyſis would throw much light upon the nature of digeſtion. For if we knew accurately the ſubſtances which were taken into the body as food, and all the new ſubſtances which were formed by digeſtion; that is to ſay, the component parts of chyle and of excrement, and the variation which different kinds of food produce in the excrement, it would be a very conſiderable ſtep towards aſcertaining preciſely the changes produced on food by digeſtion, or, which is the ſame thing, towards aſcertaining exactly the phenomena of digeſtion. The only analyſis which has hitherto been made on human excrement is that of Homberg; and as it conſiſted merely in ſubjecting it to diſtillation, it is needleſs to give an account of it. Of late, as Mr Fourcroy informs us, the ſubject has been reſumed in France, and we may ſoon expect ſome very curious and important additions to our knowledge.

342
Excrements of fowls.

Mr Vauquelin has already publiſhed an analyſis of the fixed parts of the excrements of fowls, and a compariſon of them with the fixed parts of the food; from which ſome very curious conſequences may be deduced.

He found that a hen devoured in ten days 11111.843 grains troy of oats. Theſe contained

136.509	gr. of phoſphat of lime,
219.548	ſilica,
356.057.	

During theſe ten days ſhe layed four eggs; the ſhells of which contained 98.776 gr. phoſphat of lime, and 453.417 gr. carbonat of lime. The excrements emitted during theſe ten days contained 175.529 gr. phoſphat of lime, 58.494 gr. of carbonate of lime, and 185.266 gr. of ſilica. Conſequently the fixed parts thrown out of the ſyſtem during theſe ten days amounted to

	Grains.	
	274.305	phoſphat of lime,
	511.911	carbonat of lime,
	185.266	ſilica,
Given out	971.482	
Taken in	356.057	
	615.425	

Conſequently the quantity of fixed matter given out of the ſyſtem in ten days exceeded the quantity taken in by 615.425 grains.

The ſilica taken in amounted to	219.548 gr.
That given out was only	185.266 gr.
Remains	34.282

Conſequently there diſappeared 34.282 grains of ſilica.

The phoſphat of lime taken in was	136.509 gr.
That given out was	274.305 gr.
	137.796

Conſequently

---

‡ Fordyce on *Digeſtion*, 122.

Conſequently there muſt have been formed, by digeſtion in this fowl, no leſs than 137.796 grains of phoſphat of lime, beſides 511.911 grains of carbonat. Conſequently lime (and perhaps alſo phoſphorus) is not a ſimple ſubſtance, but a compound, and formed of ingredients which exiſt in oat-ſeed, water, or air, the only ſubſtance to which the fowl had acceſs. Silica may enter into its compoſition, as a part of the ſilica had diſappeared ; but if ſo, it muſt be combined with a great quantity of ſome other ſubſtance *.

Theſe conſequences are too important to be admitted without a very rigorous examination. The experiment muſt be repeated frequently, and we muſt be abſolutely certain that the hen has no acceſs to any calcareous earth, and that ſhe has not diminiſhed in weight ; becauſe in that caſe ſome of the calcareous earth, of which part of her body is compoſed, may have been employed. This rigour is the more neceſſary, as it ſeems pretty evident, from experiments made long ago, that *ſome* birds at leaſt, cannot produce eggs unleſs they have acceſs to calcareous earth. Dr Fordyce found, that if the canary-bird was not ſupplied with lime at the time of her laying, ſhe frequently died, from her eggs not coming forward properly †. He divided a number of theſe birds at the time of their laying eggs into two parties : to the one he gave a piece of old mortar, which the little animals ſwallowed greedily ; they laid their eggs as uſual, and all of them lived : whereas many of the other party, which were ſupplied with no lime, died ‡.

[342] 9. The inteſtines ſeldom or never are deſtitute of gaſes, which ſeem to be evolved during the proceſs of digeſtion ; and may therefore, in part, be conſidered as excrementitious matter. The only perſon who has examined theſe gaſes with care, is Mr Jurine of Geneva. The reſult of his analyſis is as follows. He found in the ſtomach and inteſtines of a man who had been frozen to death, carbonic acid gas, oxygen gas, hydrogen gas, and azotic gas. The quantity of carbonic acid was greateſt in the ſtomach, and it diminiſhed gradually as the canal receded from the ſtomach ; the proportion of oxygen gas was conſiderable in the ſtomach, ſmaller in the ſmall inteſtines, and ſtill ſmaller in the great inteſtines ; the hydrogen and azotic gaſes, on the contrary, were leaſt abundant in the ſtomach, more abundant in the ſmall inteſtines, and moſt abundant in the larger inteſtines ; the hydrogen gas was moſt abundant in the ſmall inteſtines. It is well known that the flatus diſcharged *per anum* is commonly carbonated hydrogen gas ; ſometimes alſo it ſeems to hold ſulphur, or even phoſphorus in ſolution §.

343 10. The chyle, after it has been abſorbed by the lacteals, is carried by them into a pretty large veſſel, known by the name of *thoracic duct.* Into the ſame veſſel likewiſe is diſcharged a tranſparent fluid, conveyed by a ſet of veſſels which ariſe from all the cavities of the body. Theſe veſſels are called *lymphatics*, and the fluid which they convey is called *lymph.* In the thoracic duct, then, the chyle and the lymph are mixed together.

344 Very little is known concerning the nature of the *lymph*, as it is ſcarcely poſſible to collect it in any quantity. It is colourleſs, has ſome viſcidity, and is ſaid to be ſpecifically heavier than water. It is ſaid to be coagulable by heat ; if ſo, it contains albumen ; and, from its appearance, it probably contains gelatine. Its quantity is certainly conſiderable, for the lymphatics are very numerous.

Functions of Animals.

345 And conveyed to the heart and lungs.

11. The chyle and lymph being thus mixed together, are conveyed directly into the blood veſſels. The effect produced by their union in the thoracic duct is not known, but neither the colour nor external properties of the chyle is altered. In man, and many other animals, the thoracic duct enters at the junction of the left ſubclavian and carotid veins, and the chyle is conveyed directly to the heart, mixed with the blood, which already exiſts in the blood veſſels. From the heart, the blood and chyle thus mixed together are propelled into the lungs, where they undergo farther changes.

346 Reſpiration

12. The abſolute neceſſity of *reſpiration*, or of ſome thing analogous, is known to every one ; and few are ignorant that in man, and hot blooded animals, the organ by which reſpiration is performed is the lungs. For a deſcription of the reſpiratory organs, we refer to the article ANATOMY, *Encycl.* and the reader will find an account of the manner in which that function is performed in the article PHYSIOLOGY, *Encycl.* But what are the changes produced upon the blood and the chyle by reſpiration ? What purpoſes does it ſerve to the animal ? How comes it to be ſo indiſpenſably neceſſary for its exiſtence ? Theſe are queſtions which can only be anſwered by a careful examination of the phenomena of reſpiration.

347 Requires oxygen gas.

It has been long known that an animal can only breathe a certain quantity of air for a limited time, after which it becomes the moſt deadly poiſon, and produces ſuffocation as effectually as the moſt noxious gas, or a total abſence of air. It was ſuſpected long ago that this change is owing to the abſorption of a part of the air ; and Mayow made a number of very ingenious experiments in order to prove the fact. Dr Prieſtley and Mr Scheele demonſtrated, that the quantity of oxygen gas in atmoſpheric air is diminiſhed ; and Lavoiſier demonſtrated, in 1776, that a quantity of carbonic acid gas, which did not previouſly exiſt in it, was found in air after it had been for ſome time reſpired. It was afterwards proved by Lavoiſier, and many other philoſophers, who confirmed and extended his facts, that no animal can live in air totally deſtitute of oxygen. Even fiſh, which do not ſenſibly reſpire, die very ſoon, if the water in which they live be deprived of oxygen gas. Frogs which can ſuſpend their reſpiration at pleaſure, die in about forty minutes, if the water in which they have been confined be covered over with oil *. Inſects and worms, as Vauquelin has proved, exhibit preciſely the ſame phenomena. They require oxygen gas as well as other animals, and die like them if they be deprived of it. They diminiſh the quantity of the oxygen gas in which they live, and give out, by reſpiration, the very ſame products as other animals. Worms, which are more retentive of life than moſt other animals, or at leaſt not ſo much affected by poiſonous gaſes, abſorb every particle of the oxygen gas contained in the air in which they are confined before they die. Mr Vauquelin's experiments were made on the gryllus viridiſſimus, the limax flavus, and helix pomatia †.

348 Changes produced by it.

The changes which take place during reſpiration are the following :

1\. Part of the oxygen gas reſpired diſappears.

---

* ...n. de ...C ...i. xxix

† ...n Di- ...gon, p.

‡ ...bid. p.

§ Encyc. ...eth. Med. ...516.

* Corradori, Ann. de Chim. xxix. 171.

† Ann. de Chim. xii. 278.

2. Carbonic acid gas is emitted.
3. Water is emitted in the ſtate of vapour.

The firſt point is to aſcertain exactly the amount of theſe changes. Though a great many experiments have been made on this ſubject by different philoſophers, the greateſt confidence ought to be put in thoſe of Lavoiſier, both on account of his uncommon accuracy, and on account of the very complete apparatus which he always employed.

He put a guinea-pig into 708.989 grains troy of oxygen, and after the animal had breathed the gas for an hour, he took it out. He found that the oxygen gas now amounted only to 592.253 gr.
Conſequently there had diſappeared 116.736
The carbonic acid gas formed was 130.472
This was compoſed of about 94.234
oxygen, and 36.238
of carbon. Conſequently ſuppoſing, as Mr Lavoiſier did, that the oxygen abſorbed had been employed in the formation of the carbonic acid gas, there ſtill remained to be accounted for 22.502 grains of oxygen which had diſappeared. He ſuppoſed that this had been employed in the formation of water, a quantity of which had appeared. If ſo, the water formed muſt have amounted to 26.429 grains; which was compoſed of 3.927 hydrogen, the reſt oxygen *.

Since the water emitted was not actually aſcertained, this experiment can only be conſidered as an approximation to the truth. Accordingly that very ingenious philoſopher contrived an apparatus to aſcertain the quantity of oxygen gas abſorbed by man, and the quantity of carbonic acid gas and water emitted by him during reſpiration. This apparatus he had conſtructed at an expence at leaſt equal to L. 500 ſterling. The experiments were completed, and he was preparing them for publication, when, on the 8th of May 1794, he was beheaded by order of Robeſpierre, after having in vain requeſted a fortnight's delay to put his papers in order for the preſs. Thus periſhed, in the 51ſt year of his age, the man who, if he had lived a few years longer, promiſed fair to become the rival of Newton himſelf. Chemiſtry, as a ſcience, is deeply indebted to him. He ſaved it from that confuſion into which the thoughtleſs ardour of many of his contemporaries were plunging it headlong: he arranged and connected and ſimplified and explained the multitude of inſulated facts, which had been accumulating with unexampled celerity; and which, had it not been for his happy arranging genius, might have retarded, inſtead of advanced, the progreſs of the ſcience. He reduced all the facts under a few ſimple heads, and thus made them eaſily remembered and eaſily claſſified. In a few years more, perhaps, he would have traced theſe general principles to their ſources, eſtabliſhed the ſcience on the completeſt induction, and paved for his ſucceſſors a road as unerring as that which Sir Iſaac Newton formed in mechanical philoſophy.

Mr Lavoiſier's experiments have never been publiſhed, but fortunately Mr de la Place has given us the reſult of them †. He informs us that it was as follows: A man, at an average, conſumes, in twenty-four hours, by reſpiration, 32.48437 ounces troy of oxygen gas; that is to ſay, that a quantity of oxygen gas, equal to that weight, diſappears from the air which he reſpires in twenty-four hours; that he gives out by reſpiration, in the ſame time, 15.73 oz. troy of carbonic acid gas, and 28.55 of water in the ſtate of vapour.

Total 44.28 *Oxygen.*
The carbonic acid gas is compoſed of $10.48\dot{6}$
and $5.24\dot{3}$ carbon. The water of 24.2675
and 4.2825 hydrogen.
Total of the oxygen emitted $34.7541\dot{6}$
Total abſorbed 32.48437

So that there is $2.369791\dot{6}$
ounces of oxygen emitted more than is abſorbed by reſpiration. Thus it appears that, by reſpiration, the abſolute quantity of oxygen in the blood is diminiſhed.

Dr Menzies found that a man, at a medium, draws in at every reſpiration 43.77 cubic inches of air, and that $\frac{1}{20}$th of that quantity diſappears. Conſequently, according to him, at every reſpiration 2.1885 cubic inches of oxygen gas are conſumed. Now 2.1885 cubic inches of that gas amount to 0.68669 gr. troy. Suppoſing, with Hales, that a man makes 1200 reſpirations in an hour, the quantity of oxygen gas conſumed in an hour, will amount to 824.028 grains, and in 24 hours to 19776.672 grains, or 41.2014 ounces troy. This quantity exceeds that found by Lavoiſier conſiderably; but the allowance of oxygen for every reſpiration is rather too great. Indeed, from the nature of Dr Menzies's apparatus, it was ſcarce poſſible to meaſure it accurately.

The quantity of water given out by reſpiration, as determined by Hales, amounts in a day to 20.4 oz. *; but his method was not ſuſceptible of great accuracy. We may therefore, on the whole, conſider Lavoiſier's determination as by far the neareſt to the truth of any that has been given.

There is, however, a very ſingular anomaly, which becomes apparent when we compare his experiments on the reſpiration of the guinea-pig with thoſe on the reſpiration of man.

The guinea-pig conſumed in 24 hours 5.8368 oz. troy of oxygen gas, and emitted 6.5236 oz. of carbonic acid gas. Man, on the other hand, conſumes in the ſame time 32.48437 oz. of oxygen gas, and emits only 15.73 oz. of carbonic acid gas. The oxygen gas conſumed by the pig is to the carbonic gas emitted as 1 00 : 1.12; whereas in man it is as 1.000 : 0.484. If we could depend upon the accuracy of each of theſe experiments, they would prove, beyond a doubt, that the changes produced by the reſpiration of the pig are different, at leaſt in degree, from thoſe produced in man; but it is more than probable that ſome miſtake has crept into one or other of the experiments. We have more reaſon to ſuſpect the firſt, as it was made before 1778, at a time when a great many circumſtances, neceſſary to inſure accuracy, were unknown to Lavoiſier.

Such are the ſubſtances imbibed and emitted during reſpiration. It ſtill remains for us to determine what are the changes which it produces on the blood.

It has been long known that the blood which flows in the veins is of a dark reddiſh purple colour, whereas the arterial blood is of a florid ſcarlet colour. Lower obſerved that the colour of the veinous blood was converted into that of arterial during its paſſage through the

---

* *Ann. de Chim.* v. 261.

† *La Place's Eloge.*

* *Veget. Stat.* ii. 327.

ctions nimals.

the lungs. No chyle can be diſtinguiſhed by its white colour in the blood after it has paſſed through the lungs. The changes, then, which take place upon the appearance of the blood are two: 1*ſt*, It acquires a florid red colour; 2*d*, The chyle totally diſappears. Now to what are theſe changes owing?

Lower himſelf knew that the change was produced by the air, and Mayow attempted to prove that it was by abſorbing a part of the air. But it was not till Dr Prieſtley diſcovered that veinous blood acquires a ſcarlet colour when put in contact with oxygen gas, and arterial blood a dark red colour when put in contact with hydrogen gas, or, which is the ſame thing, that oxygen gas inſtantly gives veinous blood the colour of arterial; and hydrogen, on the contrary, gives arterial blood the colour of veinous blood: it was not till then that philoſophers began to attempt any thing like an explanation of the phenomena of reſpiration. Two explanations have been given; one or other of which muſt be true.

349 o hypo es to ex- n theſe ges.

The firſt is, that the oxygen of the air, which diſappears, combines with a quantity of carbon and hydrogen given out by the blood in the lungs, and forms with it carbonic acid gas and water in vapour, which are thrown out along with the air expired.

The ſecond is, that the oxygen gas, which diſappears, combines with the blood as it paſſes thro' the lungs; and that, at the inſtant of this combination, there is ſet free from the blood a quantity of carbonic acid gas and of water, which are thrown out along with the air expired.

The firſt of theſe theories was originally formed by Lavoiſier, and it was embraced by La Place, Crawford, Gren, and Girtanner, with a ſmall variation. Indeed it does not differ, except in detail, from the original hypotheſis of Dr Prieſtley, that the uſe of reſpiration is to rid the blood of phlogiſton; for if we ſubſtitute carbon and hydrogen for phlogiſton, the two theories preciſely agree. Mr Lavoiſier attempted not to prove its truth; he only tried to ſhew that the oxygen abſorbed correſponds exactly with the quantity of oxygen contained in the carbonic acid and the water emitted. This coincidence his own experiments have ſhewn not to hold; conſequently the theory is entirely deſtitute of proof, as far as the proof depends upon this coincidence.

The other hypotheſis was propoſed by Mr de la Grange, and afterwards ſupported and illuſtrated by Mr Haſſenfratz.

350 ts of ration ined.

In order to diſcover what the real effects of reſpiration are, let us endeavour to ſtate accurately the phenomena as far as poſſible.

In the *firſt* place, we are certain, from the experiments of Prieſtley, Girtanner, and Haſſenfratz, that when veinous blood is expoſed to oxygen gas confined over it, the blood inſtantly aſſumes a ſcarlet colour, and the gas is diminiſhed in bulk; therefore part of the gas has been abſorbed. We may conſider it as certain, then, that when the colour of veinous blood is changed into arterial, ſome oxygen gas is abſorbed [†].

In the *ſecond* place, no chyle can be diſcovered in the blood after it has paſſed through the lungs. Therefore the *white colour* of the chyle at leaſt, is deſtroyed by reſpiration, and it aſſumes a red colour. Now if the red colour of the blood be owing to iron, as many have ſuppoſed, this change of colour is a demonſtration that oxygen has combined with the iron; for we have ſeen already, that iron, if it exiſts in chyle, as it probably does, is in the ſtate of a white oxyd. Conſequently, when converted into a red oxyd, it muſt abſorb oxygen. Even though iron be not the colouring matter of the blood, it would ſtill be probable that the change of colour of the chyle depends on the fixation of oxygen; for Berthollet and Fourcroy have ſhewn that in ſeveral inſtances ſubſtances acquire a red colour by that proceſs.

Functions of Animals.

We may conſider it as proved, then, that oxygen enters the blood as it paſſes through the lungs.

In the *third* place, when arterial blood is put in contact with azotic gas, or carbonic acid gas, it gradually aſſumes the dark colour of veinous blood, as Dr Prieſtley found [*]. The ſame philoſopher alſo obſerved that arterial blood acquired the colour of veinous blood when placed in vacuo [†]. Conſequently this alteration of colour is owing to ſome change which takes place in the blood itſelf, independent of any external agent.

The arterial blood becomes much more rapidly and deeply dark coloured when it is left in contact with hydrogen gas placed above it [‡]. We muſt ſuppoſe therefore that the preſence of this gas accelerates and increaſes the change, which would have taken place upon the blood without any external agent.

If arterial blood be left in contact with oxygen gas, it gradually aſſumes the ſame dark colour which it would have acquired in vacuo, or in contact with hydrogen; and after this change oxygen can no longer reſtore its ſcarlet colour [§]. Therefore it is only upon a part of the blood that the oxygen acts; and after this part has undergone the change which occaſions the dark colour, the blood loſes the power of being affected by oxygen.

Mr Haſſenfratz poured into veinous blood a quantity of oxy-muriatic acid; the blood was inſtantly decompoſed, and aſſumed a deep and almoſt black colour. When he poured common muriatic acid into blood, the colour was not altered [||]. Now oxy-muriatic acid has the property of giving out its oxygen readily; conſequently the black colour was owing to the inſtant combination of a part of the blood with oxygen.

The facts therefore lead us to conclude, with La Grange and Haſſenfratz, that during reſpiration the oxygen, which diſappears, enters the blood; that during the circulation this oxygen combines with a certain part of the blood; and that the veinous colour is owing to this new combination. We muſt conclude, too, that the ſubſtance which cauſes this dark colour leaves the blood during its circulation thro' the lungs, otherwiſe it could not be capable of aſſuming the florid colour. Now we know what the ſubſtances are which are emitted during reſpiration; they are water and carbonic acid gas. It muſt be to the gradual combination of oxygen, then, during the circulation, with hydrogen and carbon, that the colour of veinous blood is owing. And ſince the ſame combination takes place every time that the blood paſſes through the lungs, we muſt conclude, that it is only a part of the hydrogen and carbon which is acted upon each time. Let us now attempt, with theſe data, to form ſome notion of the decompoſition which goes on during the circulation of the blood.

351 Contributes to the formation of blood,

It is probable that, during a conſiderable part of the day, there is a conſtant influx of chyle into the blood; and we are certain that lymph is conſtantly flowing in- to

---

[†] n de C. vii.

[*] Prieſtley, iii. 363

[†] Ibid, and Ann de Chim. ix. 269.

[‡] Fourcroy, Ann de Chim. vii. 149.

[§] Ibid ix. 168.

[||] Ibid.

to it. Now it appears, from the moſt accurate obſervations hitherto made, that neither chyle nor lymph contain fibrina, which forms a very conſpicuous part of the blood. This fibrina is employed to ſupply the waſte of the muſcles, the moſt active parts of the body, and therefore, in all probability, requiring the moſt frequent ſupply. Nor can it be doubted that it is employed for other uſeful purpoſes. The quantity of fibrina in the blood, then, muſt be conſtantly diminiſhing, and therefore new fibrina muſt be conſtantly formed. But the only ſubſtances out of which it can be formed are the chyle and lymph, neither of which contain it. There muſt therefore be a continual decompoſition of the chyle and lymph going on in the bloodveſſels, and a continual new formation of fibrina. Other ſubſtances alſo may be formed; but we are certain that this *muſt* be formed there, becauſe it does not exiſt previouſly. Now, one great end of reſpiration muſt undoubtedly be to aſſiſt this decompoſition of chyle and complete formation of blood.

It follows, from the experiments of Fourcroy formerly enumerated, that fibrina contains more azot, and leſs hydrogen and carbon, than any of the other ingredients of the blood, and conſequently alſo than any of the ingredients of the chyle. In what manner the chyle, or a part of it, is converted into fibrina, it is impoſſible to ſay: we are not ſufficiently acquainted with the ſubject to be able to explain the proceſs. But we can ſee at leaſt, that carbon and hydrogen muſt be abſtracted from that part of the chyle which is to be converted into fibrina: And we know, that theſe ſubſtances are actually thrown out by reſpiration. We may conclude, then, that *one* uſe of the oxygen abſorbed is, to abſtract a quantity of carbon and hydrogen from a part of the chyle by compound affinity, in ſuch proportions, that the remainder becomes fibrina: therefore one end of reſpiration is to form fibrina. Doubtleſs the other ingredients of the blood are alſo new modified, though we know too little of the ſubject to throw any light upon it.

352
Produces animal heat;

13. But the complete formation of blood is not the only advantage gained by reſpiration: the *temperature* of all animals depends upon it. It has been long known, that thoſe animals which do not breathe have a temperature but very little ſuperior to the medium in which they live. This is the caſe with fiſhes and many inſects. Man, on the contrary, and quadrupeds which breathe, have a temperature conſiderably higher than the atmoſphere: that of man is 98°. Birds, who breathe in proportion a ſtill greater quantity of air than man, have a temperature equal to 103° or 104°. It has been proved, that the temperature of all animals is proportional to the quantity of air which they breathe in a given time.

Theſe facts are ſufficient to demonſtrate, that the heat of animals depends upon reſpiration. But it was not till Dr Black's doctrine of latent heat became known to the world, that any explanation of the cauſe of the temperature of breathing animals was attempted. That illuſtrious philoſopher, whoſe diſcoveries form the baſis upon which all the ſcientific part of chemiſtry has been reared, ſaw at once the light which his doctrine of latent heat threw upon this part of phyſiology, and he applied it very early to explain the temperature of animals.

According to him, part of the latent heat of the air inſpired becomes ſenſible; and of courſe, the temperature of the lungs, and the blood that paſſes through them, muſt be raiſed; and the blood, thus heated, communicates its heat to the whole body. This opinion was ingenious, but it was liable to an unanſwerable objection: for if it were true, the temperature of the body ought to be greateſt in the lungs, and to diminiſh gradually as the diſtance from the lungs increaſes; which is not true. The theory, in conſequence, was abandoned even by Dr Black himſelf; at leaſt he made no attempt to ſupport it.

Lavoiſier and Crawford, who conſidered all the changes operated by reſpiration as taking place in the lungs, accounted for the origin of the animal heat almoſt preciſely in the ſame manner with Dr Black. According to them, the oxygen gas of the air combines in the lungs with the hydrogen and carbon emitted by the blood. During this combination, the oxygen gives out a great quantity of caloric, with which it had been combined; and this caloric is not only ſufficient to ſupport the temperature of the body, but alſo to carry off the new formed water in the ſtate of vapour, and to raiſe conſiderably the temperature of the air inſpired. According to theſe philoſophers, then, the whole of the caloric which ſupports the temperature of the body is evolved in the lungs. Their theory accordingly was liable to the ſame objection with Dr Black's; but they obviated it in the following manner: Dr Crawford found, that the ſpecific caloric of arterial blood was 1.0300, while that of veinous blood was only 0.8928. Hence he concluded, that the inſtant veinous blood is changed into arterial blood, its ſpecific caloric increaſes; conſequently it requires an additional quantity of caloric to keep its temperature as high as it had been while veinous blood. This addition is ſo great, that the whole new caloric evolved is employed: therefore the temperature of the lungs muſt neceſſarily remain the ſame as that of the reſt of the body. During the circulation, arterial blood is gradually converted into veinous; conſequently its ſpecific caloric diminiſhes, and it muſt give out heat. This is the reaſon that the temperature of the extreme parts of the body does not diminiſh.

This explanation is certainly ingenious; but it is not quite ſatisfactory; for the difference in the ſpecific caloric, granting it to be accurate, is too ſmall to account for the great quantity of heat which muſt be evolved. It is evident that it muſt fall to the ground altogether, provided, as we have ſeen reaſon to ſuppoſe, the carbonic acid gas and water be not formed in the lungs, but during the circulation.

Since the oxygen enters the blood, and combines with it in the ſtate of gas, it is evident that it will only part at firſt with ſome of its caloric; and this portion is chiefly employed in carrying off the carbonic acid gas and the water. For the reaſon that the carbonic acid leaves the blood at the inſtant that the oxygen gas enters it, ſeems to be this: The oxygen gas combines with the blood, and part of its caloric unites at the ſame inſtant to the carbonic acid, and converts it into gas: another portion converts the water into vapour. The reſt of the caloric is evolved during the circulation when the oxygen combines with hydrogen and carbon, and forms water and carbonic acid gas. The quantity of caloric evolved in the lungs ſeems not only ſufficient to carry off the carbonic acid and water, which the diminution

nution of the ſpecific caloric (if it really take place) muſt facilitate; but it ſeems alſo to raiſe the temperature of the blood a little higher than it was before. For Mr John Hunter conſtantly found, that the heat of the heart in animals was a degree higher than any other part of the body which he examined. Now this could ſcarcely happen, unleſs the temperature of the blood were ſomewhat raiſed during reſpiration.

353 ſup- s the ulation. Thus we have ſeen two uſes which reſpiration ſeems to ſerve. The firſt is the completion of blood by the formation of fibrina; the ſecond is the maintaining of the temperature of the body at a particular ſtandard, notwithſtanding the heat which it is continually giving out to the colder ſurrounding bodies. But there is a third purpoſe, which explains why the animal is killed ſo ſuddenly when reſpiration is ſtopped. The circulation of the blood is abſolutely neceſſary for the continuance of life. Now the blood is circulated in a great meaſure by the alternate contractions of the heart. It is neceſſary that the heart ſhould contract regularly, otherwiſe the circulation could not go on. But the heart is ſtimulated to contract by the blood: and unleſs blood be made to undergo the change produced by reſpiration, it ceaſes almoſt inſtantaneouſly to ſtimulate. As the blood receives oxygen in the lungs, we may conclude that the preſence of oxygen is neceſſary to its ſtimulating power *.

354 dneys ployed the formation of od. 14. Thus we have reaſon to ſuppoſe, that chyle and lymph are converted into blood during the circulation; and that the oxygen gas ſupplied by reſpiration is one of the principal agents in this change. But beſides the lungs and arteries, there is another organ, the ſole uſe of which is alſo to produce ſome change or other in the blood, which renders it more complete, and more proper for the various purpoſes to which it is applied. This organ is the *kidney*.

For the ſtructure of the kidneys, which in man and quadrupeds are two in number, we refer to ANATOMY, *Encycl.* A very great proportion of blood paſſes thro' them; indeed, we have every reaſon to conclude, that the whole of the blood paſſes through them very frequently.

Theſe organs ſeparate the urine from the blood, to be afterwards evacuated without being applied to any purpoſe uſeful to the animal.

The kidneys are abſolutely neceſſary for the continuance of the life of the animal; for it dies very ſpeedily when they become by diſeaſe unfit to perform their functions: therefore the change which they produce in the blood is a change neceſſary for qualifying it to anſwer the purpoſes for which it is intended.

As the urine is immediately excreted, it is evident that the change which the kidneys perform is intended ſolely for the ſake of the blood. It is not merely the abſtraction of a quantity of water and of ſalts, accumulated in the blood, which the kidney performs. A chemical change is certainly produced, either upon the whole blood, or at leaſt on ſome important part of it; for there are two ſubſtances found in the urine which do not exiſt in the blood. Theſe two ſubſtances are urea and uric acid. They are formed, therefore, in the kidneys; and as they are thrown out, after being formed, without being applied to any uſeful purpoſe, they are certainly not formed in the kidneys for their own ſake. Some part of the blood, then, muſt be decompoſed in the kidney, and a new ſubſtance, or new ſubſtances, muſt be formed; and the urea and uric acid muſt be formed at the ſame time, in conſequence of the combined action of the affinities which produce the change on the blood; and being uſeleſs, they are thrown out, together with a quantity of water and ſalts, which, in all probability, were uſeful in bringing about the changes which take place in the arteries and in the kidneys, but which are no longer of any ſervice after theſe changes are brought about.

The changes operated upon the blood in the kidneys are hitherto altogether unknown; but they muſt be important.

Provided the method of analyſing animal ſubſtances were ſo far perfected as to admit of accurate concluſions, conſiderable light might be thrown upon this ſubject, by analyſing with care a portion of blood from the emulgent vein and artery ſeparately, and aſcertaining preciſely in what particulars they differ from each other. 355 Cutaneous veſſels

15. Thus we have ſeen that the principal changes which the blood undergoes, as far at leaſt as we are at preſent acquainted with them, take place in the lungs, in the kidneys, and in the arteries. In the lungs, a quantity of water and carbonic acid gas is emitted from the blood, and in the kidney the urine is formed and ſeparated from it. There ſeems alſo to be ſomething thrown out from the blood during its circulation in the arteries, at leaſt through thoſe veſſels which are near the ſurface of the body: For it is a fact, that certain ſubſtances are conſtantly emitted from the ſkins of animals. Theſe ſubſtances are known in general by the name of *perſpirable matter*, or *perſpiration*. They have a great reſemblance to what is emitted in the lungs; which renders it probable, that they are both owing to the ſame cauſe; namely, to the decompoſition produced in the blood by the effects of reſpiration. They conſiſt chiefly of water in a ſtate of vapour, carbon, and oil.

The quantity of aqueous vapour differs very conſiderably, according to circumſtances. It has been ſhewn to be greateſt in hot weather, and in hot climates, and after great exerciſe; and its relation to the quantity of urine has been long known. When the aqueous vapour perſpired is great, the quantity of urine is ſmall, and *vice verſa*. 356 Emit aqueous vapour,

The moſt accurate experiments on this matter that we have ſeen are thoſe of Mr Cruikſhank. He put his hand into a glaſs veſſel, and luted its mouth at his wriſt by means of a bladder. The interior ſurface of the veſſel became gradually dim, and drops of water trickled down. By keeping his hand in this manner for an hour, he collected 30 grains of a liquid, which poſſeſſed all the properties of pure water*. On repeating the ſame experiment at nine in the evening (thermometer 62°), he collected only 12 grains. The mean of theſe is 21 grains. But as the hand is more expoſed than the trunk of the body, it is reaſonable to ſuppoſe that the perſpiration from it is greater than that from the hand. Let us therefore take 30 grains per hour as the mean; and let us ſuppoſe, with Mr Cruikſhank, that the hand is $\frac{1}{60}$th of the ſurface of the body. The perſpiration in an hour would amount to 1800 grains, and in 24 hours to 43200 grains, or 7 pounds 6 ounces troy.

---

* Girtanner, r. de ſ. xxxix.

* *On Inſenſible Perſpiration*, p. 68.

He repeated the experiment again after hard exerciſe, and collected in an hour 48 grains of water*. He found alſo, that this aqueous vapour pervaded his ſtocking without difficulty; and that it made its way thro' a ſhamoy leather glove, and even through a leather boot, though in much ſmaller quantity than when the leg wanted that covering†.

It is not difficult to ſee why the quantity of watery vapour diminiſhes with cold. When the ſurface of the body is expoſed to a cold temperature, the capacity of the cutaneous veſſels diminiſhes, and conſequently the quantity which flows through them muſt decreaſe

When the temperature, on the other hand, is much increaſed, either by being expoſed to a hot atmoſphere, or by violent exerciſe, the perſpired vapour not only increaſes in quantity, but even appears in a liquid form. This is known by the name of *ſweat*. In what manner ſweat is produced, is not at preſent known; but we can ſee a very important ſervice which it performs to the animal.

No ſooner is it thrown upon the ſurface of the ſkin than it begins to evaporate. But the change into vapour requires heat; accordingly a quantity of heat is abſorbed, and the temperature of the animal is lowered. This is the reaſon that animals can endure to remain for ſome time in a much higher temperature without injury than could have been ſuppoſed.

The experiments of Tillet, and the ſtill more deciſive experiments of Fordyce and his aſſociates, are well known. Theſe gentlemen remained a conſiderable time in a temperature exceeding the boiling point of water.

357 Carbon,

Beſides water, it cannot be doubted that *carbon* is alſo emitted from the ſkin; but in what ſtate, the experiments hitherto made do not enable us to decide. Mr Cruikſhank found, that the air of the glaſs veſſel in which his hand and foot had been confined for an hour, contained carbonic acid gas; for a candle burned dimly in it, and it rendered lime-water turbid*. And Mr Jurine found, that air which had remained for ſome time in contact with the ſkin, conſiſted almoſt entirely of carbonic acid gas†. The ſame concluſion may be drawn from the experiments of Ingenhouſz and Milly‡.

Now it is evident, that the carbonic acid gas which appeared during Mr Cruikſhank's experiment, did not previouſly exiſt in the glaſs veſſel; conſequently it muſt have either been tranſmitted ready formed through the ſkin, or formed during the experiment by the abſorption of oxygen gas, and the conſequent emiſſion of carbonic acid gas. The experiments of Mr Jurine do not allow us to ſuppoſe the firſt of theſe to be true; for he found, that the quantity of air allowed to remain in contact with the ſkin did not increaſe. Conſequently the appearance of the carbonic acid gas muſt be owing either to the emiſſion of carbon, which forms carbonic acid gas by combining with the oxygen gas of the air, or to the abſorption of oxygen gas, and the ſubſequent emiſſion of carbonic acid gas; preciſely in the ſame manner, and for the ſame reaſon, that theſe ſubſtances are emitted by the lungs. The laſt is the more probable opinion; but the experiments hitherto made do not enable us to decide.

358 And an oily matter.

Beſides water and carbon, or carbonic acid gas, the ſkin emits alſo a particular odorous ſubſtance. That every animal has a peculiar ſmell, is well known: the dog can diſcover his maſter, and even trace him to a diſtance by the ſcent. A dog, chained ſome hours after his maſter had ſet out on a journey of ſome hundred miles, followed his footſteps by the ſmell, and found him on the third day in the midſt of a crowd*. But it is needleſs to multiply inſtances of this fact; they are too well known to every one. Now this ſmell muſt be owing to ſome peculiar matter which is conſtantly emitted; and this matter muſt differ ſomewhat either in quantity or ſome other property, as we ſee that the dog eaſily diſtinguiſhes the individual by means of it. Mr Cruikſhank has made it probable that this matter is an oily ſubſtance; or at leaſt that there is an oily ſubſtance emitted by the ſkin. He wore repeatedly, night and day for a month, the ſame veſt of fleecy hoſiery during the hotteſt part of the ſummer. At the end of this time he always found an oily ſubſtance accumulated in conſiderable maſſes on the nap of the inner ſurface of the veſt, in the form of black tears. When rubbed on paper, it makes it tranſparent, and hardens on it like greaſe. It burns with a white flame, and leaves behind it a charry reſiduum†.

It has been ſuppoſed that the ſkin has the property of *abſorbing moiſture* from the air; but this opinion has not been confirmed by experiments, but rather the contrary.

359 Whether the ſkin abſorbs moiſture,

The chief arguments in favour of the abſorption of the ſkin, have been drawn from the quantity of moiſture diſcharged by urine being, in ſome caſes, not only greater than the whole drink of the patient, but even than the whole of his drink and food. But it ought to be remembered that, in diabetes, the diſeaſe here alluded to, the weight of the body is continually diminiſhing, and therefore part of it muſt be conſtantly thrown off. Beſides, it is ſcarcely poſſible in that diſeaſe to get an accurate account of the food ſwallowed by the patients; and in thoſe caſes where very accurate accounts have been kept, and where deception was not ſo much practiſed, the urine was found not to exceed the quantity of drink*. In a caſe of diabetes, related with much accuracy by Dr Gerard, the patient was bathed regularly during the early part of the diſeaſe in warm water, and afterwards in cold water: he was weighed before and after bathing, and no ſenſible difference was ever found in his weight†. Conſequently, in that caſe, the quantity abſorbed, if any, muſt have been very ſmall.

It is well known, that thirſt is much alleviated by cold bathing. By this plan, Captain Bligh kept his men cool and in good health during their very extraordinary voyage acroſs the South Sea. This has been conſidered as owing to the abſorption of water by the ſkin. But Dr Currie had a patient who was waſting faſt for want of nouriſhment, a tumor in the œſophagus preventing the poſſibility of taking food, and whoſe thirſt was always alleviated by bathing; yet no ſenſible increaſe of weight, but rather the contrary, was perceived after bathing. It does not appear, then, that in either of theſe caſes water was abſorbed.

Farther, Seguin has ſhewn that the ſkin does not abſorb water during bathing, by a ſtill more complete experiment: He diſſolved ſome mercurial ſalt in water, and found that the mercury produced no effect upon a perſon that bathed in the water, provided no part of the

---

* *On Inſenſible Perſpiration*, p. 70.

† *Ibid* p 82.

* *Ibid.* p. 70 and 81.

† *Enc. Meth. Med.* i. p. 515.

‡ *Ibid*, p. 511.

* *Cruikſhank, ibid.* p. 93.

† *Ibid.* p. 92.

* See *Roll on Diabete*

† *Ibid.* ii. 73.

the cuticle was injured; but upon rubbing off a portion of the cuticle, the mercurial ſolution was abſorbed, and the effects of the mercury became evident upon the body. Hence it follows irreſiſtibly, that water, at leaſt in the ſtate of *water*, is not abſorbed by the ſkin when the body is plunged into it, unleſs the cuticle be firſt removed.

This may perhaps be conſidered as a complete proof that no ſuch thing as abſorption is performed by the ſkin; and that therefore the appearance of carbonic acid gas, which takes place when air is confined around the ſkin, muſt be owing to the emiſſion of carbon But it ought to be conſidered, that although the ſkin cannot abſorb water, this is no proof that it cannot abſorb other ſubſtances; particularly, that it cannot abſorb oxygen gas, which is very different from water. It is well known, that water will not paſs through bladders, at leaſt for ſome time; yet Dr Prieſtley found that veinous blood acquired the colour of arterial blood from oxygen gas, as readily when theſe ſubſtances were ſeparated by a bladder as when they were in actual contact. He found, too, that when gaſes were confined in bladders, they gradually loſt their properties. It is clear from theſe facts, that oxygen gas can pervade bladders; and if it can pervade them, why may it not alſo pervade the cuticle? Nay, farther, we know from the experiments of Cruikſhank, that the vapour perſpired paſſes through leather, even when prepared ſo as to keep out moiſture, at leaſt for a certain time. It is poſſible, then, that water, when in the ſtate of vapour, or when diſſolved in air, may be abſorbed, although water, while in the ſtate of water, may be incapable of pervading the cuticle. The experiments, then, which have hitherto at leaſt been made upon the abſorption of the ſkin, are altogether inſufficient to prove that air and vapour cannot pervade the cuticle; provided at leaſt there be any facts to render the contrary ſuppoſition probable.

Now that there are ſuch facts cannot be denied. We ſhall not indeed produce the experiment of Van Mons as a fact of that kind, becauſe it is liable to objections, and at beſt is very undeciſive. Having a patient under his care who, from a wound in the throat, was incapable for ſeveral days of taking any nouriſhment, he kept him alive during that time, by applying to the ſkin in different parts of the body, ſeveral times a day, a ſponge dipt in wine or ſtrong ſoup *. A fact mentioned by Dr Watſon is much more important, and much more deciſive. A lad at Newmarket, who had been almoſt ſtarved in order to bring him down to ſuch a weight as would qualify him for running a horſe race, was weighed in the morning of the race day; he was weighed again juſt before the race began, and was found to have gained 30 ounces of weight ſince the morning: yet in the interval he had only taken a ſingle glaſs of wine. Here abſorption muſt have taken place, either by the ſkin, or lungs, or both. The difficulties in either caſe are the ſame; and whatever renders abſorption by one probable, will equally ſtrengthen the probability that abſorption takes place by the other (R).

Functions of animals.

361 Blood ſupplies the waſte of the ſyſtem.

16. We have now ſeen the proceſs of digeſtion, and the formation of blood, as far at leaſt as we are acquainted with it. But to what purpoſes is this blood employed, which is formed with ſo much care, and for the formation of which ſo great an apparatus has been provided? It anſwers two purpoſes. The parts of which the body is compoſed, bones, muſcles, ligaments, membranes, &c. are continually changing. In youth they are increaſing in ſize and ſtrength, and in mature age they are continually acting, and conſequently continually liable to waſte and decay. They are often expoſed to accidents, which render them unfit for performing their various functions; and even when no ſuch accident happens, it ſeems neceſſary for the health of the ſyſtem that they ſhould be every now and then renewed. Materials therefore muſt be provided for repairing, increaſing, or renewing all the various organs of the body. Phoſphat of lime and gelatine for the bones, fibrina for the muſcles, albumen for the cartilages and membranes, &c. Accordingly all theſe ſubſtances are laid up in the blood; and they are drawn from that fluid as from a ſtorehouſe whenever they are required. The proceſs by which the different parts of the blood are made part of the various organs of the body is called *aſſimilation*.

362 Aſſimilation.

Over the nature of aſſimilation the thickeſt darkneſs ſtill hangs; there is no key to explain it, nothing to lead us to the knowledge of the inſtruments employed. Facts, however, have been accumulated in ſufficient numbers to put the exiſtence of the proceſs beyond the reach of doubt. The healing, indeed, of every fractured bone, and every wound of the body, is a proof of its exiſtence, and an inſtance of its action.

363 Every aſſimilating organ produces a peculiar change,

Every organ employed in aſſimilation has a peculiar office; and it always performs this office whenever it has materials to act upon, even when the performance of it is contrary to the intereſt of the animal. Thus the ſtomach always converts food into chyme, even when the food is of ſuch a nature that the proceſs of digeſtion will be retarded rather than promoted by the change. If warm milk, for inſtance, or warm blood, be thrown into the ſtomach, they are always decompoſed by that organ, and converted into chyme; yet theſe ſubſtances are much more nearly aſſimilated to the animal before the action of the ſtomach than after it. The ſame thing happens when we eat animal food.

364 And no other change.

On the other hand, a ſubſtance introduced into an organ employed in aſſimilation, if it has undergone preciſely the change which that organ is fitted to produce, is not acted upon by that organ, but paſſed on unaltered to the next aſſimilating organ. Thus it is the office of the inteſtines to convert chyme into chyle. Accordingly, whenever chyme is introduced into the inteſtines, they perform their office, and produce the uſual change; but if chyle itſelf be introduced into the inteſtines, it is abſorbed by the lacteals without alteration. The experiment, indeed, has not been tried with true chyle, becauſe it is ſcarce poſſible to procure it in ſufficient quantity; but when milk, which reſembles chyle pretty accurately, is thrown into the jejunum, it is abſorbed unchanged by the lacteals *.

Again,

---

* Fordyce on *Digeſtion*, p. 159.

(R) The Abbé Fontana alſo found, that after walking in moiſt air for an hour or two, he returned home ſome ounces heavier than he went out, notwithſtanding he had ſuffered conſiderable evacuation from a briſk purge purpoſely taken for the experiment. This increaſe, indeed, might be partly accounted for by the abſorption of moiſture by his clothes.

Again, the office of the blood veſſels, as aſſimilating organs, is to convert chyle into blood. Chyle, accordingly, cannot be introduced into the arteries without undergoing that change; but *blood* may be introduced from another animal without any injury, and conſequently without undergoing any change. This experiment was firſt made by Lower, and it has ſince been very often repeated.

Alſo, if a piece of freſh muſcular fleſh be applied to the muſcle of an animal, they adhere and incorporate without any change, as has been ſufficiently eſtabliſhed by the experiments of Mr J. Hunter. And Buvina has aſcertained, that freſh bone may, in the ſame manner, be engrafted on the bones of animals of the ſame or of different ſpecies †.

In ſhort, it ſeems to hold, at leaſt as far as experiments have hitherto been made, that foreign ſubſtances may be incorporated with thoſe of the body, provided they be preciſely of the ſame kind with thoſe to which they are added, whether fluid or ſolid. Thus chyle may be mixed with chyle, blood with blood, muſcle with muſcle, and bone with bone. The experiment has not been extended to the other animal ſubſtances, the nerves, for inſtance; but it is extremely probable that it would hold with reſpect to them alſo.

On the other hand, when ſubſtances are introduced into any part of the body which are not the ſame with that part, nor the ſame with the ſubſtance upon which that part acts; provided they cannot be thrown out readily, they deſtroy the part, and perhaps even the animal. Thus foreign ſubſtances introduced into the blood very ſoon prove fatal; and introduced into wounds of the fleſh or bones, they prevent theſe parts from healing.

365
Their power limited.

Although the different aſſimilating organs have the power of changing certain ſubſtances into others, and of throwing out the uſeleſs ingredients, yet this power is not abſolute, even when the ſubſtances on which they act are proper for undergoing the change which the organs produce. Thus the ſtomach converts food into chyme, the inteſtines chyme into chyle, and the ſubſtances which have not been converted into chyle are thrown out of the body. If there happen to be preſent in the ſtomach and inteſtines any ſubſtance which, though incapable of undergoing the changes, at leaſt, by the action of the ſtomach and inteſtines, yet has a ſtrong affinity, either for the whole chyme and chyle, or for ſome particular part of it, and no affinity for the ſubſtances which are thrown out, that ſubſtance paſſes along with the chyle, and in many caſes continues to remain chemically combined with the ſubſtance to which it is united in the ſtomach, even after that ſubſtance has been completely aſſimilated, and made a part of the body of the animal. Thus there is a ſtrong affinity between the colouring matter of madder and phoſphat of lime. Accordingly, when madder is taken into the ſtomach, it combines with the phoſphat of lime of the food, paſſes with it through the lacteals and blood veſſels, and is depoſited with it in the bones, as was proved by the experiments of Duhamel. In the ſame manner muſk, indigo, &c. when taken into the ſtomach, make their way into many of the ſecretions.

Theſe facts ſhew us, that aſſimilation is a chemical proceſs from beginning to end; that all the changes are produced according to the laws of chemiſtry; and that we can even derange the regularity of the proceſs by introducing ſubſtances whoſe mutual affinities are too ſtrong for the organs to overcome.

365
Aſſimilation a chemical proceſs;

397
But the agent not chemical.

It cannot be denied, then, that the aſſimilation of food conſiſts merely in a certain number of chemical decompoſitions which that food undergoes, and the conſequent formation of certain new compound. But are the *agents* employed in aſſimilation merely chemical agents? We cannot produce any thing like theſe changes on the food out of the body, and therefore we muſt allow that they are the conſquence of the action of the animal organs. But this action, it may be ſaid, is merely the ſecretion of particular juices, which have the property of inducing the wiſhed-for change upon the food; and this very change would be produced out of the body, provided we could procure theſe ſubſtances, and apply them in proper quantity to the food. If this ſuppoſition be true, the ſpecific action of the veſſels conſiſts in the ſecretion of certain ſubſtances; conſequently the cauſe of this ſecretion is the *real* agent in aſſimilation. Now, can the *cauſe* of this ſecretion be ſhewn to be merely a chemical agent? Certainly not. For in the ſtomach, where only this ſecretion can be ſhewn to exiſt, it is not always the ſame, but varies according to circumſtances. Thus eagles at firſt cannot digeſt grain, but they may be brought to do it by perſiſting in making them uſe it as food. On the contrary, a lamb cannot at firſt digeſt animal food, but habit will alſo give it this power. In this caſe, it is evident that the gaſtric juice changes according to circumſtances. Now this is ſo far from being a caſe of a chemical law, that it is abſolutely incompatible with every ſuch law. The agent in aſſimilation, then, is not a chemical agent, but one which acts upon different principles. It is true, indeed, that every ſtep in the proceſs is chemical; but the agent which regulates theſe chemical proceſſes, which prevents them from acting, except in particular circumſtances and on particular ſubſtances, and modifies this action according to circumſtances, is not a mere chemical agent, but endowed with very different properties.

The preſence and power of this agent will be ſtill more evident, if we conſider the immunity of the ſtomach of the living animal during the proceſs of digeſtion. The ſtomach of animals is as fit for food as any other ſubſtance. The gaſtric juice, therefore, muſt have the ſame power of acting on it, and of decompoſing it, that it has of acting on other ſubſtances; yet it is well known that the ſtomach is not affected by digeſtion while the animal retains life; though, as Mr Hunter aſcertained, the very gaſtric juice which the living ſtomach ſecrets often diſſolves the ſtomach itſelf after death. Now what is the power which prevents the gaſtric juice from acting on the ſtomach during life? Certainly neither a chemical nor mechanical agent, for theſe agents muſt ſtill retain the ſame power after death. We muſt, then, of neceſſity conclude, that there exiſts in the animal an agent very different from chemical and mechanical powers, ſince it controuls theſe powers according to its pleaſure. Theſe powers therefore in the living body are merely the ſervants of this ſuperior agent, which directs them ſo as to accompliſh always one particular end. This agent ſeems to regulate the chemical powers, chiefly by bringing only certain ſubſtances together which are to be decompoſed, and by keeping at a diſtance thoſe ſubſtances which would interfere with, or diminiſh, or ſpoil the product, or

injure

---

† *Phil. Mag.* vi. 308.

injure the organ. And we ſee that this ſeparation is always attended to even when the ſubſtances are apparently mixed together. For the very ſame products are not obtained which would be obtained by mixing the ſame ſubſtances together out of the body that are produced by mixing them in the body; conſequently all the ſubſtances are not left at full liberty to obey the laws of their mutual affinities. The ſuperior agent, however, is not able to exerciſe an unlimited authority over the chemical powers; ſometimes they are too ſtrong for it: ſome ſubſtances accordingly, as madder, make their way into the ſyſtem; while others, as arſenic, decompoſe and deſtroy the organs of the body themſelves.

But it is not in digeſtion alone that this ſuperior agent makes the moſt wonderful diſplay of its power; it is in the laſt part of aſſimilation that our admiration is moſt powerfully excited. How comes it that the preciſe ſubſtances wanted are always carried to every organ of the body? How comes it that fibrina is always regularly depoſited in the muſcles, and phoſphat of lime in the bones? And what is ſtill more unaccountable, how comes it that prodigious quantities of ſome one particular ſubſtance are formed and carried to a particular place in order to ſupply new wants which did not before exiſt? A bone, for example, becomes diſeaſed and unfit for the uſe of the animal; a new bone therefore is formed in its place, and the old one is carried off by the abſorbents. In order to form this new bone, large-quantities of phoſphat of lime are depoſited in a place where the ſame quantity was not before neceſſary. Now, who informs this agent that an unuſual quantity of phoſphat of lime is neceſſary, and that it muſt be carried to that particular place? Or granting, as is moſt probable, that the phoſphat of lime of the old bone is partly employed for this purpoſe, who taught this agent that the old bone muſt be carried off, new modelled, and depoſited, and aſſimilated anew? The ſame wonders take place during the healing of every wound, and the renewing of every diſeaſed part.

Theſe operations are incompatible with the ſuppoſition that the body of animals is a mere chemical and mechanical machine; and demonſtrate the preſence of ſome agent beſides, which acts according to very different laws.

But neither in this caſe is the power of this agent over the chemical agents, which are employed, abſolute. We may prevent a fractured bone from healing by giving the patient large quantities of acids. And unleſs the materials for the new wanted ſubſtances be ſupplied by the food, they cannot, in many caſes, be formed at all. Thus the canary bird cannot complete her eggs unleſs ſhe be furniſhed with lime.

It is evident that the ſupreme agent of the animal body, whatever that agent may be, acts according to fixed laws; and that when theſe laws are oppoſed by thoſe which are more powerful, it cannot overcome them. Theſe laws clearly indicate deſign; and the agent has the power of modifying them ſomewhat according to circumſtances. Thus more phoſphat of lime is ſent to a limb which requires a new bone, and more lime than uſual is taken into the ſyſtem when the hen is laying eggs. Deſign and contingency are conſidered by us as infallible marks of conſciouſneſs and intelligence. That they are infallible marks of the agency of mind is certain; but that they are in all caſes the proofs of immediate conſciouſneſs and intelligence, as the Stahlians ſuppoſed, cannot be affirmed without running into inconſiſtencies. For we ourſelves are not conſcious of thoſe operations which take place during *aſſimilation*.

To ſay that a being can act with deſign without intelligence, we allow to be a flat contradiction, becauſe deſign always implies intelligence. There muſt therefore be intelligence ſomewhere. But may not this intelligence exiſt, not in the agent, but in the being who formed the agent? And may not the whole of the deſign belong in reality to that being?

368
Not material.

May not this agent, then, be material, and may not the whole of aſſimilation be performed by mere matter, acting according to laws given it by its maker? We anſwer, that what is called *matter*, or the ſubſtances enumerated in the firſt part of CHEMISTRY (*Suppl.*) act always according to certain attractions and repulſions, which are known by the name of mechanical and chemical laws.

The phenomena of aſſimilation are ſo far from being caſes of theſe laws, that they are abſolutely inconſiſtent with them, and contrary to them; conſequently the agent which preſides over *aſſimilation* is not *matter*. Concerning the nature of this ſubſtance it is not the buſineſs of this article to inquire; but as it poſſeſſes properties different from matter, and acts according to very different laws, it would be an abuſe of terms to call it *matter*.

369
Animal principle.

We would give it the name of *mind*, were it not that metaphyſicians have choſen to conſider intelligence as the eſſence of mind; whereas this ſubſtance may be conceived to act, and really does act, without intelligence. There is no reaſon, however, to ſuppoſe, with ſome, that there are two ſubſtances in animals: one poſſeſſed of conſciouſneſs as its eſſence, and therefore called *mind* or *ſoul* in man; another, deſtitute of conciouſneſs, called the *living principle*, &c. employed in performing the different functions of aſſimilation, abſorption, &c. It is much more reaſonable to ſuppoſe, that in every animal and vegetable there is a peculiar ſubſtance, different from matter, to which their peculiar properties are owing; that this ſubſtance is different in every ſpecies of animal and vegetable; that it is capable of acting according to certain fixed laws which have been impoſed upon it by its Creator, and that theſe laws are of ſuch a nature that it acts in ſubſervience to a particular end; that this ſubſtance in plants is probably deſtitute of intelligence; that in man and other animals it poſſeſſes intelligence to a certain extent, but that this intelligence is not eſſential to its exiſtence nor to its activity; that it may be deprived of intelligence altogether, and afterwards recover it without altering its nature. Phyſiologiſts have given it the name of *living principle*, becauſe its preſence conſtitutes life. Perhaps it would be proper to diſtinguiſh that of animals by the name of *animal principle*. Upon what the intelligence of the animal principle depends, it is impoſſible to ſay; but it is evidently connected with the ſtate of the brain. During a trance, or an apoplectic fit, it has often been loſt for a time, and afterwards recovered.

370
Secretion.

17. Beſides aſſimilation, the blood is alſo employed in forming all the different ſecretions which are neceſſary for the purpoſes of the animal economy. Theſe have been enumerated in the laſt chapter. The proceſs is ſimilar to that of aſſimilation, and undoubtedly the agents in both caſes are the ſame; but we are

equally ignorant of the preciſe manner in which ſecretion is performed as we are of aſſimilation.

371
Animals at length die, and why.

18. After theſe functions have gone on for a certain time, which is longer or ſhorter according to the nature of the animal, the body gradually decays, at laſt all its functions ceaſe completely, and the animal dies. The cauſe of this muſt appear very extraordinary, when we conſider the power which the animal has of renewing decayed parts; for it cannot be doubted that death proceeds, in moſt caſes at leaſt, from the body becoming incapable of performing its function. But if we conſider that this power is limited, and that it muſt ceaſe altogether, when thoſe parts of the ſyſtem begin to decay which are employed in preparing materials for future aſſimilation, our ſurpriſe will, in ſome meaſure, ceaſe. It is in theſe parts, in the organs of digeſtion and aſſimilation accordingly, that this decay uſually proves fatal. The decay in other parts deſtroys life only when the waſte is ſo rapid that it does not admit of repair.

What the reaſon is that the decay of the organs cauſes death, or, which is the ſame thing, cauſes the living principle either to ceaſe to act, or to leave the body altogether, it is perfectly impoſſible to ſay, becauſe we know too little of the nature of the living principle, and of the manner in which it is connected with the body. The laſt is evidently above the human underſtanding, but many of the properties of the living principle have been diſcovered; and were the facts already known properly arranged, and ſuch general concluſions drawn from them as their connection with each other fully warrant, a degree of light would be thrown upon the animal economy which thoſe, who have not attended to the ſubject, are not aware of.

No ſooner is the animal dead, than the chemical and mechanical agents, which were formerly ſervants, uſurp the ſupreme power, and ſoon decompoſe and deſtroy that very body which had been in a great meaſure reared by their means. But the changes which take place upon animal bodies after death, are too important, and too intimately connected with the ſubject of this article to be paſſed over ſlightly. They ſhall therefore form the ſubject of the next chapter.

Chap. IV. Of the Decompoſition of Animal Subſtances.

372
Decompoſition of animal ſubſtances expoſed to the air.

All the ſoft and the liquid parts of animals, when expoſed to a moderate temperature of ſixty-five degrees or more, paſs with more or leſs rapidity through the following changes. Their colour becomes paler, and their conſiſtence diminiſhes; if it be a ſolid part, ſuch as fleſh, it ſoftens, and a ſerous matter ſweats out, whoſe colour quickly changes; the texture of the part becomes relaxed, and its organization deſtroyed; it acquires a faint diſagreeable ſmell; the ſubſtance gradually ſinks down, and is diminiſhed in bulk; its ſmell becomes ſtronger and ammoniacal. If the ſubject be contained in a cloſe veſſel, the progreſs of putrefaction, at this ſtage, ſeems to ſlacken; no other ſmell but that of a pungent alkali is perceived; the matter effervеſces with acids, and converts ſyrup of violets to a green. But if the communication with the air be admitted, the urinous exhalation is diſſipated, and a peculiar putrid ſmell is ſpread around with a kind of impetuoſity; a ſmell of the moſt inſupportable kind, which laſts a long time, and pervades every place, affecting the bodies of living animals after the manner of a ferment, capable of altering the fluids: this ſmell is corrected, and as it were confined by ammonia. When the latter is volatilized, the putrefactive proceſs becomes active a ſecond time, and the ſubſtance ſuddenly ſwells up, becomes filled with bubbles of air, and ſoon after ſubſides again. Its colour changes, the fibrous texture of the fleſh being then ſcarcely diſtinguiſhable; and the whole is changed into a ſoft, brown, or greeniſh matter, of the conſiſtence of a poultice, whoſe ſmell is faint, nauſeous, and very active on the bodies of animals. The odorant principle gradually loſes its force; the fluid portion of the fleſh aſſumes a kind of conſiſtence, its colour becomes deeper, and it is finally reduced into a friable matter, rather deliqueſcent, which being rubbed between the fingers, breaks into a coarſe powder like earth. This is the laſt ſtate obſerved in the putrefaction of animal ſubſtances; they do not arrive at this term but at the end of a conſiderable time†.

373
Buried in the earth.

In carcaſes buried in the earth, putrefaction takes place much more ſlowly; but it is ſcarcely poſſible to obſerve its progreſs with accuracy. The abdomen is gradually dilated with elaſtic fluids which make their appearance in it, and at laſt it burſts and diſcharges a horribly fetid and noxious gas; at the ſame time a dark coloured liquid flows out. If the earth be very dry, and the heat conſiderable, the moiſture is often abſorbed ſo rapidly, that the carcaſe, inſtead of putrefying, dries, and is transformed into what is called a *mummy*.

374
When a
cumulate
together.

Such are the phenomena when dead bodies are left to putrefy ſeparately. But when great numbers of carcaſes are crowded together in one place, and are ſo abundant as to exclude the action of external air, and other foreign agents, their decompoſition is entirely the conſequence of the reciprocal action of their ingredients themſelves upon each other, and the reſult is very different. The body is not entirely diſſipated or converted into mould, but all the ſoft parts are found diminiſhed remarkably in ſize, and converted into a peculiar *ſaponaceous matter*. This ſingular change was firſt accurately obſerved in the year 1786.

375
Convert
into a ſa
naceous
matter.

The burial ground of the Innocents in Paris having become noxious to thoſe who lived in its neighbourhood, on account of the diſagreeable and hurtful odour which it exhaled, it was found neceſſary to remove the carcaſes to another place. It had been uſual to dig very large pits in that burial ground, and to fill them with the carcaſes of the poorer ſort of people, each in its proper bier; and when they were quite full, to cover them with about a foot depth of earth, and to dig another ſimilar pit, and fill it in the ſame manner. Each pit held between 1000 and 1500 dead bodies. It was in removing the bodies from theſe pits that this ſaponaceous ſubſtance was found. The grave-diggers had aſcertained, by long experience, that about thirty years were required before all the bodies had undergone this change in its full extent*. Every part of the body acquired the properties of this ſubſtance. The inteſtines and viſcera of the thorax had completely diſappeared; but what is ſingular enough, the brain had loſt but little of its ſize or appearance, though it was alſo converted into the ſame ſubſtance.

37
Its pr
ties.

This ſaponaceous matter was of a white colour, ſoft and unctuous to the touch, and melted, when heated,

like

---

† Fourcroy

* Four
Ann. de
Chim.
154.

mpoſi f Ani l Sub- ances.

like tallow. It exhibited all the properties of a *ſoap*, containing, however, an exceſs of fatty matter. Fourcroy, who analyſed it, found that it was compoſed of a fatty matter combined with ammonia, and that it contained alſo ſome phoſphat of lime and ammonia. Diluted acids decompoſed it, and ſeparated the fatty matter: alkalies and lime, on the other hand, drove off the ammonia. When expoſed to the air, it gradually loſt its white colour; the ammonia, in a great meaſure, evaporated, and what remained had ſomething of the appearance of wax. It abſorbed water with great avidity, and did not part with it readily. Its white colour was owing to the preſence of that liquid. The oily matter, when ſeparated by means of a diluted acid, was concrete, and of a white colour, owing to the mixture of a quantity of water. When dried, it acquires a greyiſh brown colour, a lamellar and cryſtalline texture, like that of ſpermaceti; but if it has been rapidly dried it aſſumes the appearance of wax It melts, when heated, to 126°; when properly purified, by paſſing it through a linen cloth while fluid, it has ſcarcely any ſmell. Alcohol does not act upon it while cold, but at the temperature of 120° it diſſolves it: when the ſolution cools, the fatty matter precipitates, and forms a gritty maſs. With alkalies it forms a ſoap; and when ſet on fire it burns preciſely like oil or fat, only that it exhales a more unpleaſant odour †.

377 oduced o in running water.

Mr Smith Gibbes found the ſame ſubſtance in the pit into which animal matters are thrown at Oxford after diſſection. A ſmall ſtream of water conſtantly paſſes through this pit; a circumſtance which induced him to try whether animal muſcle expoſed to the action of a running ſtream underwent the ſame change. The experiment ſucceeded completely: he attempted, in conſequence, to render this ſubſtance, to which he gave the name of *ſpermaceti*, uſeful in thoſe manufactures which required tallow; but the fetid odour which it conſtantly exhales was an inſurmountable objection. Attempts were indeed made to get over it; but as we do not hear that Mr Smith Gibbes's ſpermaceti has been introduced into any manufacture, we have reaſon to conclude that none of theſe attempts ſucceeded ‡.

Decompoſition of Animal Subſtances.

378 Theory of putrefaction imperfect.

Such are the phenomena of putrefaction, as far as they are at preſent known to chemiſts. Any attempt to explain the manner in which theſe changes take place, would be exceedingly imperfect indeed; not only becauſe we are ignorant of the ſtrength of the affinities of the different elementary parts of animal bodies for each other, but becauſe we do not even know the manner in which theſe elements are combined, and conſequently we cannot know by what particular forces theſe compounds are deſtroyed. We know only that a certain degree of heat, and the preſence of moiſture, are in all caſes neceſſary for the putrefactive proceſs; for animal bodies may be kept almoſt any length of time, without decompoſition, at the freezing temperature; and when dried quickly, and kept in that ſtate, they undergo no farther change.

PART III. OF DYEING.

MANKIND have in all periods of ſociety manifeſted a fondneſs for beautiful and gaudy colours Naked ſavages at firſt applied them to their ſkin. This was the caſe with the Britons, and with the Gauls, too, in the time of Cæſar; it is even ſtill the practice in the South Sea iſlands, and many parts of America. When mankind had advanced ſo far towards civilization as to wear garments, they naturally transferred to them the colours which they admired. Hence the origin of *dyeing*; which is of ſuch antiquity, that it precedes the earlieſt records left us by profane authors. We ſee from the book of Geneſis the great progreſs which it had made in the time of the patriarchs.

379 rigin of eing.

Dyeing ſeems to have originated in India, and to have ſpread gradually from that country to the weſt. The Indians were the inventors of the method of dyeing cotton and linen, which was not underſtood in Europe before the conqueſts of Alexander the Great. The Phenicians excelled in the art at a very early period. It was from them that the Jews purchaſed all the dyed ſtuffs deſcribed in Exodus. The Phenician dyers ſeem to have confined their art to wool: ſilk was unknown to them, and linen was uſually worn white. From them the art of dyeing paſſed to the Greeks and Romans.

During the fifth century, the Weſtern Empire was overturned by the northern nations, and with it the arts and ſciences, which had flouriſhed under the protection of the Romans, diſappeared. A few of the arts, indeed, were preſerved in Italy, but they were obſcured and degraded. By degrees, however, a ſpirit of induſtry began to revive in that country. Florence, Genoa, and Venice, becoming rich commercial cities, carried on a conſiderable intercourſe with the Grecian empire, where many of the arts had been preſerved. This intercourſe was much increaſed by the cruſades. The Italian cities became rich and powerful: the arts which diſtinguiſh civilized nations were cultivated with emulation, and dyeing, among others, was rapidly improved.

380 Its progreſs in modern Europe.

In the year 1429, the firſt treatiſe on dyeing made its appearance at Venice, under the name of *Moriegola del'arte de tentori*. Giovanne Ventura Roſetta collected, with great induſtry, all the proceſſes employed by the dyers of his time, and publiſhed them in 1548, under the title of *Plictho* *. For many years dyeing was almoſt excluſively confined to Italy; but it gradually made its way to France, the Low Countries, and to Britain. The miniſter Colbert, who employed his talents in extending the commerce and manufactures of France, paid particular attention to the art of *dyeing*. In the year 1672, he publiſhed a table of inſtructions, by which thoſe who practiſed the art were laid under ſeveral very improper reſtrictions. But the bad effects of theſe were in a good meaſure obviated by the judicious appointment of men of ſcience to ſuperintend the art. This plan, begun by Colbert, was continued by the French government. Accordingly, Dufay, Hellot, Macquer, and Berthollet, ſucceſſively filled the office. It is to this eſtabliſhment, and to exertions of the celebrated chemiſts who have filled it, that France is indebted for the improvements ſhe has made in the art of dyeing during the courſe of the 18th century. Under the direction of Dufay, a new table of regulations was publiſhed in 1737, which ſuperſeded that of Colbert. Hellot,

---

Fourcroy, n. de im. viii.

‡ *Phil. Tranſ.* 1794 and 1795.

* *Berthollet on Dyeing*, i 22.

Hellot, his ſucceſſor, publiſhed, in 1740, an excellent ſyſtem of dyeing wool; and Macquer in 1763 publiſhed his treatiſe on dyeing ſilk.

In Britain, though dyeing has been carried on for many years with great ſucceſs, very little progreſs was made in inveſtigating the theory of the art. The Royal Society, indeed, ſoon after its inſtitution, recommended it to ſome of its members; but as no treatiſe made its appearance in conſequence of this, it ſeems very ſoon to have loſt their attention. Lewis, many years after, publiſhed ſome very important remarks on dyeing; but they were confined to a few proceſſes. The Britiſh dyers ſatisfied themſelves with a tranſlation of Hellot. Such was the ſtate of the art when the article DYEING in the *Encyclopædia* was drawn up. It conſiſts chiefly of an abſtract of Hellot's treatiſe. But within the laſt 30 years, the attention of men of ſcience has been very much turned to [illegible] complicated art. In Sweden has appeared the treatiſe of Scheffer, and Bergman's notes on it; in Germany, the experiments of Beckmann, Poerner, and Vogler, and the diſſertation of Francheville; in France, the treatiſes of D'Ambournay, D'Apligny, Hauſſmann, Chaptal, and, above all, of Berthollet; in this country, the ingenious remarks of Delaval, of Henry, and the valuable treatiſe of Dr Bancroft; beſides many other important eſſays. Theſe, together with the progreſs of the ſcience of chemiſtry, on which the theory of dyeing depends, have thrown ſo much new light upon the art, that we find ourſelves under the neceſſity of tracing the whole over again. We ſhall paſs over, however, very ſlightly thoſe parts of the art which have been ſufficiently explained in the article DYEING, *Encycl.*

To underſtand the art of *dyeing*, we muſt be acquainted with the *ſubſtances* on which it is practiſed, with the nature of *colour*, and with the method of permanently changing the colour of bodies. Theſe three things we ſhall conſider in the three following chapters. In the firſt, we ſhall give an account of the ſubſtances of which garments are uſually made, with which alone the art of dyeing is concerned; in the ſecond, we ſhall inquire into the nature of colour; and in the third, explain the theory of dyeing, as far as it is at preſent underſtood. In ſome ſubſequent chapters, we ſhall give a general view of the proceſſes by which the different colours are given to ſtuffs.

CHAP. I. OF THE SUBSTANCES USED FOR CLOTHING.

381 Clothing

THE ſubſtances commonly employed for clothing may be reduced to four; namely *wool*, *ſilk*, *cotton*, *linen*. As there is no name in the Engliſh language which includes all theſe ſubſtances, we ſhall take the liberty, in the remainder of this article, to uſe the word *cloth* for that purpoſe. They are all made into *cloth*, of ſome kind or other, before they can be uſeful as articles of *clothing*.

382 Conſiſts of wool,

1. WOOL, as is well known, is the hair which covers the bodies of ſheep; it differs from common *hair* merely in fineneſs and ſoftneſs. Its filaments poſſeſs a conſiderable degree of elaſticity; they may be drawn out beyond their uſual length, and afterwards recover their form when the external force is removed. The ſurface of wool and hair is by no means ſmooth: No inequality, indeed, can be perceived by a microſcope; nor is any reſiſtance felt when a hair is laid hold of in one hand, and drawn between the fingers of the other, from the *root* towards the *point*; but if it be drawn from the *point* towards the *root*, a reſiſtance is felt which did not take place before, a tremulous motion is perceived, and a noiſe may be diſtinguiſhed by the ear. If, after laying hold of a hair between the thumb and fore finger, we rub them againſt each other in the longitudinal direction of the hair, it acquires a progreſſive motion *towards the root*; the *point* gradually approaches the fingers, while the *root* recedes from them; ſo that the whole hair very ſoon paſſes through between the fingers.

Theſe obſervations, firſt made by Mr Monge, demonſtrate that the ſurface of hair and wool is compoſed, either of ſmall laminæ, placed over each other in a ſlanting direction from the root towards the point, like the ſcales of a fiſh—or of zones, placed one above another, as takes place in the horns of animals *.

On this ſtructure of the filaments of hair and wool depend the effects of *felting* and *fulling*. In both of theſe operations, the filaments are made, by an external force, to rub againſt each other; the poſition of their aſperities prevents them from moving, except in one direction: they are mutually entangled, and obliged to approach nearer each other. Hence the thickneſs which cloth acquires in the fulling mill. The filaments have undergone a certain degree of felting, and are interwoven like the fibres of a hat. The cloth is contracted both in length and breadth: it may be cut without being ſubject to ravel; nor is there any neceſſity for hemming the different pieces employed to make a garment. See FELTING and FULLING, in this *Suppl.*

Wool is naturally covered with a kind of greaſe, which preſerves it from moths. This is always removed before the wool is dyed; becauſe its preſence is very prejudicial to the ſucceſs of that operation. The aſperities of the ſurface of woolly fibres would impede the converting of it into thread by ſpinning; but they are in a great meaſure covered, previous to that operation, by ſoaking the wool with oil. The oil muſt alſo be removed before the wool be dyed. This proceſs is called SCOURING, which ſee in this *Suppl.*

We have already, in the ſecond part of this article, given an account of what is at preſent known concerning the compoſition of wool and hair. It would be foreign to the ſubject of this chapter, to deſcribe the method of *ſpinning* and *weaving* wool.

Wool is of different colours; but that which is white is preferred for making cloth; becauſe it anſwers better for the purpoſes of dying than any other kind.

383 Silk,

2. SILK is a ſubſtance ſpun in fine threads by the *ſilk worm*. Its fibres are not ſcaly like thoſe of wool; neither have they the ſame elaſticity: but ſilk, in its natural ſtate, before it has undergone any preparation, has a conſiderable degree of ſtiffneſs and elaſticity. In this ſtate it is known by the name of *raw ſilk*. It is covered with a kind of gummy varniſh, which may be removed by ſcouring with ſoap. The ſcouring deprives it of its ſtiffneſs and elaſticity. Raw ſilk is of a yellow colour, owing to yellow reſinous matter with which it is naturally combined. We have given the method of ſeparating this matter, and alſo the gum, in the article BLEACHING, *Supplement*.

Silk, before it is dyed, is always freed from its gum, and generally alſo from its reſin. It may be dyed without

---

* *Ann. de Chim.* vi. 300.

out the application of heat ; which is not the caſe with wool.

3. COTTON is a fine downy ſubſtance, contained in the pods of different ſpecies of goſſypium. The ſpecies from which the greater part of the cotton brought to this country is taken is the *herbaceum*. The quantity imported annually into Britain is very great ; in 1786 it amounted to 20 millions of pounds ‡. Cotton varies greatly, according to the plant on which it grows, and the climate where it is cultivated. The chief differences are in colour, and in the length, fineneſs, and ſtrength of the filaments.

No aſperities can be diſcovered on the ſurface of theſe filaments ; but Lewenhoeck obſerved, by means of a microſcope, that they are triangular, and have three ſharp edges. This is probably the reaſon of a well known fact, that cotton cloth, when applied by way of dreſſing, always irritates a ſore.

Some cottons are naturally white ; others a fine light yellow, as thoſe of which nankeen is made ; but moſt commonly cotton is of a dirty browniſh yellow colour, which muſt be removed before the ſtuff can be dyed. This is done by the proceſs of *bleaching*. The fibres of cotton, even after being bleached, retain almoſt always ſome lime and oxyd of iron, which muſt be removed before we attempt to dye the cotton ; becauſe their preſence would ſpoil the colour. This is done by ſteeping the cotton for ſome time in water acidulated with ſulphuric acid.

Cotton, like ſilk, may be dyed without the aſſiſtance of heat. It is not nearly ſo eaſy to dye cotton any particular colour as it is to dye wool or ſilk. If wool and cotton be put into the ſame dyeing veſſel, the wool frequently acquires the wiſhed-for colour before the cotton has loſt any of its original whiteneſs.

4. LINT, from which *linen* is made, is the inner bark of the *linum uſſitatiſſimum*, or *flax* ; a plant too well known in this country to require any deſcription.

The flax, when ripe, is pulled and ſteeped for ſome days in water, in order to ſeparate the green coloured glutinous matter which adheres to the inner bark. This matter undergoes a degree of putrefaction ; carbonic acid gas and hydrogen gas, are diſengaged * : it is decompoſed, and carried off by the water. If the water, in which the flax is ſteeped, be completely ſtagnant, the putrefaction is apt to go too far, and to injure the fibres of the lint ; but in a running ſtream, it does not go far enough, ſo that the green matter ſtill continues to adhere to the lint. Flax, therefore, ſhould be ſteeped in water neither completely ſtagnant, nor flowing too freely, like a running ſtream.

The flax is afterwards ſpread upon the graſs, and expoſed for ſome time to the air and ſun : this improves the colour of the lint, and renders the woody part ſo brittle, that it is eaſily ſeparated by the action of the lint mill. The ſubſequent operations, of *dreſſing*, *ſpinning*, *weaving*, and *bleaching*, do not belong to this article.

The fibres of lint have very little elaſticity. They appear to be quite ſmooth ; for no aſperities can be perceived by the microſcope, nor detected by the feel ; nor does linen irritate ſores, as is the caſe with cotton.

Linen may be dyed without the aſſiſtance of heat ; but it is more difficult to give it permanent colours than even cotton.

Thus we have given a ſhort deſcription of wool, ſilk, cotton, and linen. The firſt two are animal ſubſtances ; the two laſt vegetable. The animal contain much azot and hydrogen ; the vegetable much carbon : The animal are readily deſtroyed by acids and alkalies ; the vegetable withſtand the action of theſe ſubſtances better ; even nitric acid does not readily deſtroy the texture of cotton. The animal ſubſtances are more eaſily dyed than the vegetable, and the colours which they receive are more permanent than thoſe given to cotton and linen by the ſame proceſſes.

Such are the properties of the cloths on which the art of dyeing is exercited. But what is the nature of theſe *colours* which it is the object of that art to communicate ? We ſhall examine this ſubject in the following chapter.

CHAP. II. OF COLOURS.

Colours.

ALL viſible objects, as has been long ago ſufficiently eſtabliſhed, are ſeen by means of rays of light paſſing off from them in all directions, and partly entering the eye of the ſpectator.

386 Colour produced by light.

1. For the theory of light and viſion we are indebted to Sir Iſaac Newton. He firſt demonſtrated, that light is compoſed of ſeven rays, differing from each other in refrangibility, and other properties. Each of theſe rays is diſtinguiſhed by its particular colour. Hence their names, red, orange, yellow, green, blue, indigo, violet. By mixing together theſe different rays, in various proportions, all the colours known may be obtained. Thus red and yellow conſtitute orange ; yellow and blue conſtitute green ; blue and red conſtitute purple, violate, aurora, &c. according to their proportions. When all the rays are mixed together, they form a white.

387 Bodies reflect different rays.

2. Bodies differ very much from each other in their power of reflecting light. Some reflect it in vaſt quantity, as metals ; others reflect but little, as charcoal. In general, the ſmoother the ſurface of a body is, the greater is the quantity of light which it reflects. Hence the effect of poliſhing in increaſing the brightneſs of bodies. But it is not in the quantity of the light reflected alone that bodies differ from each other ; they differ alſo in the quality of the light which they reflect. Some bodies reflect one or more particular ſpecies of ray to the excluſion of the reſt. This is the reaſon that they appear to us of different colours. Thoſe bodies which reflect only red rays are red ; thoſe that reflect yellow rays are yellow ; thoſe that reflect all the rays equally are white ; thoſe that reflect too little to affect the eye are black. It is to the different combinations of rays reflected from the ſurface of bodies that all the different ſhades of colour are owing.

388 Hence their different colours.

Colour, then, in *opaque* bodies, is owing to their diſpoſition to *reflect* certain rays of light, and to *abſorb* the reſt ; in *tranſparent* bodies, to their diſpoſition to *tranſmit* certain rays, and to *abſorb* the others. But this ſubject has been diſcuſſed, at ſufficient length, in the article OPTICS, *Encycl.* ; to which, therefore, we beg leave to refer the reader. Here we mean only to inquire into the *cauſe* of this diſpoſition of the particles of bodies.

389 Newtonian theory to explain this difference.

3. Sir Iſaac Newton, to whom we are indebted for the exiſtence of optics as a ſcience, made a ſet of experiments to aſcertain the changes of colour which thin plates of matter aſſume in conſequence of an increaſe or dimi-

diminution of their thickneſs. Theſe experiments were of a very delicate nature; but Newton conducted them with ſo much addreſs, and varied and repeated them with ſo much induſtry, that he was enabled to render them ſurpriſingly accurate

Upon a large double convex lens of a 50 feet focus, he placed the plane ſurface of a planoconvex lens, and preſſed the lenſes ſlowly together. A circle, of a particular colour, appeared in the centre, where the two glaſſes touched each other. This circle gradually increaſed in diameter as the preſſure was augmented; and at laſt a new circle, of another colour, occupied the centre, while the firſt colour aſſumed the form of a circular ring. By increaſing the preſſure, a new coloured circle appeared in the centre, and the diameter of the other two increaſed. In this manner he proceeded, till he produced no leſs than 25 different coloured circular rings. Theſe he divided into ſeven orders, on account of the repetition of the ſame colour. They were as follows, reckoning from the central colour, which was always black *.

1. Black, blue, white, yellow, red.
2. Violet, blue, green, yellow, red.
3. Purple, blue, green, yellow, red
4. Green, red.
5. Greeniſh blue, red.
6. Greeniſh blue, pale red.
7. Greeniſh blne, reddiſh white.

Theſe different colours were occaſioned by the thin film of air between the two glaſſes. Now this film varies in thickneſs from the centre of the lens towards the circumference; that part of it which cauſes the black colour is thinneſt, and the other coloured circles are occaſioned by air gradually increaſing in thickneſs. Newton meaſured the *relative thickneſs* of the air which produced each of theſe coloured circles; and he found it as follows †:

1.	Black	1
	blue	$2\frac{2}{5}$
	white	$5\frac{1}{4}$
	yellow	$7\frac{1}{6}$
	red	$8\frac{1}{2}$
2.	Violet	$11\frac{1}{6}$
	blue	14
	green	$15\frac{1}{8}$
	yellow	$16\frac{2}{7}$
	red	$18\frac{1}{3}$
3.	Purple	21
	blue	$23\frac{2}{3}$
	green	$25\frac{1}{5}$
	yellow	$27\frac{1}{7}$
	red	31
4.	Green	35
	red	$40\frac{1}{3}$
5.	Gr. blue	46
	red	$52\frac{1}{2}$
6.	Gr. blue	$58\frac{3}{4}$
	red	65
7.	Gr. blue	71
	reddiſh white	77

The *abſolute* thickneſs of theſe films cannot be aſcertained, unleſs the diſtance between the two glaſſes, at that part where the black ſpot appears, were known. Now there is no method of meaſuring this diſtance; but it certainly is not greater than the thouſandth part of an inch.

He repeated theſe experiments with films of water, and even of glaſs, inſtead of air; and he found, that in theſe caſes the thickneſs of the films, reflecting any particular colour, was diminiſhed, and that this diminution was proportional to the denſity of the reflecting film.

From theſe experiments Sir Iſaac Newton concluded, that the diſpoſition of the particles of bodies to reflect or tranſmit particular rays depended upon their ſize and their denſity: and he even attempted to aſcertain the ſize, or at leaſt the thickneſs, of the particles of bodies from their colours. Thus a particle of matter, whoſe denſity is the ſame with that of glaſs which reflects a green of the third order, is of the thickneſs of $\frac{16\frac{1}{4}}{1000000}$ of an inch *.

In the year 1765, Mr Delaval publiſhed, in the Philoſophical Tranſactions, a very ingenious paper on the ſame ſubject. In this paper, he endeavours to prove, by experiment, that the colours of metallic bodies depend upon their denſity. He takes it for granted, at the ſame time, that the ſize of the particles of bodies is inverſely as the denſity of bodies. The denſeſt bodies, according to him, are red; the next in denſity, orange; the next, yellow; and ſo on, in the order of the refrangibility of the different rays. Some time after, the ſame ingenious gentleman, in his *Experimental Inquiry into the Cauſe of the Permanent Colours of Opaque Bodies*, extended his views to animal and vegetable ſubſtances, and endeavoured to prove the truth of Newton's theory by a very great number of experiments.

Such is a view of the opinion of Newton and Delaval reſpecting the cauſe of bodies reflecting or tranſmitting particular rays of light, as far, at leaſt, as that theory relates to colour. They aſcribed this cauſe *ſolely* to the *ſize* and the *denſity* of the particles of bodies.

By *particles*, it is evident that nothing elſe can be meant than the *integrant particles* of bodies. Newton, indeed, does not expreſs himſelf preciſely in this language; but it is plain that nothing elſe could be his meaning. Mr Delaval undoubtedly is of that opinion.

According to the Newtonian theory of colour, then, it depends ſolely upon the *ſize* of the integrant particles of bodies whoſe denſity is the ſame; and upon the *ſize* and the *denſity* jointly of all bodies (T).

390 Examin

It is evident that the truth of the Newtonian theory muſt depend upon its coincidence with what actually takes place in nature, and that therefore it can only be determined by experiment. Newton himſelf produced but very few experiments in ſupport of it; and though this deficiency was amply ſupplied by Mr Delaval, it is needleſs for us to adduce any of theſe here; becauſe, from the prodigious accumulation of chemical facts ſince theſe experiments were made, the very baſis upon which they ſtood has been deſtroyed, and conſequently all the evidence reſulting from them has been annihilated. They proceeded on the ſuppoſition, that acids render the particles of bodies *ſmaller*, and alkalies *larger* than they were before, without producing any other change whatever in the bodies on which they act. To attempt a refutation of this opinion at preſent would be unneceſſary, as it is well known not to be true.

Let us therefore compare the Newtonian theory of colour with thoſe chemical changes which we know for certain to alter the ſize of the particles of bodies, in order to ſee whether they coincide with it. If the theory be true, the two following conſequences muſt hold

---

* *Newton's Optics*, 191. Clarke's edition.

† *Ibid.* p. 225.

* *Newt* *Optics*, 2

(T) Newton, however, pointed ont an exception to this law, concerning which Mr Delaval has been more explicit. Combuſtible bodies do not follow that law, but ſome other. Mr Delaval has ſuppoſed, that this deviation is owing to the preſence of phlogiſton.

hold in all caſes: 1. Every alteration in the ſize of the integrant particles of bodies muſt cauſe theſe particles to aſſume a different colour. 2. Every ſuch alteration muſt correſpond preciſely with the theory; that is to ſay, the new colour muſt be the very colour, and no other, which the theory makes to reſult from an increaſe or diminution of ſize.

Argument deciſive.

Now neither of theſe conſequences holds in fact. We have no method indeed of aſcertaining the ſizes of the integrant particles of bodies, nor of meaſuring the preciſe degree of augmentation or diminution which they ſuffer; but we can in many caſes aſcertain, whether any new matter has been added to a particle, or any matter abſtracted from it; and conſequently whether it has been augmented or diminiſhed; which is ſufficient for our preſent purpoſe.

For inſtance, whatever be the ſize of an integrant particle of gold, it cannot be denied that an integrant particle of oxyd of gold is greater; becauſe it contains an integrant particle of gold combined with at leaſt one integrant particle of oxygen. Now the colour both of gold and of its oxyd is yellow, which ought not to be the caſe, according to the Newtonian theory. In like manner, the amalgam of ſilver is white, preciſely the colour of ſilver and of mercury; yet an integrant particle of the amalgam muſt be larger than an integrant particle either of ſilver or of mercury. Many other inſtances beſides theſe will occur to every one, of changes in the ſize of the particles taking place without any change of colour. All theſe are incompatible with the Newtonian theory.

It may be ſaid, perhaps, in anſwer to this objection, that there are different orders of colours; that the ſame colour is reflected by particles of different ſizes; and that the increaſed particles, in the inſtances above alluded to, retain their former colour, becauſe the increment has been preciſely ſuch as to enable them to reflect the ſame colour in the next higher order.

This very anſwer is a complete proof that the Newtonian theory is not ſufficient to account for the colours of bodies; for if particles of *different* ſizes reflect the ſame colour, *ſize* certainly is not the only cauſe of this reflection*. There muſt be ſome other cauſe very different from ſize. Nor is this all; the moſt common colour which remains after an increaſe of the ſize of the integrant particles of bodies is white; yet white does not appear in any of the orders except the firſt, and therefore its permanence cannot be accounted for by any ſuppoſition compatible with the Newtonian theory.

Even when alterations in the colour of bodies accompany the increaſe or diminution of the ſize of their particles, theſe alterations ſeldom or never follow an order which correſponds with the theory. As for metals, it is ſelf-evident that their colour does not depend upon their denſity. Platinum is the denſeſt body known, and yet it is not red, as it ought to be, but white like tin; a metal which has little more than one third of the denſity of platinum.

The green oxyd of iron, when combined with pruſſic acid, becomes white; yet the ſize of its particles muſt be increaſed. Now this change of colour is incompatible with the theory; for, according to it, every change from green to white ought to be accompanied by a diminution inſtead of an increaſe of ſize. A particle of indigo, which is naturally green, becomes blue by the addition of oxygen, which muſt increaſe its ſize. This change is alſo incompatible with the theory. But it is unneceſſary to accumulate inſtances, as they will naturally occur in ſufficient number to every one.

It follows irreſiſtibly from theſe facts, that the Newtonian theory is not ſufficient to explain the *cauſe* of colour; or what cauſes bodies to reflect or tranſmit certain rays, and to abſorb the reſt.

392
Bodies owe their colour to their affinity for light.

4. We have endeavoured, in the article CHEMISTRY, *Suppl.* to ſhew, that bodies have a particular affinity for the rays of light; and that the phenomena of light depend entirely upon theſe affinities. Indeed this conſequence follows from the properties of light eſtabliſhed by Newton himſelf. We ſhall not repeat here the proofs upon which the exiſtence of theſe affinities is founded: the reader may eaſily ſatisfy himſelf by conſulting the article above referred to.

Every coloured body, then, has a certain *affinity for* ſome of the rays of light. Thoſe rays for which it has a ſtrong affinity are abſorbed by it and retained, and the other rays for which it has no affinity are either reflected or tranſmitted, according to the nature of the body and the direction of the incident ray. Thus a red body has an affinity for all the rays except the red; it abſorbs therefore the other ſix, and reflects only the red: a green body abſorbs all but the green rays, or perhaps the red and yellow: a black body has a ſtrong affinity for all the rays, and therefore abſorbs them all: while a white body, having no ſtrong affinity for any of the rays, reflects or tranſmits them all.

If affinity, as we have endeavoured to ſhew in the article CHEMISTRY, *Suppl.* be an attraction of the ſame nature with gravitation, and increaſing as the diſtance diminiſhes, it muſt depend upon the nature of the attracting particles. Now the only differences which we can conceive to exiſt between the particles of bodies, are differences in *ſize*, in *denſity*, and in *figure*. Changes in theſe three things will account for all the varieties of affinity. Now if affinity depends upon theſe three things, and if colour depends upon the affinity between the particles of bodies and the different rays of light as cannot be denied, it is clear that the cauſe of the colour of bodies may be ultimately reſolved into the ſize, denſity, and figure, of their particles. Newton's theory, then, was defective, becauſe he omitted the *figure* of the particles, and aſcribed the whole to variations in *ſize* and *denſity*.

When we ſay, then, that colour is owing to *affinity*, we do not contradict the opinion of Newton, as ſome philoſophers have ſuppoſed, but merely extend it: Newton was *not miſtaken* in ſaying, that colour depends upon the ſize and the denſity of the particles of bodies; his miſtake lay in ſuppoſing that it depends upon theſe *alone*.

393
Why bodies change their colour.

5. Since the colour of bodies depends upon their affinity for light, and ſince every body has a certain colour, becauſe it abſorbs and retains particular rays while it tranſmits or reflects the reſt, it is evident that every body muſt continue of its firſt colour till one of two things happen; either till it be ſaturated with the rays which it abſorbs, and of courſe ceaſe to abſorb any more, or till its particles change their nature, by being either decompoſed or combined with ſome new ſubſtance. We have no poſitive proof that the firſt cauſe

---

* Bancroft Perma. Colours,

cauſe of change ever occurs, as many ſubſtances have been expoſed to the action of light for a very long time without any change of colour. The abſorbed light ſeems to make its eſcape, either in its own form, or in ſome unknown or unſuſpected one. The ſecond cauſe of change is very common: indeed its action may be detected in almoſt every caſe of alteration in the colour of bodies. The green oxyd of iron, by combining with oxygen, becomes red; and this red oxyd, when combined with pruſſic acid, aſſumes a blue colour, and with gallic acid a black colour. The cauſe of this change of colour, when the compoſition of a body changes, is obvious: every change of compoſition muſt alter the affinity, becauſe it muſt of neceſſity produce changes in the ſize, denſity, or figure of the particles, or perhaps in all of theſe. Now if the affinity of a body for other bodies be altered, it is natural to ſuppoſe that it will be altered alſo for light. Accordingly this happens in moſt inſtances. It does not, however, take place conſtantly, for very obvious reaſons. It may happen that the new denſity, ſize, or figure of the altered body is ſuch, as to render it ſtill proper for attracting the very ſame rays of light which it formerly attracted. Juſt as iron, after being combined with a certain doſe of oxygen, is converted into green oxyd, which ſtill retains an affinity for oxygen.

It is evident from all this, that in moſt caſes the permanence of colour in bodies will depend upon the permanence of their compoſition, or on the degree of facility with which they are acted upon by thoſe bodies, to the agency of which they are expoſed.

394 Permanency of colour of great importance in *dyeing*.

In *dyeing*, the permanence of colour is of very great importance. Of what value is the beauty of a colour, provided that colour be fugitive or liable to change into ſome other. In all caſes, therefore, it is of conſequence to attend to the ſubſtances to which dyed cloth is expoſed, and to aſcertain their action upon every particular dyeing ingredient. Now the bodies to which dyed cloth is almoſt conſtantly expoſed are *air* and *light*; the combined action of which has ſo much influence, that very few dyes can reſiſt it.

395 How dyes loſe their colour.

It is evident that thoſe ſubſtances which have a ſtrong affinity for oxygen cannot retain their colour, provided they be able to take it from atmoſpheric air. Thus the green colour of green oxyd of iron and of indigo is not permanent, becauſe theſe ſubſtances readily abſorb oxygen from air. In order, then, that a colour can have any permanence, the coloured body muſt not have ſo great an affinity for oxygen as to be able to take it from air. Thoſe bodies have in general the moſt permanent colours which are already ſaturated with oxygen, and therefore not liable to abſorb more. Such is the caſe with red oxyd of iron.

All coloured bodies are compounds; ſome of thoſe only excepted which ſtill retain an affinity for oxygen. Coloured bodies, therefore, are compoſed of ſeveral ingredients; and in every coloured body, at leaſt *ſome* of the ingredients have a ſtrong affinity for oxygen. Now, before the colour of a body can be permanent, its ingredients muſt be combined together by ſo ſtrong affinities, that oxygen gas is unable to decompoſe it by combining with one or more of its ingredients and carrying it off. If this decompoſition take place at once, it is impoſſible for the colour of a body to have any permanence. If it takes place ſlowly, the colour of the body gradually decays. The action of oxygen gas upon bodies is much increaſed in particular circumſtances. Almoſt all coloured bodies are decompoſed by oxygen gas by the aſſiſtance of heat. Thus if wheat flour be expoſed to the heat of 448°, it loſes its white colour, and becomes firſt brown and then black. At this temperature it is decompoſed, and a part, or even the whole of its hydrogen, combining with oxygen, flies off. Cloth is ſcarcely ever expoſed to ſo high a temperature; but there are other circumſtances in which it may be placed which may have a ſimilar effect. Thus the action of light ſeems in ſome ſubſtances to be ſimilar to that of heat, and to facilitate the decompoſition of the coloured matter by the combination of ſome of its ingredients with oxygen *.

Coloured bodies, in order to have permanent colours, muſt not be liable to be decompoſed by other ſubſtances more than by oxygen. For inſtance, if they contain oxygen and hydrogen, theſe two bodies muſt not be liable to combine together and form water, nor muſt oxygen and carbon be liable to combine and form carbonic acid gas. Light ſeems to have a tendency to decompoſe many bodies in this manner, and even to carry off oxygen from them in the form of oxygen gas. Thus it renders the nitrat of ſilver black by carrying off part of its oxygen, and it reduces oxy-muriatic acid to common muriatic acid by the ſame means.

Theſe are the cauſes which induce a change in the colour of coloured bodies, as far as they have been traced; namely, the addition of oxygen, the abſtraction of oxygen, partial decompoſition by ſome one of their ingredients combining with oxygen, complete or partial decompoſition by the ingredients entering into new combinations with each other. The coloured matters uſed in dyeing are very liable to theſe changes, becauſe they are in general animal or vegetable ſubſtances of a very compound nature. Of courſe their ingredients have often no very ſtrong affinity for each other, and therefore are very liable to decompoſition; and every one of the ingredients has in general a very ſtrong affinity for oxygen. This renders the choice of proper colouring matters for dyeing a very important point. In order to have permanency, they muſt not be liable to the above changes, not to mention their being able alſo to withſtand the action of ſoap, acids, alkalies, and every other ſubſtance to which dyed cloth may be expoſed.

396 Metho aſcertai ing the manen dyes.

It becomes therefore a point of ſome conſequence to be able to aſcertain whether cloth dyed of any particular colour be permanently dyed or not. The proper method of aſcertaining this is by actually expoſing ſuch cloth to the ſun and air; becauſe as theſe are the agents to which it is to be expoſed, and which have the moſt powerful action, it is clear, that if it withſtand them, the colour muſt be conſidered as permanent. But this is a tedious proceſs. Berthollet propoſed expoſing ſuch cloth to the action of oxy-muriatic acid; thoſe colours that withſtand it being conſidered as permanent. This method anſwers in many caſes: but it is not always to be depended on; for it deſtroys ſome permanent colours very ſpeedily, and does not alter others which are very fading *. But we ſhall have occaſion to reſume this ſubject afterwards.

397 Divi colour

Dyers divide colours into two claſſes; namely, *ſimple* and *compound*. The ſimple colours are thoſe which cannot

---

* Bertho on Dyein i. 45.

* Ban i. 49.

Dyeing in General.

cannot be produced by the mixture of other colours. They are in number four.

1. Blue, 3. Red,
2. Yellow, 4. Black.

Some add a fiſth, *brown;* but it may be produced by combining two others.

The compound colours are thoſe which are produced by mixing together any two ſimple colours in various proportions. They conſtitute all the colours except the four ſimple and their various ſhades.

Thus we have examined the nature of colours; but we have ſtill to explain the method of giving permanent colours to cloth. This ſhall be the ſubject of the next chapter.

CHAP. III. OF DYEING IN GENERAL.

FROM the theory of colour laid down in the laſt chapter, it follows, that permanent alterations in the colour of cloth can only be induced two ways; either by producing a chemical change in the cloth, or by covering its fibres with ſome ſubſtance which poſſeſſes the wiſhed for colour. Recourſe can ſeldom or never be had to the firſt method, becauſe it is hardly poſſible to produce a chemical change in the fibres of cloth without ſpoiling its texture and rendering it uſeleſs. The dyer, therefore, when he wiſhes to give a new colour to cloth, has always recourſe to the ſecond method.

98 1. The ſubſtances employed for this purpoſe are called *colouring matters*, or *dye ſtuffs*. They are for the moſt part extracted from *animal and vegetable ſubſtances*, and have uſually the colour which they are intended to give to the cloth. Thus a blue colour is given to cloth by covering its fibres with indigo, a blue powder extracted from a ſhrub; a red colour, by the colouring matter extracted by water from an inſect called *cochineal*, or from the root of a plant called *madder.*

99 2. Mr Delaval has publiſhed a very intereſting ſet of experiments on colouring matters in the ſecond volume of the Mancheſter Memoirs. He has proved, by a very numerous ſet of experiments, that they are all tranſparent, and that they do not *reflect* any light, but only tranſmit it: For every colouring matter which he tried, even when diſſolved in a liquid, and forming a tranſparent coloured ſolution, when ſeen merely by reflected light, was black, whatever was the colour of the matter; but when ſeen by tranſmitted light, it appeared of its natural colour *. This diſcovery, which Mr Delaval has eſtabliſhed very completely, and to which, as far at leaſt as dye ſtuffs are concerned, there are but few exceptions, is of very great importance to the art of dyeing, and explains ſeveral particulars which would otherwiſe be unintelligible.

Since the particles of the colouring matter with which cloth, when dyed, is covered, are tranſparent, it follows, that all the light reflected from dyed cloth muſt be reflected, not by the dye ſtuff itſelf, but by the fibres of the cloth below the dye ſtuff. The colour therefore does not depend upon the dye alone, but alſo upon the previous colour of the cloth. If the cloth be *black*, it is clear that we cannot dye it any colour whatever; becauſe as no light in that caſe is reflected, none can be tranſmitted, whatever dye ſtuff we employ. If the cloth were red, or blue, or yellow, we could not dye it any colour except black; becauſe as only red, or blue, or yellow rays were reflected, no other could be tranſmitted (x). Hence the importance of a fine white colour when cloth is to receive bright dyes: It then reflects all the rays in abundance; and therefore any colour may be given, by covering it with a dye ſtuff which tranſmits only ſome particular rays.

400 They muſt be combined with the cloth.

3. If the colouring matters were merely ſpread over the ſurface of the fibre of cloth by the dyer, the colours produced might be very bright, but they could not be permanent; becauſe the colouring matter would be very ſoon rubbed off, and would totally diſappear whenever the cloth was waſhed, or even barely expoſed to the weather. The colouring matter, then, however perfect a colour it poſſeſſes, is of no value, unleſs it alſo adheres ſo firmly to the cloth, that none of the ſubſtances uſually applied to cloth in order to clean it, &c. can diſplace it. Now this can only happen when there is a ſtrong *affinity* between the colouring matter and the cloth, and when they are actually combined together in conſequence of that affinity.

401 Can only be applied in a ſtate of ſolution.

4. Dyeing, then, is merely a chemical proceſs, and conſiſts in combining a certain colouring matter with the fibres of cloth. This proceſs can in no inſtance be performed, unleſs the dye ſtuff be firſt reduced to its integrant particles; for the attraction of aggregation between the particles of dye ſtuffs is too great to be overcome by the affinity between them and cloth, unleſs they could be brought within much ſmaller diſtances than is poſſible, while they both remain in a ſolid form. It is neceſſary, therefore, previouſly to diſſolve the colouring matter in ſome liquid or other, which has a weaker affinity for it than the cloth has. When the cloth is dipped into this ſolution, the colouring matter, reduced by this contrivance to a liquid ſtate, is brought within the attracting diſtance; the cloth therefore acts upon it, and by its ſtronger affinity takes it from the ſolvent, and fixes it upon itſelf. By this contrivance, too, the equality of the colour is in ſome meaſure ſecured, as every part of the cloth has an opportunity of attracting to itſelf the proper proportion of colouring particles.

The facility with which cloth imbibes a dye, depends upon two things, namely, the affinity between the cloth and the dye ſtuff, and the affinity between the dye ſtuff and its ſolvent. It is directly as the former, and inverſely as the latter. It is of importance to preſerve a due proportion between theſe two affinities, as upon that proportion much of the accuracy of dyeing depends. If the affinity between the colouring matter and the cloth be too great, compared with the affinity between the colouring matter and the ſolvent, the cloth will take the dye too rapidly, and it will be ſcarce poſſible to prevent its colour from being unequal. On the other hand, if the affinity between the colouring matter and the ſolvent be too great, compared with

---

(x) Theſe remarks hold only on the ſuppoſition, that the *whole* of the ſurface is of the given colour, which in many inſtances is not the caſe.

that between the colouring matter and the cloth, the cloth will either not take the colour at all, or it will take it very ſlowly and very faintly.

Wool has the ſtrongeſt affinity for almoſt all colouring matters, ſilk the next ſtrongeſt, cotton a conſiderably weaker affinity, and linen the weakeſt affinity of all. Therefore, in order to dye cotton or linen, the dye ſtuff ſhould in many caſes be diſſolved in a ſubſtance for which it has a weaker affinity than for the ſolvent employed in the dyeing of wool or ſilk. Thus we may uſe oxyd of iron diſſolved in ſulphuric acid, in order to dye wool; but for cotton and linen, it is better to diſſolve it in acetous acid.

402
Nature of mordants.

5. Were it poſſible to procure a ſufficient number of colouring matters having a ſtrong affinity for cloth, to anſwer all the purpoſes of dyeing, that art would be exceedingly ſimple and eaſy. But this is by no means the caſe: if we except indigo, the dyer is ſcarcely poſſeſſed of a dye ſtuff which yields of itſelf a good colour ſufficiently permanent to deſerve the name of a dye.

This difficulty, which at firſt ſight appears inſurmountable, has been obviated by a very ingenious contrivance. Some ſubſtance is pitched upon which has a ſtrong affinity both for the cloth and the colouring matter. This ſubſtance is previouſly combined with the cloth, which is then dipped into the ſolution containing the dye ſtuff. The dye ſtuff combines with the intermediate ſubſtance; which, being firmly combined with the cloth, ſecures the permanence of the dye. Subſtances employed for this purpoſe are denominated *mordants* (y).

The moſt important part of dyeing is undoubtedly the proper choice and the proper application of mordants, as upon them the permanency of almoſt every dye depends. Every thing which has been ſaid reſpecting the application of colouring matters, applies equally to the application of mordants. They muſt be previouſly diſſolved in ſome liquid, which has a weaker affinity for them than the cloth has to which they are to be applied; and the cloth muſt be dipped, or even ſteeped, in this ſolution, in order to ſaturate itſelf with the mordant.

Almoſt the only ſubſtances uſed as mordants are, earths, metallic oxyds, tan, and oil.

403
Earthy mordants.

6. Of earthy mordants, by far the moſt important and moſt generally uſed is alumina. It was uſed as a mordant in very early ages, and ſeems indeed to have been the very firſt ſubſtance employed for that purpoſe. Alumina has a very ſtrong affinity for wool and for ſilk; but its affinity for cotton and linen is a good deal weaker.

It is uſed as a mordant in two ſtates; either in the ſtate of alum, in which it is combined with ſulphuric acid and a little potaſs; or in the ſtate of acetite of alumina, in which it is combined with acetous acid.

Alum was employed as a mordant very early. The ancients, indeed, do not ſeem to have been generally acquainted with pure alum; they uſed it in that ſtate of impurity in which it is found native; of courſe it was uſed in dyeing long before the nature of its ingredients was underſtood, and therefore long before the part which it acts was ſuſpected. Indeed, it is but a very ſhort time ſince the office which mordants perform was ſuſpected: the firſt perſon that hit upon it was Mr Keir; he gave an account of the real uſe of mordants in his tranſlation of Macquer's Dictionary, publiſhed in 1771*.

* Macqu
p. 215.

Alum, when uſed as a mordant, is diſſolved in water, and very frequently a quantity of tartar is diſſolved along with it. Into this ſolution the cloth is put and kept in it till it has abſorbed as much alumina as is neceſſary. It is then taken out, and for the moſt part waſhed and dried. It is now a good deal heavier than it was before, owing to the alumina which has combined with it. The tartar ſerves two purpoſes: the potaſs which it contains combines with the ſulphuric acid of the alum, and thus prevents that very corroſive ſubſtance from injuring the texture of the cloth, which otherwiſe might happen; the tartarous acid, on the other hand, combines with part of the alumina, and forms a tartrite of alumina, which is more eaſily decompoſed by the cloth than alum.

Acetite of alumina has been introduced into dyeing ſince the commencement of the 18th century; and, like many other very important improvements, we are indebted for it to the ignorance of the calico printers, who firſt introduced it. As they did not underſtand the nature nor uſe of the mordants which they employed, they were accuſtomed to mix with their alum an immenſe farrago of ſubſtances, a great proportion of which were injurious inſtead of being of ſervice. Some one or other had mixed with alum acetite of lead: the good effects of this mixture would be ſoon perceived; the quantity of acetite was gradually increaſed, and the other ingredients omitted*. This mordant is now prepared, by pouring acetite of lead into a ſolution of alum: a double decompoſition takes place, the ſulphuric acid combines with the lead, and the compound precipitates in the form of an inſoluble powder; while the alumina combines with the acetous acid, and remains diſſolved in the liquid. This mordant is employed for cotton and linen, which have a weaker affinity than wool for alumina. It anſwers much better than alum, the cloth is more eaſily ſaturated with alumina, and takes, in conſequence, both a richer and a more permanent colour.

* Banc
p. 170.

Beſides alumina, *lime* is ſometimes uſed as a mordant. Cloth has a ſtrong enough affinity for it; but in general it does not anſwer ſo well, as it does not give ſo good a colour. When uſed, it is either in the ſtate of lime-water or of ſulphat of lime diſſolved in water.

40
Metall
morda

7. Almoſt all the metallic oxyds have an affinity for cloth; but only two of them are extenſively uſed as mordants, namely, the oxyds of tin and of iron.

The oxyd of tin was firſt introduced into dyeing by Kuſter (z), a German chemiſt, who brought the ſecret to London in 1543. This period forms an era in the hiſtory of dyeing. The oxyd of tin has enabled the moderns

---

(y) This term, impoſed by the French dyers before the action of mordants was underſtood, ſignifies *biters* or *corroders*. Theſe bodies were ſuppoſed to act merely by corroding the *cloth*. Mr Henry of Mancheſter has propoſed to ſubſtitute the word *baſis* for *mordant*; but that word is too general to anſwer the purpoſe well.

(z) Mr Delaval has ſuppoſed, that the Tyrians were acquainted with the uſe of tin in dyeing, and Mr Henry moderns greatly to ſurpaſs the ancients in the fineneſs of their colours: by means of it alone, *ſcarlet*, the brighteſt of all colours, is produced. The method of producing the celebrated purple dye of the ancients is underſtood at preſent, and the ſhell fiſh which yield the dye ſtuff are found abundantly on the coaſts of Britain and France; but no perſon thinks now of putting the ancient mode in practice, becauſe infinitely more beautiful colours can be produced at a ſmaller price. Much of this ſuperiority is owing to the employment of the oxyd of tin.

Tin, as Prouſt has proved, is capable of two degrees of oxydation: The firſt oxyd is compoſed of 0.70 parts of tin, and 0.30 of oxygen; the ſecond, or white oxyd, of 0.60 parts of tin, and 0.40 of oxygen *. The firſt oxyd abſorbs oxygen with very great facility even from the air, and is rapidly converted into white oxyd. This fact makes it certain, that it is the white oxyd of tin which is the real mordant: even if the other oxyd alone were applied to cloth, as it probably often is, it muſt ſoon be converted into white oxyd, by abſorbing oxygen from the atmoſphere.

Tin is uſed as a mordant in three ſtates; diſſolved in nitro-muriatic acid, in acetous acid, and in a mixture of ſulphuric and muriatic acids. Nitro-muriat of tin is the common mordant employed by dyers. They prepare it by diſſolving tin in diluted nitric acid, to which a certain proportion of muriat of ſoda, or of ammonia, is added. Part of the nitric acid decompoſes theſe ſalts, combines with their baſe, and ſets the muriatic acid at liberty. They prepared it at firſt with nitric acid alone; but that mode was very defective; becauſe the nitric acid very readily converts tin to white oxyd, and then is incapable of diſſolving it. The conſequence of which was, the precipitation of the whole of the tin. To remedy this defect, common ſalt, or ſal ammoniac, was very ſoon added; muriatic acid having the property of diſſolving white oxyd of tin very readily. A conſiderable ſaving of nitric acid might be obtained, by employing as much ſulphuric acid as is juſt ſufficient to ſaturate the baſe of the common ſalt, or ſal ammoniac, employed.

When the nitro-muriat of tin is to be uſed as a mordant, it is diſſolved in a large quantity of water, and the cloth is dipped in the ſolution, and allowed to remain till ſufficiently ſaturated. It is then taken out, and waſhed and dried. Tartar is uſually diſſolved in the water along with the nitro-muriat. The conſequence of this is a double decompoſition; the nitro-muriatic acid combines with the potaſs of the tartar, while the tartarous acid diſſolves the oxyd of tin. When tartar is uſed, therefore, in any conſiderable quantity, the mordant is not a nitro-muriat, but a tartrite of tin.

Mr Hauſſman, to whom the art of dyeing lies under numerous obligations, has propoſed to ſubſtitute acetite of tin for nitro-muriat as a mordant for cotton and linen. It may be prepared by mixing together acetite of lead and nitro-muriat of tin. This mordant is preferable for theſe ſtuffs; becauſe it is much more eaſily decompoſed than the nitro-muriat †.

Dr Bancroft has propoſed to ſubſtitute a ſolution of tin in a mixture of ſulphuric and muriatic acid, inſtead of nitro-muriat of tin, as a mordant for wool. This mordant, he informs us, is much cheaper, and equally efficacious. It may be prepared by diſſolving ſomewhat leſs than one part of tin in two parts of ſulphuric and three of muriatic acid, at the degree of concentration at which they are commonly ſold in this country ‡. This mordant, like the others, muſt be diſſolved in a ſufficient quantity of water, in order to be uſed.

Iron, like tin, is capable of two degrees of oxydation; but the green oxyd abſorbs oxygen ſo readily from the atmoſphere, that it is very ſoon converted into the red oxyd. It is only this laſt oxyd which is really uſed as a mordant in dyeing. The green oxyd is indeed ſometimes applied to cloth; but it very ſoon abſorbs oxygen, and is converted into the red oxyd. This oxyd has a very ſtrong affinity for all kinds of cloth. The permanency of the iron ſpots on linen and cotton is a ſufficient proof of this. As a mordant, it is uſed in two ſtates; in that of ſulphat of iron, and acetite of iron. The firſt is commonly uſed for wool. The ſalt is diſſolved in water, and the cloth dipped in it. It may be uſed alſo for cotton; but in moſt caſes acetite of iron is preferred. It is prepared by diſſolving iron, or its oxyd, in vinegar, ſour beer, &c. and the longer it is kept, the more is it preferred. The reaſon is, that this mordant ſucceeds beſt when the iron is in the ſtate of red oxyd. It would be better then to oxydate the iron, or convert it into ruſt, before uſing it; which might eaſily be done, by keeping it for ſome time in a moiſt place, and ſprinkling it occaſionally with water. Of late, pyrolignous acid has been introduced inſtead of acetous. It is obtained by diſtilling wood or tar.

Tan.

8. Tan, which has been already deſcribed in the firſt part of this article, has a very ſtrong affinity for cloth, and for ſeveral colouring matters. It is therefore very frequently employed as a mordant. An infuſion of *nut galls*, or of *ſumach* (A), or any other ſubſtance containing tan, is made in water, and the cloth is dipped in this infuſion, and allowed to remain till it has abſorbed a ſufficient quantity of tan. Silk is capable of abſorbing a very great proportion of tan, and by that means acquires a very great increaſe of weight. Manufacturers ſometimes employ this method of increaſing the weight of ſilk *.

Tan is often employed alſo, along with other mordants, in order to produce a compound mordant. Oil is alſo uſed for the ſame purpoſe in the dyeing of cotton and linen. The mordants, with which tan moſt frequently is combined, are alumina and oxyd of iron.

406
Other mordants.

Beſides theſe mordants, there are ſeveral other ſubſtances frequently uſed as auxiliaries, either to facilitate the combination of the mordant with the cloth, or to alter

* nn. de .xxviii

† *Ann. de Chim.* xxx. 15.

‡ *Bancroft*, p. 290.

* *Bertholet*, ii. 10.

---

ry has declared himſelf of the ſame opinion. But his reaſoning, as Dr Bancroft has ſhewn, proceeds upon a miſtake. He ſuppoſes that tin is *neceſſary* for the production of red colours.

(A) Sumach is the *rhus coriaria*; a ſhrub which is cultivated in the ſouthern parts of Europe. Its ſhoots are dried, and afterwards ground to powder; in which ſtate they are ſold to the dyer and tanner.

alter the ſhade of colour. The chief of theſe are, *tartar, acetite of lead, common ſalt, ſal ammoniac, ſulphat* or *acetite of copper*, &c.

407
Mordants affect the colour.

9. Mordants not only render the dye permanent, but have alſo conſiderable influence on the colour produced. The ſame colouring matter produces very different dyes, according as the mordant is changed. Suppoſe, for inſtance, that the colouring matter be cochineal; if we uſe the aluminous mordant, the cloth will acquire a crimſon colour; but the oxyd of iron produces with it a black. Theſe changes, indeed, might naturally have been expected: for ſince the colour of a dye ſtuff depends upon its affinity for light, every new combination into which it enters, having a tendency to alter theſe affinities, will naturally give it a new colour. Now, in all caſes, the colouring matter and mordant combine together: the colour of the cloth, then, muſt be that which the particles of the dye and of the mordant, when thus combined together, exhibit. Indeed ſome mordants may be conſidered in the light of colouring matters alſo, as they always communicate a particular colour to cloth. Thus, iron communicates a brown colour, and iron and tan together conſtitute a black dye.

In dyeing, then, it is not only neceſſary to procure a mordant which has a ſufficiently ſtrong affinity for the colouring matter and the cloth, and a colouring matter which poſſeſſes the wiſhed-for colour in perfection, we muſt procure a mordant and a colouring matter of ſuch a nature, that when *combined together* they ſhall poſſeſs the wiſhed-for colour in perfection. It is evident, too, that a great variety of colours may be produced with a ſingle dye ſtuff, provided we can change the mordant ſufficiently.

408
How applied.

10. Every thing which tends to weaken the affinity between the mordant and the cloth, or between the mordant and the colouring matter, and every thing which tends in any way to alter the nature of the mordant, muſt injure the permanency of the dye: becauſe, whenever the mordant is deſtroyed, there is no longer any thing to cauſe the dye ſtuff to adhere; and when its nature is altered, the colour of the dye muſt alter at the ſame time. All the obſervations, then, which were made in the laſt chapter, concerning the nature of colouring matters, and the changes to which they are ſubject, apply equally to mordants. Theſe ſubſtances, indeed, are ſcarcely liable themſelves to any alteration. They are of a much more ſimple nature, in general, than dye ſtuffs; and therefore not nearly ſo liable to decompoſition. But when the colouring matter itſelf is altered, it comes to the ſame thing. Its affinity for the mordant being now deſtroyed, there is nothing to retain it.

As the permanency of a dye depends upon the degree of affinity between the mordant and the colouring matter, it is clear, that a dye may want permanency, even though it reſiſt the oxy muriatic acid, and all the other ſaline teſts propoſed by chemiſts. Theſe ſubſtances may happen to have very little action on the dye ſtuff, and therefore may not affect it; yet it may ſoon diſappear, in conſequence of its want of affinity for the mordant.

409
Dye-ſtuffs do not cover the whole ſurface of the cloth.

11. The colouring matter with which cloth is dyed, does not cover every portion of its ſurface; its particles attach themſelves to the cloth at certain diſtances from each other: for cloth may be dyed different ſhades of the ſame colour, lighter or darker, merely by varying the quantity of colouring matter. With a ſmall quantity, the ſhade is light; and it becomes deeper as the quantity increaſes. Now this would be impoſſible, if the dye ſtuff covered the whole of the cloth. Newton has demonſtrated, that colours are rendered faint when the rays of light which occaſion them are mixed with white rays. Conſequently, from cloth dyed of a light ſhade, a conſiderable quantity of white rays paſſes off unchanged: but this could not be the caſe if the ſtuff were covered with coloured matter; becauſe all the white rays would be decompoſed as they paſs through the coloured matter. Therefore, in light ſhades, the colouring matter does not cover the cloth; its particles adhere to it, at a certain diſtance from each other, and from every part of the cloth which is uncovered, the white rays paſs off unchanged. Even when the ſhade of colour is as deep as poſſible, the colouring particles do not cover the whole of the cloth, but are at a certain diſtance from each other. This diſtance, undoubtedly, is diminiſhed in proportion to the deepneſs of the ſhade: for the deeper the ſhade, the ſmaller is the number of white rays which eſcape undecompoſed; the more, therefore, of the ſurface is covered, and, conſequently, the ſmaller is the diſtance at which each of them is placed. A ſhade may be even conceived ſo very deep, that not a particle of white light eſcapes the action of the colouring matter; in which caſe, the diſtance between the particles of colouring matter could not exceed double that diſtance at which a particle of matter is able to act upon light.

410
Compound colours.

That the particles of colouring matter, even when the ſhade is deep, are at ſome diſtance, is evident from this well-known fact, that cloth may be dyed two colours at the ſame time. All thoſe colours, to which the dyers give the name of *compound*, are in fact two different colours applied to the cloth at once. Thus cloth gets a *green* colour, by being firſt dyed *blue* and then *yellow*. The rays of light that paſs from green cloth thus dyed are blue and yellow; by the mixture of which it is well known that green is produced. In this caſe, it is clear, that each of the colouring matters performs the very ſame office as if it were alone; and that the new colour is not produced by the combination of the two colouring matters. That part of the white light, reflected from the cloth, which paſſes through the blue colouring matter, is decompoſed, and the blue rays only tranſmitted; and that part of the white light which paſſes through the yellow colouring matter is alſo decompoſed, and only the yellow rays tranſmitted. It is clear, therefore, that both of the colouring matters equally cover the naked fibres of the cloth; conſequently the one muſt be placed in the intervals of the other: wherefore the particles of each of the colouring matters are at ſome diſtance. Now the ſame effect happens how deep ſoever the ſhade be; and it makes no difference which of the two dyes be firſt given. Nay, if one of the dyes have a ſtrong affinity for the cloth, and the other only a weak affinity, the latter will ſoon diſappear, and leave the cloth of the colour which the firſt dye gives it.

The difference, then, in the ſhade of colour, and alſo the compound colours which cloth may receive, depend entirely upon the diſtance between the particles of the colouring matters attached to the cloth, and the poſſibi-

lity

lue.

lity of partly filling up the intervals, either with the ſame colouring matter, or with a different one.

Thus we have taken a view of the theory of dyeing, as far, at leaſt, as it is at preſent underſtood. It remains for us ſtill to give an account of the particular manner by which each of the colours is imparted to cloth. This ſhall be the ſubject of the three following chapters. In the *firſt* we ſhall treat of the manner of dyeing the ſimple colours; in the *ſecond*, of dyeing the compound colours; and in the *third*, of dyeing cloth partially ſeveral different colours at the ſame time, or of that branch of the art of dyeing which is known in this country by the name of *calico printing*.

CHAP. IV. OF DYEING SIMPLE COLOURS.

THE colours denominated by dyers *ſimple*, becauſe they are the foundation of all their other proceſſes, are four; namely, 1*ſt*, blue;—2*d*, yellow;—3*d*, red;—4*th*, black. To theſe they uſually add a fifth, under the name of *root*, or brown colour. Theſe ſhall form the ſubject of the following ſections.

SECT. I. *Of* BLUE.

411 e dyes.

THE only colouring matters employed in dyeing blue are *woad* and *indigo*: attempts, indeed, have been made to dye with pruſſiat of iron; but theſe attempts have hitherto failed.

412 oad.

1. The *iſatis tinctoria*, or *woad*, is a plant commonly enough cultivated in this kingdom, and even found wild in ſome parts of England. It is of a yellowiſh colour. Some perſons think that it was this plant with which the ancient Britons ſtained their bodies, to make them appear terrible to their enemies. When arrived at maturity, this plant is cut down, waſhed, dried haſtily in the ſun, ground in a mill, placed in heaps, and allowed to ferment for a fortnight; then well mixed together, formed into balls, which are piled upon each other, and expoſed to the wind and ſun. In this ſtate they gradually become hot, and exhale a putrid ammoniacal ſmell. The fermentation is promoted, if neceſſary, by ſprinkling the balls with water. When it has continued for a ſufficient time, the woad is allowed to fall to a coarſe powder. In this ſtate it is ſold to the dyers.

413 digo.

2. Indigo, is a blue coloured powder extracted from the *indigofera tinctoria*, and from ſeveral other ſpecies of the ſame genus of plants, which are cultivated for that purpoſe both in the Eaſt and Weſt Indies.

414 low prepared.

When the *indigofera* has arrived at maturity, it is cut a few inches above ground, placed in ſtrata in a large veſſel, and covered with water. The plants ſoon acquire heat, ferment, and diſcharge abundance of carbonic acid gas. When the fermentation is far enough advanced, which is judged of by the paleneſs of the leaves, the liquid, now of a green colour, is decanted into large flat veſſels, where it is conſtantly agitated till blue flocculæ begin to make their appearance. Lime water is now poured in, which cauſes the blue flocks to precipitate. The colourleſs liquid is decanted off, and the blue ſediment poured into linen bags. When the water has drained from it ſufficiently, it is formed into ſmall lumps, and dried in the ſhade. In this ſtate it is ſold to the dyer under the name of *indigo*.

Blue.

Dr Roxbourgh, who firſt drew the attention of manufacturers to the *nerium tinctorium*, a tree very common in Indoſtan, from the leaves of which indigo may be extracted with much advantage, has given a much ſhorter method of obtaining that pigment. The leaves are kept in a copper full of water, ſupported at the temperature of 160°, till they aſſume a yellowiſh hue, and the liquid acquire a deep green colour. The liquid is then to be drawn off, agitated in the uſual manner, till the blue flocculæ appear; and then the indigo is be precipitated with lime water *.

* *Bancroft*, 423.

This proceſs, which ſucceeds equally well with the indigofera, ſhews us that the plants, from which indigo may be extracted, contain a peculiar green pollen, ſoluble in water. The intention, both of the fermentation of the common method, and of the ſcalding, according to Dr Roxbourgh's method, is merely to extract this pollen. Mr Hauſſman firſt ſhewed, that this green baſis of indigo has a ſtrong affinity for oxygen; and the ſubſequent experiments of Drs Roxbourgh and Bancroft have confirmed his obſervations, and put them beyond the reach of doubt. It gradually attracts oxygen from the air; in conſequence of which, it acquires a blue colour, and becomes inſoluble in water. The agitation is intended to facilitate this abſorption, by expoſing a greater ſurface to the action of the air. The lime water, by abſorbing a quantity of carbonic acid, with which the green pollen ſeems to be combined, greatly facilitates the ſeparation of the indigo.

The method of preparing indigo, and of applying it to the purpoſes of dyeing, ſeems to have been very early known in India. But in Europe, though it had been occaſionally uſed as a paint *, its importance as a dye ſtuff was not underſtood before the middle of the 16th century. It is not even mentioned in the *Plictho*, which was publiſhed in 1548. At that period, then, the uſe of indigo muſt have been unknown to the Italian dyers. The Dutch were the people who firſt imported it from India, and made its importance known in Europe. It was afterwards cultivated in Mexico and the Weſt Indies with ſuch ſucceſs, that the indigo from theſe countries was preferred to every other. In conſequence of this preference, they ſupplied almoſt the whole of the European market. But within theſe few years, the Eaſt Indian indigo, owing entirely to the enlightened exertions of ſome of our own countrymen, has recovered its character, and is now imported, in very conſiderable quantities, into Britain.

* *Plinii*, l. 35. c. 6.

The indigo of commerce has different ſhades of colour, according to the manner in which it has been prepared, and the proportion of foreign ſubſtances with which it is mixed. The principal ſhades are copper colour, violet, and blue. That indigo, which has the ſmalleſt ſpecific gravity, is always moſt eſteemed; becauſe it is moſt free from impurities. Bergman † found the pureſt indigo of commerce which he could procure, compoſed of

47	pure indigo,
12	gum,
6	reſin,
22	earth,
13	oxyd of iron.
100 (B).	

† *Berg.* v. 36.

Pure

(B) Prouſt informs us, that he found magneſia, even abundantly, in indigo.—*Nicholſon's Jour.* III. 325.

415 Its properties.

Pure indigo is inſoluble in water, alcohol, æther, and oils: neither alkalies nor earths have any action on it; none of the acids hitherto tried have any effect on it, except the nitric and ſulphuric. Nitric acid very ſoon converts it into a dirty white colour, and at laſt decompoſes it completely *. When the acid is concentrated, it even ſets fire to the indigo (c); when it is diluted, the indigo becomes brown, cryſtals make their appearance, reſembling thoſe of oxalic and tartarous acids; and there remains behind, after the acid and the cryſtals are waſhed off, a viſcid ſubſtance, of a very bitter taſte, and poſſeſſing many of the properties of a reſin †.

Concentrated ſulphuric acid diſſolves indigo readily, and much heat is evolved. The ſaturated ſolution is opaque, and conſequently black; but it aſſumes a deep blue colour when diluted with water. This ſolution is well known in commerce under the name of *liquid blue.* Bancroft has given it the name of *ſulphat of indigo.* During the ſolution of the indigo, ſome ſulphurous acid, and ſome hydrogen gas, are evolved ‡, and the blue colour of the indigo is much heightened. Theſe facts have led Bancroft to ſuppoſe, that the indigo, during its ſolution, combines with an additional quantity of oxygen *. This *may* poſſibly be the caſe, but the phenomena are not ſufficient to eſtabliſh it: for the hydrogen gas and ſulphurous acid evolved may owe their formation, not to the action of the ſulphuric acid on indigo, but upon the impurities with which it is always mixed; and the improvement of the colour may be owing to the abſence of theſe impurities. The carbonats of fixed alkalies precipitate ſlowly from ſulphat of indigo a blue coloured powder, which poſſeſſes the properties of indigo; but it is ſoluble in moſt acids and in alkalies. Pure alkalies deſtroy the colour and properties of ſulphat of indigo: they deſtroy alſo precipitated indigo §. Theſe facts give ſome probability to Bancroft's opinion; but they do not eſtabliſh it: becauſe the differences between common and precipitated indigo may depend merely on the ſtate of greater minuteneſs to which it is reduced, which prevents the attraction of aggregation from obſtructing the action of other bodies. Even ſilica, when newly precipitated, is ſoluble in many menſtrua.

416 Method of dyeing with ſulphat of indigo.

3. Indigo has a very ſtrong affinity for wool, ſilk, cotton, and linen. Every kind of cloth, therefore, may be dyed with it, without the aſſiſtance of any mordant whatever. The colour thus induced is very permanent; becauſe the indigo is already ſaturated with oxygen, and becauſe it is not liable to be decompoſed by thoſe ſubſtances, to the action of which the cloth is expoſed. But it can only be applied to cloth in a ſtate of ſolution; and the only ſolvent known being ſulphuric acid, it would ſeem at firſt ſight that the ſulphuric acid ſolution is the only ſtate in which indigo can be employed as a dye.

The ſulphat of indigo is indeed often uſed to dye wool and ſilk blue; but it can ſcarcely be applied to cotton and linen, becauſe the affinity of theſe ſubſtances for indigo is not great enough to enable them readily to decompoſe the ſulphat. The colour given by ſulphat of indigo is exceedingly beautiful: it is known by the name of Saxon blue; becauſe the proceſs, which was diſcovered by councellor Barth in 1740, was firſt carried on at Groſſenhayn in Saxony. The method of the original inventor was very complicated, from the great number of uſeleſs ingredients which were mixed with the ſulphat. But theſe ingredients were gradually laid aſide, and the compoſition ſimplified by others, after the nature of it, which was for ſome time kept ſecret, became known to the public. The beſt proceſs is that of Mr Poerner *.

One part of indigo is to be diſſolved in four parts of concentrated ſulphuric acid; to the ſolution one part of dry carbonat of potaſs is to be added, and then it is to be diluted with eight times its weight of water. The cloth muſt be boiled for an hour in a ſolution, containing five parts of alum and three of tartar for every 32 parts of cloth. It is then to be thrown into a water bath, containing a greater or ſmaller proportion of the diluted ſulphat of indigo, according to the ſhade which the cloth is intended to receive. In this bath it muſt be boiled till it has acquired the wiſhed for colour. The alum and tartar are not intended to act as mordants, but to facilitate the decompoſition of the ſulphat of indigo. Bergman aſcertained that alum poſſeſſes this property. The alkali added to the ſulphat anſwers the ſame purpoſe. Theſe ſubſtances, alſo, by ſaturating part of the ſulphuric acid, ſerve, in ſome meaſure, to prevent the texture of the cloth from being injured by the action of the acid, which is very apt to happen in this proceſs.

417 Method of dyeing by decompoſing indigo.

4. But ſulphat of indigo is by no means the only ſolution of that pigment employed in dyeing. By far the moſt common method, and indeed the only method known before 1740, is to deprive indigo of the oxygen to which it owes its blue colour, and thus to reduce it to the ſtate of green pollen; and then to diſſolve it in water by means of alkalies, or alkaline earths, which in that ſtate act upon it very readily. Indigo is preciſely in the ſtate of green pollen when it is firſt extracted from the plant in the ſcalding proceſs deſcribed by Dr Roxbourgh. If, therefore, there were any method of ſtopping ſhort here, and of ſeparating the pigment while it retains its green colour, it would be preciſely in the ſtate beſt adapted for dyeing. Nothing more would be neceſſary but to diſſolve it in water by means of an alkali, and to dip the cloth into the ſolution †.

But as indigo is not brought home to us in that ſtate, the dyer is under the neceſſity of undoing the laſt part of the indigo maker's proceſs, by ſeparating again the oxygen, and reſtoring it to its original green colour. Two different methods are employed for this purpoſe. The firſt of theſe methods is to mix with indigo a ſolution of ſome ſubſtance which has a ſtronger affinity for oxygen than the green baſis of indigo. Green oxyd of iron, for inſtance, and different metallic ſulphurets. If, therefore, indigo, lime, and green ſulphat of iron, be mixed together in water, the indigo gradually

---

* *Berg.* v. 3.

† *Hauſſmann.*

‡ *Id.*

* *Bancroft,* i. 130.

§ *Berg.* v. 7.

* *Inſtruction ſur l'Art de la Teinture,* p. 183.

† *Bancroft.*

(c) The combuſtion of indigo by nitric acid, of the denſity 1.52°, was firſt publiſhed by Mr Sage; but Woulfe appears to have obſerved the fact before him, and to have pointed it out to Rouelle, who ſhewed it in his lectures. *Prouſt, Nicholſon's Jour.* III. 325.

gradually loſes its blue colour, becomes green, and is diſſolved, while the green oxyd of iron is converted into the red oxyd. The manner in which theſe changes take place is obvious. Part of the lime decompoſes the ſulphat of iron; the green oxyd, the inſtant that it is ſet at liberty, attracts oxygen from the indigo, decompoſes it, and reduces it to the ſtate of green pollen. This green pollen is immediately diſſolved by the action of the reſt of the lime. In like manner, indigo is diſſolved, when mixed in water, with pure antimony and potaſs, or with ſulphuret of arſenic and potaſs. For theſe intereſting facts we are indebted to Mr Hauſſman.

The ſecond method is to mix the indigo in water with certain vegetable ſubſtances which readily undergo fermentation. During this fermentation, the indigo is deprived of its oxygen, and diſſolved by means of quicklime or alkali, which is added to the ſolution. The firſt of theſe methods is uſually followed in dyeing cotton and linen; the ſecond, in dyeing wool and ſilk.

418 ow to in- ce a blue our on ol,

5. In the dyeing of wool, woad and bran are commonly employed as vegetable ferments, and lime as the ſolvent of the green baſe of the indigo. Woad contains itſelf a colouring matter preciſely ſimilar to indigo; by following the common proceſs, indigo may be extracted from it. In the uſual ſtate of woad, when purchaſed by the dyer, the indigo which it contains is probably not far from the ſtate of green pollen. Its quantity in woad is but ſmall, and it is mixed with a great proportion of other vegetable matter. Before the introduction of indigo into Europe, woad alone was employed as a blue dye; and even as late as the 17th century, the uſe of indigo was reſtricted in different countries, and dyers obliged to employ a certain quantity of woad (D). But theſe abſurd reſtrictions were at laſt removed, and woad is now ſcarcely uſed in dyeing, except as a ferment to indigo. The blue colouring matter, however, which it contains, muſt, in all caſes, contribute conſiderably to the dye.

A ſufficient quantity of woad, mixed with bran, is put into a wooden veſſel filled with warm water, whoſe temperature is kept up ſufficiently to enſure fermentation. Afterwards quicklime and indigo are added. The indigo is deprived of its oxygen, and diſſolved by the lime. When the ſolution is complete, the liquid has a green colour, except at the ſurface, where it is copper coloured, or blue, becauſe the indigo at the ſurface abſorbs oxygen from the air, and aſſumes its natural colour. The woollen cloth is dipped in, and paſſed thro' the liquid as equably as poſſible, piece after piece; thoſe pieces being firſt dyed which are to aſſume the deepeſt ſhade. No part of the cloth ſhould come in contact with the ſediment, which would ſpoil the colour. When the cloth is firſt taken out of the vat, it is of a green colour; but it ſoon becomes blue, by attracting oxygen from the air. It ought to be carefully waſhed, to carry off the uncombined particles. This ſolution of indigo is liable to two inconveniences: 1. It is apt ſometimes to run too faſt into the putrid fermentation: this may be known by the putrid vapours which it exhales, and by the diſappearing of the green colour. In this ſtate it would ſoon deſtroy the indigo altogether. The inconvenience is remedied by adding more lime, which has the property of moderating the putreſcent tendency. 2. Sometimes the fermentation goes on too languidly. This defect is remedied by adding more bran or woad, in order to diminiſh the proportion of quicklime.

419 Silk,

6. Silk is uſually dyed blue by the following proceſs: Six parts of bran, and ſix of indigo, with nearly one part of madder, are ſtirred into a ſufficient quantity of water, in which ſix parts of common potaſh of commerce is diſſolved. The liquid is kept at a temperature proper for fermentation. When the indigo, deprived of its oxygen by the fermentation, is diſſolved by the potaſs, the liquid aſſumes a green colour. The ſilk, previouſly well ſcoured, is put into the ſolution in ſmall quantities at a time; then wrung out of the dye, and hung up in the open air, till the green colour which it has at firſt is changed into blue. By this method, ſilk can only be made to receive a light blue colour. In order to give ſilk a dark blue, it muſt previouſly receive what is called a ground colour; that is, be previouſly dyed ſome other colour. A particular kind of red dye-ſtuff, called *archil* (E), is commonly employed for this purpoſe.

The madder employed in the above proceſs may, at firſt ſight, appear ſuperfluous; it ſeems, however, to contribute ſomething to the colour.

420 Cotton, and linen.

7. Cotton and linen are dyed blue by the following proceſs: One part of indigo, one part of green ſulphat of iron, and two parts of quicklime, are ſtirred into a ſufficient quantity of water. The ſolution is at firſt green, but it gradually aſſumes a yellow colour, and its ſurface is covered with a ſhining copper coloured pellicle. The cloth is to be allowed to remain in the ſolution for five or ſix minutes. When taken out, it has a yellow colour; but on expoſure to the atmoſphere, it ſoon becomes green, and then blue, in conſequence of the abſorption of oxygen. The indigo, in this proceſs, ſeems to be deprived of a greater quantity of oxygen than is neceſſary to reduce it to the ſtate of green pollen. Mr Hauſſman has obſerved, that the cloth acquires a much deeper colour, provided it be plunged, the inſtant it is taken out of the dyeing vat, into water acidulated with ſulphuric acid. It is uſual to dip the cloth into a ſucceſſion of vats, variouſly charged with colouring matter; beginning with the vat which contains leaſt colouring matter, and paſſing gradually to thoſe which contain moſt. By this contrivance the cloth is dyed more equally, than it probably would be, if it were plunged all at once into a ſaturated ſolution of colouring matter.

SECT. II. *Of YELLOW.*

421 Yellow dyes.

THE principal colouring matters employed to dye yellow are *weld*, *fuſtic*, and *quercitron bark*.

1. Reſeda luteola, known in this country by the name of

(D) The employment of indigo was ſtrictly prohibited in England in the reign of Queen Elizabeth; nor was the prohibition taken off till the reign of Charles II. It was prohibited alſo in Saxony. In the edict it is ſpoken of as a corroſive ſubſtance, and called *food for the devil*. Colbert reſtricted the French dyers to a certain quantity of it.

(E) This will be deſcribed in a ſubſequent ſection.

Yellow.

422 Weld. of *weld*, is a plant which grows wild very commonly in Scotland, and in moſt European countries. Cultivated weld has a more ſlender ſtem than the wild kind, but it is more valuable, becauſe it is much more rich in colouring matter. It is an annual plant, of a yellowiſh green colour, furniſhed with a great number of ſmall leaves. When ripe it is pulled, dried, tied up in parcels, and in that ſtate ſold to the dyer.

Weld readily yields its colouring matter to water. The ſaturated decoction of it is brown; but when ſufficiently diluted with water it becomes yellow. Acids render its colour ſomewhat paler, but alkalies give it a deeper ſhade. When alum is added to it, a yellow coloured precipitate falls down, conſiſting of alumina combined with the colouring matter of weld. The affinity therefore of this colouring matter for alumina is ſo great, that it is able to abſtract it from ſulphuric acid. Its affinity for oxyd of tin is at leaſt equally great; for muriat of tin cauſes a copious bright yellow precipitate, compoſed of the colouring matter and the oxyd combined. Moſt of the metallic ſalts occaſion ſimilar precipitates, but varying in colour according to the metal employed. With iron, for inſtance, the precipitate is dark grey, and with copper browniſh green *.

* *Berthollet*, ii. 260.

423 Fuſtic. 2. The *morus tinctoria* is a large tree which grows in the Weſt India iſlands. The wood of this tree is of a yellow colour, with orange veins. The French call it *yellow wood (bois jaune)*; but the Engliſh dyers have given it the abſurd name of *old fuſtic* (F). This wood has been introduced into dyeing ſince the diſcovery of America. The preciſe time is not known; but that it was uſed in England ſoon after the middle of the 17th century, is evident from Sir William Petty's paper on *Dyeing*, read to the Royal Society ſoon after its inſtitution. In that paper particular mention is made of *old fuſtic*.

Fuſtic gives out its colouring matter with great facility to water. The ſaturated decoction of it is of a deep reddiſh yellow colour; when ſufficiently diluted it becomes orange yellow. Acids render it turbid, give it a pale yellow colour, and occaſion a ſlight greeniſh precipitate, which alkalies rediſſolve. Alkalies give the decoction a very deep colour, inclining to red; ſome time after they have been added, a yellow matter ſeparates from the liquid, and either ſwims on the ſurface, or adheres to the ſides of the veſſel. Alum, ſulphat of iron, of copper, and of zinc, produce precipitates compoſed of the colouring matter combined reſpectively with the baſes of theſe different ſalts; and the colour varies according to the ſubſtance with which this colouring matter is combined. With alumina it is yellow; with iron, yellowiſh brown; with copper, browniſh yellow; and with zinc, greeniſh brown †.

† *Id.* ii. 269.

424 Quercitron. 3. The *quercus nigra*, to which Dr Bancroft has given the name of *quercitron*, is a large tree which grows naturally in North America. Dr Bancroft diſcovered, about the year 1784, that the bark of this tree contains a great quantity of yellow colouring matter, and ſince that time it has been introduced into dyeing with much advantage. To prepare it for the dyer, the epidermis is ſhaved off, and then it is ground in a mill. It ſeparates partly into ſtringy filaments, and partly into a fine light powder. Both of theſe contain colouring matter, and therefore are to be employed; but as they contain unequal quantities, they ſhould be uſed in their natural proportions.

Quercitron bark readily gives out its colouring matter to water at the temperature of 100°. The infuſion has a yellowiſh brown colour, which is rendered lighter by acids, and darker by alkalies. Alum occaſions a ſcanty precipitate of a deep yellow colour; muriat of tin, a copious bright yellow precipitate; ſulphat of tin, a dark olive precipitate; and ſulphat of copper, a precipitate of a yellow colour inclining to olive ‡.

‡ *Bancroft*, i. 320.

425 Other yellow dyes. 4. Beſides theſe dye ſtuffs there are others occaſionally uſed by dyers. The following are the moſt remarkable:

Geniſta tinctoria, or *dyers broom*. This plant yields a very inferior yellow; it is only uſed for coarſe woollen ſtuffs.

Serratula tinctoria, or *ſaw wort*. This plant yields a yellow nearly of the ſame nature with *weld*; for which, therefore, it is a good ſubſtitute

Juglans alba, or *American hiccory*. The bark of this tree yields a colouring matter exactly ſimilar to that of quercitron bark, but much ſmaller in quantity.

Anotta is a name given to a red paſte formed of the berries of the bixa orellana, a tree which is a native of America. This paſte yields its colouring matter to a ſolution of alkali in water. The ſolution affords an exceedingly beautiful yellow dye, but very fading, and incapable of being fixed by any known mordant.

Turmeric is the root of the *curcuma longa*, a plant which grows both in the Eaſt and Weſt Indies. It is richer in colouring matter than any other yellow dye ſtuff. It yields very beautiful yellows, but too fading to be of much uſe, and no mordant has any influence in contributing to their permanence.

416 Yellow requires a mordant. 5. Yellow colouring matters have too weak an affinity for cloth to produce permanent colours without the uſe of mordants. Cloth, therefore, before it be dyed yellow, is always prepared by combining ſome mordant or other with it. The mordant moſt commonly employed for this purpoſe is alumina. Oxyd of tin is ſometimes uſed when very fine yellows are wanted. Tan is often employed as a ſubſidiary to alumina, in order to fix it more copiouſly on cotton and linen. Tartar is alſo uſed as an auxiliary to brighten the colour; and muriat of ſoda, ſulphat of lime, and even ſulphat of iron, in order to render the ſhade deeper.

6. The yellow dyed by means of fuſtic is more permanent, but not ſo beautiful as that given by weld or quercitron. As it is permanent, and not much injured by acids, it is often uſed in dyeing compound colours

where

(F) The *rhus cotinus*, or Venice ſumach, is a ſmall ſhrub, formerly employed as a yellow dye, but now almoſt out of uſe. The French call it *fuſtet*, from which word it is probable, as Dr Bancroft ſuppoſes, that our dyers formed the term *fuſtic*. When the *morus tinctoria* was introduced as a dye-ſtuff, they gave it the ſame name: but in order to diſtinguiſh the two, they called the ſumach, which was a ſmall ſhrub, *young fuſtic*; and the morus, which was a large tree, *old fuſtic*. See *Bancroft*, i. 412.

llow. where a yellow is required. The mordant is alumina. When the mordant is oxyd of iron, fuſtic dyes a good permanent drab colour.

Weld and quercitron bark yield nearly the ſame kind of colour; but as the bark yields colouring matter in much greater abundance, it is much more convenient, and, upon the whole, cheaper than weld. It is probable, therefore, that it will gradually ſuperſede the uſe of that plant. The method of uſing each of theſe dye ſtuffs is nearly the ſame.

27 thod of icing a ow co- on l,

7. Wool may be dyed yellow by the following proceſs: Let it be boiled for an hour, or more, with about $\frac{1}{6}$th of its weight of alum, diſſolved in a ſufficient quantity of water. It is then to be plunged, without being rinced, into a bath of warm water, containing in it as much quercitron bark as equals the weight of the alum employed as a mordant. The cloth is to be turned through the boiling liquid till it has acquired the intended colour. Then a quantity of clean powdered chalk, equal to the hundredth part of the weight of the cloth, is to be ſtirred in, and the operation of dyeing continued for eight or ten minutes longer. By this method a pretty deep and lively yellow may be given fully as permanent as weld yellow [*].

For very bright *orange*, or *golden yellows*, it is neceſſary to have recourſe to the oxyd of tin as a mordant. A fine orange yellow may be given to woollen cloth, by putting, for every ten parts of cloth, one part of bark into a ſufficient quantity of hot water; after a few minutes, an equal weight of murio-ſulphat of tin is to be added, and the mixture well ſtirred. The cloth acquires the wiſhed for colour in a few minutes when briſkly turned in this bath [†].

The ſame proceſs will ſerve for producing *bright golden yellows*, only ſome alum muſt be added along with the tin. For the brighteſt golden yellow, the proportions ſufficient for dyeing 100 parts of cloth are, 10 parts of bark, 7 parts of murio-ſulphat of tin, and 5 parts of alum. All the poſſible ſhades of golden yellow may be given to cloth merely by varying the proportion of the ingredients according to the ſhade [‡].

In order to give the yellow that delicate *green* ſhade ſo much admired for certain purpoſes, the ſame proceſs may be followed, only tartar muſt be added in different proportions according to the ſhade. Thus to dye 100 parts of cloth a *full bright yellow*, delicately inclining to *green*, 8 parts of bark, 6 of murio-ſulphat, 6 of alum, and 4 of tartar, are to be employed. The tartar is to be added at the ſame time with the other mordants. If the proportion of alum and tartar be increaſed, the green ſhade is more lively: to render it as lively as poſſible, all the four ingredients ought to be employed in equal proportions. As theſe fine lemon-yellows are generally required only pale, 10 parts of each of the ingredients will be ſufficient to dye about 300 parts of cloth [§].

By adding a ſmall proportion of cochineal, the colour may be raiſed to a fine orange, or even an aurora [‖].

428 Silk,

8. Silk may be dyed different ſhades of yellow, either by weld or quercitron bark, but the laſt is the cheapeſt of the two. The proportion ſhould be from 1 to 2 parts of bark to 12 parts of ſilk, according to the ſhade. The bark, tied up in a bag, ſhould be put into the dyeing veſſel while the water which it contains is cold, and when it has acquired the heat of about 100°, the ſilk, previouſly alumed, ſhould be dipped in, and continued till it aſſumes the wiſhed-for colour. When the ſhade required is deep, a little chalk or pearlaſh ſhould be added towards the end of the operation. When a very lively yellow is wanted, a little murio-ſulphat of tin ſhould be added, but not too much, becauſe tin always injures the gloſſineſs of ſilk. The proportions may be 4 parts of bark, 3 of alum, and 2 of murio-ſulphat of tin [¶].

Silk is dyed fine orange and aurora colours by annotta. The proceſs is merely dipping the ſilk into an alkaline ſolution of annotta. To produce the orange ſhade the alkali is ſaturated with lemon juice. The colours thus produced are exceedingly beautiful, but they want permanency.

429 Cotton, and linen.

9. The common method of dyeing cotton and linen yellow, has been deſcribed in the article DYEING in the *Encyclopædia*. The cloth is firſt ſoaked in a ſolution of alum, and then dyed in a decoction of weld. After this it is ſoaked for an hour in a ſolution of ſulphat of copper, and, laſtly, it is boiled for an hour in a ſolution of hard ſoap. This proceſs, beſides the expence of it, is defective; becauſe the yellow is neither ſo beautiful nor ſo permanent as it might be if the mordant were uſed in a different form.

The method recommended by Dr Bancroft is much more advantageous, yielding more permanent and beautiful colours at a ſmaller expence. The mordant ſhould be acetite of alumina, prepared by diſſolving 1 part of acetite of lead, and 3 parts of alum, in a ſufficient quantity of water. This ſolution ſhould be heated to the temperature of 100°, the cloth ſhould be ſoaked in it for two hours, then wrung out and dried. The ſoaking may be repeated, and the cloth again dried as before. It is then to be barely wetted with lime water, and afterwards dried. The ſoaking in the acetite of alumina may be again repeated; and if the ſhade of yellow is required to be very bright and durable, the alternate wetting with lime water, and ſoaking in the mordant, may be repeated three or four times. By this contrivance a ſufficient quantity of alumina is combined with the cloth, and the combination is rendered more permanent by the addition of ſome lime. The dyeing bath is prepared by putting 12 or 18 parts of quercitron bark (according to the depth of the ſhade required), tied up in a bag, into a ſufficient quantity of cold water. Into this bath the cloth is to be put, and turned round in it for an hour, while its temperature is gradually raiſed to about 120°. It is then to be brought to a boiling heat, and the cloth allowed to remain in it after that only a few minutes. If it be kept long at a boiling heat the yellow acquires a ſhade of brown [*].

Another way of dyeing cotton and linen very permanent yellows, would be to imitate the method adopted for dyeing cotton in the Eaſt. That method is indeed exceedingly tedious, but it might be very much ſhortened by carefully attending to the uſes of the ingredients. The eſſential part of the proceſs is to cauſe the alumina to combine in ſufficient quantity with the cloth, and to adhere with ſufficient firmneſs to enſure a permanent colour. This is accompliſhed by uſing three mordants; firſt oil, then tan, and laſtly alum. The combination of theſe three ſubſtances produces a mordant which enſures a very permanent colour.

The cotton is firſt ſoaked in a bath compoſed of a ſufficient quantity of oil, and mixed with a weak ſolution

[*] Bancroft, i 15.

[†] bid. 329.

[‡] bid. 330.

[§] Ibid.

[‖] Ibid. 335.

[¶] Bancroft, i. 345.

[*] Ibid. 351.

tion of ſoda. Animal oil ſeems to anſwer beſt for the purpoſe. Vogler found that glue anſwered extremely well. The ſoda ſhould be cauſtic: In that ſtate it combines with the oil, and enables the cloth to abſorb it equally. It is then, after being waſhed, put into an infuſion of nut galls (the whiter the better). The tan combines with the oil, while the gallic acid carries off the alkali that may remain attached to the cloth. The infuſion ought to be hot; and the cotton, after coming out of it, ſhould be dried as quickly as poſſible. Care ſhould be taken that the quantity of galls do not exceed a juſt proportion compared with the oil, otherwiſe the colour will be darkened. The cotton, thus prepared, is to be put into a ſolution of alum. There is a ſtrong affinity between tan and alumina; in conſequence of which, the alum is decompoſed, and the alumina combines with the tan in ſufficient abundance †. The cotton, thus prepared, is to be dyed, as above deſcribed, with quercitron bark.

† *Chaptal, Ann de Chim.* xxvi. 251.

430 Chaptal's proceſs for cotton.

Mr Chaptal, whoſe ingenious labours have contributed exceedingly to elucidate the theory of dyeing, has propoſed an exceedingly ſimple and cheap method of dyeing cotton a fine permanent nankeen yellow. His proceſs is as follows (G).

Cotton has ſo ſtrong an affinity for oxyd of iron, that if put into a ſolution of that oxyd in any acid whatever, it decompoſes the ſalt, abſorbs the iron, and acquires a yellow colour. The cotton to be dyed is to be put into a cold ſolution of ſulphat of iron, of the ſp. gr. 1.020; it is then wrung out, and put directly into a ley of potaſs, of the ſp. gr. 1.010, into which a ſolution of alum has been poured till it was ſaturated with it. After the cotton has remained in this bath four or five hours, it may be taken out, waſhed, and dried. By this proceſs cotton may be dyed all the different ſhades of nankeen, by varying the proportion of the ſulphat of iron. This colour has the advantage of not being injured by waſhing, and of being exceedingly cheap §.

§ *Ibid.* 270.

Sect. III. *Of Red.*

431 Red dyes.

The principal colouring matters employed in dyeing *red* are, *kermes*, *cochineal*, *archil*, *madder*, *carthamus*, and *Brazil wood*.

432 Kermes,

1. In different parts of Aſia and the ſouth of Europe, there grows a ſmall ſpecies of oak, to which Linnæus gives the name of *quercus coccifera*. On this oak reſides a ſmall inſect, of a reddiſh brown colour; in commerce it is known by the name of *kermes*. This inſect is a ſpecies of *coccus*: Linnæus called it *coccus ilicis*. Theſe inſects are gathered in the month of June, when the female, which alone is uſeful, is ſwelled with eggs. They are ſteeped for ten or twelve hours in vinegar to kill the young inſects contained in the eggs, and afterwards dried on a linen cloth. In this ſtate they are ſold to the dyer.

Kermes readily gives out its colouring matter to water or alcohol. It was much uſed by the ancients in dyeing; the colours which it produced were highly eſteemed, being inferior in price only to their celebrated purple. They gave it the name of *coccus*.

The colour which it communicates to cloth is exceedingly permanent, but being far inferior in beauty to thoſe which may be obtained from cochineal, it has been but little employed by dyers ſince that ſplendid pigment came into common uſe.

433 Cochineal,

2. Cochineal is likewiſe an inſect, a ſpecies of *coccus*. Linnæus diſtinguiſhes it by the name *coccus cacti*. It inhabits different ſpecies of cacti, but the moſt perfect variety is confined to the *cactus coccinillifer*. The cochineal inſect was firſt diſcovered in Mexico; the natives had employed it in their red dyes before the arrival of the Spaniards. It became known in Europe ſoon after the conqueſt of Mexico; and the beauty of the colour which it communicates to cloth very ſoon attracted general attention. For many years it was miſtaken for a vegetable production, as had been the caſe alſo with the kermes. Different accounts of its real nature had indeed appeared very early in the Philoſophical Tranſactions; but the opinion of Pomet, who inſiſted that it was the ſeed of a particular plant, gained ſo much credit, that it was not entirely deſtroyed till the publication of Mr Ellis's paper in the 52d volume of the Philoſophical Tranſactions, which eſtabliſhed the contrary beyond the poſſibility of doubt.

The female cochineal inſect remains like the kermes, during her whole life adhering to a particular ſpot of the tree on which it feeds. After fecundation, her body ſerves merely as a nidus for her numerous eggs, and gradually ſwells as theſe advance towards maturity. In this ſtate the inſects are gathered, put into a linen bag, which is dipt into hot water to deſtroy the life of the young animals contained in the eggs, and then dried. In this ſtate they are ſent to Europe and ſold to the dyer.

The quantity of cochineal diſpoſed of in Europe is very great. Bancroft informs us, that the Spaniards annually bring to market about 600,000 lbs. of it. Hitherto the rearing of the inſects has belonged almoſt excluſively to that nation. Other nations have indeed attempted to ſhare it with them, but without any remarkable ſucceſs; as the Spaniards uſe every precaution to confine the true cochineal, and even the ſpecies of cactus on which it feeds, to Mexico. Mr Thiery de Menonville was fortunate enough to procure ſome ſpecimens of both, and to tranſfer them in ſafety to St Domingo; but after his death, the inſects were allowed to periſh. The wild cochineal inſect, which differs from the cultivated kind merely in being ſmaller, and containing leſs colouring matter, was produced in St Domingo, in conſiderable quantities, before the commencement of the preſent war. Several ſpirited Britiſh gentlemen have lately contrived to procure the inſect; and vigorous efforts are making to rear it in the Eaſt Indies. We have not yet learned the ſucceſs of theſe attempts; but we have reaſon to hope every thing from the zeal and abilities of thoſe gentlemen who have taken an active part in the enterprize.

Cochineal readily gives out its colouring matter to water. The decoction is of a crimſon colour, inclining to violet: It may be kept for a long time without putrifying or loſing its tranſparency. Sulphuric acid gives

---

(G) We ought to mention, that this proceſs, or at leaſt one very ſimilar, has been long well known to the calicoe printers of this country. Moſt of their brown yellows, or drabs, are dyed with iron.

gives it a red colour, inclining to yellow, and occaſions a ſmall fine red precipitate. Tartar gives it a yellowiſh red colour, which becomes yellow after a ſmall quantity of red powder has ſubſided. Alum brightens the colour of the decoction, and occaſions a crimſon precipitate. Muriat of tin gives a copious fine red precipitate; ſulphat of iron, a browniſh violet precipitate; ſulphat of zinc, a deep violate precipitate; acetite of lead, and ſulphat of copper, violet precipitates †.

Water is not capable of extracting the whole of the colouring matter of cochineal; but the addition of a little alkali or tartar enables the water to extract the whole of it *.

.34 chil,

3. Archil (H) is a paſte formed of the *lichen roccella*, pounded and kept moiſt for ſome time with ſtale urine. It gives out its colouring matter to water, to alcohol (I), and to a ſolution of ammonia in water.

The lichen roccella grows abundantly in the Canary iſlands, from which it is imported and ſold to the dyers. Other lichens are likewiſe uſed to dye red, eſpecially the *parellus*, from which the pigment called *litmus*, and by chemiſts *turſole*, is prepared; the *omphalodes* and *tartareus*, which are often employed in this country to dye coarſe cloths. To theſe many others might be added; but the reader may conſult the treatiſes of Hoffman and Weſtring on the ſubject.

135 dder,

4. The *rubia tinctorum* is a ſmall well known plant, cultivated in different parts of Europe for the ſake of its roots, which are known by the name of *madder*. They are about the thickneſs of a gooſe quill, ſomewhat tranſparent, of a reddiſh colour, and a ſtrong ſmell. They are dried, cleaned, ground in a mill, and in that ſtate uſed by dyers.

Madder gives out its colouring matter to water. The infuſion is of a browniſh orange colour; alum produces in it a deep browniſh red precipitate; alkaline carbonats, a blood red precipitate, which is rediſſolved on adding more alkali. The precipitate occaſioned by acetite of lead is browniſh red; by nitrat of mercury, purpliſh brown; by ſulphat of iron, a fine bright brown. After the red colouring matter has been extracted from madder by water, it is ſtill capable of yielding a brown colour ‡.

.36 thamus,

5. *Carthamus tinctorius* is an annual plant, cultivated in Spain, Egypt, and the Levant, for the ſake of its flowers, which alone are uſed in dyeing. After the juice has been ſqueezed out of theſe flowers, they are waſhed repeatedly with ſalt water, preſſed between the hands, and ſpread on mats to dry. Care is taken to cover them from the ſun during the day, and to expoſe them to the evening dews, in order to prevent them from drying too faſt. Such is the method followed in Egypt.

The flowers of carthamus contain two colouring matters; a yellow, which is ſoluble in water, and a red, inſoluble in water, but ſoluble in alkaline carbonats. The method of preparing them above deſcribed, is intended to carry off the yellow colouring matter, which is of no uſe, and to leave only the red. After the flowers are thus prepared, they are of a red colour, and have loſt nearly one-half of their weight. An alkaline ley readily extracts their colouring matter, which may be precipitated by ſaturating the alkali with an acid. Lemon juice is commonly uſed for this purpoſe, becauſe it does not injure the colour of the dye. Next to citric, ſulphuric acid is to be preferred, provided too great a quantity be not uſed. The red colouring matter of carthamus, extracted by carbonat of ſoda, and precipitated by lemon juice, conſtitutes the *rouge* employed by the ladies as a paint. It is afterwards ground with a certain quantity of talc. The fineneſs of the talc, and the proportion of it mixed with the carthamus, occaſion the difference between the cheaper and dearer kinds of *rouge*.

437 Brazil wood.

6. *Brazil wood*, or *fernambouc*, as it is called by the French, is the wood of the *caſalpinia criſta*, a tree which grows naturally in America and the Weſt Indian iſlands. It is very hard; its ſpecific gravity is greater than that of water; its taſte is ſweetiſh: its colour, when freſh cut, is pale; but after expoſure to the atmoſphere, it becomes reddiſh.

Brazil wood yields its colouring matter to alcohol, and likewiſe to boiling water. The decoction is of a fine red colour. The mineral acids make it yellow, and occaſion a reddiſh brown precipitate. Oxalic acid cauſes an orange red precipitate. Fixed alkali gives the decoction a crimſon colour, inclining to brown; ammonia, bright purple. Alum occaſions a copious crimſon precipitate, eſpecially if alkali is added at the ſame time. Sulphat of iron renders the decoction black. The precipitate produced by muriat of tin is roſe coloured; that by acetite of lead of a fine deep red *.

The decoction of Brazil wood is fitter for dyeing after it has ſtood ſome time, and undergone a kind of fermentation.

438 Re quires a mordant.

7. None of the red colouring matters has ſo ſtrong an affinity for cloth as to produce a permanent red, without the aſſiſtance of mordants. The mordants employed are alumina and oxyd of tin; oil and tan, in certain proceſſes, are alſo uſed; and tartar and muriat of ſoda are frequently called in as auxiliaries.

8. Coarſe woollen ſtuffs are dyed red with madder

† ertbollet, i 73.

* id 175.

Ban. , i. 271.

‡ ertbollet, i 15.

* Bertbollet, ii 240.

(H) If we believe Tournefort, this dye ſtuff was known to the ancients. They employed it to dye the colour known by the name of *purple* of Amorgos, one of the Cyclades iſlands. If this account be accurate, the knowledge of it had been loſt during the dark ages. It was accidentally diſcovered by a Florentine merchant about the year 1300, who obſerved, that urine gave a very fine colour to the lichen roccella. Mr Duſay diſcovered, that archil poſſeſſes the property of tinging indelibly white marble, of forming veins, and giving it the appearance of jaſper. See *Mem. Par.* 1732.

(I) The tincture of archil is uſed for making *ſpirit of wine thermometers*. It is a ſingular fact, that this tincture becomes gradually colourleſs when excluded from the contact of air, and that it again recovers its colour when expoſed to the atmoſphere. The phenomenon was firſt obſerved by the Abbé Nollet, and deſcribed by him in an eſſay, publiſhed among the memoirs of the Academy of Sciences for 1742.

or archil ; but fine cloth is almoſt excluſively dyed with cochineal ; though the colour which it receives from kermes is much more durable. Brazil wood is ſcarcely uſed, except as an auxiliary ; becauſe the colour which it imparts to wool is not permanent.

439 Wool how dyed crimſon, Wool is dyed *crimſon*, by firſt impregnating it with alumina by means of an alum bath, and then boiling it in a decoction of cochineal till it has acquired the wiſhed-for colour. The crimſon will be finer if the tin mordant be ſubſtituted for alum : indeed it is uſual with dyers to add a little nitro-muriat of tin when they want fine crimſons. The addition of archil and potaſs to the cochineal, both renders the crimſon darker and gives it more bloom ; but the bloom very ſoon vaniſhes. For paler crimſons, one half of the cochineal is withdrawn, and madder ſubſtituted in its place.

440 And ſcarlet. Wool may be dyed *ſcarlet*, the moſt ſplendid of all colours, by firſt boiling it in a ſolution of murio-ſulphat of tin ; then dyeing it pale yellow with quercitron bark, and afterwards crimſon with cochineal : For ſcarlet is a compound colour, conſiſting of *crimſon* mixed with a little *yellow*. This method was ſuggeſted by Dr Bancroft, who firſt explained the nature of the common method. The proportions which he gives are eight parts of murio-ſulphat of tin for 100 parts of cloth. After the cloth has been boiled in this ſolution for a quarter of an hour, it is to be taken out, and about four parts of cochineal, and two and a half parts of quercitron bark, are to be thrown into the bath. After theſe are well mixed, the cloth is to be returned again to the bath, and boiled in it, till it has acquired the proper colour *.

The common proceſs for dyeing ſcarlet is as follows: Twelve parts of tartar are diſſolved in warm water; then one part of cochineal is added, and ſoon after ten parts of nitro muriat of tin. When the bath boils, 100 parts of cloth are put in, turned briſkly through the bath, boiled in it for two hours ; then taken out, aired, waſhed, and dried. Into another bath eleven parts of cochineal are put ; and after its colouring matter is ſufficiently extracted, 28 parts of nitro-muriat of tin are added. In this bath the cloth is boiled for an hour, and then waſhed and dried.

Every preceding writer on dyeing took it for granted, that the yellow tinge neceſſary for ſcarlet was produced by the nitro muriat of tin, or rather by the nitric acid of that compound, and that the tartar was only uſeful in enlivening the colour. But Dr Bancroft aſcertained, by actual experiment, that nitro-muriat of tin has no ſuch effect ; that cloth, impregnated with this or any other tin mordant, and afterwards dyed with cochineal, acquires only a crimſon colour, unleſs tartar be added ; that the tartar has the property of converting part of the cochineal to yellow ; and therefore is the real agent in producing the ſcarlet colour. Good ſcarlet, indeed, cannot be made without tin ; becauſe every other mordant ſullies the colour, and renders it dull†.

441 Red dyes employed for ſilk, 9. Silk is uſually dyed red with cochineal or carthamus, and ſometimes with Brazil wood. Kermes does not anſwer for ſilk ; madder is ſcarcely ever uſed for that purpoſe, becauſe it does not yield a bright enough colour. Archil is employed to give ſilk a bloom ; but it is ſcarcely uſed by itſelf, unleſs when the colour wanted is lilac.

442 In dyeing crimſon, Silk may be dyed crimſon by ſteeping it in a ſolution of alum, and then dyeing it in the uſual way in a cochineal bath. But the common proceſs is to plunge the ſilk, after it has been alumed, into a bath formed of the following ingredients : Two parts of white galls, three parts of cochineal, three-ſixteenths of tartar, and three-ſixteenths of nitro-muriat of tin, for every ſixteen parts of ſilk. The ingredients are to be put into boiling water in the order they have been enumerated ; the bath is then to be filled up with cold water ; the ſilk put into it, and boiled for two hours. After the bath has cooled, the ſilk is uſually allowed to remain in it for three hours longer.

443 Poppy, The colours known by the names of poppy, cherry, roſe, and fleſh colour, are given to ſilk by means of carthamus. The proceſs conſiſts merely in keeping the ſilk, as long as it extracts any colour, in an alkaline ſolution of carthamus, into which as much lemon juice as gives it a fine cherry colour has been poured. To produce a deep poppy red, the ſilk muſt be put ſucceſſively into a number of ſimilar baths, and allowed to drain them. When the ſilk is dyed, the colour is brightened by plunging it into hot water acidulated with lemon juice. The ſilk ought to be previouſly dyed yellow with anotta.

444 Cherry, Cherry red is produced the ſame way, only the anotta ground is omitted, and leſs colouring matter is neceſſary. 445 Fleſh red, When a fleſh colour is required, a little ſoap ſhould be put into the bath, which ſoftens the colour, and prevents it from taking too quickly.

To leſſen the expence, ſome archil is often mixed with carthamus for dark ſhades.

The ſame ſhades may be dyed by means of brazil wood, but they do not ſtand.

446 Scarlet. Silk cannot be dyed a full ſcarlet ; but a colour approaching to ſcarlet may be given it, by firſt impregnating the ſtuff with murio-ſulphat of tin, and afterwards dyeing it in a bath compoſed of four parts of cochineal and four parts of quercitron bark. To give the colour more body, both the mordant and the dye may be repeated *. A colour approaching ſcarlet may be alſo given to ſilk, by firſt dyeing it crimſon, then dyeng it with *carthamus*, and laſtly yellow without heat. †.

447 How to dye cotton and linen red. 10. Cotton and linen are dyed red with madder. The proceſs was borrowed from the Eaſt ; hence the colour is often called *Adrianople* or *Turkey red*. The cloth is firſt impregnated with oil, then with galls, and laſtly with alum, in the manner deſcribed in the laſt ſection. It is then boiled for an hour in a decoction of madder, which is commonly mixed with a quantity of blood. After the cloth is dyed, it is plunged into a ſoda ley, in order to brighten the colour. The red given by this proceſs is very permanent, and when properly conducted it is exceedingly beautiful. The whole difficulty conſiſts in the application of the mordant, which is by far the moſt complicated employed in the whole art of dyeing.

Cotton may be dyed ſcarlet by means of murio-ſulphat of tin, cochineal, and quercitron bark, uſed as for ſilk ; but the colour is too fading to be of any value *.

SECT. IV. *Of BLACK.*

448 Black dyes. 1. THE ſubſtances employed to give a black colour to cloth are red oxyd of iron and tan. Theſe two ſubſtances

---

* *Bancroft*, i. 291.

† *Ibid.* 288.

* *Bancro* i. 312.

† *Bertholl.* ii. 203.

* *Bancro* i. 316.

lack.

ſtances have a ſtrong affinity for each other; and when combined, aſſume a deep black colour, not liable to be deſtroyed by the action of air and light. The affinity which each of them has for the different kinds of cloth has been already mentioned.

2. Logwood is uſually employed as an auxiliary, becauſe it communicates luſtre, and adds conſiderably to the fulneſs of the black. It is the wood of the tree called by Linnæus *hæmatoxylum campechianum*, which is a native of ſeveral of the Weſt India iſlands, and of that part of Mexico which ſurrounds the Bay of Honduras. It yields its colouring matter to water. The decoction is at firſt a fine red bordering on violet, but if left to itſelf it gradually aſſumes a black colour. Acids give it a deep red colour; alkalies a deep violet, inclining to brown. Sulphat of iron renders it as black as ink, and occaſions a precipitate of the ſame colour. The precipitate produced by alum is dark red; the ſupernatent liquid becomes yellowiſh red *.

ertbollet, 55.

3. Cloth, before it receive a black colour, is uſually dyed blue. This renders the colour much fuller and finer than it otherwiſe would be. If the cloth be coarſe, the blue dye may be too expenſive; in that caſe a brown colour is given by means of walnut peels.

49
w to in-
a
k on
d,

4. Wool is dyed black by the following proceſs. It is boiled for two hours in a decoction of nut galls, and afterwards kept for two hours more in a bath compoſed of logwood and ſulphat of iron, kept during the whole time at a ſcalding heat, but not boiled. During the operation it muſt be frequently expoſed to the air; becauſe the green oxyd of iron, of which the ſulphat is compoſed, muſt be converted into red oxyd by abſorbing oxygen, before the cloth can acquire a proper colour. The common proportions are five parts of galls, five of ſulphat of iron, and 30 of logwood for every 100 of cloth. A little acetite of copper is commonly added to the ſulphat of iron, becauſe it is thought to improve the colour.

50
ilk,

5. Silk is dyed nearly in the ſame manner. It is capable of combining with a very great deal of tan; the quantity given is varied at the pleaſure of the artiſt, by allowing the ſilk to remain a longer or ſhorter time in the decoction. After the galling, the ſilk is put into a ſolution of ſulphat of iron, which is uſually mixed with a certain quantity of iron filings and of gum. It is occaſionally wrung out of the bath, expoſed for ſome time to the air, and again immerſed. When it has acquired a ſufficiently full colour, it is waſhed in cold water, and afterwards ſteeped in a decoction of ſoap to take off the harſhneſs, which ſilk always has after being dyed black.

51
en, and
on.

6. It is by no means ſo eaſy to give a full black to linen and cotton. The cloth, previouſly dyed blue, is ſteeped for 24 hours in a decoction of nut galls. A bath is prepared, containing acetite of iron, formed by ſaturating acetous acid with brown oxyd of iron. Into this bath the cloth is put in ſmall quantities at a time, wrought with the hand for a quarter of an hour, then wrung out and aired, again wrought in a freſh quantity of the bath, and afterwards aired. Theſe alternate proceſſes are repeated till the colour wanted is given. A decoction of alder bark is uſually mixed with the liquor containing the nut galls.

It would probably contribute to the goodneſs and permanence of the colour, if the cloth, before being galled, were impregnated with oil, by being ſteeped in a mixture of alkaline ley and oil combined, as is practiſed for dyeing cotton red.

Brown.

SECT. V. *Of BROWN.*

THAT particular *brown* colour, with a caſt of *yellow*, which the French call *fauve*, and to which the Engliſh writers on *dyeing* have appropriated the word *fawn*, though in fact a compound, is commonly ranked among ſimple colours; becauſe it is applied to cloth by a ſingle proceſs. The ſubſtances employed to produce this colour are numerous; but we ſhall ſatisfy ourſelves with enumerating the following:

452
Brown
dyes.

Walnut peels are the green covering of the walnut. When firſt ſeparated, they are white internally; but ſoon aſſume a brown, or even a black colour, on expoſure to the air. They readily yield their colouring matter to water. They are uſually kept in large caſks, covered with water, for above a year, before they are uſed. To dye wool brown with them, nothing more is neceſſary than to ſteep the cloth in a decoction of them till it has acquired the wiſhed-for colour. The depth of the ſhade is proportional to the ſtrength of the decoction. The root, as well as the peel of the walnut tree, contains the ſame colouring matter, but in ſmaller quantity. The bark of the birch, alſo, and many other trees, may be uſed for the ſame purpoſe.

It is very probable, that the brown colouring matter is in theſe vegetable ſubſtances combined with tan. This is certainly the caſe in ſumach, which is often employed to produce a brown. This combination explains the reaſon why no mordant is neceſſary; the tan has a ſtrong affinity for the cloth; and the colouring matter for the tan. The dye ſtuff and the mordant are already, in fact, combined together.

CHAP. V. OF COMPOUND COLOURS.

COMPOUND colours are produced by mixing together two ſimple ones; or, which is the ſame thing, by dyeing cloth firſt one ſimple colour, and then another. The reſult is a compound colour, varying in ſhade according to the proportions of each of the ſimple colours employed.

453
Diviſion of
compound
colours.

Compound colours are exceedingly numerous, varying almoſt to infinity, according to the proportions of the ingredients employed. They may be all arranged under the four following claſſes:

Mixtures of 1. blue and yellow,
2. blue and red,
3. yellow and red,
4. black and other colours.

To deſcribe all the different ſhades which belong to each of theſe claſſes, would be impoſſible; and even if it were poſſible, it would be unneceſſary; becauſe all the proceſſes depend upon the principles laid down in the preceding chapters, and may eaſily be conceived and varied by thoſe who underſtand theſe principles. In the following ſections, therefore, it will be ſufficient to mention the principal compound colours produced by the mixture of ſimple colours, and to exhibit a ſpecimen or two of the mode of producing them.

SECT. I. *Of Mixtures of BLUE and YELLOW.*

THE colour produced by mixtures of blue and yellow is

Mixtures of Blue and Yellow.

is *green*; which is diſtinguiſhed by dyers by a great variety of names, according to the depth of the ſhade, or the prevalence of either of the component parts. Thus we have *ſea green, meadow* or *graſs green, pea green*, &c. &c.

454 How to induce green

455 On wool,

Wool is uſually dyed green by giving it firſt a blue colour, and afterwards dyeing it yellow; becauſe, when the yellow is firſt given, ſeveral inconveniences follow: the yellow partly ſeparates again in the blue vat, and communicates a green colour to it; and thus renders it uſeleſs for every other purpoſe, except dyeing green. Any of the proceſſes for dyeing blue, deſcribed in the laſt chapter, may be followed; care being taken always to proportion the depth of the blue to the ſhade of green which is required. The cloth thus dyed blue may receive a yellow colour, by following the proceſſes deſcribed in the laſt chapter for that purpoſe. When the ſulphat of indigo is employed, it is uſual to mix all the ingredients together, and to dye the cloth at once: the colour produced is known by the name of *Saxon*, or *Engliſh green*. One of the moſt convenient methods of conducting this proceſs is the following:

Six or eight parts of quercitron bark, tied up in a bag, are to be put into the dyeing veſſel, which ſhould contain only a ſmall quantity of warm water. When the water boils, ſix parts of murio ſulphat of tin, and four parts of alum, are to be added. In a few minutes, the dyeing veſſel ſhould be filled up with cold water, till the temperature is reduced to about 130°. After this, as much ſulphat of indigo is to be poured in as is ſufficient to produce the intended ſhade of green. When the whole has been ſufficiently ſtirred, a hundred parts of cloth are to be put in, and turned briſkly for about fifteen minutes, till it has acquired the wiſhed-for ſhade *. By this method, a much more beautiful colour is obtained than is given by the uſual proceſs, in which fuſtic is employed to give the yellow ſhade.

456 Silk,

Silk, intended to receive a green colour, is uſually dyed yellow firſt, by means of weld, according to the proceſs deſcribed in the laſt chapter; afterwards, it is dipped into the blue vat, and dyed in the uſual manner. To deepen the ſhade, or to vary the tint, decoctions of logwood, anotta, fuſtic, &c. are added to the yellow bath. Or ſilk may be dyed at once green, by adding ſuitable proportions of ſulphat of indigo to the common quercitron bark bath, compoſed of four parts of bark, three parts of alum, and two parts of murio ſulphat of tin †.

457 Cotton, and linen.

Cotton and linen muſt be firſt dyed blue, and then yellow, according to the methods deſcribed in the laſt chapter. It is needleſs to add, that the depth of each of theſe colours muſt be proportioned to the ſhade of green colour which it is the intention of the dyer to give.

SECT. II. *Of Mixtures of* BLUE *and* RED.

458 Violet, purple, lilac,

THE mixture of blue and red produces *violet, purple*, and *lilac*, of various ſhades, and known by various names, according to the proportion of the ingredients employed. When the colour is deep, and inclines moſt to blue, it is called *violet*; but when the red is prevalent, it gets the name of *purple*. When the ſhade is light, the colour is uſually called *lilac*. For violet, therefore, the cloth muſt receive a deeper blue; for purple, a deeper red; and for lilac, both of theſe colours muſt be light.

Mixtures of Blue and Red.

459 How induced on wool,

Wool is uſually dyed firſt *blue*; the ſhade, even for violet, ought not to be deeper than that called *ſky blue*; afterwards it is dyed ſcarlet, in the uſual manner. The violets and purples are dyed firſt; and when the vat is ſomewhat exhauſted, the cloth is dipped in which is to receive the lilac, and the other lighter ſhades. By means of ſulphat of indigo, the whole proceſs may be performed at once. The cloth is firſt alumed, and then dyed in a veſſel, containing cochineal, tartar, and ſulphat of indigo, in proportions ſuited to the depth of the colour required *. A violet colour may alſo be given to wool, by impregnating it with a mordant compoſed of tin diſſolved in a mixture of ſulphuric and muriatic acids, formed by diſſolving muriat of ſoda in ſulphuric acid: to which ſolution a quantity of tartar and ſulphat of copper is added. The wool is then boiled in a decoction of logwood till it has acquired the wiſhed-for colour †.

460 Silk,

Silk is firſt dyed crimſon, by means of cochineal, in the uſual way, excepting only that no tartar, nor ſolution of tin, is employed: It is then dipped into the indigo vat till it has acquired the wiſhed-for ſhade. The cloth is often afterwards paſſed through an archil bath, which greatly improves the beauty of the colour. Archil is often employed as a ſubſtitute for cochineal: The ſilk firſt receives a red colour, in the uſual way, by being dyed in an archil bath; afterwards it receives the proper ſhade of blue. The violet, or purple, given by this proceſs is very beautiful, but not very laſting ‡.

Silk may be dyed violet or purple at once, by firſt treating it with a mordant, compoſed of equal parts of nitro-muriat of tin and alum, and then dipping it into a cochineal bath, into which a proper quantity of ſulphat of indigo has been poured. But this dye is fading; the blue colour ſoon decays, and the ſilk becomes red *.

461 Cotton, and linen.

Cotton and linen are firſt dyed blue, then galled, then ſoaked in a decoction of logwood; ſome alum and acetite of copper are added to the decoction, and the cloth is ſoaked again. This proceſs is repeated till the proper colour is obtained †. The colour produced by this method is not nearly equal in permanency to that deſcribed in this *Supplement* under the word IRON; to which we beg leave to refer the reader. The proceſs there deſcribed has been long known; but Mr Chaptal has ſimplified it ſomewhat.

SECT. III. *Of Mixtures of* YELLOW *and* RED.

462 Orange and olive,

THE colour produced by the mixture of *red* and *yellow* is *orange*; but almoſt an infinity of ſhades reſults from the different proportions of the ingredients, and from the peculiar nature of the yellow employed. Sometimes *blue* is combined with red and yellow on cloth: the reſulting colour is called *olive*.

463 How induced on wool,

Wool may be dyed orange by preciſely the ſame proceſs which is uſed for ſcarlet, only the proportion of red muſt be diminiſhed, and that of yellow increaſed. When wool is firſt dyed red with madder, and then yellow with weld, the reſulting colour is called *cinnamon colour*. The mordant, in this caſe, is a mixture of alum and tartar. The ſhade may be varied exceedingly, by uſing other yellow dye ſtuffs inſtead of weld, and by varying the proportions, according to circumſtances. Thus a reddiſh yellow may be given to cloth, by firſt dyeing it yellow, and then paſſing it through a madder bath.

464 Silk,

Silk is dyed orange by means of carthamus: the method

---

* *Bancroft*, i. 336.

† *Ibid.* 346.

* *Poerner*.

† *Decroyzille*. *Berthollet*, ii. 331.

‡ *Berthollet* ii. 327.

* *Guhliche* *Berthollet*, ii. 329.

† *Bertholle* ii. 337.

xtures Black h other ours.

method has been deſcribed in the laſt chapter. Cinnamon colour is given to it by dyeing it, previouſly alumed, in a bath compoſed of the decoctions of logwood, Brazil wood, and fuſtic, mixed together.

65 on, linen.

Cotton and linen receive a cinnamon colour by means of weld and madder. The proceſs is complicated. The cloth is firſt dyed with weld and acetite of copper, then dipped in a ſolution of ſulphat of iron, then galled, then alumed, and then dyed in the uſual way with madder *.

ertbollet, i 44.

For *olive*, the cloth is firſt dyed blue, then yellow, and laſtly paſſed through a madder bath. The ſhade depends upon the proportion of each of theſe colours. For very deep ſhades the cloth is alſo dipped into a ſolution of ſulphat of iron. Cotton and linen may be dyed *olive* by dipping them into a bath, compoſed of the decoction of four parts of weld and one of potaſs, mixed with the decoction of Brazil wood and a little acetite of copper †.

† Aplig- bid.

SECT. IV. *Of Mixtures of* BLACK *with other Colours.*

66 ys, and vns.

STRICTLY ſpeaking, the mixtures belonging to this ſection are not mixtures of *black colours* with other colours, but combinations of the *black dye* with other colours; the ingredients of which, galls and brown oxyd of iron, being both mordants, variouſly modify other colouring matters by combining with them. Thus if cloth be previouſly combined with brown oxyd of iron, and afterwards dyed yellow with quercitron bark, the reſult will be a *drab* of different ſhades, according to the proportion of mordant employed. When the proportion is ſmall, the colour inclines to olive or yellow; on the contrary, the drab may be deepened or ſaddened, as the dyers ſpeak, by mixing a little ſumach with the bark *. The precautions formerly mentioned in applying the oxyd muſt be obſerved.

ancr-ft, 43.

It is very common to dip cloth already dyed ſome particular colour into a ſolution of ſulphat of iron, and galls or ſome other ſubſtance containing tan, called the *black bath*, in order to alter the ſhade, and to give the colour greater permanency. We ſhall give a few inſtances: greater minuteneſs would be inconſiſtent with the nature of this article.

Cloth dyed blue, by being dipped into the *black* bath, becomes *bluiſh grey*. Cloth dyed *yellow*, by the ſame proceſs, becomes *blackiſh grey*, *drab*, or *yellowiſh brown*. Cloth previouſly alumed, and dyed in a decoction of cochineal and acetite of iron, acquires a permanent *violet colour* inclining to *brown*, or a *lilac*, if the dyeing veſſel be ſomewhat exhauſted *. Cloth ſteeped in a mordant, compoſed of alum and acetite of iron diſſolved in water, and afterwards dyed in a bath compoſed of the decoction of galls and madder mixed together, acquires a fine deep *brown*. The method of varying the ſhades of linen and cotton will be readily conceived, after we have given an account of calico printing, which forms the ſubject of the next chapter.

ubliche, bollet, 49.

CHAP. VI. OF CALICO PRINTING.

CALICO printing is the art of communicating different colours to particular ſpots or figures on the ſurface of cotton or linen cloth, while the reſt of the ſtuff retains its original whiteneſs.

Calico Printing.

467 Origin of calico printing.

This ingenious art ſeems to have originated in India, where we know it has been practiſed for more than 2000 years. Pliny indeed inform us, that the Egyptians were acquainted with calico printing; but a variety of circumſtances combine to render it more than probable that they borrowed it from India. The art has but lately been cultivated in Europe; but the enlightened induſtry of our manufacturers has already improved prodigiouſly upon the tedious proceſſes of their Indian maſters. No art has riſen to perfection with greater celerity: a hundred years ago it was ſcarcely known in Europe; at preſent, the elegance of the patterns, the beauty and permanency of the colours, and the expedition with which the different operations are carried on, are really admirable.

A minute detail of the proceſſes of calico printing would not only be foreign to the plan of this article, but of very little utility. To the artiſt the proceſſes are already known; an account of them therefore could give him no new information; while it would fatigue and diſappoint thoſe readers who wiſh to underſtand the principles of the art. We ſhall content ourſelves, therefore, with a ſhort view of theſe principles.

468 It conſiſts in applying mordants partially to cotton,

Calico printing conſiſts in impregnating thoſe parts of the cloth which are to receive a colour with a mordant, and then dyeing it as uſual with ſome dye ſtuff or other. The dye ſtuff attaches itſelf firmly only to that part of the cloth which has received the mordant. The whole ſurface of the cotton is indeed more or leſs tinged; but by waſhing it, and bleaching it for ſome days on the graſs with the wrong ſide uppermoſt, all the unmordanted parts reſume their original colour, while thoſe which have received the mordant retain it. Let us ſuppoſe, that a piece of white cotton cloth is to receive red ſtripes; all the parts where the ſtripes are to appear are penciled over with a ſolution of acetite of alumina. After this, the cloth is dyed in the uſual manner with madder. When taken out of the dyeing veſſel, it is all of a red colour; but by waſhing and bleaching, the madder leaves every part of the cloth white except the ſtripes impregnated with the acetite of alumina, which remain red. In the ſame manner, may yellow ſtripes, or any other wiſhed-for figure, be given to cloth, by ſubſtituting quercitron bark, weld, &c. for madder.

469 Which is afterwards dyed and bleached.

When different colours are to be given to different parts of the cloth at the ſame time, it is done by impregnating it with various mordants. Thus if ſtripes be drawn upon a cotton cloth with acetite of alumina, and other ſtripes with acetite of iron, and the cloth be afterwards dyed in the uſual way with madder and then waſhed and bleached, it will be ſtriped *red* and *brown*. The ſame mordants with quercitron bark give *yellow*, and *olive* or *drab*.

470 Mordants employed.

The mordants employed in calico printing are acetite of alumina and acetite of iron, prepared in the manner deſcribed in the third chapter of this part. Theſe mordants are applied to the cloth, either with a pencil or by means of blocks, on which the pattern, according to which the cotton is to be printed, is cut. As they are applied only to particular parts of the cloth, care muſt be taken that none of them ſpread to the part of the cloth which is to be left white, and that they do not interfere with one another when more than one are applied.

applied. If theſe precautions be not attended to, all the elegance and beauty of the print muſt be deſtroyed. It is neceſſary, therefore, that the mordants ſhould be of ſuch a degree of conſiſtence that they will not ſpread beyond thoſe parts of the cloth on which they are applied. This is done by thickening them with flour or ſtarch when they are to be applied by the block, and with gum arabic when they are to be put on with a pencil. The thickening ſhould never be greater than is ſufficient to prevent the ſpreading of the mordants; when carried too far, the cotton is apt not to be ſufficiently ſaturated with the mordant; of courſe the dye takes but imperfectly.

471 How applied.

In order that the parts of the cloth impregnated with mordants may be diſtinguiſhed by their colour, it is uſual to tinge the mordants with ſome colouring matter or other. The printers commonly uſe the decoction of Brazil wood for this purpoſe; but Bancroft has objected to this method, becauſe he thinks that the Brazil wood colouring matter impedes the ſubſequent proceſs of dyeing. It is certain, that the colouring matter of the Brazil wood is diſplaced during that operation by the ſuperior affinity of the dye ſtuff for the mordant. Were it not for this ſuperior affinity, the colour would not take at all. Dr Bancroft * adviſes to colour the mordant with ſome of the dye ſtuff afterwards to be applied; and he cautions the uſing of more for that purpoſe than is ſufficient to make the mordant diſtinguiſhable when applied to the cloth. The reaſon of this precaution is obvious. If too much dye be mixed with the mordant, a great proportion of the mordant will be combined with colouring matter; which muſt weaken its affinity for the cloth, and of courſe prevent it from combining with it in ſufficient quantity to enſure a permanent dye.

* *Bancroft*, i. 373.

Sometimes theſe two mordants are mixed together in different proportions; and ſometimes one or both is mixed with an infuſion of ſumach or of nut galls. By theſe contrivances, a great variety of colours are produced by the ſame dye ſtuff.

472 Subſequent treatment of the cloth

After the mordants have been applied, the cloth muſt be completely dried. It is proper for this purpoſe to employ artificial heat; which will contribute ſomething towards the ſeparation of the acetous acid from its baſe, and towards its evaporation; by which the mordant will combine in a greater proportion, and more intimately with the cloth.

When the cloth is ſufficiently dried, it is to be waſhed with warm water and cow dung, till all the flour or gum employed to thicken the mordants, and all thoſe parts of the mordants which are uncombined with the cloth, are removed. The cow dung ſerves to entangle theſe looſe particles of mordants, and to prevent them from combining with thoſe parts of the cloth which are to remain white. After this the cloth is thoroughly rinſed in clean water.

473 Dye ſtuffs uſed.

Almoſt the only dye ſtuffs employed by calico printers are, indigo, madder, and quercitron bark or weld. This laſt ſubſtance, however, is now but little uſed by the printers of this country, except for delicate greeniſh yellows. The quercitron bark has almoſt ſuperſeded it; becauſe it gives colours equally good, and is much cheaper, and more convenient, not requiring ſo great a heat to fix it. Indigo, not requiring any mordant, is commonly applied at once either with the block or a pencil. It is prepared by boiling together indigo, potaſs made cauſtic by quicklime, and orpiment: the ſolution is afterwards thickened with gum (K). It muſt be carefully ſecluded from the air, otherwiſe the indigo would ſoon be regenerated, which would render the ſolution uſeleſs. Dr Bancroft has propoſed to ſubſtitute coarſe brown ſugar for orpiment. It is equally efficacious in decompoſing the indigo and rendering it ſoluble; while it likewiſe ſerves all the purpoſes of gum *.

* *Bancroft* i. 123.

When the cloth, after being impregnated with the mordant, is ſufficiently cleanſed, it is dyed in the uſual manner. The whole of it is more or leſs tinged with the dye ſtuff. It is well waſhed, and then ſpread out for ſome days on the graſs, and bleached with the wrong ſide uppermoſt. This carries the colour off completely from all the parts of the cotton which has not imbibed the mordant, and leaves them of their original whiteneſs, while the mordanted ſpots retain the dye as ſtrongly as ever.

Let us now give an example or two of the manner in which the printers give particular colours to calicoes. Some calicoes are only printed of one colour, others have two, others three, or more, even to the number of eight, ten, or twelve. The ſmaller the number of colours, the fewer in general are the proceſſes.

474 Method of printing drabs,

1. One of the moſt common colours on cotton prints is a kind of nankeen yellow, of various ſhades, down to a deep yellowiſh brown or drab. It is uſually in ſtripes or ſpots. To produce it, the printers beſmear a block, cut out into the figure of the print, with acetite of iron thickened with gum or flour; apply it to the cotton; which, after being dried and cleaned in the uſual manner, is plunged

---

(K) Different proportions are uſed by different perſons. Mr Hauſſman mixes 25 gallons of water with 16 pounds of indigo well ground (or a greater or ſmaller quantity, according to the quality of the indigo and the depth of colour wanted); to which he adds 30 pounds of good carbonat of potaſs, placing the whole over a fire; and as ſoon as the mixture begins to boil, he adds, by a little at a time, 12 pounds of quick lime, to render the alkali cauſtic, by abſorbing its carbonic acid. This being done, 12 pounds of red orpiment are alſo added to the mixture; which is then ſtirred, and left to boil for ſome little time, that the indigo may be perfectly diſſolved; which may be known by its giving a yellow colour immediately upon being applied to a piece of white tranſparent glaſs. M. Oberkampf, proprietor of the celebrated manufactory at Jouy near Verſailles, uſes a third more of indigo; and others uſe different proportions, not only of indigo, but of lime, potaſs, and orpiment; which all ſeem to anſwer with nearly equal ſucceſs: but with the beſt copper-coloured Guatamala indigo, it is certain that a good blue may be obtained from only half the quantity preſcribed by Mr Hauſſman, by uſing as much ſtone, or oyſter ſhell lime, as of indigo, nearly twice as much potaſs, and a fourth part leſs of orpiment than of indigo. See *Bancroft*, I. 113.

plunged into a potaſs ley. The quantity of acetite of iron is always proportioned to the depth of the intended ſhade.

75 llow, 2. For yellow, the block is beſmeared with acetite of alumina. The cloth, after receiving this mordant, is dyed with quercitron bark, and then bleached.

76 ed, 3. Red is communicated by the ſame proceſs, only madder is ſubſtituted for the bark.

77 lue, 4. The fine light blues, which appear ſo often on printed cottons, are produced, by applying to the cloth a block beſmeared with a compoſition, conſiſting partly of wax, which covers all thoſe parts of the cloth which are to remain white. The cloth is then dyed in a cold indigo vat; and after it is dry, the wax compoſition is removed by means of hot water.

78 ac, own, 5. Lilac, flea brown, and blackiſh brown, are given by means of acetite of iron; the quantity of which is always proportioned to the depth of the ſhade. For very deep colours, a little ſumach is added. The cotton is afterwards dyed in the uſual manner with madder, and then bleached.

79 dove. 6. Dove colour and drab, by acetite of iron and quercitron bark.

80 lica- of dif- nt co- s to the cloth. When different colours are to appear in the ſame print, a greater number of operations are neceſſary. Two or more blocks are employed, upon each of which that part of the print only is cut which is to be of ſome particular colour. Theſe are beſmeared with different mordants, and applied to the cloth, which is afterwards dyed as uſual. Let us ſuppoſe, for inſtance, that three blocks are applied to cotton; one with acetite of alumina, another with acetite of iron, a third with a mixture of theſe two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with the mordants would have the following colours.

Acetite of alumina,	Yellow,
iron,	Olive, drab, dove (L),
The mixture,	Olive green, olive.

If part of the yellow be covered over with the indigo liquor, applied with a pencil, it will be converted into *green:* By the ſame liquid, blue may be given to ſuch parts of the print as require it.

If the cotton be dyed with madder inſtead of quercitron bark, the print will exhibit the following colours:

Acetite of alumina,	Red,
iron,	Brown, black,
The mixture,	Purple.

When a greater number of colours are to appear; for inſtance, when thoſe communicated by bark and thoſe by madder are wanted at the ſame time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath and bleached; then the reſt of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark and bleached. This ſecond dyeing does not much affect the madder colours; becauſe the mordants, which render them permanent, are already ſaturated. The yellow tinge is eaſily removed by the ſubſequent bleaching. Sometimes a new mordant is alſo applied to ſome of the madder colours; in conſequence of which they receive a new permanent colour from the bark. After the laſt bleaching, new colours may be added by means of the indigo liquor. The following table will give an idea of the colours which may be given to cotton by theſe complicated proceſſes.

I. *Madder dye.*	*Colours.*
Acetite of alumina,	Red,
iron,	Brown, black,
Ditto diluted,	Lilac,
Both mixed,	Purple.
II. *Bark dye.*	
Acetite of alumina,	Yellow,
iron,	Dove, drab,
Lilac and acetite of alumina,	Olive,
Red and acetite of alumina,	Orange.
III. *Indigo dye.*	
Indigo,	Blue,
Indigo and yellow	Green.

Thus no leſs than 12 colours may be made to appear together in the ſame print by theſe different proceſſes.

Theſe inſtances will ſerve to give the reader an idea of the nature of calico printing, and at the ſame time afford an excellent illuſtration of the importance of mordants in dyeing.

481 Colours for penciling. If it were poſſible to procure colours ſufficiently permanent, by applying them at once to the cloth by the block or the pencil, as is the caſe with the mordants, the art of calico printing would be brought to the greateſt poſſible ſimplicity: but at preſent this can only be done in one caſe, that of indigo; every other colour requires dyeing. Compoſitions indeed may be made by previouſly combining the dye ſtuff and the mordants. Thus *yellow* may be applied at once by employing a mixture of the infuſion of quercitron bark and acetite of alumina; *red*, by mixing the ſame mordant with the decoction of alumina, and ſo on. Unfortunately the colours applied in this way are far inferior in permanency to thoſe produced when the mordant is previouſly combined with the cloth, and the dye ſtuff afterwards applied ſeparately. In this way are applied almoſt all the fugitive colours of calicoes which waſhing or even expoſure to the air deſtroys.

As the application of colours in this way cannot always be avoided by calico printers, every method of rendering them more permanent is an object of importance. We ſhall therefore conclude this chapter with a deſcription of ſeveral colours of this kind propoſed by Dr Bancroft, which have a conſiderable degree of permanence.

A *yellow* printing colour may be formed by the following method: Let three pounds of alum, and three ounces of clean chalk, be firſt diſſolved in a gallon of hot water, and then add two pounds of ſugar of lead; ſtir this mixture occaſionally during the ſpace of 24 or 36 hours, then let it remain 12 hours at reſt, and afterwards decant and preſerve the clear liquor; this be-

---

(L) According to the proportion of acetite of iron employed.

Calico Printing.

ing done, pour ſo much more warm water upon the remaining ſediment, as after ſtirring and leaving the mixture to ſettle will afford clear liquor enough to make, when mixed with the former, three quarts of this aluminous mordant or acetite of alumine. Then take not leſs than ſix, nor more than eight, pounds of quercitron bark properly ground; put this into a tinned copper veſſel, with four or five gallons of clean ſoft water, and make it boil for the ſpace of one hour at leaſt, adding a little more water, if at any time the quantity of liquor ſhould not be ſufficient to cover the ſurface of the bark: the liquor having boiled ſufficiently, ſhould be taken from the fire, and left undiſturbed for half an hour, and then the clear decoction ſhould be poured off through a fine ſieve or canvas ſtrainer. This being done, let ſix quarts more of clear water be poured upon the ſame bark, and made to boil ten or fifteen minutes, both having been firſt well ſtirred; and being afterwards left a ſufficient time to ſettle, the clean decoction may then be ſtrained off, and put with the former into a ſhallow wide veſſel to be evaporated by boiling, until what remains, being joined to the three quarts of aluminous mordant before mentioned, and to a ſufficient quantity of gum or paſte for thickening, will barely ſuffice to make three gallons of liquor in the whole. It will be proper, however, not to add the aluminous mordant, until the decoction is ſo far cooled as to be but little more than blood warm; and theſe being thoroughly mixed by ſtirring, may afterwards be thickened by the gum of Senegal or by gum arabic, if the mixture is intended for penciling; or by a paſte made with ſtarch or flour, if it be intended for printing.

Calico Printing.

By ſubſtituting a pound of murio-ſulphat of tin for the aluminous mordant in the above compoſition, a mixture may be formed which affords a very bright and full yellow, of conſiderable durability.

Sulphat of tin, mixed with a decoction of quercitron bark, communicates to cotton a *cinnamon* colour, which is ſufficiently permanent *.

When the decoctions of quercitron bark and logwood are boiled together, and ſuitable proportions of ſulphat of copper and of verdigris are added to them, with a little carbonat of potaſs, a compound is formed, which gives a *green* colour to cotton. Bancroft has made trial of this; and though it has not fully anſwered his expectation, his attempts were attended with ſufficient ſucceſs to determine him to perſevere in his experiments †.

If acetite of iron be mixed with a decoction of quercitron bark, and the mixture be properly thickened, the compound will communicate to cotton a *drab* colour of ſome durability. This compound, mixed with the olive colouring liquor above deſcribed, will produce an olive. If a ſolution of iron, by a diluted muriatic acid, or by a diluted nitric acid, be employed for this purpoſe inſtead of iron liquor, it will produce colours a little more laſting; but theſe ſolutions ſhould be employed ſparingly, that they may not hurt the texture of the linen or cotton to which they are intended to be applied.

Bancroft, i. 400.

† *Ibid*, 401.

SUL

Subtriple || Sulphuret.

SUBTRIPLE, is when one quantity is the 3d part of another; as 2 is ſubtriple of 6. And *Subtriple Ratio* is the ratio of 1 to 3.

SUBTRIPLICATE RATIO, is the ratio of the cube roots. So the ſubtriplicate ratio of a to b, is the ratio of $\sqrt[3]{a}$ to $\sqrt[3]{b}$, or of $a^{\frac{1}{3}}$ to $b^{\frac{1}{3}}$.

SUCCESSION OF SIGNS, in aſtronomy, is the order in which they are reckoned, or follow one another, and according to which the ſun enters them; called alſo *conſequentia*. As Aries, Taurus, Gemini, Cancer, &c.

SULPHURET OF LIME having lately been recommended by an eminent chemiſt * as a ſubſtitute for *potaſh* in the new method of bleaching, which, if it anſwer, may certainly be afforded at leſs expence, we ſhall here give the method of preparing the ſulphuret.

Take of ſulphur, or brimſtone in fine powder, four pounds; lime, well ſlaked and ſifted, twenty pounds; water, ſixteen gallons:—theſe are all to be well mixed and boiled for about half an hour in an iron veſſel, ſtirring them briſkly from time to time. Soon after the agitation of boiling is over, the ſolution of the ſulphuret of lime clears, and may be drawn off free from the inſoluble matter, which is conſiderable, and which reſts upon the bottom of the boiler (A). The liquor in this ſtate is pretty nearly of the colour of ſmall beer, but not quite ſo tranſparent.

* *W. Higgins, M. R. T. A.*

SUN

Sulphuret, Sun.

Sixteen gallons of freſh water are afterwards to be poured upon the inſoluble dregs in the boiler, in order to ſeparate the whole of the ſulphuret from them. When this clears (being previouſly well agitated), it is alſo to be drawn off and mixed with the firſt liquor; to theſe again thirty-three gallons more of water may be added, which will reduce the liquor to a proper ſtandard for ſteeping the cloth.

Here we have (an allowance being made for evaporation, and for the quantity retained in the dregs) ſixty gallons of liquor from four pounds of brimſtone.

Although ſulphur by itſelf is not in any ſenſible degree ſoluble in water, and lime but very ſparingly ſo, water diſſolving but about one ſeven-hundredth part of its weight of lime; yet the ſulphuret of lime is highly ſoluble.

When the above proportion of lime and ſulphur is boiled with only twelve gallons of water, the ſulphuret partly cryſtallizes upon cooling; and when once cryſtallized it is not eaſy of ſolution.

SUN (ſee ASTRONOMY-*Index*, Encycl.) is certainly that celeſtial body which, of all others, ſhould moſt attract our attention. It has accordingly employed much of

---

(A) Although lime is one of the conſtituent principles of the ſulphuret, yet being ſo intimately united to the ſulphur, it has no longer the property of lime; upon the ſame principle that ſulphuric acid in ſulphat of potaſh has not the property of that acid.

of the time and meditation, not only of the aſtronomer, but alſo of the ſpeculative philoſopher, in all ages of the world; and many hypotheſes have been formed, and ſome diſcoveries made, reſpecting the nature and the uſes of this vaſt luminary.

Sir Iſaac Newton has ſhewn, that the ſun, by its attractive power, retains the planets of our ſyſtem in their orbits: he has alſo pointed out the method whereby the quantity of matter which it contains may be accurately determined. Dr Bradley has aſſigned the velocity of the ſolar light with a degree of preciſion exceeding our utmoſt expectation. Gallileo, Scheiner, Hevelius, Caſſini, and others, have aſcertained the rotation of the ſun upon its axis, and determined the poſition of its equator. By means of the tranſit of Venus over the diſk of the ſun, our mathematicians have calculated its diſtance from the earth, its real diameter and magnitude, the denſity of the matter of which it is compoſed, and the fall of heavy bodies on its ſurface. We have therefore a very clear notion of the vaſt importance and powerful influence of the ſun on its planetary ſyſtem; but with regard to its internal conſtruction, we are yet extremely ignorant. Many ingenious conjectures have indeed been formed on the ſubject; a few of which we ſhall mention as an introduction to Dr Herſchel's, of which, as it is the lateſt, and perhaps the moſt plauſible, we ſhall give a pretty full account nearly in his own words.

The dark ſpots in the ſun, for inſtance, have been ſuppoſed to be ſolid bodies revolving very near its ſurface. They have been conjectured to be the ſmoke of volcanoes, or the ſcum floating upon an ocean of fluid matter. They have alſo been taken for clouds. They were explained to be opaque maſſes ſwimming on the fluid matter of the ſun, dipping down occaſionally. It has been ſuppoſed that a fiery liquid ſurrounded the ſun, and that by its ebbing and flowing the higheſt parts of it were occaſionally uncovered, and appeared under the ſhape of dark ſpots; and that by the return of the fiery liquid, they were again covered, and in that manner ſucceſſively aſſumed different phaſes. The ſun itſelf has been called a globe of fire, though perhaps metaphorically. The waſte it would undergo by a gradual conſumption, on the ſuppoſition of its being ignited, has been ingeniouſly calculated; and in the ſame point of view its immenſe power of heating the bodies of ſuch comets as draw very near to it has been aſſigned.

In the year 1779 there was a ſpot on the ſun which was large enough to be ſeen with the naked eye. By a view of it with a ſeven feet reflector, charged with a very high power, it appeared to be divided into two parts. The largeſt of the two, on the 19th of April, meaſured 1′ 8″.06 in diameter, which is equal in length to more than 31,000 miles. Both together muſt certainly have extended above 50,000. The idea of its being occaſioned by a volcanic exploſion violently driving away a fiery fluid, ought to be rejected (ſays Dr Herſchel) on many accounts. "To mention only one, the great extent of the ſpot is very unfavourable to ſuch a ſuppoſition. Indeed a much leſs violent and leſs pernicious cauſe may account for all the appearances of the ſpot. When we ſee a dark belt near the equator of the planet Jupiter, we do not recur to earthquakes and volcanoes for its origin. An atmoſphere, with its natural changes, will explain ſuch belts. Our ſpot on the ſun may be accounted for on the ſame principles. The earth is ſurrounded by an atmoſphere compoſed of various elaſtic fluids. The ſun alſo has its atmoſphere; and if ſome of the fluids which enter into its compoſition ſhould be of a ſhining brilliancy, in the manner that will be explained hereafter, while others are merely tranſparent, any temporary cauſe which may remove the lucid fluid will permit us to ſee the body of the ſun through the tranſparent ones. If an obſerver were placed on the moon, he would ſee the ſolid body of the earth only in thoſe places where the tranſparent fluids of our atmoſphere would permit him. In others, the opaque vapours would reflect the light of the ſun without permitting his view to penetrate to the ſurface of our globe. He would probably alſo find, that our planet had occaſionally ſome ſhining fluids in its atmoſphere; as, not unlikely, ſome of our northern lights might not eſcape his notice, if they happened in the unenlightened part of the earth, and were ſeen by him in his long dark night. Nay, we have pretty good reaſon to believe, that probably all the planets emit light in ſome degree; for the illumination which remains on the moon in a total eclipſe cannot be entirely aſcribed to the light which may reach it by the refraction of the earth's atmoſphere. For inſtance, in the eclipſe of the moon October 22. 1790, the rays of the ſun refracted by the atmoſphere of the earth towards the moon, admitting the mean horizontal refraction to be 30′ 50″.8, would meet in a focus 189,000 miles beyond the moon; ſo that conſequently there could be no illumination from rays refracted by our atmoſphere. It is, however, not improbable, that about the polar regions of the earth there may be refraction enough to bring ſome of the ſolar rays to a ſhorter focus. The diſtance of the moon at the time of the eclipſe would require a refraction of 54′ 6″, equal to its horizontal parallax at that time, to bring them to a focus ſo as to throw light on the moon.

The unenlightened part of the planet Venus has alſo been ſeen by different perſons; and not having a ſatellite, thoſe regions that are turned from the ſun cannot poſſibly ſhine by a borrowed light; ſo that this faint illumination muſt denote ſome phoſphoric quality of the atmoſphere of Venus.

In the inſtance of the large ſpot on the ſun already mentioned, Dr Herſchel concludes, from appearances, that he viewed the real body of the ſun itſelf, of which we rarely ſee more than its ſhining atmoſphere. In the year 1783 he obſerved a fine large ſpot, and followed it up to the edge of the ſun's limb. Here he took notice that the ſpot was plainly depreſſed below the ſurface of the ſun, and that it had very broad ſhelving ſides. He alſo ſuſpected ſome part, at leaſt, of the ſhelving ſides to be elevated above the ſurface of the ſun; and obſerved that, contrary to what uſually happens, the margin of that ſide of the ſpot which was fartheſt from the limb was the broadeſt.

The luminous ſhelving ſide of a ſpot may be explained by a gentle and gradual removal of the ſhining fluid, which permits us to ſee the globe of the ſun. As to the uncommon appearance of the broadeſt margin being on that ſide of the ſpot which was fartheſt from the limb when the ſpot came near the edge of it, we may ſurmiſe that the ſun has inequalities on its ſurface, which may poſſibly be the cauſe of it. For when mountainous countries are expoſed, if it ſhould chance that the higheſt parts of the landſcape are ſituated ſo as to be near that ſide of the margin or penumbra of the ſpot which is towards the limb, they may partly intercept our view of it when the ſpot is ſeen very obliquely. This would require elevations at leaſt five or ſix hundred miles high; but conſidering the great attraction exerted by the ſun upon bodies at its ſurface, and the ſlow revolution it has upon its axis, we may readily admit inequalities to that amount. From the centrifugal force at the ſun's equator, and the weight of bodies at its ſurface, he computes, that the power of throwing down a mountain by the exertion of the former, balanced by the ſuperior force of keeping it in its place of the latter, is near 6¼ times leſs on the ſun than on our equatorial regions; and as an elevation ſimilar to one of three miles on the earth would not be leſs than 334 miles on the ſun, there can be no doubt but that a mountain much higher would ſtand very firmly. The little denſity of the ſolar body ſeems alſo to be in favour of the height of its mountains; for, *cæteris paribus*, denſe bodies will ſooner come to their level than rare ones. The difference in the vaniſhing of the ſhelving ſide, inſtead of explaining it by mountains, may alſo, and perhaps more ſatisfactorily, be accounted for from the real difference of the extent, the arrangement, the height, and the intenſity of the ſhining fluid, added to the occaſional changes that may happen in theſe particulars during the time in which the ſpot approaches to the edge of the diſk. However, by admitting large mountains on the face of the ſun, we ſhall account for the different opinions of two eminent aſtronomers; one of whom believed the ſpots depreſſed below the ſurface of the ſun, while the other believed them elevated above it. For it is not impoſſible that ſome of the ſolar mountains may be high enough occaſionally to project above the ſhining elaſtic fluid, when, by ſome agitation or other cauſe, it is not of the uſual height; and this opinion is much ſtrengthened by the return of ſome remarkable ſpots which ſerved Caſſini to aſcertain the period of the ſun's rotation. A very high country, or chain of mountains, may oftener become viſible, by the removal of the obſtructing fluid, than the lower regions, on account of its not being ſo deeply covered with it.

In 1791 the Doctor examined a large ſpot on the ſun, and found it evidently depreſſed below the level of the ſurface. In 1792 he examined the ſun with ſeveral powers from 90 to 500, when it appeared evidently, that the black ſpots are the opaque ground, or body of the ſun; and that the luminous part is an atmoſphere, which, being interrupted or broken, gives us a tranſient glimpſe of the ſun itſelf. He perceived likewiſe, that the ſhining ſurface of the ſun is unequal, many parts of it being elevated and others depreſſed; and that the elevations, to which Hevelius gave the name of *faculæ*, ſo far from reſembling torches, were rather like the ſhrivelled elevations upon a dried apple, extended in length, and moſt of them joined together, making waves or waving lines. The faculæ being elevations, very ſatisfactorily explains the reaſon why they diſappear towards the middle of the ſun, and reappear on the other margin; for about the place where we loſe them, they begin to be edgewiſe to our view; and if between the faculæ ſhould lie dark ſpots, they will moſt frequently break out in the middle of the ſun, becauſe they are no longer covered by the ſide-views of theſe faculæ.

The Doctor gives a very particular account of all his obſervations, which ſeem to have been accurately made, and we need ſcarcely add with excellent teleſcopes. For that account, however, we muſt refer to the memoir itſelf, and haſten to lay before our readers the reſult of his obſervations. "That the ſun (ſays he) has a very extenſive atmoſphere, cannot be doubted; and that this atmoſphere conſiſts of various elaſtic fluids, that are more or leſs lucid and tranſparent, and of which the lucid one is that which furniſhes us with light, ſeems alſo to be fully eſtabliſhed by all the phenomena of its ſpots, of the faculæ, and of the lucid ſurface itſelf. There is no kind of variety in theſe appearances but what may be accounted for with the greateſt facility, from the continual agitation which, we may eaſily conceive, muſt take place in the regions of ſuch extenſive elaſtic fluids.

"It will be neceſſary, however, to be a little more particular as to the manner in which I ſuppoſe the lucid fluid of the ſun to be generated in its atmoſphere. An analogy that may be drawn from the generation of clouds in our own atmoſphere, ſeems to be a very proper one, and full of inſtruction. Our clouds are probably decompoſitions of ſome of the elaſtic fluids of the atmoſphere itſelf, when ſuch natural cauſes, as in this grand chemical laboratory are generally at work, act upon them: we may therefore admit, that in the very extenſive atmoſphere of the ſun, from cauſes of the ſame nature, ſimilar phenomena will take place; but with this difference, that the continual and very extenſive decompoſitions of the elaſtic fluids of the ſun are of a phoſphoric nature, and attended with lucid appearances, by giving out light.

"If it ſhould be objected, that ſuch violent and unremitting decompoſitions would exhauſt the ſun, we may recur again to our analogy, which will furniſh us with the following reflections. The extent of our own atmoſphere, we ſee, is ſtill preſerved, notwithſtanding the copious decompoſitions of its fluids in clouds and falling rain; in flaſhes of lightning, in meteors, and other luminous phenomena; becauſe there are freſh ſupplies of elaſtic vapours continually aſcending to make good the waſte occaſioned by thoſe decompoſitions. But it may be urged, that the caſe with the decompoſition of the elaſtic fluids in the ſolar atmoſphere would be very different, ſince light is emitted, and does not return to the ſun, as clouds do to the earth when they deſcend in ſhowers of rain. To which I anſwer, that, in the decompoſition of phoſphoric fluids, every other ingredient but light may alſo return to the body of the ſun. And that the emiſſion of light muſt waſte the ſun, is not a difficulty that can be oppoſed to our hypotheſis: for as it is an evident fact that the ſun does emit light, the ſame objection, if it could be one, would equally militate againſt every other aſſignable way to account for the phenomenon.

"There are, moreover, conſiderations that may leſſen the preſſure of this alleged difficulty. We know the exceeding ſubtilty of light to be ſuch, that in ages of time its emanation from the ſun cannot very ſenſibly leſſen the ſize of this great body. To this may be added, that very poſſibly there may always be ways of reſtoration to compenſate for what is loſt by the emiſſion of light, though the manner in which this can be brought about ſhould not appear to us. Many of the operations of Nature are carried on in her great laboratory which we cannot comprehend, but now and then we ſee ſome of the tools with which ſhe is at work. We need not wonder that their conſtruction ſhould be ſo ſingular as to induce us to confeſs our ignorance of the method of employing them; but we may reſt aſſured that they are not a mere *luſus naturæ*." Here he alludes to the great number of ſmall teleſcopic comets; which he ſuppoſes, as others had done before him, may be employed to reſtore to the ſun what had been loſt by the emiſſion of light. "My hypotheſis, however, (continues he) does not lay me under any obligation to explain how the ſun can ſuſtain the waſte of light, nor to ſhew that it will ſuſtain it for ever; and I ſhould alſo remark that, as in the analogy of generating clouds, I merely allude to their production as owing to a decompoſition of ſome of the elaſtic fluids of our atmoſphere, that analogy, which firmly reſts upon the fact, will not be leſs to my purpoſe, to whatever cauſe theſe clouds may owe their origin. It is the ſame with the lucid clouds, if I may ſo call them, of the ſun. They plainly exiſt, becauſe we ſee them; the manner of their being generated may remain an hypotheſis—and mine, till a better can be propoſed, may ſtand good; but whether it does or not, the conſequences I am going to draw from what has been ſaid will not be affected by it."

Before he proceeds to draw theſe conſequences, he informs us that, according to the above theory, a dark ſpot in the ſun is a place in its atmoſphere, which happens to be free from luminous decompoſitions; that faculæ are, on the contrary, more copious mixtures of ſuch fluids as decompoſe each other; and that the regions, in which the luminous ſolar clouds are formed, adding thereto the elevation of the faculæ, cannot be leſs than 1843, nor much more than 2765 miles in depth. It is true, continues he, that in our atmoſphere the extent of the clouds is limited to a very narrow compaſs; but we ought rather to compare the ſolar ones to the luminous decompoſitions which take place in our *aurora borealis*, or luminous arches, which extend much farther than the cloudy regions. The denſity of the luminous ſolar clouds, though very great, may not be exceedingly more ſo than that of our *aurora borealis*. For if we conſider what would be the brilliancy of a ſpace two or three thouſand miles deep, filled with ſuch corruſcations as we ſee now and then in our atmoſphere, their apparent intenſity, when viewed at the diſtance of the ſun, might not be much inferior to that of the lucid ſolar fluid.

From the luminous atmoſphere of the ſun, he proceeds to its opaque body; which, by calculation from the power it exerts upon the planets, we know to be of great ſolidity; and from the phenomena of the dark ſpots, many of which, probably on account of their high ſituations, have been repeatedly ſeen, and otherwiſe denote inequalities in their level, we ſurmiſe that its ſurface is diverſified with mountains and valleys.

What has been ſaid, enables us to come to ſome very important concluſions, by remarking, that this way of conſidering the ſun and its atmoſphere removes the great diſſimilarity we have hitherto been uſed to find between its condition and that of the reſt of the great bodies of the ſolar ſyſtem.

The ſun, viewed in this light, appears to be nothing elſe than a very eminent, large, and lucid planet, evidently the firſt, or, in ſtrictneſs of ſpeaking, the only primary one of our ſyſtem, all others being truly ſecondary to it. Its ſimilarity to the other globes of the ſolar ſyſtem with regard to its ſolidity, its atmoſphere, and its diverſified ſurface, the rotation upon its axis, and the fall of heavy bodies, leads us on to ſuppoſe that it is moſt probably alſo inhabited, like the reſt of the planets, by beings whoſe organs are adapted to the peculiar circumſtances of that vaſt globe.

It may, however, not be amiſs to remove a certain difficulty, which ariſes from the effect of the ſun's rays upon our globe. The heat which is here, at the diſtance of 95 millions of miles, produced by theſe rays, is ſo conſiderable, that it may be objected, that the ſurface of the globe of the ſun itſelf muſt be ſcorched up beyond all conception.

This may be very ſubſtantially anſwered by many proofs drawn from natural philoſophy, which ſhew that heat is produced by the ſun's rays only when they act upon a calorific medium; they are the cauſe of the production of heat, by uniting with the matter of fire which is contained in the ſubſtances that are heated; as the colliſion of flint and ſteel will inflame a magazine of gunpowder, by putting all the latent fire it contains into action. But an inſtance or two of the manner in which the ſolar rays produce their effect, will bring this home to our moſt common experience.

On the tops of mountains of a ſufficient height, at an altitude where clouds can very ſeldom reach to ſhelter them from the direct rays of the ſun, we always find regions of ice and ſnow. Now if the ſolar rays themſelves conveyed all the heat we find on this globe, it ought to be hotteſt where their courſe is leaſt interrupted. Again, our aeronauts all confirm the coldneſs of the upper regions of the atmoſphere; and ſince, therefore, even on our earth, the heat of any ſituation depends upon the aptneſs of the medium to yield to the impreſſion of the ſolar rays, we have only to admit, that on the ſun itſelf, the elaſtic fluids compoſing its atmoſphere, and the matter on its ſurface, are of ſuch a nature as not to be capable of any exceſſive affection from its own rays: and indeed this ſeems to be proved by the copious emiſſion of them; for if the elaſtic fluids of the atmoſphere, or the matter contained on the ſurface of the ſun, were of ſuch a nature as to admit of an eaſy chemical combination with its rays, their emiſſion would be much impeded.

Our author then proceeds to ſupport his theory by analogical reaſonings; but as theſe will occur to ſuch of our readers as are converſant with the ſpeculations of aſtronomers, we paſs on to his reflections upon the conſequences of this theory. "That the ſtars are ſuns can hardly admit of a doubt. Their immenſe diſtance would perfectly exclude them from our view, if the light they ſend us were not of the ſolar kind. Beſides, the analogy may be traced much farther. The ſun turns on its axis; ſo does the ſtar Algol; ſo do the ſtars called β Lyræ, δ Cephei, η Antinoi, ο Ceti, and many more; moſt probably all. From what other cauſe can we ſo probably account for their periodical changes? Again, our ſun has ſpots on its ſurface; ſo has the ſtar Algol, and ſo have the ſtars already named, and probably every ſtar in the heavens. On our ſun theſe ſpots are changeable; ſo they are on the ſtar ο Ceti, as evidently appears from the irregularity of its changeable luſtre, which is often broken in upon by accidental changes while the general period continues unaltered. The ſame little deviations have been obſerved in other periodical ſtars, and ought to be aſcribed to the ſame cauſe. But if ſtars are ſuns, and ſuns are inhabitable, we ſee at once what an extenſive field for animation opens itſelf to our view.

"It is true, that analogy may induce us to conclude, that ſince ſtars appear to be ſuns, and ſuns, according to the common opinion, are bodies that ſerve to enlighten, warm, and ſuſtain a ſyſtem of planets, we may have an idea of numberleſs globes that ſerve for the habitation of living creatures. But if theſe ſuns themſelves are primary planets, we may ſee ſome thouſands of them with our own eyes, and millions by the help of teleſcopes, when at the ſame time the ſame analogical reaſoning ſtill remains in full force with regard to the planets which theſe ſuns may ſupport."

The Doctor then obſerves, that from other conſiderations, the idea of ſuns or ſtars being *merely* the ſupporters of ſyſtems of planets, is not abſolutely to be admitted as a general one. "Among the great number of very compreſſed cluſters of ſtars I have given (ſays he) in my catalogues, there are ſome which open a different view of the heavens to us. The ſtars in them are ſo very cloſe together, that, notwithſtanding the great diſtance at which we may ſuppoſe the cluſter itſelf to be, it will hardly be poſſible to aſſign any ſufficient mutual diſtance to the ſtars compoſing the cluſter, to leave room for crowding in thoſe planets, for whoſe ſupport theſe ſtars have been, or might be, ſuppoſed to exiſt. It ſhould ſeem, therefore, highly probable, that they exiſt for themſelves; and are, in fact, only very capital, *lucid*, primary planets, connected together in one great ſyſtem of mutual ſupport.

"The ſame remark may be made with regard to the number of very cloſe double ſtars, whoſe apparent diameters being alike, and not very ſmall, do not indicate any very great mutual diſtance: from which, however, muſt be deducted all thoſe where the different diſtances may be compenſated by the real difference in their reſpective magnitudes.

"To what has been ſaid may be added, that, in ſome parts of the milky way, where yet the ſtars are not very ſmall, they are ſo crowded, that in the year 1792, Aug. 22. I found by the gauges that, in 41 minutes of time, no leſs than 258,000 of them had paſſed through the field of view of my teleſcope.

"It ſeems, therefore, upon the whole, not improbable, that in many caſes ſtars are united in ſuch cloſe ſyſtems as not to leave much room for the orbits of planets or comets; and that conſequently, upon this account alſo, many ſtars, unleſs we would make them mere uſeleſs brilliant points, may themſelves be lucid planets, perhaps unattended by ſatellites."

What a magnificent idea does this theory give of the univerſe, and of the goodneſs, as well as power, of its Author? And how cold muſt be that heart, and clouded that underſtanding, who, after the contemplation of it, can for one moment liſten to the atheiſtical doctrines of thoſe men who preſume to account for all the phenomena of nature by chemical affinities and mechanical attraction? The man who, even in his heart, can ſay, that ſuch an immenſe ſyſtem, differing ſo widely in the ſtructure of the different parts of it, but everywhere crowded with life, is the effect of unintelligent agency, is indeed, to uſe the emphatic language of an ancient aſtronomer—*a fool*.

SUNDA, Straits of, are formed by the approach of the ſouth-eaſt extremity of the iſland of Sumatra to the north-weſt extremity of the iſland of Java (See theſe iſlands, *Encycl.*). The ſtraits are interſperſed with a number of ſmall iſles; the whole diſplaying a ſcenery ſcarcely to be exceeded in the ſoftneſs, richneſs, and gaiety of its appearance. The two great iſlands, which are low, and in ſome places marſhy near the ſhore, riſe afterwards, in a gradual ſlope, towards the interior of the country, admitting in their aſcent every variety of ſituation, and all the different tints of verdure. Of the ſmaller iſlands, a few have ſteep and naked ſides, ſuch as one in the middle of the ſtrait, which the Engliſh navigators have diſtinguiſhed, on that account, by the name of Thwart-the-way, and two very ſmall round ones, called, from their figures, the Cap and Button (ſee theſe iſlands, *Suppl.*); but moſt of the others are entirely level, founded upon beds of coral, and covered with trees. Some of theſe iſlands are ſurrounded with a white ſandy beach, viſited frequently by turtle; but moſt of them are adorned with thick ſhrubbery to the water's edge, the roots being waſhed by the ſea, or the branches dipping into it; and on the outſide are ſhoals, in which a multitude of little aquatic animals are buſied in framing calcareous habitations for their reſidence and protection. Thoſe fabrics gradually emerge above the ſurface of the water, and at length, by the adventitious adheſion of vegetable matter, giving birth to plants and trees, become new iſlands, or add to the ſize of thoſe already produced by the ſame means. It is impoſſible not to be ſtruck with the diverſified operations of Nature for obtaining the ſame end, whether employed in originally fixing the granite foundation of the Brazils, or in throwing up, by ſome ſudden and ſubſequent convulſion, the iſland of Amſterdam, or in continuing to this hour, through the means of animated beings, the formation of new lands in the Straits of Sunda.—*Sir George Staunton's Account of the Britiſh Embaſſy to China.*

SUNNUD, a grant, patent, or charter, in Bengal.

SUPERPARTICULAR Proportion, or Ratio, is that in which the greater term exceeds the leſs by unit or 1. As the ratio of 1 to 2, or 2 to 3, or 3 to 4, &c.

SUPERPARTIENT Proportion, or Ratio, is when the greater term contains the leſs term once, and leaves ſome number greater than 1 remaining. As the ratio

of 3 to 5, which is equal to that of 1 to $1\frac{2}{3}$;

of 7 to 10, which is equal to that of 1 to $1\frac{3}{7}$; &c.

SUPPLEMENT, of an Arch or Angle, in geometry or trigonometry, is what it wants of a ſemicircle, or of 180°; as the *complement* is what it wants of a quadrant, or of 90°. So, the ſupplement of 50° is 130°; as the complement of it is 40°.

SUTTON (Thomas, Eſq;), founder of the charterhouſe, was born at Knaith in Lincolnſhire, in 1532, of an ancient and genteel family. He was educated at Eton ſchool, and probably at Cambridge, and ſtudied the law in Lincoln's Inn; but this profeſſion not ſuiting his diſpoſition, he travelled into foreign countries, and made ſo long a ſtay in Holland, France, Spain, and Italy, as to acquire the languages of thoſe various nations. During his abſence, his father died, and left him a conſiderable fortune. On his return home, being a very accompliſhed gentleman, he became ſecretary to the earl of Warwick and his brother the earl of Leiceſter. By the former of theſe noblemen, in 1569, he was appointed maſter of the ordnance at Berwick; and diſtinguiſhing himſelf greatly in that ſituation, on the rebellion which at that time broke out in the north, he obtained a patent for the office of maſter-general of the ordnance for that diſtrict for life. He is named as one of the chiefs of thoſe 1500 men who marched into Scotland, by the order of Queen Elizabeth, to the aſſiſtance of the regent, the earl of Morton, in 1573; and he commanded one of the five batteries which obliged the ſtrong caſtle of Edinburgh to ſurrender to the Engliſh. He purchaſed of the biſhop of Durham the manors of Gateſhead and Wickham; which, producing coal-mines, became to him a ſource of extraordinary wealth. In 1580, he was reputed to be worth L. 50,000

Soon after this, he married a rich widow, who brought him a conſiderable eſtate; and taking up the buſineſs of a merchant, riches flowed in to him with every tide. He is ſaid to have had no leſs than thirty agents abroad. He was likewiſe one of the chief victuallers of the navy; and ſeems to have been maſter of the barque called Sutton, in the liſt of volunteers attending the Engliſh fleet againſt the Spaniſh armada. It is probable, alſo, that he was a principal inſtrument in the defeat of it, by draining the bank of Genoa of that money with which Philip intended to equip his fleet, and thereby hindering the invaſion for a whole year. He is likewiſe ſaid to have been a commiſſioner for prizes under Lord Charles Howard, High Admiral of England; and going to ſea with letters of marque, he took a Spaniſh ſhip worth L. 20,000. His whole fortune, at his death, appears to have been in land L. 5,000 *per annum*; in money, upwards of L. 60,000; the greateſt eſtate in the poſſeſſion of any private gentleman till much later times. He lived with great munificence and hoſpitality; but loſing his lady in 1602, he retired from the world, leſſened his family, and lived in a private frugal manner; and, having no iſſue, reſolved to diſtinguiſh his name by ſome important charity. Accordingly, he purchaſed of the Earl of Suffolk Howard-Houſe, or the late diſſolved charter-houſe, near Smithfield, for the ſum of L. 13,000, where he founded the preſent hoſpital, in 1611, for the relief of poor men and children. Before he had fixed upon this deſign, the court endeavoured to divert him from his purpoſe, and to engage him to make Charles I. then Duke of York, his heir, by conferring on him a peerage; but being free from ambition, and now near his grave, the luſtre of the coronet could not tempt him to change his plan. He died the 11th of December, 1611, at Hackney, aged 79. His body was conveyed, with the moſt ſolemn proceſſion, to Chriſt-church in London, and there depoſited, till 1614, when it was removed to the charter-houſe, and interred in a vault on the north ſide of the chapel, under a magnificent tomb.

SUWOROW (A) **RIMNIKSKI** (Count Alexander), was a man ſo eminent in his profeſſion, that, if war be an art founded on ſcience, it would be improper not to give ſome account of his life in a Work of this nature. Various accounts of him, indeed, are already in the hands of the public; but they differ ſo much from one another in the pictures which they preſent of the *man*, that it is not eaſy, if it be always poſſible, to diſtinguiſh truth from falſehood. With reſpect to the talents of the *General*, there is not room for the ſame difference of repreſentation; becauſe a train of military ſucceſſes, almoſt unrivalled, has rendered theſe conſpicuous to all Europe. In the ſhort detail that our limits permit us to give of the life of this ſingular man, we ſhall avail ourſelves of all the information, public and private, which we have been able to obtain, and believe to be authentic; and we hope to make our readers acquainted with ſome particulars reſpecting his perſon and domeſtic habits which are not yet generally known.

The family of Suworow is ſaid to have been from Sweden, and of a noble deſcent. The firſt of this name ſettled in Ruſſia about the latter end of the laſt century; and having engaged in the wars againſt the Tartars and the Poles, were rewarded by the Czars of that period with lands and peaſants. Baſil, the father of our hero, is ſaid to have been the godſon of Peter the Great; to have been held in high eſtimation for his political knowledge and extenſive erudition; and to have enjoyed, at his death, the two-fold rank of General and Senator *.

As this account is given by a man who profeſſes to have formed an intimate acquaintance with Suworow himſelf, it ought to be correct; and yet we cannot help entertaining ſome doubts of its truth, or at leaſt of its accuracy. It is well known, that extenſive erudition was in no eſteem in Ruſſia at the period when Baſil Suworow is here ſaid to have been ſo learned; and it is likewiſe known, that if, by erudition, be meant a knowledge of ancient literature, it was even deſpiſed, at a much later period, by all who were at once noble, and poſſeſſed of lands and peaſants (See RUSSIA, *Encycl.*). The truth is, as we have learned from unqueſtionable authority, that the family of Suworow was ancient and reſpectable; but being far from affluent, and their little property lying at the very extremity of the empire, we have reaſon to believe, that the ſubject of this memoir was the firſt of the family that ever was at court. Baſil, however, if his anceſtors were from Sweden, may have been free from the Ruſſian prejudices againſt Greek and Latin; and this is the more probable, that he certainly gave a learned education to his ſon.

That ſon, Alexander Baſilowitch Suworow, was, according to the author already quoted, born in the year 1730;

* See *the Hiſtory of the Campaigns of Count Alexander Suworow, by Frederick Antling.*

(A) This name is ſpelled ſometimes as we have ſpelled it, ſometimes SUWARROW, and ſometimes SUVOROFF. This laſt is according to the pronunciation; but we have adopted the orthography of the General himſelf, in his letter to Charette, the hero of Vendee.

1730 : we have ſome reaſon to believe, that he was not born before 1732. His father had deſtined him, we are told, for the robe ; but his early inclinations impelled him to the profeſſion of a ſoldier ; and in 1742 he was enrolled as a fuſilier in the guards of Seimonow. He was afterwards a corporal, then a ſerjeant, and, in 1754, he quitted the guards with the brevet of Lieutenant in the army. He made his firſt campaign in the ſeven years war againſt the Pruſſians, in the year 1759, entering upon actual ſervice under Prince Wolgonſki. As ſenior officer on duty, he attended on the commander in chief Count Fermor, who, admiring the conſummate reſolution which he appeared to poſſeſs, ſavoured him with his particular confidence. In 1761, he was ordered on ſervice in the light troops under General Berg ; and with the rank of a field-officer (we think that of Lieutenant-colonel) he performed prodigies of valour, and exhibited much of that character which was afterwards ſo fully developed and diſplayed. Even then he ſeems to have formed the reſolution of dying on the field of battle rather than ſuffer himſelf to be taken priſoner ; for when, with a handful of troops, he was once ſurrounded by a large detachment of Pruſſians, he determined to cut his way through them, or periſh in the attempt. In this daring enterpriſe he was not only ſucceſsful, but contrived to carry off with him twenty priſoners, though he was obliged to abandon two field-pieces, which he had a little before taken from a ſmaller detachment.

At the peace of 1762, he received from the Empreſs a colonel's commiſſion, written with her own hand ; and being advanced, in 1768, to the rank of brigadier, he was, in the month of November, ordered to repair, with all poſſible ſpeed, to the frontiers of Poland. At that unfavourable ſeaſon, he croſſed rivers and moraſſes, whoſe paſſage was rendered more difficult by ſlight froſts ; and, in the courſe of a month, traverſed 500 Engliſh miles, with the loſs of only a few men in the environs of Smolenſko.

The object of the Empreſs, at this time, was to ſubdue the Poliſh confederates, and to poſſeſs herſelf of certain provinces of that ill-fated kingdom. How completely ſhe and her two allies, the Emperor of Germany and the King of Pruſſia, ſucceeded in their enterpriſe, has been related elſewhere (ſee POLAND, *Encycl.*). It is ſufficient, in this memoir, to obſerve, that the ſucceſſes of the Ruſſians were chiefly owing to the military ſkill and intrepidity of Suworow, who was their only active General, and was indeed, for four years, almoſt conſtantly employed in offenſive operations againſt the confederates. Not to mention the numerous actions and ſkirmiſhes of an inferior kind, in which his conduct and courage were always diſplayed, the victory at Staloviz, over a ſuperior force, ably commanded, and the capture of Cracow, were alone ſufficient to intitle him to the character which he ever afterwards ſo well ſupported. The former of theſe drew the higheſt encomiums from the great Frederick of Pruſſia ; and the latter decided the fate of Poland. It is proper to add, that Suworow, on theſe occaſions, did not tarniſh his laurels by unneceſſary cruelty. When a French officer, who ſurrendered at Cracow, offered him his ſword, according to the cuſtom of war, he refuſed it, ſaying, that he would not take the ſword of a brave man, whoſe maſter was not at war with his ſovereign ; and, even to the leaders of the confederates, he granted better terms of capitulation than they had the preſumption to aſk.

In the year 1770, he had been promoted to the rank of Major general ; and for his exploits in the Poliſh war, the Empreſs conferred upon him, at different times, the orders of St Ann, St George, and Alexander Newſky.

After performing ſome important ſervices on the frontiers of Sweden, Suworow received orders, in the beginning of 1773, to join the army in Moldavia, under the command of Field-marſhal Romanzow ; and there he began that glorious career, which ſoon made his name a terror to the Turks. His firſt exploit was the taking of Turtukey ; of which he wrote the following laconic account to the commander in chief :

" Honour and glory to God ! Glory to you, Romanzow ! We are in poſſeſſion of Turtukey, and I am in it ! " SUWOROW."

During the remainder of the war, which was of ſhort continuance, Suworow was conſtantly engaged, and conſtantly ſucceſsful. In the beginning of the year 1774, he was promoted to the rank of Lietenant-general ; and on the 11th of June of the ſame year, he defeated the Turks in a great battle, in which they loſt 3000 men killed, ſome hundreds of priſoners, 40 pieces of artillery, and 80 ſtandards, with their ſuperb camp. Soon after this victory, peace was concluded between the two courts ; and Lieutenant-general Suworow was ordered to proceed with all poſſible haſte to Moſcow, to aſſiſt in appeaſing the interior troubles of that part of the empire.

Theſe troubles were occaſioned by a Coſſac rebel, of the name of *Pugatchew*, or *Pugatcheff*, who, at the head of a party of his diſcontented countrymen, had long eluded the vigilance of Count Panin, the commander in chief in Muſcovy, and frequently cut off detachments of the army which were ſent out in queſt of him. The chace of Pugatcheff, for ſuch it may be called, was now wholly entruſted to the well-known activity of Suworow ; and that General, after purſuing the rebel with inconceivable rapidity, through woods and deſerts, came up with him at a place called Urlaſk, and carried him priſoner to Count Panin, who ſent him to Moſcow, where he ſuffered the puniſhment due to his crimes. This inſurgent, it is ſaid, had at one time collected ſuch a force, and was followed with ſuch enthuſiaſm, that, if his underſtanding had been equal to his courage, and his moderation had kept pace with his power, he might have poſſeſſed himſelf of Moſcow, and made the Imperial Catharine tremble on her throne.

For ſeveral years after the taking of Pugatcheff, Suworow was employed in the Crimea, on the Cuban, and againſt the Nogay Tartars, in a kind of ſervice which, though it was of the utmoſt importance to the Empreſs, and required all the addreſs of the Lieutenant-general, furniſhed no opportunities for that wonderful diſplay of promptitude and reſource which had characteriſed his more active campaigns. One incident, however, muſt be mentioned, even in this ſhort memoir, becauſe it ſhews the natural diſpoſition of the man. During the winter that Suworow paſſed among the Tartars, he was frequently viſited by the chiefs of that nation ; and at one of theſe viſits, Mechmed Bay, the chief of the Gediſſens, often joked with Muſſa Bay, another chief, on his inclination to marry. Muſſa Bay was ſo extremely old, that Suworow thought the converſation ridiculous; and one day aſked him, What ground Mechmed could have for ſuch idle talk? Muſſa replied, that Mechmed Bey was right; that he wiſhed to marry; and that he hoped the General would make him a preſent of a beautiful Tartar girl of ſixteen! Suworow immediately bought a young Tartar ſlave of a Coſſac for 100 rubles, and ſent her to Muſſa Bey; who married her, lived with her a very few years, and died at the age of one hundred and eight! regretted, we are told, by the Lieutenant-general, who regarded him with great eſteem and attachment.

In the end of the year 1786, Suworow was promoted to the rank of General in Chief; and, at the breaking out of the war with the Turks in 1787, he ſhewed how well he was intitled to that rank, by his maſterly defence of Kinburn; a place of no ſtrength, but of great importance, as it is ſituated at the mouth of the Dneiper, oppoſite to Oczakow. For the zeal and abilities which he diſplayed on this occaſion, the Empreſs decorated him with the order of St Andrew; gave him ſix croſſes of the order of St George, to be diſtributed, according to his judgment, among ſuch of his officers as had moſt diſtinguiſhed themſelves; and, in a very flattering letter, regretted the wounds which he had received in defending the place.

At the ſiege of Oczakow, Suworow, who commanded the left wing of the army under Prince Potemkin, received a dangerous wound in the nape of the neck, which was followed by ſo ſmart a fever, that, for ſome time, his life was deſpaired of; but he perſevered in his long accuſtomed practice of preferring regimen to medicine, and his health was gradually re-eſtabliſhed. In the year 1789, he was appointed to the command of the army which was to co-operate with the Prince of Saxe Cobourg in Walachia; and, by marches of inconceivable rapidity, he twice, in the ſpace of two months, preſerved the army of that Prince from inevitable deſtruction. Putting himſelf at the head of 8000 Ruſſians, and literally running to the aid of his ally, he came up with the Turks in time to change the fate of the day at the battle of Forhani, which was fought on the 21ſt of July; and again at Rymnik, which, with 7000 men, he had reached with equal celerity, he gained, on the 22d of September, in conjunction with the Prince, one of the greateſt victories that have ever been atchieved. According to the leaſt exaggerated account, the Turkiſh army, commanded by the Grand Viſier in perſon, amounted to 90,000 or 100,000 men; of which 70,000 were choſen troops: whilſt the army of the allies exceeded not 25,000. At the commencement of the attack, Suworow, who had reconnoitered the country, and formed the plan of the battle, called out to his Ruſſians, "My friends, look not at the eyes of your enemies, but at their breaſts; it is there that you muſt thruſt your bayonets." No quarter was given to the Turks; and on this account the Ruſſian General has been charged with ſavage ferocity: but the charge, if not groundleſs, muſt be ſhared equally between him and the Prince of Cobourg. The commanders of the allied army, aware of the immenſe ſuperiority of their enemies, had reſolved, before the engagement, not to encumber themſelves with priſoners, whom they could not ſecure without more than hazarding the fate of the day: And where is the man, who admits the lawfulneſs of war, that will condemn ſuch conduct in ſuch critical circumſtances?

The taking of Bender and Belgrade were the immediate conſequences of the victory of Rymnik; and ſo ſenſible was the Emperor Joſeph how much the rapid movements and military ſkill of Suworow had contributed to that victory, that he immediately created him a Count of the Roman empire, and accompanied the diploma with a very flattering letter. Similar honours were conferred upon him by his own ſovereign, who ſent him the diploma of Count of the empire of Ruſſia, with the title of Rymnikſki, and the order of St Andrew of the firſt claſs.

In the autumn of 1790, Prince Potemkin wrote to Count Suworow, requeſting a particular conference. The General, who conjectured the object of it, ſent him the following anſwer: "The flotilla of row-boats will get poſſeſſion of the mouths of the Danube; Tulcia and Iſaccia will fall into our power; our troops, ſupported by the veſſels, will take Iſmailow and Brahilow, and make Tchiſtow tremble." He was perfectly right in his conjecture: it was to concert with him meaſures for the taking of Iſmailow that the Prince had requeſted the conference. He did not, however, receive orders to undertake that deſperate enterpriſe till the beginning of November, when he rapidly approached towards that fortreſs. His army, by ſea and land, conſiſted of 23,000 men; of whom one-half were Coſſacs, and of theſe many were ſick. The troops of the garriſon, which were under the orders of ſeven Sultans, amounted to 43,000 men, of whom nearly one half were Janiſſaries; the fortreſs was by much the ſtrongeſt of any on the Turkiſh frontier: it was under the command of an old warrior, who had twice refuſed the dignity of Grand Viſier, and had diſplayed againſt the Auſtrians conſiderable abilities, as well as the moſt intrepid courage; and the Grand Seignior had publiſhed a firman, forbidding the garriſon, on pain of death without trial, to ſurrender on any terms whatever.

Potemkin, knowing that Suworow had with him no battering cannon, and dreading the conſequences of a repulſe, wrote to the General, that if he was not certain of ſucceſs, he would do well not to riſk an aſſault. The laconic reply was; "My plan is fixed. The Ruſſian army has already been twice at the gates of Iſmailow; and it would be ſhameful to retreat from them the third time without entering the place." To ſpare the effuſion of blood, however, if poſſible, he ſent a note to the Seraſkier who commanded in Iſmailow, to aſſure him, upon Count Suworow's word of honour, that if he did not hang out a white flag that very day, the place would be taken by aſſault, and all the garriſon put to the ſword. The Seraſkier returned no anſwer to the note; but another commander was pleaſed to ſay, that "The Danube would ceaſe to flow, or the heavens bow down to the earth, before Iſmailow would ſurrender to the Ruſſians!"

Having concerted with the Admiral proper meaſures for the aſſault, Suworow paſſed the night, with ſome officers of his ſuite, in impatient vigilance for the appointed hour when the ſignals were to be given. Theſe were the firing of a muſket at three, four, and five in the morning, when the army ruſhed upon the place; and notwithſtanding the deſperate oppoſition of the Turks, the depth of the moat, and the height of the ramparts, they were completely maſters of Iſmailow by four o'clock P. M. In this one dreadful day the Ottomans loſt 33,000 men killed or dangerouſly wounded; 10,000 who were taken priſoners; beſides 6000 women and children, and 2000 Chriſtians of Moldavia, who fell in the general maſſacre. The place was given up to plunder for three days, according to agreement with the army before the aſſault; but we have authority to ſay, that no perſon was murdered in cold blood, who did not prefer his property to his life.

The Ruſſians found in Iſmailow 232 pieces of cannon, many large and ſmall magazines of gunpowder, an immenſe quantity of bombs and balls, 345 ſtandards almoſt all ſtained with blood, proviſions for the Turkiſh army for ſix months, and about 10,000 horſes, of which many were extremely beautiful. Suworow, who was inacceſſible to any views of private intereſt, did not appropriate to himſelf a ſingle article, not ſo much as a horſe; but having, according to his cuſtom, rendered ſolemn thanks to God for his victory, wrote to Prince Potemkin the following Spartan letter: "The Ruſſian colours wave on the ramparts of Iſmailow."

Peace being concluded with the Turks in December 1791, no political events occurred from that period to call forth the military talents of Suworow till 1794. In the beginning of that year mutinies having broken out among the Poliſh troops in the ſervice of Ruſſia, and the Empreſs, with her two potent allies, having digeſted the plan for the partition of Poland, Count Suworow received orders, in the month of May, to proceed, by forced marches, into Red Ruſſia, with a corps of 15,000 men, and to diſarm all the Poliſh troops in that province. This ſervice he performed without the effuſion of blood, diſarming in leſs than a fortnight 8000 men, diſperſed over a country of 150 miles in circuit. Soon afterwards he was ordered to march into the interior of Poland; the King of Pruſſia having been obliged to raiſe the ſiege of Warſaw, and the Empreſs perceiving that more vigorous meaſures than had hitherto been purſued, were neceſſary to accompliſh her deſigns.

To give a detailed account of his route to Warſaw, would be to write the hiſtory of the Poliſh war, and not the memoirs of Count Suworow. It has been raſhly ſuppoſed, that he had to contend only with raw troops, commanded by inexperienced leaders, who were not cordially united among themſelves; but the fact is otherwiſe, and Suworow never diſplayed greater reſource in the day of danger, than in the numerous battles and ſkirmiſhes in which he was engaged on his march to the capital of Poland. At laſt, after ſurmounting every obſtacle, he ſat down, on the 22d of October, before Praga, a ſtrongly fortified ſuburb of Warſaw, defended by a formidable artillery, and a garriſon of 30,000 men, rendered deſperate by their ſituation. The Ruſſian army exceeded not 22,000; and with that comparatively ſmall force he reſolved to ſtorm Praga, as he had ſtormed Iſmail. Having erected ſome batteries to deceive the garriſon into a belief that they were to be regularly beſieged, he concerted with the other Generals the mode of aſſault; and when every thing was ready, he gave his orders in theſe words: "Storm, and take the batteries, and cut down all who reſiſt; but ſpare the inhabitants, unarmed perſons, and all who ſhall aſk for quarter."

There are but few examples of a military operation ſo boldly conceived, ſo ſkilfully performed, or ſo important in its conſequences, as the taking of Praga. The aſſault was made at once in ſeven different places at five in the morning; and at nine the Ruſſians were maſters of the place, having penetrated by pure force a triple entrenchment. Of the Poles 13,000 lay dead on the field of battle, one-third of whom were the flower of the youth of Warſaw; above 2000 were drowned in the Viſtula; and 14,680 were taken priſoners, of whom 8000 were diſarmed and immediately ſet at liberty, and the remainder the next day. We mention theſe circumſtances, becauſe they completely refute the tales of thoſe Jacobin ſcribblers, who have ſo ſtrenuouſly endeavoured to tarniſh the laurels of the Ruſſian hero, by repreſenting him as having ordered a general maſſacre of men, women, and children. The artillery taken from the enemy conſiſted of 104 pieces of cannon and mortars, chiefly of large calibre. The Ruſſians had 580 men killed, of whom eight were ſuperior and ſtaff-officers, and 900 wounded, of whom 23 were officers.

Soon after the ſtorming of Praga, Warſaw capitulated, and Suworow was received into the city by the magiſtrates in a body, and in their ceremonial habits. When the preſident preſented to him the keys of the city, he preſſed them to his lips, and then, holding them up towards heaven, he ſaid, "Almighty God, I render thee thanks, that I have not been compelled to purchaſe the keys of this place as dear as . . . . ." Turning his face towards Praga, his voice failed him, and his cheeks were inſtantly bathed with tears. As he rode through the ſtreets, the windows were filled with ſpectators, who were delighted with the return of order, and the aſſurance of peace; and the air reſounded with the exulting exclamations of "Long live Catharine! Long live Suworow!"

Thus did Count Suworow, in the courſe of a very few months, overturn the kingdom and republic of Poland. It is not our buſineſs, in this article, to decide on the juſtice of the cauſe in which he was embarked. Of the Poliſh revolution, which gave riſe to the war that ſubverted the republic, and ſwept it from the number of ſovereign ſtates, the reader will find ſome account under the title POLAND in the *Encyclopædia*; but it is here proper to acknowledge, that we do not now think ſo favourably, as when we wrote that article, of the views and principles of thoſe who framed the conſtitution, which brought upon them the Ruſſian and Pruſſian arms. Subſequent events ſeem to have proved completely, that if Poland had not been conquered by the allied powers, it would ſoon have been involved, under Koſkiuſko and his Jacobinical adherents, in all the horrors of revolutionary France; and the unhappy king, inſtead of being carried captive into Ruſſia, would probably have finiſhed his courſe on a ſcaffold. Suworow, who never concerned himſelf with the intrigues of courts, and expreſſed on all occaſions the moſt ſovereign contempt of thoſe Generals who affected to poſſeſs the ſecrets of ſtateſmen, probably never enquired into the final object of the war, but thought it his duty to execute, in his own ſphere, the orders of his Imperial miſtreſs. So ſenſible was Catharine of the propriety of this conduct, and of the zeal and abilities which he had diſplayed in the Poliſh campaign, that immediately on receiving accounts of the ſtorming of worow.

Praga and the ſubmiſſion of Warſaw, ſhe announced to him, in a letter written with her own hand, his well-earned advancement to the rank of Field-marſhal General. Nor did her munificence ſtop there: She loaded him with jewels, and preſented him with an eſtate of 7000 peaſants, in the diſtrict of Kubin, which had been the ſcene of his firſt battle in the courſe of the campaign.

From the ſubjugation of Poland we hear little more of Field marſhal Suworow till he entered upon his glorious career in Italy. He is ſaid, indeed, to have given offence to the preſent Emperor ſoon after his acceſſion to the throne, by affording protection to ſome meritorious officers, whom his Majeſty had in an arbitrary manner diſmiſſed from the ſervice; but that offence was overlooked, and Suworow called again into action, when Paul joined the coalition againſt France.

Of the exploits of the Field marſhal in Italy, where, to uſe his own words, he deſtroyed armies and overturned ſtates, we have given a full account under the title REVOLUTION in this *Supplement*. In his former campaigns, the wiſdom of his meaſures, the diſtribution of his forces, the undaunted character of his operations, and the progreſſive continuance of his ſucceſſes, furniſh proofs of the ſuperiority of his talents hardly to be paralleled in the annals of modern war; but, animated by the nobleneſs of his cauſe, and confiding, as he ſaid, in the God of battles, he ſeems in his laſt campaign to have ſurpaſſed himſelf (B). It would appear, however, that his own Sovereign thought otherwiſe; and if he did, he was certainly as ſingular in that opinion as he is ſaid to be in many others. Conſidering the Field-marſhal as the conqueror of Italy, he had indeed created him a Prince by the ſtyle and title of Prince Suworow-*Italiſki*; but how did he receive him, when he returned into the Ruſſian dominions at the head of his veteran and victorious bands?

Suworow.

Though the old warrior thought himſelf almoſt betrayed at the end of the campaign by the crooked policy of the court of Vienna, he doubtleſs hoped to be received at the court of St Peterſburgh, if not with triumphal arches, at leaſt with the moſt public teſtimo-

---

(B) Were any other proof than a ſimple narrative of his ſucceſs neceſſary to evince the abilities diſplayed by Marſhal Suworow in the laſt campaign, that proof might be found in the ſad reverſes of the preſent. At the opening of the campaign of 1800, the allies poſſeſſed infinitely greater advantages over the enemy than at the beginning of the campaign of 1799; and we ventured to ſay, towards the end of the article REVOLUTION, in this *Supplement*, that the affairs of the French ſeemed in Italy to be deſperate. But how egregiouſly have we been miſtaken? By the moſt unaccountable infatuation, the Auſtrian commander in Italy would not *believe* that the French army of reſerve, which was advancing upon him with the uſual celerity of the Firſt Conſul's movements, conſiſted of more than *ſix thouſand men!* Inſtead therefore of marching rapidly to meet them before they could be wholly diſentangled from the paſſes over the Alps, he waited patiently for them in the plains of Marengo. If we may judge of the future by the paſt, we may ſurely ſay that ſuch would not have been the conduct of Suworow. Even after the two hoſtile armies met, and fought, on the 10th of July, one of the bloodieſt battles of the preſent war, the ſucceſs of the French was not ſuch as to intitle them to the acquiſitions which were the conſequence of their dear-bought victory. The fate of the day was long doubtful; and it was at laſt decided, not by any extraordinary exertions of the Conſul, but partly by the provident conduct of General Deſſaix, who, with the aid of freſh troops, erected a new battery at a critical point, and at a critical period; and ſtill more by the ſituation of General Melas, whoſe faculties, though frequently ſupported by wine and ſpirits, are ſaid to have wholly forſaken him in the latter part of the day. When he was in this ſtate, one falſe movement, which weakened his centre, afforded an opportunity to Deſſaix to make a vigorous and ſucceſsful charge with a body of cavalry that had not yet been engaged.

But even after this defeat, what was the ſtate of the two armies? The Auſtrians had loſt 9000 men, and the French from 12,000 to 14,000: the former, enraged at having had the victory ſo wreſted out of their hands, were eager to renew the conteſt on the following day; and the latter had obtained only the barren advantage of keeping poſſeſſion of the field of battle. In ſuch a ſituation, Suworow would certainly have encouraged the ardour of his men; but the Auſtrian commander, who complained laſt year of the Field-marſhal for being too little ſparing of blood, inſtead of following the example which he had ſet him at the battle of Trebia, concluded a capitulation unparalleled, we believe, in the annals of war; a capitulation by which he voluntarily ſurrendered into the hands of the enemy nearly all the fruits of one of the moſt glorious campaigns recorded in hiſtory. We wiſh not to throw any undue aſperſion upon the character of General Melas: We believe him to be a brave man, and ſuch he has been repreſented to us in various accounts which we have had directly from Germany; but all theſe accounts agree in repreſenting him likewiſe as fit, not to have the ſupreme command of a great army, but only to execute the orders of a ſuperior mind.

In Germany, the gallant Kray has been obliged to retreat before the equally gallant Moreau; but he has wiſely not hazarded the conſequences of a general action. We ſay *wiſely*; becauſe we have learned from authority which we cannot queſtion, that his army is in a ſtate little better than that of mutiny. To his officers he is in a great meaſure a ſtranger; and therefore theſe gentlemen think themſelves at liberty to diſobey his orders! What the conſequence of all this will be, it becomes not us to conjecture. An armiſtice has in the mean time * taken place both in Italy and in Germany; and it is not impoſſible that the Aulic Council, aided by the mob of Vienna, may induce the Emperor to make a ſeparate peace.—We need hardly make an apology for the length of this note, which our readers will conſider as a continuation, the lateſt that we ſhall have an opportunity to give, of the progreſs of the French revolution, which we once flattered ourſelves would, by this time, have taken a very different turn; and a different turn it would have taken if another Suworow had commanded in Italy.

* September the 4th 1800.

nies of his Sovereign's approbation. It is ſaid, that he expected to be ſent back at the head of a large army, with full powers to act as he ſhould judge proper for bringing the war to a happy termination, and reſtoring peace and order to Europe; and he certainly expreſſed, in letters to different correſpondents, his earneſt wiſh to conclude his military career with contributing to the accompliſhment of ſo deſirable an object. What then muſt have been his diſappointment, when the Ruſſian Emperor would not ſee him, and poſitively forbad his appearance at court? To the meſſenger who brought the order, the Field-marſhal gave a purſe of money, turned his carriage another way, and drove to a wooden houſe, at a diſtance from the court, and from his former friends, "where burſt his mighty heart;" and the conqueror of the Turks, the Poles, and the French republicans, died, almoſt unattended, on the 18th of May 1800. The ſovereign, who thus diſgraced him at the end of his life, gave him a magnificent funeral!

In his perſon Suworow was tall, conſiderably exceeding ſix feet, and full cheſted. His countenance was ſtern; but among his friends his manners were pleaſant, and his diſpoſitions were kind. His temper was naturally violent; but that violence he conſtantly laboured to moderate, though he was never able completely to extinguiſh it. According to M. Anthing, an effervefcent ſpirit of impatience predominated in his character; and it perhaps never happened (ſays that author) that the execution of his orders equalled the rapidity of his wiſhes. Though he diſliked all public entertainments, yet when circumſtances led him to any of them, he appeared to partake, and endeavoured to promote, the general pleaſure. Sometimes he condeſcended even to dance and play at cards, though very rarely, and merely that he might not interrupt the etiquette of public manners, to which, when not in the field, he was very attentive. In the field he may be ſaid to have ſpent the whole of his life from the period at which he firſt joined the army in the ſeven years war; for during the time that he was not engaged in actual warfare, and that time, taken altogether, did not exceed twelve years, he was always placed at the head of armies ſtationed on the frontier of ſome enemy's country. He was therefore a mere warrior, and as ſuch had no fixed habitation. With reſpect to his table and lodging, he contented himſelf with whatever he found, requiring nothing but what abſolute neceſſity demands, and what might be tranſported with eaſe from one place to another. His couch conſiſted of a heap of freſh hay ſufficiently elevated, and ſcattered into conſiderable breadth, with a white ſheet ſpread over it, with a cuſhion for his pillow, and with a cloak for his coverlid. He has been repreſented as dirty (c); but the repreſentation is falſe. M. Anthing aſſures, that he was clean in his perſon, and that, when not on actual ſervice, he waſhed himſelf frequently during the courſe of the day. It is among the ſingular, though unimportant circumſtances of his life (ſays the ſame author), that, for the laſt twenty years, he had not made uſe of a looking-glaſs, or incumbered his perſon with either watch or money.

He was ſincerely religious; took every opportunity of attending the offices of public devotion; and has been known, on Sundays and feſtivals, to deliver lectures on piety to thoſe whom duty called to attend on him. We are told by an anonymous writer, in a miſcellany not very forward to praiſe ſuch men as Suworow, or indeed to praiſe piety in men of any deſcription, that chancing one evening to overhear a captain abridge the prayer which his duty required him to repeat at the guard, the Field-marſhal called out to him, "Thou unconſcionable, abominable, impious man, thou wouldſt cheat Heaven! Thou wouldſt, no doubt, cheat likewiſe the Empreſs and me! I ſhall diſmiſs thee." His regard for ſacred things is indeed very apparent in the elegant letter which, on the 1ſt of October 1795, he wrote to Charette, the hero of Vendee, whom he congratulates upon taking up arms to reſtore the temples of the God of his fathers. Alluding to this trait of his character, and to his deteſtation of Jacobiniſm under every form, a late writer in a moſt reſpectable miſcellany has well characterized him as the

"Foe to religion's foe; of Ruſſia's throne
The prop, th' avenger, and the pride in one;
Whoſe conquering arms, in bold defiance hurl'd,
Cruſhed the rude monſter of the weſtern world."

We have already, when we thought not that we ſhould ſo ſoon be called upon to write his life, obſerved, that he was a ſcholar, a man of ſcience, and a poet. M. Anthing aſſures us, that from his earlieſt years he was enamoured of the ſciences, and improved himſelf in them; but that as the military ſcience was the ſole object of his regard, thoſe authors of every nation who inveſtigate, illuſtrate, or improve it, engroſſed his literary leiſure. Hence Cornelius Nepos was with him a favourite claſſic; and he read, with great avidity and attention, the hiſtories of Montecuculi and Turenne. Cæſar, however, and Charles XII. (ſays the ſame author) were the heroes whom he moſt admired, and whoſe activity and courage became the favourite objects of his imitation.

With reſpect to his moral character, we have every reaſon to believe that he was a man of the moſt incorruptible probity, immoveable in his purpoſes, and inviolable in his promiſes; that the cruelties of which he has been accuſed were the cruelties of Potemkin, and that by thoſe who knew him he was conſidered as a man of unqueſtionable humanity. The love of his country, and the ambition to contend in arms for its glory, were the predominant paſſions of his active life; and to them, like the ancient Romans, he ſacrificed every inferior ſentiment, and conſecrated, without reſerve, all the powers of his body and mind. His military career was one long and uniform courſe of ſucceſs and triumph, produced by his enterpriſing courage and extraordinary preſence of mind; by his perſonal intrepidity and promptitude of execution; by the rapid and unparalleled movements of his armies; and by their perfect aſſurance of victory when fighting under his banners. Such was Alexander Beſilovitch Count Suworow. In the year 1774 he married a daughter of the General Prince Iwan Proſorowſki, by whom he had two children, now living: Natalia, married to General Count Nicolai Zubow; and Arcadius Count Suworow,

a

(c) By the anonymous author of the life of Catharine II.

a youth of great promiſe, who accompanied his father in his unparalleled march from Italy to Switzerland.

SWALLOW's-Tail, in fortification, is a ſingle tenaille, which is narrower towards the place than toward the country.

SWAN (See Anas, *Encycl.*). It is now aſcertained, beyond the poſſibility of doubt, that there are *black* ſwans, of equal ſize, and the ſame habitudes, with the common white ſwan of this iſland. Theſe fowls have been ſeen chiefly in New Holland; and Captain Vancouver, when there, ſaw ſeveral of them in very ſtately attitudes, ſwimming on the water; and, when flying, diſcovering the under part of their wings and breaſts to be white. Black ſwans were likewiſe ſeen in New Holland by Governor Philips, Captain White, and by a Dutch navigator, ſo long ago as in 1697. Governor Philips deſcribes the black ſwan as a very noble bird, larger than the common ſwan, and equally beautiful in form. Mr White indeed ſays, that its ſize is not quite equal to that of the European ſwan; but both theſe authors agree with Captain Vancouver in mentioning ſome white feathers in its wings.

SWINTON (John), a very celebrated Engliſh antiquary, was a native of the county of Cheſter, the ſon of John Swinton of Bexton in that county, gent. He was born in 1703. The circumſtances of his parents were probably not affluent, as he was entered at Oxford in the rank of a ſervitor at Wadham college. This was in October 1719. It may be preſumed, that he recommended himſelf in that ſociety by his talents and behaviour, as on June 30. 1723, he was elected a ſcholar on a Cheſhire foundation in the college. In the December following, he took his firſt degree in arts. Before he became maſter of arts (which was on December 1. 1726), he had choſen the church for his profeſſion, and was ordained deacon by the biſhop of Oxford, May 30. 1725; and was afterwards admitted to prieſt's orders on May 28. 1727. He was not long without ſome preferment, being admitted to the rectory of St Peter le Bailey in Oxford (a living in the gift of the crown), under a ſequeſtration, and inſtituted to it in February 1728. In June, the ſame year, he was elected a fellow of his college; but, deſirous probably to take a wider view of the world, he accepted, not long after, the appointment of chaplain to the Engliſh factory at Leghorn, to which he had been choſen. In this ſituation he did not long enjoy his health; and leaving it on that account, he was at Florence in April 1733, where he attended Mr Coleman, the Engliſh envoy, in his laſt moments. Mr Swinton returned thro' Venice and Vienna; and, in company with ſome Engliſh gentlemen of fortune, viſited Preſburgh in Hungary, and was preſent at one of their aſſemblies.

It is poſſible that he had not quitted England in the ſummer of 1730, for he was elected a Fellow of the Royal Society in June that year, and admitted about three months later. It was probably while he was abroad that he was admitted into ſome foreign ſocieties; namely, the academy *degli Apatiſti* at Florence, and the *Etruſcan Academy* of Cortona. On his return, he ſeems to have taken up his abode at Oxford, where he reſided all the latter part of his life, and was for many years chaplain to the gaol in that city. It may be preſumed that he married in 1743; it was then, at leaſt, that he gave up his fellowſhip. In 1759 he became bachelor of divinity: in 1767, he was elected *Cuſtos Archivorum*, or keeper of the univerſity records: and, on April 4. 1777, he died; leaving no children. His wife ſurvived till 1784, and both were buried, with a very ſhort and plain inſcription, in the chapel of Wadham college.

Swinton.

It remains to take notice of the moſt important monuments of a literary man's life, his publications. Theſe were numerous and learned, but not of great magnitude. He publiſhed, 1. "De Linguæ Etruriæ Regalis vernacula Diſſertatio," 4to, 19 pages, Oxon, 1738. 2. "A critical eſſay concerning the words Δαιμων and Δαιμονιον, occaſioned by two late inquiries into the meaning of the demoniacs in the New Teſtament," 8vo, London, 1739. 3. "De priſcis Romanorum literis diſſertatio," 4to, 20 pages, Oxon, 1746. 4. "De Primogenio Etruſcorum Alphabeto, diſſertatio," Oxon, 1746. 5. "Inſcriptiones Citieæ: ſive in binas Inſcriptiones Phœnicias, inter rudera Citii nuper repertas, conjecturæ. Accedit de nummis quibuſdam Samaritanis et Phœniciis, vel inſolitam præ ſe literaturam ferentibus, vel in lucem hactenus non editis, diſſertatio," 4to, 87 pages, Oxon, 1750. 6. "Inſcriptiones Citieæ: ſive in binas alias Inſcriptiones Phœnicias, inter rudera Citii nuper repertas, conjecturæ," 4to, 19 pages. 7. "De nummis quibuſdam Samaritanis et Phœniciis, vel inſolitam præ ſe literaturam ferentibus, vel in lucem hactenus non editis, diſſertatio ſecunda," 4to, 36 pages. 8. "Metilia: ſive de quinario Gentis Metiliæ, e nummis vetuſtis cæteroquin minimum notæ, diſſertatio," 4to, 22 pages, Oxon, 1750. 9. Several diſſertations publiſhed in the Philoſophical Tranſactions of the Royal Society. As, "A diſſertation upon a Parthian Coin; with characters on the reverſe reſembling thoſe of the Palmyrenes," vol. xlix. p. 593. "Some remarks on a Parthian Coin, with a Greek and Parthian legend, never before publiſhed," vol. l. p. 16. "A diſſertation upon the Phœnician numeral characters anciently uſed at Sidon," vol. l. p. 791. "In nummum Parthicum hactenus ineditum conjecturæ," vol. li. p. 683. "A diſſertation upon a Samnite Denarius, never before publiſhed," vol. lii. p. 28. "An account of a ſubærated Denarius of the Plætorian family, adorned with an Etruſcan inſcription on the reverſe, never before publiſhed or explained," vol. lxii. p. 60. "Obſervations upon five ancient Perſian Coins, ſtruck in Paleſtine or Phœnicia before the diſſolution of the Perſian empire," vol. lxii. p. 345. Other papers by him may be found in the general index to the Philoſophical Tranſactions. 10. A part of the Ancient Univerſal Hiſtory, contained in the ſixth and ſeventh volumes of that great work. The particulars of this piece of literary hiſtory were communicated by Dr Johnſon to Mr Nichols, in a paper printed in the Gentleman's Magazine for December 1784, p. 892. The original of that paper, which affords a ſtrong proof of the ſteady attachment of Johnſon to the intereſts of literature, has been, according to his deſire, depoſited in the Britiſh Muſeum. The letter is as follows:

"To Mr Nichols.

"The late learned Mr Swinton of Oxford having one day remarked, that one man, meaning, I ſuppoſe, no man but himſelf, could aſſign all the parts of the Univerſal Hiſtory to their proper authors, at the requeſt of Sir Robert Chambers, or of myſelf, gave the account which I now tranſmit to you in his own hand, Swinton.

being willing, that of ſo great a work the hiſtory ſhould be known, and that each writer ſhould receive his due proportion of praiſe from poſterity. I recommend to you to preſerve this ſcrap of literary intelligence, in Mr Swinton's own hand, or to depoſite it in the Muſeum, that the veracity of the account may never be doubted.—I am, Sir, your moſt humble ſervant,

Dec. 6, 1784. SAM. JOHNSON."

The paper alluded to, beſides ſpecifying ſome parts written by other perſons, aſſigns the following diviſions of the hiſtory to Mr Swinton himſelf. "The hiſtory of the Carthaginians, Numidians, Mauritanians, Gætulians, Garamantes, Melano-Gætulians, Nigritæ, Cyrenaica, Marmarica, the Regio Syrtica, Turks, Tartars, and Moguls, Indians, and Chineſe, a diſſertation on the peopling of America, and one on the independency of the Arabs.

In the year 1740, Mr Swinton was involved in a law ſuit, in conſequence of a letter he had publiſhed. It appears from a paper of the time *, that a letter from the Rev. Mr Swinton, highly reflecting on Mr George Baker, having fallen into the hands of the latter, the court of King's Bench made the rule abſolute for an information againſt Mr Swinton. Theſe two gentlemen were alſo engaged for ſome time in a controverſy at Oxford; which took its riſe from a matter relative to Dr Thiſtlethwaite, ſome time warden of Wadham, which then attracted much attention. Mr Swinton had the manners, and ſome of the peculiarities, often ſeen in very recluſe ſcholars, which gave riſe to many whimſical ſtories. Among the reſt, there is one mentioned by Mr Boſwell, in the Life of Johnſon, as having happened in the year 1754. Johnſon was then on a viſit in the univerſity of Oxford. "About this time (he ſays) there had been an execution of two or three criminals at Oxford, on a Monday. Soon afterwards, one day at dinner, I was ſaying that Mr Swinton, the chaplain of the gaol, and alſo a frequent preacher before the univerſity, a learned man, but often thoughtleſs and abſent, preached the condemnation ſermon on repentance, before the convicts, on the preceding day, Sunday; and that, in the cloſe, he told his audience, that he ſhould give them the remainder of what he had to ſay on the ſubject the next Lord's day. Upon which, one of our company, a doctor of divinity, and a plain matter-of-fact man, by way of offering an apology for Mr Swinton, gravely remarked, that he had probably preached the ſame ſermon before the univerſity. Yes, Sir (ſays Johnſon); but the univerſity were not to be hanged the next morning!"

T.

Tacquet || Talus.

TACQUET (Andrew), a Jeſuit of Antwerp, who died in 1660. He was a moſt laborious and voluminous writer in mathematics. His works were collected, and printed at Antwerp, in one large volume in folio, 1669.

TALLOW-Tree. See Croton (*Encycl.*), where, however, we have fallen into a miſtake, which it is here our duty to correct. We learn from Sir George Staunton, that the candles made of the vegetable tallow are firmer than thoſe made of animal tallow, and free from all offenſive ſmell, contrary to what was raſhly ſaid in the article referred to. They are not, however, equal to thoſe of wax or ſpermaceti; but the latter of theſe ſubſtances is not within the reach of the Chineſe, and the art of blanching the former is little known to them. The tallow tree is ſaid to have been tranſplanted to Carolina, and to flouriſh there as well as in China.

TALOOK, an Arabic word, which ſignifies literally attachment, connection, dependence. In Bengal, however, where it occurs perpetually in the enumeration of the diſtricts and ſubdiviſions of that province contained in the inſtitutes of Akber, it ſignifies a tenure of land. Hence the *talook* of Caſhinat, the *talook* of Meheys the headman, the *talook* of Ahmed Khan, &c. See *A Diſſertation concerning the Landed Property of Bengal*, by Sir Charles Rouſe Boughton.

TALOOKDAR, the poſſeſſor of a talook.

TALOOKDARY, tenure of a talookdar.

TALUS, or Talud, in architecture, the inclination or ſlope of a work; as of the outſide of a wall, when its thickneſs is diminiſhed by degrees, as it riſes in height, to make it the firmer.

Talus || Tanning.

Talus, in fortification, means alſo the ſlope of a work, whether of earth or maſonry.

TAMASCAL, the name given in California to a kind of ſand-bath employed by the natives in the cure of the venereal diſeaſe. It is prepared by ſcooping a trench in the ſand, two feet wide, one foot deep, and of a length proportioned to the ſize of the patient; a fire is then made through the whole extent of it, as well as upon the ſand which was dug out of the hollow. When the whole is thoroughly heated, the fire is removed, and the ſand ſtirred about, that the warmth may be equally diffuſed. The ſick perſon is then ſtripped, laid down in the trench, and covered up to his chin with heated ſand. In this poſition a very profuſe ſweat ſoon breaks out, which gradually diminiſhes according as the ſand cools. The patient then riſes and bathes in the ſea, or the neareſt river. This proceſs is repeated till a complete cure is obtained. While the patient is undergoing the operation of the tamaſcal, he drinks a conſiderable quantity of a warm ſudorific, prepared by the decoction of certain herbs, chiefly of the ſhrub called by the Spaniards Gouvernante, which ſee in this *Supplement*.

TAN is a ſubſtance found in moſt vegetables, which, not having hitherto been reſolved into component parts, is therefore conſidered as ſimple. See *Vegetable and Animal* Substances in this *Suppl.*

TANNING is an art, of which a full account, according to the general practice in London and its vicinity, has been given under the proper title in the *Encyclopædia*. But ſince that article was written, the ſuperior knowledge which has been obtained of the tan-

---

* *The Champions, or Evening Advertiſer*, June 17th 1740.

ning principle, as well as of the compoſition of the ſkins of animals (See *Vegetable and Animal* SUBSTANCES, *Suppl.*), has ſuggeſted to ſcientific artiſts various methods of ſhortening the proceſs by which leather is manufactured. M. Seguin is ſaid to have thrown much light upon the art of the tanner as it is practiſed in France; and in 1795 Mr William Deſmond obtained a patent for practiſing Seguin's method in England. He obtains the tanning principle by digeſting oak bark, or other proper material, in cold water, in an apparatus nearly ſimilar to that uſed in the ſaltpetre works. That is to ſay, the water which has remained upon the powdered bark for a certain time, in one veſſel, is drawn off by a cock, and poured upon freſh tan. This is again to be drawn off, and poured upon other freſh tan; and in this way the proceſs is to be continued to the fifth veſſel. The liquor is then highly coloured, and marks, as Mr Deſmond ſays, from ſix to eight degrees on the hydrometer for ſalts. He calls this the tanning lixivium. The criterion to diſtinguiſh its preſence is, that it precipitates glue from its aqueous ſolution, and is alſo uſeful to examine how far other vegetable ſubſtances, as well as oak bark, may be ſuitable to the purpoſe of tanning. The ſtrong tanning liquor is to be kept by itſelf. It is found by trials with the glue, that the tanning principle of the firſt digeſter which receives the clear water, is, of courſe, firſt exhauſted. But the ſame tan will ſtill give a certain portion of the aſtringent principle, or gallic lixivium, to water. The preſence of this principle is aſcertained by its ſtriking a black colour when added to a ſmall quantity of the ſolution of vitriol of iron or green copperas. As ſoon as the water from the digeſter ceaſes to exhibit this ſigu, the tan is exhauſted, and muſt be replaced with new. The gallic lixivium is reſerved for the purpoſe of taking the hair off from hides.

Strong hides, after waſhing, cleaning, and fleſhing, in the uſual way, are to be immerſed for two or three days in a mixture of gallic lixivium and one thouſandth part by meaſure of denſe vitriolic acid. By this means the hair is detached from the hides, ſo that it may be ſcraped off with a round knife. When ſwelling or raiſing is required, the hides are to be immerſed for ten or twelve hours in another vat filled with water and one five-hundredth part of the ſame vitriolic acid. The hides being then repeatedly waſhed and dreſſed, are ready for tanning; for which purpoſe they are to be immerſed for ſome hours in a weak tanning lixivium of only one or two degrees; to obtain which, the latter portions of the infuſions are ſet apart; or elſe ſome of that which has been partly exhauſted by uſe in tanning. The hides are then to be put into a ſtronger lixivium, where in a few days they will be brought to the ſame degree of ſaturation with the liquor in which they are immerſed. The ſtrength of the liquor will by this means be conſiderably diminiſhed, and muſt therefore be renewed. When the hides are by this means completely ſaturated, that is to ſay, perfectly tanned, they are to be removed, and ſlowly dried in the ſhade.

Calf ſkins, goat ſkins, and the like, are to be ſteeped in lime-water after the uſual fleſhing and waſhing. Theſe are to remain in the lime water, which contains more lime than it can diſſolve, and requires to be ſtirred ſeveral times a day. After two or three days, the ſkins are to be removed, and perfectly cleared of their lime by waſhing and preſſing in water. The tanning proceſs is then to be accompliſhed in the ſame manner as for the ſtrong hides, but the lixivium muſt be conſiderably weaker. Mr Deſmond remarks, that lime is uſed inſtead of the gallic lixivium for ſuch hides as are required to have a cloſe grain; becauſe the acid mixed with that lixivium always ſwells the ſkins more or leſs; but that it cannot with the ſame convenience be uſed with thick ſkins, on account of the conſiderable labour required to clear them of the lime; any part of which, if left, would render them harſh and liable to crack. He recommends, likewiſe, as the beſt method to bring the whole ſurface of the hides in contact with the lixivium, that they ſhould be ſuſpended vertically in the fluid by means of tranſverſe rods or bars, at ſuch a diſtance as not to touch each other. By this practice much of the labour of turning and handling may be ſaved.

Mr Deſmond concludes his ſpecification, by obſerving, that in ſome caſes it will be expedient to mix freſh tan with the lixivium; and that various modifications of ſtrength, and other circumſtances, will preſent themſelves to the operator. He affirms that, in addition to the great ſaving of time and labour in this method, the leather, being more completely tanned, will weigh heavier, wear better, and be leſs ſuſceptible of moiſture than leather tanned in the uſual way; that cords, ropes, and cables, made of hemp or ſpeartery, impregnated with the tanning principle, will ſupport much greater weights without breaking, be leſs liable to be worn out by friction, and will run more ſmoothly on pulleys; inſomuch that, in his opinion, it will render the uſe of tar in may caſes, particularly in the rigging of ſhips, unneceſſary; and, laſtly, that it may be ſubſtituted for the preſervation of animal food inſtead of ſalt.

Mr Nicholſon, from whoſe Philoſophical Journal we have taken this account of Mr Deſmond's method of tanning, made ſome very proper enquiries at one of the firſt manufacturing houſes in the borough of Southwark, concerning its value. He was told by one of the partners, that the principle upon which the new proceſs is founded had been long known to them; but that they preferred the old and ſlower method, becauſe the hides are found to feed and improve in their quality by remaining in the pit. He could gain no ſatiſfactory information of what is meant by this feeding and improving; and, without taking upon us to decide between the advantages peculiar to Deſmond's method and thoſe of the common practice, we cannot help ſaying that this objection of the tanner at Southwark appears to us to be that of a man who either underſtands not the principles of his own art, or has ſome reaſon for oppoſing the progreſs of improvement, if it do not originate in his own houſe.

TASSIE (James) modeller, whoſe hiſtory is intimately connected with a branch of the fine arts in Britain, was born in the neighbourhood of Glaſgow of obſcure parents; and began his life as a country ſtone maſon, without the expectation of ever riſing higher. Going to Glaſgow on a fair day, to enjoy himſelf with his companions, at the time when the Foulis's were attempting to eſtabliſh an academy for the fine arts in that city, he ſaw their collection of paintings, and felt an irreſiſtible impulſe to become a painter. He removed to Glaſgow; and in the academy acquired a knowledge of drawing, which unfolded and

improved

improved his natural taſte. He was frugal, induſtrious, and perſevering; but he was poor, and was under the neceſſity of devoting himſelf to ſtone-cutting for his ſupport: not without the hopes that he might one day be a ſtatuary if he could not be a painter. Reſorting to Dublin for employment, he became known to Dr Quin, who was amuſing himſelf in his leiſure hours with endeavouring to imitate the precious ſtones in coloured paſtes, and take accurate impreſſions of the engravings that were on them.

That art was known to the ancients; and many ſpecimens from them are now in the cabinets of the curious. It ſeems to have been loſt in the middle ages; was revived in Italy under Leo X. and the Medici family at Florence; became more perfect in France under the regency of the Duke of Orleans, by his labours and thoſe of Homberg. By thoſe whom they inſtructed as aſſiſtants in the laboratory it continued to be practiſed in Paris, and was carried to Rome. Their art was kept a ſecret, and their collections were ſmall. It is owing to Quin and to Taſſie that it has been carried to ſuch high perfection in Britain, and attracted the attention of Europe.

Dr Quin, in looking out for an aſſiſtant, ſoon diſcovered Taſſie to be one in whom he could place perfect confidence. He was endowed with fine taſte: he was modeſt and unaſſuming: he was patient; and poſſeſſed the higheſt integrity. The Doctor committed his laboratory and experiments to his care. The aſſociates were fully ſucceſsful; and found themſelves able to imitate all the gems, and take accurate impreſſions of the engravings.

As the Doctor had followed the ſubject only for his amuſement, when the diſcovery was completed, he encouraged Mr Taſſie to repair to London, and to devote himſelf to the preparation and ſale of thoſe paſtes as his profeſſion.

In 1766 he arrived in the Capital. But he was diffident and modeſt to exceſs; very unfit to introduce himſelf to the attention of perſons of rank and of affluence: beſides, the number of engraved gems in Britain was ſmall; and thoſe few were little noticed. He long ſtruggled under difficulties which would have diſcouraged any one who was not poſſeſſed of the greateſt patience, and the warmeſt attachment to the ſubject. He gradually emerged from obſcurity, obtained competence; and what to him was much more, he was able to increaſe his collection, and add higher degrees of perfection to his art. His name ſoon became reſpected, and the firſt cabinets in Europe were open for his uſe; and he uniformly preſerved the greateſt attention to the exactneſs of the imitation and accuracy of the engraving, ſo that many of his paſtes were ſold on the Continent by the fraudulent for real gems. His fine taſte led him to be peculiarly careful of the impreſſion; and he uniformly deſtroyed thoſe with which he was in the leaſt diſſatisfied. The art has been practiſed of late by others; and many thouſands of paſtes have been ſold as Taſſie's, which he would have conſidered as injurious to his fame. Of the fame of others he was not envious; for he uniformly ſpake with frankneſs in praiſe of thoſe who executed them well, though they were endeavouring to rival himſelf.

To the ancient engravings he added a numerous collection of the moſt eminent modern ones; many of which approach in excellence of workmanſhip, if not in ſimplicity of deſign and chaſtity of expreſſion, to the moſt celebrated of the ancient. Many years before he died he executed a commiſſion for the late Empreſs of Ruſſia, conſiſting of about 15,000 different engravings (See GEM, *Encycl.*). At his death, in 1799, they amounted to near 20,000; a collection of engravings unequalled in the world. Every lover of the fine arts muſt be ſenſible of the advantage of it for improvement in knowledge and in taſte. The collection of Feloix at Paris conſiſted of 1800 articles; and that of Dehn at Rome of 2500.

For a number of years, Mr Taſſie practiſed the modelling of portraits in wax, which he afterwards moulded and caſt in paſte. By this, the exact likeneſs of many eminent men of the preſent age will be tranſmitted to poſterity as accurately as thoſe of the philoſophers and great men have been by the ancient ſtatuaries. In taking likeneſſes he was, in general, uncommonly happy; and it is remarkable, that he believed there was a certain kind of inſpiration (like that mentioned by the poets) neceſſary to give him full ſucceſs. The writer of this article, in converſing with him repeatedly on the ſubject, always found him fully perſuaded of it. He mentioned many inſtances in which he had been directed by it; and even ſome, in which, after he had laboured in vain to realize his ideas on the wax, he had been able, by a ſudden flaſh of imagination, to pleaſe himſelf in the likeneſs ſeveral days after he had laſt ſeen the original.

He poſſeſſed alſo an uncommonly fine taſte in architecture, and would have been eminent in that branch if he had followed it.

In private life Mr Taſſie was univerſally eſteemed for his uniform piety, and for the ſimplicity, the modeſty, and benevolence, that ſhone in the whole of his character.

TASTELESS EARTH (*aguſt erde*), the name given by Profeſſor Trommſdorff to a new ſimple earth, which he diſcovered in the Saxon beryl. It is diſtinguiſhed (he ſays) from other earths by the following properties: It is white, and totally inſoluble in water. In a freſh ſtate, when moiſtened with water, it is ſomewhat ductile. In the fire it becomes tranſparent and very hard, ſo as to ſcratch glaſs, but remains inſipid and inſoluble in water. The burnt earth diſſolves very eaſily in acids, and produces with them peculiar ſalts, which are entirely devoid of taſte; and hence he gave it the name of *taſteleſs earth*. Fixed alkalies do not diſſolve this earth either in the dry or in the wet way; and it is equally inſoluble with the carbonic acid and with cauſtic ammonia. It has a greater affinity to the oxalic than to other acids. Profeſſor Trommſdorff informs us, that a full account of this earth, accompanied with an accurate deſcription, by Dr Bernhardi, of the foſſil in which it is found, will appear in the firſt part of the eight volume of his *Journal of Pharmacy*.

TEETH, of various ſorts of machines, as of mill wheels, &c. Theſe are often called cogs by the workmen; and by working in the pinions, rounds, or trundles, the wheels are made to turn one another. Mr Emerſon (in his Mechanics, prop. 25.) treats of the theory of teeth, and ſhews that they ought to have the figure of epicycloids, for properly working in one another.

TEKAWY, in Bengal, money advanced by government cope, pera- of the e of ſic.

ment to the proprietors or cultivators of land to aſſiſt them under circumſtances of diſtreſs.

TELESCOPE, is an inſtrument which has been ſo completely deſcribed in the *Encyclopædia*, that it is introduced into this place merely to notice an ingenious ſuggeſtion of Mr Nicholſon's for improving the achromatic teleſcope, by adding an artificial iris to the object glaſs. Suppoſe (ſays he) a braſs ring to ſurround the object end of the teleſcope, and upon this let eight or more triangular ſlips of braſs be fixed, ſo as to revolve on equi-diſtant pins paſſing through each triangle near one of its corners. If the triangles be ſlided inwards upon each other, it may readily be apprehended that they will cloſe the aperture; and if they be all made to revolve or ſlide backwards alike, it is clear that their edges will leave an octagonal aperture, greater or leſs according to circumſtances. The equable motion of all the triangles may be produced either by pinions and one concave toothed wheel, or by what is called ſnail-work. Another kind of iris, more compact, may be made, by cauſing thin elaſtic ſlips of braſs to ſlide along parallel to the tube, and be conducted each through a ſlit in a braſs cap which ſhall lead them acroſs the aperture in a radial direction. It is probable alſo that the artiſt, who ſhall carry theſe hints into effect, may alſo think of ſeveral other methods.

This thought occurred to the author, from contemplating the contraction and dilatation of the iris of the eye, according as we look at an object more or leſs luminous. Theſe variations are ſo great, that in the obſervable variations of the human eye, the aperture is thirty times as large at one time as at another, whilſt in the cat the proportion is greater than a hundred to one.

In luc- tio

TEMPERAMENT OF THE SCALE OF MUSIC. When the conſiderate reader reflects on the large and almoſt numberleſs diſſertations on this ſubject, by the moſt eminent philoſophers, mathematicians, and artiſts, both of ancient and modern times, and the important points which divided, and ſtill divide, their opinions, he will not ſurely expect, in a Work like our's, the deciſion of a queſtion which has hitherto eluded their reſearches. He will rather be diſpoſed, perhaps, to wonder how a ſubject of this nature ever acquired ſuch importance in the minds of perſons of acknowledged talents (for ſurely no perſon will refuſe this claim to Pythagoras, to Ariſtotle, Euclid, Ptolemy, Galileo, Wallis, Euler, and many others, who have written elaborate treatiſes on the ſubject); and his ſurpriſe will increaſe, when he knows that the treatiſes on the ſcale of muſic are as numerous and voluminous in China, without any appearance of their being borrowed from the ingenious and ſpeculative Greeks.

The ingenious, in all cultivated nations, have remarked the great influence of muſic; and they found no difficulty in perſuading the nations that it was a gift of the gods. Apollo and his ſacred choir are perhaps the moſt reſpectable inhabitants of the mythological heavens of the Greeks. Therefore all nations have conſidered muſic as a proper part of their religious worſhip. We doubt not but that they found it fit for exciting or ſupporting thoſe emotions and ſentiments which were ſuited to adoration, thanks, or petition. Nor would the Greeks have admitted muſic into their ſerious dramas, if they had not perceived that it heightened the effect. The ſame experience made them employ it as an aid to military enthuſiaſm; and it is recorded as one of the reſpectable accompliſhments of Epaminondas, that he had the muſical inſtructions of the firſt maſters, and was eminent as a performer.

Temperament of the Scale of Muſic.

Thus was the ſtudy of muſic ennobled, and recommended to the attention of the greateſt philoſophers. Its cultivation was held an object of national concern, and its profeſſors were not allowed to corrupt it in order to gratify the faſtidious taſte of the luxurious or the ſenſualiſt, who ſought from it nothing but amuſement. But its influence was not confined to theſe public purpoſes; and, while the men of ſpeculation found in muſic an inexhauſtible fund of employment for their genius and penetration, and their poets felt its aid in their compoſitions, it was hailed by perſons of all ranks as the ſoother of the cares and anxieties, and ſweetener of the labours of life. *O Phœbi decus!—laborum dulce lenimen.* Poor Ovid, the victim of what remained of good in the cold heart of Octavius, found its balm.

Exul eram (ſays he): *requieſque mihi, non ſama petita eſt.*
Mens intenta ſuis ne foret uſque malis.
Hoc eſt cur cantet vinctus quoque compede foſſor,
Indocili numero cum grave mollit opus.
Cantet et inniteus limoſæ pronus arenæ
Adverſo tardam qui trahit amne ratem,
Quique ferens pariter lentos ad pectora remos,
In numerum pulsâ brachia verſat aquâ.
Feſſus ut incubuit baculo, ſaxove reſedit
Paſtor; arundineo carmine mulcet oves.
Cantantis pariter, pariter data penſa trahentis
Fallitur ancillæ, decipiturque labor.

2
Scale of muſic. It requires temperament.

It is chiefly in this humble department of muſical influence that we propoſe at preſent to lend our aid. What has been ſaid in the article MUSIC, *Encycl.* is ſufficient for informing the reader of what is received as the ſcale of muſic, and the inequality of its different ſteps, the tones major and minor, ſemitone, comma, &c. We ſhall only obſerve, that what is there delivered on temperament by M. d'Alembert, after Rameau, bears the evident mark of uncertainty or want of confidence in the principle adopted as the rule of temperament; and we have learned, ſince the printing of that article, that the inſtructions there delivered have not that perſpicuity and preciſion that are neceſſary for enabling a perſon to execute the temperament recommended by Rameau; that is, to tune a keyed inſtrument with certainty, according to that ſyſtem or conſtruction of the ſcale.

If ſuch be the caſe, we are in ſome meaſure diſappointed; becauſe we ſelected that treatiſe of D'Alembert as the performance of a man of great eminence as a mathematician and philoſopher, aiming at public inſtruction more than his own fame, by this elementary abſtract of the great work of the moſt eminent muſician in France.

Few can tune a harpſichord;

To be able to tune a harpſichord with certainty and accuracy, ſeems an indiſpenſable qualification of any perſon worthy of the name of a *muſician*. It would certainly be thought an unpardonable deficiency in a violin performer if he could not tune his inſtrument; yet we are well informed, that many profeſſional performers on the harpſichord cannot do it, or cannot do it any other way than by uncertain and painful trial, and, as it were, groping

groping in the dark; and that the tuning of harpſichords and organs is committed entirely to tuners by profeſſion. This is a great inconvenience to perſons reſiding in the country; and therefore many take leſſons from the profeſſed harpſichord tuners, who alſo profeſs to teach this art. We have been preſent during ſome of theſe leſſons; but it did not appear to us that the inſtructions were ſuch as could enable the ſcholar to tune an inſtrument when alone, unleſs the leſſons had been ſo frequent as to form the ear to an inſtantaneous judgment of tune by the ſame habit that had inſtructed the teacher. There ſeemed to be little principle that could be treaſured up and recollected when wanted.

3
Yet Nature furniſhes abundant means of doing this.

Yet we cannot help thinking that there are phenomena or facts in muſic, ſufficiently preciſe to furniſh principles of abſolute certainty for enabling us to produce temperaments of the ſcale which ſhall have determined characters, and among which we may chooſe ſuch a one as ſhall be preferable to the others, according to the purpoſes we have in view; and we think that theſe principles are of ſuch eaſy application, that any perſon, of a moderate ſenſibility to juſt intonation, may, without much knowledge or practice in muſic, tune his harpſichord with all deſirable accuracy. We propoſe to lay theſe before the reader. We might content ourſelves with ſimply giving the practical rules deduced from the principles; but it is ſurely more deſirable to perceive the validity of the principles. This will give us confidence in the deduced rules of practice. In the employment of ſacred muſic, an inſpired writer counſels us to ſing, not only "with the heart, but with the underſtanding alſo." We may, without irreverence, recommend the ſame thing here. Let us therefore attend a little to the dictate of untutored Nature, and ſee how ſhe teaches all mankind to form the ſcale of melody.

4
All nations ſing by one ſcale.

It is a moſt remarkable fact, that, in all nations, however they may differ in the ſtructure of that chaunt which we call the accent, or tone, or twang, in the colloquial language of a particular nation, or in the favourite phraſes or paſſages which are moſt frequent in their ſongs, all men make uſe of the ſame riſes and falls, or inflexions of voice, in their muſical language or airs. We have heard the ſongs of the Iroquois, the Cherokee, and the Eſquimaux, of the Carib, and the inhabitant of Paraguay; of the African of Negroland and of the Cape, and of the Hindoo, the Malay, and the native of Otaheite—and we found none that made uſe of a different ſcale from our own, although ſeveral ſeemed to be very ſorry performers by any ſcale. There muſt be ſome natural foundation for this uniformity. We may never diſcover this; but we may be fortunate enough to diſcover facts in the phenomena of ſound which invariably accompany certain modifications of muſical ſentiment. If we ſucceed, we are intitled to ſuppoſe that ſuch inſeparable companions are naturally connected; and to conclude, that if we can inſure the appearance of thoſe facts in ſound, we ſhall alſo give occaſion to thoſe muſical ſentiments or impreſſions.

5
Muſical pitch, what?

There is a quality in lengthened or continued ſound which we call its pitch or note, by which it may be accounted ſhrill or hoarſe. It may be very hoarſe in the beginning, and during its continuance it may grow more and more ſhrill by imperceptible gradations. In this caſe we are ſenſible of a kind of progreſs from the one ſtate of ſound to the other. Thus, while we gently draw the bow acroſs the ſtring of a baſs viol, if we at the ſame time ſlide the finger ſlowly along the ſtring, from the nut toward the bridge, the ſound, from being hoarſe, becomes gradually acute or ſhrill. Hoarſe and ſhrill therefore are not different qualities, although they have different names, but are different ſtates or degrees of the ſame quality, like cold and heat, near and far, early and late, or, what is common to all theſe, little and great. A certain ſtate of the air is accounted neither hot nor cold. All ſtates on one ſide of this are called warm, or hot; and all on the other are cold. In like manner, a certain ſound is the boundary between thoſe that are called hoarſe and thoſe called ſhrill. The chemiſt is accuſtomed to ſay, that the temperature of a body is higher when it is warmer, and lower when colder. In like manner, we are accuſtomed to ſay, that a perſon raiſes or depreſſes the pitch of his voice when it becomes more ſhrill or more hoarſe. The ancient Greeks, however, called the ſhriller ſounds *low*, and the hoarſer ſounds *high*; probably becauſe the hoarſer ſounds are generally ſtronger or louder, which we are alſo accuſtomed to conſider as higher. In common language, a low pitch of voice means a faint ſound, but in muſical language it means a hoarſer ſound. The ſound that is neither hoarſe nor ſhrill is ſome ordinary pitch of voice, but without any preciſe criterion.

6. The change obſerved in the pitch of a violin ſtring, when the finger is carried along the finger-board with a continued motion, is alſo continuous; that is, not by ſtarts: we call it gradual, for want of a better term, although gradual properly means *gradatim*, by degrees, ſteps, or ſtarts, which are not to be diſtinguiſhed in this experiment. But we may make the experiment in another way. After ſounding the open ſtring, and while the bow is yet moving acroſs it, we may put down the finger about $1\frac{2}{3}$ inches from the nut. This will change the ſound into one which is *ſenſibly* ſhriller than the former, and there is a manifeſt ſtart from the one to the other. Or we may put down the finger $2\frac{1}{2}$ inches from the nut; the ſound of the open ſtring will change to a ſhriller ſound, and we are ſenſible that this change or ſtep is greater than the former. Moreover, we may, while drawing the bow acroſs the ſtring, put down one finger at $1\frac{2}{3}$ inches, and, immediately after, put down another finger at $2\frac{1}{2}$ inches from the nut. We ſhall have three ſounds in ſucceſſion, each more ſhrill than the preceding, with two manifeſt ſteps, or ſubſultory changes of pitch.

7. Now ſince the laſt ſound is the ſame as if the ſecond had not been ſounded, we muſt conceive the ſum of the two ſucceſſive changes as equivalent or equal to the change from the firſt to the third. This change ſeems ſomehow to include the other two, and to be made up of them, as a whole is made up of its parts, or as $2\frac{1}{2}$ inches are made up of $1\frac{2}{3}$ and $\frac{5}{6}$ of an inch, or as the ſum 15 is made up of 10 and 5.

8
We hav notion o ſomethi like an terval b tween t notes of muſic.

Thus it happens that thinking perſons conceive ſomething like or analogous to a diſtance, or interval, between theſe ſounds. It is plain, however, that there can be no real diſtance or ſpace interpoſed between them; and it is not eaſy to acquire a diſtinct notion of the bulk or magnitude of theſe intervals. This conception is purely figurative and analogical; but the analogy is very good, and the obſervation of it, or conjecture

T pera- m of the le of ific.

jecture about it, has been of great ſervice in the ſcience of muſic, by making us ſearch for ſome preciſe meaſure of thoſe manifeſt intervals of muſical ſounds.

It muſt now be remarked, that it is in this reſpect alone that ſounds are ſuſceptible of muſic. Nor are all ſounds poſſeſſed of this quality. The ſmack of a whip, the exploſion of a muſket, the ruſhing of water or wind, the ſcream of ſome animals, and many other ſounds, both momentary and continuous, are mere noiſes; and can neither be called hoarſe nor ſhrill. But, on the other hand, many ſounds, which differ in a thouſand circumſtances of loudneſs, ſmoothneſs, mellowneſs, &c. which make them pleaſant or diſagreeable, have this quality of muſical pitch, and may thus be compared. The voice of a man or woman, the ſound of a pipe, a bell, a ſtring, the voice of an animal, nay, the ſingle blow on an empty caſk—may all have one pitch, or we may be ſenſible of the interval between them. We can, in all caſes, tighten or ſlacken the ſtring of a violin, till the moſt uninformed hearer can pronounce with certainty that the pitch is the ſame. We are indebted to the celebrated Galileo for the diſcovery of that phyſical circumſtance in all thoſe ſounds which communicates this remarkable quality to them, and even enables us to induce it on any noiſe whatever, and to determine, with the utmoſt preciſion, the muſical pitch of the ſound, and the interval between any two ſuch ſounds. Of this we ſhall ſpeak fully hereafter; and at preſent we only obſerve, that two ſounds, having the ſame pitch, are called UNISONS by muſicians, or are ſaid to be in *uniſon* to one another.

10. When two untaught men attempt to ſing the ſame air together, they always ſing in uniſon, unleſs they expreſsly mean to ſing in different pitches of voice. Nay, it is an extremely difficult thing to do otherwiſe, except in a few very peculiar caſes. Alſo, when a man and woman, wholly uninſtructed in muſic, attempt to ſing the ſame air, they alſo *mean* to ſing the ſame muſical notes through the whole air; and they generally imagine that they do ſo. But there is a manifeſt difference in the ſounds which they utter, and the woman is ſaid to ſing more SHRILL, and the man more HOARSE. A very plain experiment, however, will convince them that they are miſtaken. *N. B.* We are now ſuppoſing that the performers have ſo much of a muſical ear, and flexible voice, as to be able to ſing a common ballad, or a pſalm tune, with tolerable exactneſs, and that they can prolong or dwell upon any particular note when deſired.

Let them ſing the common pſalm tune called St David's, in the ſame way that they practiſe at church; and when they have done it two or three times, in order to fix their voices in tune, and to feel the general impreſſion of the tune, let the woman hold on in the firſt note of the tune, which we ſuppoſe to be *g*, while the man ſings the firſt three in ſucceſſion, namely *g*, *d*, $\bar{g}$. He will now perceive, that the laſt note ſung by himſelf is the ſame with that ſung by the woman, and which ſhe thinks that ſhe is ſtill holding on in the firſt note of the tune. Let this be repeated till the performance becomes eaſy. They will then perceive the perfect ſameneſs, in reſpect of muſical pitch, of the woman's firſt note of this tune and the man's third note. Some difference, however, will ſtill be perceived; but it will not be in the pitch, but in the ſmoothneſs, or clearneſs, or other agreeable quality of the woman's note.

Temperament of the Scale of Muſic.

11 There are ſeven ſteps in the natural ſcale, and eight notes.

When this is plainly perceived, let the man try by what continued ſteps he muſt raiſe his pitch, in order to arrive at the woman's note from his own. If he is accuſtomed to common ballad ſinging, he will have no great difficulty in doing this; and will find that, beginning with his own note, and ſinging gradually up, his eighth note will be the woman's note. In ſhort, if two flutes be taken, one of which is twice as long as the other, and if the man ſing in uniſon with the larger flute, the woman, while ſinging, as ſhe thinks, the ſame notes with the man, will be found to be ſinging in uniſon with the ſmaller flute.

12 OCTAVE.

This is a remarkable and moſt important fact in the phenomena of muſic. This interval, comprehending and made up of ſeven ſmaller intervals, and requiring eight ſounds to mark its ſteps, is therefore called an OCTAVE. Now, ſince the female performer follows the ſame dictates of natural ear in ſinging her tune that the man follows in ſinging his, and all hearers are ſenſible that they are ſinging the ſame tune, it neceſſarily follows, that the two ſerieſes of notes are perfectly ſimilar, though not the ſame: For there muſt be the ſame interval of an octave between any ſtep of the lower octave and the ſame ſtep of the upper one. In whatever way, therefore, we conceive one of theſe octaves to be parcelled out by the different ſteps, the partition of both muſt be ſimilar. If we repreſent both by lines, theſe lines muſt be ſimilarly divided. Each partial interval of the one muſt bear the ſame relation to the whole, or to any other interval, as its ſimilar interval in the other octave bears to the whole of that octave, or to the other correſponding interval in it.

13 All octaves are ſimilar.

Farther, we muſt now obſerve, that although this ſimilarity of the octaves was firſt obſerved or diſcovered by means of the ordinary voices of man and woman, and is a legitimate inference from the perfect ſatisfaction that each feels in ſinging what they think the ſame notes, this is not the only foundation or proof of the ſimilarity. Having acquired the knowledge of that phyſical circumſtance, on which the pitch of muſical ſounds depends, we can demonſtrate, with all the rigour of geometry, that the ſeveral notes in the man and woman's octave *muſt* have the ſame relation to their reſpective commencements, and that theſe two great intervals are ſimilarly divided. But farther ſtill, we can demonſtrate that this ſimilarity is not confined to theſe two octaves. This may even be proved, to a certain extent, by the ſame original experiment. Many men can ſing two octaves in ſucceſſion, and there are ſome rare examples of perſons who can ſing three. This is more common in the female voice. This being the caſe, it is plain that there will be two octaves common to both voices; and therefore four octaves in ſucceſſion, all ſimilar to each other. The ſame ſimilarity may be obſerved in the ſounds of inſtruments which differ only by an octave. And thus we demonſtrate that all octaves are ſimilar to each other. This ſimilarity does not conſiſt merely in the ſimilarity of its diviſion. The ſound of a note and its octave are ſo like each other, that if the ſtrength or loudneſs be properly adjuſted, and there be no difference in kind, or other circumſtances of clearneſs, ſmoothneſs, &c. the two notes, when ſounded together, are indiſtinguiſhable, and appear only like a more brilliant note. They coaleſce into one ſound. Nay, moſt clear mellow notes, ſuch as theſe of a fine human voice, really contain each two notes, one of which is octave to the other.

14 All muſic contained in the octave; hence called DIAPASON.

We ſaid that this reſemblance of octaves is an important fact in the ſcience of muſic. We now ſee why it is ſo. The whole ſcale of muſic is contained in one octave, and all the reſt are only repetitions of this ſcale. And thus is the doctrine of the ſcale of melody brought within a very moderate compaſs, and the problem is reduced to that of the repartition of a ſingle octave, and ſome attention to the junction with the ſimilar ſcales of the adjoining octaves. This partition is now to be the ſubject of diſcuſſion.

15 Melodies, or tunes, or airs, were the firſt muſic.

In the infancy of ſociety and cultivation, it is probable that the melodies or tunes, which delighted the ſimple inhabitants, were equally ſimple. Being the ſpontaneous effuſions of individuals, perhaps only occaſional, and never repeated, they would periſh as faſt as produced. The airs were probably connected with ſome of the rude rhimes, or gingles of words, which were bandied about at their feſtivals; or they were aſſociated with dancing. In all theſe caſes they muſt have been very ſhort, conſiſting of a few favourite paſſages or muſical phraſes. This is the caſe with the common airs of all ſimple people to this day. They ſeldom extend beyond a ſhort ſtanza of poetry, or a ſhort movement of dancing. The artiſt who could compoſe and keep in mind a piece of conſiderable length, muſt have been a great rarity, and a minſtrel fit for the entertainment of princes; and therefore much admired, and highly rewarded: his excellencies were almoſt incommunicable, and could not be preſerved in any other way but by repeated performance to an attentive hearer, who muſt alſo be an artiſt, and muſt patiently liſten, and try to imitate; or, in ſhort, to get the tune by heart. It muſt have been a long time before any diſtinct notion was formed of the relation of the notes to each other. It was perhaps impoſſible to recollect today the preciſe notes of yeſterday. There was nothing in which they were fixed till inſtrumental muſic was invented. This has been found in all nations; but it appears that long continued cultivation is neceſſary for raiſing this from a very ſimple and imperfect ſtate. The moſt refined inſtrument of the Greek muſicians was very far below our very ordinary inſtruments. And, till ſome method of notation was invented, we can ſcarcely conceive how any determined partition of the octave could be made generally known.

16 KEY-NOTE or FUNDAMENTAL.

Accordingly, we find that it was not till after a long while, and by very rude and awkward ſteps, that the Greeks perceived that the whole of muſic was compriſed in the octave. The firſt improved lyre had but four ſtrings, and was therefore called a TETRACHORD; and the firſt flutes had but three holes, and four notes; and when more were added to the ſcale, it was done by joining two lyres and two flutes together. Even this is an inſtructive ſtep in the hiſtory of muſical ſcience: For the four ſounds of the inſtrument have a natural ſyſtem, and the awkward and groping attempts to extend the muſic, by joining two inſtruments, the ſcale of the one following, or being a continuation of that of the other, pointed out the DIAPASON or *totality* of the octave, and the relation of the whole to a principal ſound, which we now call the *fundamental* or *key*, it being the loweſt note of our ſcale, and the one to which the other notes bear a continual reference. It would far exceed the limits of this Work to narrate the ſucceſſive changes and additions made by the Greeks in their lyre; yet would this be a very ſure way of learning the natural formation of our muſical ſcale. We muſt refer our readers to Dr Wallis's Appendix to his edition of the Commentary of Porphyrius in Ptolemy's Harmonics, as by far the moſt perſpicuous account that is extant of the Greek muſic. We ſhall pick out from among their different attempts ſuch plain obſervations as will be obvious to the feelings of any perſon who can ſing a common tune.

17 The octav is naturall divided into two TETRACHORDS.

Let ſuch a perſon firſt ſing over ſome plain and cheerful, or at leaſt not mournful, tune, ſeveral times, ſo as to retain a laſting impreſſion of the chief note of the tune, which is generally the laſt. Then let him begin, on the ſame note, to ſing in ſucceſſion the riſing ſteps of the ſcale, pronouncing the ſyllables *do*, *re*, *mi*, *fa*, *ſol*, *la*, *ſi*, *do*. He will perhaps obſerve, that this chaunt naturally divides itſelf into two parts or phraſes, as the muſicians term it. If he does not, of himſelf, make this remark, let him ſing it, however, in that manner, pauſing a little after the note *fa*. Thus, *do*, *re*, *mi*, *fa*; *ſol*, *la*, *ſi*. *do*.—*Do*, *re*, *mi*, *fa*; *ſol*, *la*, *ſi*, *do*.

Having done this ſeveral times, and then repeated it without a pauſe, he will become very ſenſible of the propriety of the pauſe, and of this natural diviſion of the octave. He will even obſerve a conſiderable ſimilarity between theſe two muſical phraſes, without being able, at firſt, to ſay in what it conſiſts.

18 The ſteps of the ſca are unequal, and the two t trachords are ſimilar.

Let him now ſtudy each phraſe apart, and try to compare the magnitude of the changes of ſound; or ſteps which he makes in riſing from *do* to *re*, from *re* to *mi*, and from *mi* to *fa*. We apprehend that he will have no difficulty in perceiving, after a few trials, that the ſteps *do re*, and *re mi*, are ſenſibly greater than the ſtep *mi fa*. We feel the laſt ſtep as a ſort of ſlide; as an attempt to make as little change of pitch as we can. Once this is perceived, it will never be forgotten. This will be ſtill more clearly perceived, if, inſtead of theſe ſyllables, he uſe only the vowel *a*, pronounced as in the word *hall*, and if he ſing the ſteps, ſliding or ſlurring from the one to the other. Taking this method, he cannot fail to notice the ſmallneſs of the third ſtep.

19. Let the ſinger farther conſider, whether he does not feel this phraſe muſical or agreeable, making a ſort of tune or chaunt, and ending or cloſing agreeably after this ſlide of a ſmall, or, as it were, half ſtep. It is generally thought ſo; and is therefore called a CLOSE, a CADENCE, when we end with a half ſtep aſcending.

20. Let the ſinger now reſume the whole ſcale, ſinging the four laſt notes *ſol*, *la*, *ſi*, *do*, louder than the other four, and calling off his attention from the low phraſe, and fixing it on the upper one. He will now be able to perceive that this, like the other, has two conſiderable ſteps; namely, *ſol la* and *la ſi*, and then a ſmaller ſtep, *ſi do*. A few repetitions will make this clear, and he will then be ſenſible of the nature of the ſimilarity between theſe two phraſes, and the propriety of this great diviſion of the ſcale into the intervals *do*, *fa*, and *ſol*, *do*, with an interval *fa*, *ſol* between them.

This was the foundation of the tetrachords, or lyres of four ſtrings, of the Greeks. Their earlieſt muſic or modulation ſeems to have extended no farther than this phraſe. It pleaſed them, as a ring of four bells pleaſes many country pariſhes.

21 CLOSE CADEN

The ſinger will perceive the ſame ſatiſfaction with the cloſe of this ſecond phraſe as with that of the former: and if he now ſing them both, in immediate ſucceſſion,

ſucceſſion, with a ſlight pauſe between, we imagine that he will think the cloſe or cadence on the upper *do* even more ſatisfactory than that on the *fa*. It ſeems to us to complete a tune. And this impreſſion will be greatly heightened, if another perſon, or an inſtrument, ſhould ſound the lower *do*, while he cloſes on the upper *do* its octave *Do* ſeems to be expected, or looked for, or ſought after. We take *ſi* as a ſtep to *do*, and there we reſt.

22
e third l ſeventh p are the alleſt.

Thus does the octave appear to be naturally compoſed of ſeven ſteps. of which the firſt, ſecond, fourth, fifth, and ſixth, are more conſiderable, and the third and ſeventh very ſenſibly ſmaller. Having no direct meaſures of their quantity, nor even a very diſtinct notion of what we mean by their quantity, magnitude, or bulk, we cannot pronounce, with any certainty, whether the greater ſteps are equal or unequal; and we preſume them to be equal. Nor have we any diſtinct notion of the proportion between the larger and ſmaller ſteps. In a looſe way we call them half notes, or ſuppoſe the riſe from *mi* to *fa*, or from *ſi* to *do*, to be one-half of that from *do* to *re*, or from *re* to *mi*.

23
ie Pytharean diſ- veries did t im- ove the eek mu-

Accordingly, this ſeems to have been all the muſical ſcience attained by the Greek artiſts, or thoſe who did not profeſs to ſpeak philoſophically on the ſubject. And even after Pythagoras publiſhed the diſcovery which he had made, or more probably had picked up among the Chaldeans or Egyptians, by which it appeared, that accurate meaſures of ſounds, in reſpect to gravity and acuteneſs, were attainable, it was affirmed by Ariſtoxenus, a ſcholar of Ariſtotle, and other eminent philoſophers, that theſe meaſures were altogether artificial, had no connection with muſic, and that the ear alone was the judge of muſical intervals. The artiſt had no other guide in tuning his inſtrument; becauſe the ratios, which were ſaid to be inherent in the ſounds (though no perſon could ſay how), were never perceived by the ear. The juſtice of this opinion is abundantly confirmed by the awkward attempt of the Greeks to improve the lyre by means of theſe boaſted ratios. Inſtead of illuſtrating the ſubject, they ſeem rather to have brought an additional obſcurity upon it, and threw it into ſuch confuſion, that although many voluminous diſſertations were written on it, and on the compoſition of their muſical ſcale, the account is ſo perplexed and confuſed, that the firſt mathematicians and artiſts of Europe acknowledge, that the whole is an impenetrable myſtery. Had the philoſophers never meddled with it, had they allowed the practical muſicians to conſtruct and tune their inſtruments in their own way, ſo as to pleaſe their ear, it is ſcarcely poſſible that they ſhould not have hit on what they wanted, without all the embarraſſment of the chromatic and enharmonic ſcales of the lyre. It is ſcarcely poſſible to contrive a more cumberſome method of extending the ſimple ſcale of Nature to every caſe that could occur in their muſical compoſitions, than what aroſe from the employment of the muſical ratios. This ſeems a bold aſſertion; but we apprehend that it will appear to be juſt as we proceed.

24
ie tranſ- ſition of ſic made ercalary tes neceſ- y in the ave.

The practical muſicians could not be long of finding the want of ſomething more than the mere diatonic ſcale of their inſtruments. As they were always accompanied by the voice, it would often happen that a lyre or flute, perfectly tuned, was too low or too high for the voice that was to accompany it. A ſinger can pitch his tune on any ſound as a key; and if this be too high for the ſinger who is to accompany him, he can take it on a lower note. But a lyriſt cannot do this. Suppoſe his inſtrument two notes too low, and that his accompanyiſt can only ſing it on the key which is the *ſi* of the lyre. Should the lyriſt begin it on that key, his very firſt ſtep is wrong, being but a half ſtep, whereas it ſhould be a whole one. In ſhort, all the ſteps but one will be found wrong, and the lyriſt and ſinger will be perpetually jarring. This is an evident conſequence of the inequality of the fourth and ſeventh ſteps to the reſt. And if the other ſteps, which we imagine to be equal, be not exactly ſo, the diſcordance will be ſtill greater.

Diſputes of the Pythagoreans and Ariſtoxeneans about muſical ratios.

The method of remedying this is very obvious. If the intervals *mi fa* and *ſi do*, are half notes, we need only to interpoſe other ſounds in the middle between each of the whole notes; and then, in place of ſeven unequal ſteps, we ſhall have twelve equal ones, or twelve intervals, each of them equal to a ſemitone. The lyre thus conſtructed will now ſuit any voice whatever. It will perfectly reſemble our keyed inſtruments, the harpſichord, or organ, which have twelve ſeemingly equal intervals in the octave. Accordingly, it appears that ſuch additions were practiſed by the muſicians of Greece, and approved of by Ariſtoxenus, and by all thoſe who referred every thing to the judgment of the ear. And we are confident that this method would have been adopted, if the philoſophers had had leſs influence, and if the Greeks had not borrowed their religious ceremonies along with their muſical ſcience. Both of theſe came from the ſame quarter; they came united; and it was ſacrilegious to attempt innovations. The doctrine of muſical ratios was an occupation only for the refined, the philoſophers; and by ſubjecting muſic to this myſterious ſcience, it became myſterious alſo, and ſo much the more venerable. The philoſophers ſaw, that there was in Nature a certain inſcrutable connection between mathematical ratios and thoſe intervals which the ear reliſhed and required in melody: but they were ignorant of the nature and extent of this connection.

Ratios of octave, diapente, and diateſſaron.

What is this connection, or what is meant when we ſpeak of the ratios of ſounds? Simply this:—Pythagoras is ſaid to have found, that if two muſical cords be ſtrained by equal weights, and one of them be twice the length of the other, the ſhort one will ſound the octave to the note of the other. If it be two-thirds of the length of the long ſtring, it will ſound the fifth to it. If the long ſtring ſound *do*, the ſhort one will ſound *ſol*. If it be three-fourths of the length, it will ſound the fourth or *fa*. Thus the ratio of 2 : 1 was called the ratio of the DIAPASON; that of 3 : 2 was called the DIAPENTE; and that of 4 : 3 the DIATESSARON. Moreover, if we now take all the four ſtrings, and make that which ſounds the graveſt note, and is the longeſt, twelve inches in length; the ſhort or octave ſtring muſt be ſix inches long, or one-half of twelve; the diapente muſt be eight inches, or two-thirds of twelve; and the diateſſaron muſt be nine inches, which is three-fourths of twelve. If we now compare the diapente, not with the graveſt ſtring, but with the octave of ſix inches, we ſee that they are in the ratio of 4 to 3, or the ratio of diateſſaron. And if we compare the diateſſaron with

the

the octave, we ſee that their ratio is that of 9 : 6, or of 3 : 2, or the ratio of diapente. Thus is the octave divided into a fifth and a fourth, *do ſol*, and *ſol do*, in ſucceſſion. Alſo the fourth *do fa*, and the fifth *fa do*, make up the octave. The note which ſtands as a fifth to one of the extreme ſounds of the octave, ſtands as a fourth to the other. And, laſtly, the two fourths *do fa*, and *ſol do*, leave an interval *fa ſol* between them; which is alſo determined by nature, and the ratio correſponding to it is evidently that of 9 to 8.

25
The diſcovery of Pythagoras is either a fable, or falſely narrated.

This is all that was known of the connection of muſic with mathematical ratios. It is indeed ſaid by Iamblichus, that Pythagoras did not make this diſcovery by means of ſtrings, but by the ſounds made by the hammers on the anvil in a ſmith's ſhop. He obſerved the ſounds to be the key, the diateſſaron, and the diapente of muſic; and he found, that the weights of the hammers were in this proportion; and as ſoon as he went home, he tried the ſounds made by cords, when weights, in the proportions above-mentioned, were appended to them. But the whole ſtory has the air of a fable, and of ignorance. The ſounds given by a ſmith's anvil have little or no dependence on the weight of the hammers; and the weights which are in the proportions of the numbers mentioned above will by no means produce the ſounds alleged. It requires *four* times the weight to make a ſtring ſound the octave, and *twice and a quarter* will produce the diapente, and *one and ſeven-ninths* will produce the diateſſaron. It is plain, therefore, that they knew not of what they were ſpeaking: yet, on this ſlight foundation, they erected a vaſt fabric of ſpeculation; and in the courſe of their reſearches, theſe ratios were found to contain all that was excellent. The attributes of the Divinity, the ſymmetry of the univerſe, and the principles of morality, were all reſolvable into the harmonic ratios.

26
Conjoined and disjoined tetrachords.

In the attempts to explain, by means of the myſterious properties of the ratios 2 : 1, 3 : 2, 4 : 3, and 9 : 8, which were thus defined by Nature, it was obſerved, that their favourite lyres of four ſtrings could be combined in two principal manners, ſo as to produce an extenſive ſcale. One lyre may contain the notes *do, re, mi, fa*; and the acuter lyre may contain the notes *ſol, la, ſi, do*; and, being ſet in ſucceſſion, having the interval *fa ſol* between the higheſt note of the one and the loweſt of the other, they make a complete octave. Theſe were called *disjoined tetrachords*. Again, a third tetrachord may be joined with the upper tetrachord laſt mentioned, in ſuch ſort, that the loweſt note of the third tetrachord may be the ſame with the higheſt of the ſecond. Theſe were called *conjoined* tetrachords (A).

27
The lyres were tuned entirely by the ear,

By thus conſidering the ſcale as made up of tetrachords, the tuning of the lyre was reduced to great ſimplicity. The muſician had only to make himſelf perfect in the ſhort chaunt *do, re, mi, fa*, or to get it by heart, and to ſing it exactly. This intonation would apply equally to the other *ſol, la, ſi, do*. We are well informed that this was really the practice. The directions given by Ariſtoxenus, Nicanor, and others, for varying the tuning, according to certain occaſional accommodations, ſhew diſtinctly that they did not tune as we do, ſounding the two ſtrings together, except in the caſe of the diapaſon or octave. It was all done by the judgment of the ear in melody. The moſt valuable circumſtance in the diſcovery of Pythagoras was the determination of the interval between the fourth and the fifth, by which the tetrachords were ſeparated. The filling up of each tetrachord was left entirely to the ear; and when the doctrine of the mathematical ratios ſhewed that the large intervals *do re, re mi, fa ſol, ſol la, la ſi*, ſhould not be preciſely equal, Ariſtoxenus refuſed the authority of the reaſons alleged for this inequality, becauſe the ear perceived none of the ratios as ratios, and could judge only of ſounds. He farther aſſerted, that the inequalities which the Pythagoreans enjoined, were ſo trifling, that no ear could poſſibly perceive them. And accordingly, the theoriſts diſputed about the reſpective ſituations of the greater and ſmaller tones (ſo they named the great ſteps) ſo much ſpoken of, and had different ſyſtems on the ſubject.

28
And by melody alone:

But the ſtrongeſt proof of the indiſtinct notion that the theoriſts entertained about the influence of theſe ratios in muſic is, that they would admit no more but thoſe introduced by Pythagoras; and their reaſons for the rejection of the ratio of 5 to 4, and of 6 to 5, were either the moſt whimſical fancies about the perfections of the ſacred ratios, or aſſumptions expreſsly founded on the ſuppoſition, that the ear perceives and judges of the ratios as ratios; than which nothing can be more falſe. Had they admitted the ratio of 5 to 4, they would have obtained the third note of the ſcale, and would at once have gotten the whole ſcale of our muſic. The ratios of 6 : 5, and 16 : 15, follow of courſe; and every ſound of the tetrachords would have been determined. For 5 : 4 being the ratio of the major third, which is perfectly pleaſing to the ear, as the *mi* to the note *do*, and 3 : 2 being the ratio of the fifth *do ſol*, there is another interval *mi ſol* determined; and this ratio, being the difference between *do ſol* and *do mi*, or between 3 : 2 and 5 : 4, is evidently 6 : 5. In like manner, the interval *mi fa* is determined, and its ratio, being 4 : 3 — 5 : 4, is 16 : 15.

But farther; we ſhall find, upon trial, that if we put in a ſound above *ſol*, having the relation 5 : 4 to *fa*, it will be perfectly ſatisfactory to the ear if ſung as the note *la*. And if, in like manner, we put in a note above *la*, having the relation 5 : 4 to *ſol*, we find it ſatisfactory to the ear when uſed as *ſi*. If we now examine the ratios of theſe artificial notes, we ſhall find the ratio of the notes *ſol la* to be 10 : 9, and that of *la ſi* to be 9 : 8, the ſame with that *fa ſol*; alſo *ſi do* will appear to be 16 : 15, like that of *mi fa*.

We have no remains of the muſic of the Greeks, by which we can learn what were their favourite paſſages or muſical phraſes; and we cannot ſee what cauſed them to prefer the fourth to the major third. Few muſicians of our times think the fourth in any degree comparable with the major third for melodiouſneſs, and ſtill fewer for harmoniouſneſs. The piece or tune publiſhed by Kircher from Alypius is very ſuſpicious, as no

---

(A) This is the *principle*, but not the preciſe *form*, of the disjoined and conjunct tetrachords. The Greeks did not begin the tetrachord with what we make the firſt note of our chaunt of four notes, but began one of them with *mi*, and the other with *ſi*; to which they afterwards added a note below. This beginning ſeems to have been directed by ſome of their favourite cadences; but it would be tedious to explain it.

npera- t of the le of Iuſic.

no other perſon has ſeen the MS.; and the collection found at Buda is too much disfigured, and probably of too late a date, to give us any ſolid help. In all probability, the common melodies of the Greeks abounded in eaſy leaps up and down on the third and fifth, and on the fourth and ſixth, juſt as we obſerve in the airs for dancing among all ſimple people. Their accompliſhed performers had certainly great powers both of invention and execution; and the chromatic and enharmonic diviſions of the ſcale were certainly practiſed by them, and not merely the ſpeculations of mathematicians. To us, the enharmonic ſcale appears the moſt jarring diſcord; but this is certainly owing to our not ſeeing any pieces of the muſic ſo compoſed, and becauſe we cannot in the leaſt judge by harmony what the effect of enharmonic melody would be. But we have ſufficient evidence from the writings of the ancient Greeks, that the enharmonic muſic fell into diſuſe even before the time of Ptolemy, and was totally and irrecoverably loſt before the 5th century. Even the chromatic was little practiſed, and was chiefly employed for extending the common ſcale to keys which were ſeldom uſed. The uncertainties reſpecting even the common ſcale remained the ſame as ever; and although Ptolemy gives (among others) the very ſame that is now admitted as the only perfect one, namely, his *diatonicum intenſum*, his reaſons of preference, though good, are not urged with ſtrong marks of his confidence in them, nor do they ſeem to have prevailed.

29 t me- y is re in- ficient.

Theſe obſervations ſhew clearly, that the perception of melody alone is not ſufficiently preciſe for enabling us to acquire exact conceptions of the ſcale of muſic. The whole of the practicable ſcience of the ancients ſeems to amount to no more than this, that the octave contained five greater and two ſmaller intervals, which the voice employed, and the ear reliſhed. The greater intervals ſeemed all of one magnitude; and the ſmaller intervals appeared alſo equal, but the ear cannot judge what proportion they bear to the larger ones. The muſicians thought them larger than one-half of the great intervals (and indeed the ratio 16 : 15 of the artificial *mi fa* and *ſi do*, is greater than the half of 9 : 8 or 10 : 9). Therefore they allowed the theoriſts to call them *limmas* inſtead of *hemitones*; but they, as well as the theoriſts, differed exceedingly in the magnitudes which they aſſigned them.

30 rcular re- eſenta- n of the le. Plate XLIV.

The beſt way that we can think of for expreſſing the ſcale of the octave is, by dividing the circumference of a circle in the points C, D, E, F, G, A, and B (fig. 1.), in the proportion we think moſt ſuitable to the natural ſcale of melody. According to the practical notion now under our conſideration, the arches CD, DE, FG, GA, and AB, are equal, containing nearly 59°; and the arches EF and BC are alſo equal, but ſmaller than the others, containing about 33½. Now, ſuppoſe another circle, on a piece of card paper, divided in the ſame manner, to move round their common centre, but inſtead of having its points of diviſion marked C, D, E, &c. let them be marked *do, re, mi, fa, ſol, la, ſi*. It is plain, that to whatever point of the outer circle we ſet the point *do* of the inner one, the other points of the outer circle will ſhew the common notes which are fit for thoſe ſteps of the ſcale. The ſimilarity of all octaves makes this ſimple octave equivalent to a rectilineal ſcale ſimilarly divided, and repeated as often as we pleaſe. Fig. 1. repreſents this inſtrument, and will be often referred to. A ſort of ſymmetry may be obſerved in it. The point D ſeems to occupy the middle of the ſcale, and *re* ſeems to be the middle note of the octave. The oppoſite arch GA, and the correſponding interval *ſol la*, ſeems to be the middle interval of the octave. The other notes and intervals are ſimilarly diſpoſed on each ſide of theſe. This circumſtance ſeems to have been obſerved by the Greeks, by the inhabitants of India, by the Chineſe, and even by the Mexicans. The note *re*, and the interval *ſol la*, have gotten diſtinguiſhed ſituations in their inſtruments and ſcales of muſic.

Tempera-ment of the Scale of Muſic.

31 Ariſtoxenean ſcale of mean tones and limmas.

With reſpect to the diviſion of the circles, we ſhall only obſerve at preſent, that the dotted lines are conformable to the principles of Ariſtoxenus, the whole octave being portioned out into five larger and equal intervals, and two ſmaller, alſo equal. The larger are called *mean* or *medium tones*; and the ſmaller are called *limmas* or *ſemitones*. The full lines, to which the letters and names are affixed, divide the octave into the artificial portions, determined by means of the muſical ratios, the arches being made proportional to the meaſures of thoſe ratios. Thus the arches CD, FG, AB, are proportional to the meaſure or logarithm of the ratio 9 : 8; GA and DE are proportional to the logarithm of 10 : 9; and the arches EF and BC are proportional to the logarithm of 16 : 15. We have already mentioned the way in which thoſe ratios were applied, and the authority on which they were ſelected. We ſhall have occaſion to return to this again. The only farther remark that is to be made with propriety in this place is, that the diviſion on the Ariſtoxenean principles, which is expreſſed in this figure, is one of an indefinite number of the ſame kind. The only principle adopted in it is, that there ſhall be five mean tones, and two ſmall equal ſemitones; but the magnitude of theſe is arbitrary. We have choſen ſuch, that two mean tones are exactly equal to the arch CE, determined by the ratio 5 : 4. The reaſons for this preference will appear as we proceed (B).

By this little inſtrument (the invention, we believe, of a Mr D'Ormiſſon, about the beginning of laſt century), we ſee clearly the inſufficiency of the ſeven notes of the octave for performing muſic on different keys. Set the flower de luce at the Ariſtoxenean B, and we ſhall ſee that E is the only note of our lyre which will do for one of the ſteps of the octave in which we intend to ſing and accompany. We have no ſounds in the lyre for *re, mi, ſol, la, ſi*. The remedy is as clearly pointed out. Let a ſet of ſtrings be made, having the ſame relation to *ſi* which thoſe of the preſent lyre have to *do*, and inſert them in the places pointed out by the Ariſtoxenean diviſions of the moveable octave. We need only five of them, becauſe the *ſi* and *fa* of the preſent lyre will anſwer. Theſe new ſounds are marked by a +.

32 Found imperfect, and required TEMPERAMENT.

But it was ſoon found, that theſe new notes gave but indifferent melody, and that either the ear could not determine

---

(B) We ſhall be abundantly exact, if we make CD=61°,72; CE=115°,9; CF=149°,42; CG=210°,58; CA=265°,3; and CB=326°,48.

determine the equality of the tones and ſemitones exactly enough, or that no ſuch partition of the octave would anſwer. The Pythagoreans, or partiſans of the muſical ratios, had told them this before. But they were in no better condition themſelves; for they found, that if a ſeries of ſounds, in perfect relation to the octave, be inſerted in the manner propoſed, the melody will be no better. They put the matter to a very fair trial. It is eaſy to ſee, that no ſyſtem of mean tones and limmas will give the ſame muſic on every key, unleſs the tones be increaſed, and the limmas diminiſhed, till the limma becomes juſt half a tone. Then all the intervals will be perfectly equal. The mathematicians computed the ratios which would produce this equality, and deſired the Ariſtoxeneans to pronounce on the muſic. It is ſaid, that they allowed it to be very bad in all their moſt favourite paſſages. Nothing now remained to the Ariſtoxeneans but to attempt occaſional methods of tuning. They ſaw clearly, that they were making the notes unequal which Nature made equal. The Pythagoreans, in like manner, pointed out many alterations or corrections of intervals which ſuited one tetrachord, or one part of the octave, but did not ſuit another. Both parties ſaw that they were obliged to deviate from what they thought natural and perfect: therefore they called theſe alterations of the natural or perfect ſcale a *temperament*.

The accompliſhed performers were the beſt judges of the whole matter, and they derived very little aſſiſtance from the mathematicians: For although the rigid rules delivered by them be acknowledged to be perfectly exact, the execution of thoſe rules is not ſuſceptible of the ſame exactneſs. Their lyres are tuned, not by mathematical operations, but by the ear. It does not appear that they had muſical inſtruments with divided finger boards, like our baſs viols and guitars; and even on theſe, it is well known that the preſſure and touch of the finger may vary ſo much, that the moſt exact placing of the frets will not inſure the nice degrees of the ſounds. The flutes are the only inſtruments of the ancients that are capable of accurate ſounds. But flutemakers know very well, that they cannot be tuned by mathematical operations, but by the ear alone. This accounts for the great prices paid for a well tuned flute. Some have coſt L. 700, and L. 50 was a very common price.

33 The Greeks did not cultivate the harmony of ſimultaneous ſounds

Such ſeems to have been the ſtate of the ancient muſic. There was little or no ſcience in it. There was, indeed, a moſt abſtruſe and refined ſcience coupled with it; but by a very ſlight connection: and it ſeems to have been nothing more than an amuſement for the ingenious and ſpeculative Greeks. Nor could it, in our opinion, be better, ſo long as they had no guide in tuning but the judgment of the ear in melody. Many writers inſiſt that the Greeks had a knowledge of what *we* call *harmony* alſo The word ἁρμονια is conſtantly uſed by them: but it does not mean what we call harmony, the pleaſant coaleſcence of ſimultaneous ſounds. It comes from ἁρμος, or from ἁρμοζω, and ſignifies *aptitude*, *fitneſs*, and would, in general, be better tranſlated by *ſymmetry*. But we cannot conceive that they paid any marked attention to the effect of ſimultaneous ſounds, ſo as to enjoy the pleaſure of certain conſonances, and employ them in their compoſitions. We judge in this way from the rank which they gave them in their ſcale. To prefer the fourth to the major third ſeems to us to be impoſſible, if it be meant of ſimultaneous ſounds. And the reaſon which is aſſigned for the preference can have no value in the opinion of a muſician. It is becauſe the ratio of 4 : 3 is ſimpler than that of 5 : 4. For the ſame reaſon, the fifth is preferred to both, and the octave to all the three, and uniſon to every other conſonance. They would not allow the major third 5 : 4 to be a concord at all. We have made numberleſs trials of the different concords with perſons altogether ignorant of muſic. We never ſaw an inſtance of one who thought that mere uniſon gave any poſitive pleaſure. None of all whom we examined had much pleaſure from an octave. All, without exception, were delighted with a fifth, and with a major third; and many of them preferred the latter. All of them agreed in calling the pleaſure from the fifth a *ſweetneſs*, and that from the major third a *cheerfulneſs*, or *ſmartneſs*, or by names of ſimilar import. The greater part preferred even the major ſixth to the fourth, and ſome felt no pleaſure at all from the fourth. Few had much pleaſure from the minor third or minor ſixth. *N. B.* Care was taken to ſound theſe concords without any preparation -- merely as ſounds — but not as making part of any muſical paſſage. This circumſtance has a great effect on the mind. When the minor third and ſixth were heard as making part of the minor mode, all were delighted with it, and called it ſweet and mournful. In like manner, the chord $^{6}_{4}$ never failed to give pleaſure. Nothing can be a ſtronger proof of the ignorance of the ancients of the pleaſures of harmony.

34 The pleaſures of harmony ſeem to be a modern diſcovery.

We do not profeſs to know when this was diſcovered. We think it not unlikely that the Greeks and Italians got it from ſome of the northern nations whom they called *Barbarians*. We cannot otherwiſe account for its prevalence through the whole of the Ruſſian empire—the ancient Slavi had little commerce with the empire of Rome or of Conſtantinople; yet they ſung in parts in the moſt remote periods of their hiſtory of which we have any account; and to this day, the moſt uncultivated boor in the Ruſſian empire would be aſhamed to ſing in uniſon. He liſtens a little while to a new tune, holding his chin to his breaſt; and as ſoon as he has got a notion of it, he burſts out in concert, throwing in the harmonic notes by a certain rule which he feels, but cannot explain. His harmonics are generally alternate major and minor thirds. and he ſeldom miſſes the proper cadences on the fifth and key. Perhaps the invention of the organ produced the diſcovery. We know that this was as early as the ſecond century (c). It was hardly poſſible to make much uſe of that inſtrument without perceiving the pleaſure of concordant ſounds.

The

(c) It is ſaid that the Chineſe had an inſtrument of this kind long before the Europeans. Cauſeus ſays, that it was brought from China by a native, and was ſo ſmall as to be carried in the hand. It is certain that the Emperor Conſtantine Copronymus ſent one to Pepin king of France in 757, and that his ſon Charlemagne got another from the Emperor Michael Paleologus. But they appear to have been known in the Engliſh churches before that time.

pera- of the ale of uſic.

35 mony e a t ge in ſcience uſic.

The diſcovery of the pleaſures of harmony occaſioned a total change in the ſcience of muſic During the dark ages of Europe, it was cultivated chiefly by the monks: the organ was ſoon introduced into the churches, and the choral ſervice was their chief and almoſt their only occupation. The very conſtruction of this inſtrument muſt have contributed to the improvement of muſic, and inſtructed men in the nature of the ſcale. The pipes are all tuned by their lengths; and theſe lengths are in the ratios of the ſtrings which give the ſame notes, when all are equally ſtretched. This muſt have revived the ſtudy of the muſical ratios. The tuning of the organ was performed by conſonance, and no longer depended on the nice judgment of ſounds in ſucceſſion. The dulleſt ear, even with total ignorance of muſic, can judge, without the ſmalleſt error, of an exact octave, fifth, third, or other concord; and a very mean muſician could now tune an organ more accurately than Timotheus could tune his lyre. Other keyed inſtruments, reſembling our harpſichord, were invented, and inſtruments with fretted finger boards. Theſe ſoon ſupplanted the lyres and harps, being much more compendious, and allowing a much greater variety and rapidity of modulation. All theſe inſtruments were the fruits of harmony, in the modern ſenſe of that word. The deficiences of the old diatonic ſcale were now more apparent, and the neceſſity of a number of intercalary notes. The finger-board of an organ or harpſichord, running through a ſeries of octaves, and admitting much more than the accompanyment of one note, pointed out new ſources of muſical pleaſure ariſing from the fulneſs of the harmoy; and, above all, the practice of choral ſinging ſuggeſted the poſſibility of a pleaſure altogether new. While a certain number of the choir performed the Cantus or Air of the muſic, it was irkſome to the others to utter mere ſounds, ſupporting or compoſing the harmony of the Cantus, without any melody or air in their own parts. It was thought probable that the harmonic notes might be ſo portioned out among the reſt of the choir, that the ſucceſſion of ſounds uttered by each individual might alſo conſtitute a melody not unpleaſant, and perhaps highly grateful. On trial, it was found very practicable. Canons, motets, fugues, and other harmonies, were compoſed, where the airs performed by the different parts were not inferior in beauty to the principal. The notes which could not be thrown into this agreeable ſucceſſion, were left to the organiſt, and by him thrown into the baſs.

36. By all theſe practices, the imperfections of the ſcale of fixed ſounds became every day more ſenſible, eſpecially in full harmony. Scientific muſic, or the properties of the ratios, now recovered the high eſtimation in which they were held by the ancient theoriſts; and as the muſicians were now very frequently men of letters, chiefly monks, of ſober characters and decent manners, muſic again became a reſpectable ſtudy. The organiſt was generally a man of ſcience, as well as a performer. At the firſt revival of learning in Europe, we find muſic ſtudied and honoured with degrees in the univerſities, and very ſoon we have learned and excellent diſſertations on the principles of the ſcience. The inventions of Guido, and the diſſertations of Salinas, Zarlino, and Xoni, are among the moſt valuable publications that are extant on muſic. The improvements introduced by Guido are founded on a very refined examination of the ſcale; and the temperaments propoſed by the other two have ſcarcely been improved by any labours of modern date. Both theſe authors had ſtudied the Greek writers with great care, and their improvements proceed on a complete knowledge of the doctrines of Pythagoras and Ptolemy

Temperament of the Scale of Muſic.

37 Galileo diſcovered that muſical pitch conſiſted in the frequency of the aëreal undulations.

At laſt the celebrated Galileo Galilei put the finiſhing hand to the doctrines of thoſe ancient philoſophers, by the diſcovery of the connection which ſubſiſts in nature between the ratios of numbers and the muſical intervals of ſounds. He diſcovered, that theſe numbers expreſs the frequency of the recurring pulſes or undulations of air which excite in us the ſenſation of ſound. He demonſtrated that if two ſtrings, of the ſame matter and thickneſs, be ſtretched by equal weights, and be twanged or pinched ſo as to vibrate, the times of their vibrations will be as their lengths, and the frequency or number of oſcillations made in a given time will be inverſely as their lengths. The frequency of the ſonorous undulations of the air is therefore inverſely as the length of the ſtring. When therefore we ſay that 2 : 1 is the ratio of the octave, we mean, that the undulations which produce the upper ſound of this interval are twice as frequent as thoſe which produce its fundamental ſound. And the ratio 3 : 2 of the diapente or fifth, indicates, that in the ſame time that the ear receives three undulations from the upper ſound, it receives only two from the lower. Here we have a natural connection, not peculiar to the ſounds produced by ſtrings; for we are now able to demonſtrate, that the ſounds produced by bells are regulated by the ſame law. Nay, the improvements which have been made in the ſcience of motion ſince the days of Galileo, ſhew us that the undulations of the air in pipes, where the air is the *only* ſubſtance moved, is regulated by the ſame law. It ſeems to be the general property of ſounds which renders them ſuſceptible of muſical pitch, of acuteneſs, or gravity; and that a certain frequency of the ſonorous undulations gives a determined and unalterable muſical note. The writer of this article has verified this by many experiments. He finds, that *any noiſe whatever*, if repeated 240 times in a ſecond, at equal intervals, produces the note C *ſol fa ut* of the Gindonian gamut. If it be repeated 360 times, it produces the G *ſol re ut*, &c. It was imagined, that only certain regular agitations of the air, ſuch as are produced by the tremor or vibration of elaſtic bodies, are fitted for exciting in us the ſenſation of a muſical note. But he found, by the moſt diſtinct experiments, that any noiſe whatever will have the ſame effect, if repeated with due frequency, not leſs than 30 or 40 times in a ſecond. Nothing ſurely can have leſs pretenſion to the name of a muſical ſound than the ſolitary ſnap which a quill makes when drawn from one tooth of a comb to another: but when the quill is held to the teeth of a wheel, whirling at ſuch a rate, that 720 teeth paſs under it in a ſecond, the ſound of *g in alt.* is heard moſt diſtinctly; and if the rate of the wheel's motion be varied in any proportion, the noiſe made by the quill is mixed in the moſt diſtinct manner with the muſical note correſponding to the frequency of the ſnaps. The *kind* of the original noiſe determines the kind of the continuous ſound produced by it, making it harſh and fretful, or ſmooth and mellow, according as the original noiſe is abrupt or gradual: but even the moſt abrupt noiſe produces a tolerably ſmooth ſound when ſufficiently frequent. Nothing can be more abrupt than the ſnap juſt now mentioned; yet the *g* produced by it has the ſmoothneſs of a bird's chirrup. An experiment was made, which was leſs promiſing of a ſound than any that can be thought of. A ſtop cock was ſo conſtructed, that it opened and ſhut the paſſage through a pipe 720 times in a ſecond. This apparatus was fitted to the pipe of a conduit leading from the bellows to the wind cheſt of an organ. The air was ſimply allowed to paſs gently along this pipe by the opening of the cock. When this was repeated 720 times in a ſecond, the ſound *g in alt.* was moſt ſmoothly uttered, equal in ſweetneſs to a clear female voice. When the frequency was reduced to 360, the ſound was that of a clear but rather harſh man's voice. The cock was now altered in ſuch a manner, that it never ſhut the hole entirely, but left about one third of it open. When this was repeated 720 times in a ſecond, the ſound was uncommonly ſmooth and ſweet. When reduced to 360, the ſound was more mellow than any man's voice at the ſame pitch. Various changes were made in the form of the cock, with the intention of rendering the primitive noiſe more analogous to that produced by a vibrating ſtring. Sounds were produced which were pleaſant in the extreme. The intelligent reader will ſee here an opening made to great additions to practical muſic, and the means of producing muſical ſounds, of which we have at preſent ſcarcely any conception; and this manner of producing them is attended with the peculiar advantage, that an inſtrument ſo conſtructed can never go out of tune in the ſmalleſt degree. But of this enough at preſent.

38
This frequency is expreſſed by the muſical ratios of Pythagoras.

This diſcovery of Galileo's completed the Pythagorean theories, by ſupplying the only thing wanted for procuring confidence in them. We now ſee that the muſic of ſounds depends on principles as certain and as plain as the elements of Euclid, and that every thing relating to the ſcale of muſic is attainable by mathematics. It is very true that we do not perceive the ratio 3 : 2 in the diapente, as having any relation to the numbers 3 and 2. But we perceive the ſweetneſs of ſound which characteriſes this concord. This is undoubtedly the perception of a certain phyſical fact involving this ratio, as much as the ſweetneſs on our tongue is the perception of a certain manner of acting of the particles of ſugar during their diſſolution in the ſaliva.

CONCORD, DISCORD, are properties of particular ratios of frequency.

The pleaſure ariſing from certain conſonances, ſuch as *do ſol*, is not more diſtinctly perceived than is the diſagreeable feeling which other conſonances produce, ſuch as *do re*; and it was a fair field of diſquiſition to diſcover why the one pleaſed and the other diſpleaſed. We cannot ſay that this queſtion has been completely decided. It has been aſcribed to the coincidence of vibrations. In the octave, every ſecond vibration of the treble note may be made to coincide with every vibration of the baſs. But the pleaſure ariſing from the different conſonances does by no means follow the proportions of thoſe coincidences of vibrations; for when two notes are infinitely near to the ſtate which would produce a complete coincidence, the actual coincidence is then exceedingly rare; and yet we know that ſuch ſounds yield very fine harmony. In tuning any concord, when the two notes are very diſcordant, the coinciding vibrations recur very frequently; and as we approach nearer and nearer to perfect concord, theſe coincidences become rarer and rarer; and if it be infinitely near to perfect concord, the coincidences of vibration will be infinitely diſtant from each other. This, and many other irrefragable arguments, demonſtrate that coaleſcence of ſound, which makes the pleaſing harmony of a fifth, for example, does not ariſe from the coincidence of vibrations; and the only thing which we can demonſtrate to obtain in all the caſes where we enjoy this pleaſure, is a certain arrangement of the component pulſes, and a certain law of ſucceſſion of the diſlocations or intervals between the non-coinciding pulſes. We are perfectly able to demonſtrate that when, by continually ſcrewing up one of the notes of a conſonance, we render the real coincidence of pulſes leſs frequent; the diſlocations, or deviations from perfect coincidence, approach nearer and nearer to a certain defineable law of ſucceſſion; and that this law obtains completely, when the perfect ratio of the duration of the pulſe is attained, although perhaps at that time not one pulſe of the one ſound coincides with a pulſe of the other. Suppoſe two organ pipes, ſounding the note C *ſol fa ut*, at the diſtance of ten feet from each other, and that their pulſes begin and end at the ſame inſtants, making the moſt perfect coincidence of pulſes—there is no doubt but that there will be the moſt perfect harmony; and we learn by experience that this harmony is perfectly the ſame, from whatever part of the room we hear it. This is an unqueſtionable fact. A perſon ſituated exactly in the middle between them will receive coincident pulſes. But let him approach one foot nearer to one of the pipes, it is now demonſtrable that the pulſes, at their arrival at his ear, will be the moſt diſtant from coincidence that is poſſible; for every pulſe of one pipe will biſect the pulſe from the other: but the law of ſucceſſion of the deviations from coincidence will then obtain in the moſt perfect manner. A muſical ſound is the ſenſation of a certain form of the aerial undulation which agitates the auditory organ. The perception of harmonious ſound is the ſenſation produced by another definite form of the agitation. This is the compoſition of two other agitations; but it is the compound agitation only that affects the ear, and it is its form or kind which determines the ſenſation, making it pleaſant or unpleaſant.

39
Hence ariſes the great uſe of mathematics in muſic.

Our knowledge of mechanics enables us to deſcribe this form, and every circumſtance in which one agitation can differ from another, and to diſcover general features or circumſtances of reſemblance, which, in fact, accompany all perceptions of harmony. We are ſurely intitled to ſay that theſe circumſtances are ſure teſts of harmony; and that when we have enſured their preſence, we have enſured the hearing of harmony in the adjuſted ſounds. We can even go farther in ſome caſes: We can explain ſome appearances which accompany imperfect harmony, and perceive the connection between certain diſtinct reſults of imperfect coincidences, and the magnitude of the deviations from perfect harmony which are then heard. Thus, we can make uſe of theſe phenomena, in order to aſcertain and meaſure thoſe deviations; and if any rules of temperament ſhould require a certain determinate deviation from perfect harmony in the tuning of an inſtrument, we can ſecure the appearance of that phenomenon which correſponds to the deviation, and thus can produce the preciſe temperament

mpera-
it of the
ale of
Muſic.

rament ſuggeſted by our rules. We can, for example, deſtroy the perfect harmony of the fifth C *g*, and flatten the note *g* till it deviates from a perfect fifth in the exact ratio of 320 to 321, which the muſicians call the one-fourth of a comma. The moſt exquiſite ear for melody is almoſt inſenſible of a deviation four times greater than this; and yet a perſon who has no muſical ear at all, can execute this temperament by the rules of harmony without the error of the fortieth part of a comma.

40
ATINGS
mper-
: conſo-
ces.

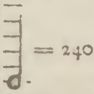
For this moſt valuable piece of knowledge we are indebted to the late Dr Robert Smith of Cambridge, a very eminent geometer and philoſopher, and a good judge of muſic, and very pleaſing performer on the organ and harpſichord. This gentleman, in his Diſſertation on the Principles of Harmonics, publiſhed for the firſt time in 1749, has paid particular attention to a phenomenon in coexiſtent ſounds, called a *beating*. This is an alternate enforcement and diminution of the ſtrength of ſound, ſomething like what is called a cloſe ſhake, but differing from it in having no variation in the pitch of the ſounds. It is a ſort of undulation of the ſound, in which it becomes alternately louder and fainter. It may be often perceived in the ſound of bells and muſical glaſſes, and alſo in the ſounds of particular ſtrings. It is produced in this way: Suppoſe two uniſons quite perfect; the vibrations of each are either perfectly coincident, or each pulſe of one ſound is interpoſed in the ſame ſituation between each pulſe of the other. In either caſe they ſucceed each other with ſuch rapidity, that we cannot perceive them, and the whole appears an uniform ſound. But ſuppoſe that one of the ſounds has 240 pulſes in a ſecond, which is the undulation that is produced in a pipe of 24 inches long; ſuppoſe that the other pipe is only 23 inches and $\frac{7}{10}$ths long. It will give 243 pulſes in a ſecond. Therefore the 1ſt, the 80th, the 160th, and the 240th pulſe of the firſt pipe will coincide with the 1ſt, the 81ſt, the 162d, and the 243d pulſe of the other. In the inſtants of coincidence, the agitation produced by one pulſe is increaſed by that produced by the other. The commencement of the next two pulſes is ſeparated a little, and that of the next is ſeparated ſtill more, and ſo on continually: the *diſlocations* of the pulſes, or their deviations from perfect coincidence, continually increaſing, till we come to the 40th pulſe of the one pipe, which will commence in the middle of the 41ſt pulſe of the other pipe; and the pulſes will now biſect each other, ſo that the agitations of the one will counteract or weaken thoſe of the other. Thus the compounded ſound will be ſtronger at the coincidences of the pulſes, and fainter when they biſect each other. This reinforcement of ſound will therefore recur thrice in every ſecond. The frequency of the pulſes are in the ratio of a comma, or 81 : 80. Therefore this conſtitutes an *uniſon imperfect by a comma.* If therefore any circumſtance ſhould require that theſe two pulſes ſhould form an uniſon imperfect by a comma, we have only to alter one of the pipes, till the two, when ſounded together, beat thrice in a ſecond. Nothing can be plainer than this. Now let us ſuppoſe a third pipe tuned an exact fifth to the firſt of theſe two. There will be no beating obſervable; becauſe the recurrence of coincident pulſes is ſo rapid as to appear a continued ſound. They recur at every ſecond vibration of the baſs, or 120 times in a ſecond. But now, inſtead of ſounding the third pipe along with the firſt, let it ſound along with the ſecond. Dr Smith demonſtrates, that they will beat in the ſame manner as the uniſons did, but thrice as often, or nine times in a ſecond. When therefore the fifth C *g* beats nine times in a ſecond, we know that it is too ſharp or too flat (very nearly) by a comma.

Temperament of the Scale of Muſic.

41
Dr Smith applies them to the ſcience and practice of muſic with great effect.

Dr Smith ſhews, in like manner, what number of beats are made in any given time by any concord, imperfect or tempered, in any aſſigned degree. We humbly think that the moſt inattentive perſon muſt be ſenſible of the very great value of this diſcovery. We are obliged to call it *his* diſcovery. Merſennus, indeed, had taken particular notice of this undulation of imperfect conſonances, and had offered conjectures as to their cauſe; conjectures not unworthy of his great ingenuity. Mr Sauveur alſo takes a ſtill more particular notice of this phenomenon *, and makes a moſt ingenious uſe of it for the ſolution of a very important muſical problem; namely, to determine the preciſe number of pulſes which produce any given note of the gamut. His method is indeed operoſe and delicate, even as ſimplified and improved by Dr Smith. The following may be ſubſtituted for it, founded on the mechaniſm of ſounding cords. Let a violin, guitar, or any ſuch inſtrument, be fixed up againſt a wall, with the finger-board downward, and in ſuch a manner, that a violin ſtring, ſtrained by a weight, may preſs on the bridge, but hang free of the lower end of the finger-board. Let another ſtring be ſtrained by one of the tuning pins till it be in uniſon with ſome note (ſuppoſe C) of the harpſichord. Then hang weights on the other ſtring, till, upon drawing the bow acroſs both ſtrings, at a ſmall diſtance below the bridge, they are perfect uniſons, without the ſmalleſt beating or undulation, and taking care that the preſſure of the bow on that ſtring which is tuned by the pin be ſo moderate as not to affect its tenſion ſenſibly. Note exactly the weight that is now appended to it. Now increaſe this weight in the proportion of the ſquare of 80 to the ſquare of 81; that is, add to it its 40th part very nearly. Now draw the bow again acroſs the ſtrings with the ſame caution as before. The ſounds will now beat remarkably; for the vibrations of the loaded ſtring are now accelerated in the proportion of 80 to 81. Count the number of undulations made in ſome ſmall number (ſuppoſe 10) of ſeconds. This will give the number of beats in a ſecond; 80 times this number are the ſingle pulſes of the loweſt ſound; and 81 times the ſame number gives the pulſes of the higheſt of theſe imperfect uniſons.

Pulſes of



= 240.

If this experiment be tried for the C in the middle of our harpſichords, it will be found to contain 240 pulſes very nearly; for the ſtrings will beat thrice in a ſecond. The beats are beſt counted by means of a little ball hung to a thread, and made to keep time with the beats.

42
They afford exact meaſures of the temperament of concords,

Here, then, is a phenomenon of the moſt eaſy obſervation, and requiring no ſkill in muſic, by which the pitch of any ſound, and the imperfection of any concord, may be diſcovered with the utmoſt preciſion; and by this method may concordant ſounds be produced, which are abſolutely perfect in their harmony, or having any degree of imperfection or temperament that we pleaſe. An inſtrument may generally be tuned to perfect harmony, in ſome of its notes, without any difficulty,

* Mem. Acad. Par. 1701, 1702, 1707, and 1713.

ficulty, as we ſee done by every blind Crouder. But if a certain determinate degree of imperfection, different perhaps in the different concords, be neceſſary for the proper performance of muſical compoſitions on inſtruments of fixed ſounds, ſuch as thoſe of the organ or harpſichord kind, we do not ſee how it can be diſputed, that Dr Smith's theory of the beating of imperfect conſonances is one of the moſt important diſcoveries, both for the practice and the ſcience of muſic, that have been offered to the public. We are inclined to conſider it as the moſt important that has been made ſince the days of Galileo. The only rivals are Dr Brook Taylor's mechanical demonſtration of the vibrations of an elaſtic cord, and its companion, and of the undulations of the air in an organ pipe, and the beautiful inveſtigations of Daniel Bernoulli of the harmonic ſounds which frequently accompany the fundamental note. The muſical theory of Rameau we conſider as a mere whim, not founded in any natural law; and the theory of the grave harmonics by Tartini or Romieu is included in Dr Smith's theory of the beating of imperfect conſonances. This theory enables us to execute any harmonic ſyſtem of temperament with preciſion, and certainty, and eaſe, and to decide on its merit when done.

We are therefore ſurpriſed to ſee this work of Dr Smith greatly undervalued, by a moſt ingenious gentleman in the Philoſophical Tranſactions for 1800, and called a large and obſcure volume, which leaves the matter juſt as it was, and its reſults uſeleſs and impracticable. We are ſorry to ſee this; becauſe we have great expectations from the future labours of this gentleman in the field of harmonics, and his late work is rich in refined and valuable matter. We preſume humbly to recommend to him attention to his own admonitions to a very young and ingenious gentleman, who, he thinks, proceeded too far in animadverting on the writings of Newton, Barrow, and other eminent mathematicians. We alſo beg his leave to obſerve, that Dr Smith's application of his theory may be very erroneous (we do not ſay that it is perfect), in conſequence of his notion of the proportional effects produced on the general harmony by equal temperaments of the different concords. But the theory is untouched by this improper uſe, and ſtands as firmly as any propoſition in Euclid's Elements. We are bound to add to theſe remarks, that we have oftener than once heard muſic performed on the harpſichord deſcribed in the ſecond edition of Dr Smith's Harmonics, both before it was ſent home by the maker (the firſt in his profeſſion), and afterwards by the author himſelf, who was a very pleaſing performer, and we thought its harmony the fineſt we ever heard. Mr Watt, the celebrated engineer, and not leſs eminent philoſopher, built a handſome organ for a public ſociety, and, without the leaſt ear or reliſh for muſic, tuned three octaves of the open diapaſon by one of Dr Smith's tables of beats, with the help of a variable pendulum. Signior Doria, leader of the Edinburgh concert, tried it in preſence of the writer of this article, and ſaid, " Belliſſima – ſopra modo belliſſima!" Signior Doria attempted to ſing along with it, but would not continue, declaring it impoſſible, becauſe the organ was ill tuned. The truth was, that, on the major key of E♭, the tuning was exceedingly different from what ſhe was accuſtomed to, and ſhe would not try another key. We mention this particular, to ſhew how accurately Mr Watt had been able to execute the temperament he intended.

43
And accurate methods of temperament.

This theory is valuable, therefore, by giving us the management of a phenomenon intimately connected with harmony, and affording us preciſe and practicable meaſures of all deviations from it. It bids fair, for this reaſon, to give us a method of executing any ſyſtem of temperament which we may find reaſon to prefer. But we have another ground of eſtimation of this theory. By its aſſiſtance, we are able to aſcertain with certainty and preciſion the true untempered ſcale of muſic, which eluded all the attempts of the ingenious Greeks; and we determine it in a way ſuited to the favourite muſic of modern times, of which almoſt all the excellencies and pleaſures are derived from harmony. We do not ſay that this *total* innovation in the principle of muſical pleaſure is unexceptionable; we rather think it very defective, believing that the thrilling pleaſures of muſic depend more upon the melody or air. We appeal even to inſtructed muſicians, whether the heart and affections are not more affected *(and with much more diſtinct variety of emotion)* by a fine melody, ſupported, but not obſerved, by harmonies judiciouſly choſen? It appears to us that the effect of harmony, always filled up, is more uniformly the ſame, and leſs touching to the ſoul, than ſome ſimple air ſung or played by a performer of ſenſibility and powers of utterance. We do not wonder, then, that the ingenious Greeks deduced all their rules from this department of muſic, nor at their being ſo ſatisfied with the pleaſures which it yielded, that they were not ſolicitous of the additional ſupport of harmony. We ſee that melody has ſuffered by the change in every country. There is no Scotchman, Iriſhman, Pole, or Ruſſian, who does not lament that the ſkill in compoſing heart-touching airs is degenerated in his reſpective nation; and all admire the productions of their muſe of " the days that are paſt." They are " pleaſant and mournful to the ſoul."

But we ſtill prefer the harmonical method of forming the ſcale, on account of its preciſion and facility: and we prefer the theory of beats, *becauſe it alſo gives us the moſt ſatisfactory ſcale of melody*; and this, not by repeated corrections and recorrections, but by a direct proceſs. By a table of beats, every note may be fixed at once, and we have no occaſion to return to it and try new combinations; for the beatings of the different concords to one baſs being once determined, every beating of any one note with any other is alſo fixed.

44
Fundamental experiment.

We therefore requeſt the reader's patient attention to the experiment which we have now to propoſe. This experiment is beſt made with two organ pipes equally voiced, and pitched to the note C in the middle of our harpſichords. Let one of them at leaſt be a ſtopped pipe, its piſton being made extremely accurate, and at the ſame time eaſily moved along the pipe. Let the ſhank of it be divided into 240 equal parts. The advantage of this form of the experiment is, that the ſounds can be continued, with perfect uniformity, for any length of time, if the bellows be properly conſtructed. In default of this apparatus, the experiment may be made with two harpſichord wires in perfect uniſon, and touched by a wheel rubbed with roſin inſtead of a bow, in the way the ſounds of the vielle or hurdygurdy are produced. This contrivance alſo will continue the ſounds uniformly at pleaſure. A ſcale of 240 parts muſt

muſt be adapted to one ſtring, and numbered from that end of the ſtring where the wheel or bow is applied to it. Great care muſt be taken that the ſhifting of the moveable bridge do not alter the ſtrain on the wire. We may even do pretty well with a bow in place of the wheel; but the ſound cannot be long held on in any pitch. In deſcribing the phenomena, we ſhall rather abide by the ſtring, becauſe the numbers of the ſcale, or length of the ſounding part of the wire, correſpond, in fact, much more exactly with the ſounds. The deviations of the ſcale of the pipe do not in the leaſt affect the concluſions we mean to draw, but would require to be mentioned in every inſtance, which would greatly complicate the proceſs.

Having brought the two open ſtrings into perfect uniſon, ſo that no beating whatever is obſerved in the conſonance, ſlide the moveable bridge ſlowly along the ſtring while the wheel is turning, beginning the motion from the end moſt remote from the bow. All the notes of the octave, and all kinds of concords and diſcords, will be heard; each of the concords being preceded and followed by a ruffling beating, and that ſucceeded by a grating diſcord. After this general view of the whole, let the particular harmonious ſtations of the bridge be more carefully examined as follows.

45 Determination of the octave, and character of the concord.

I. Shift the moveable bridge to the diviſion 120. If it has been exactly placed, we ſhall hear a perfect octave without any beating. It is, however, ſeldom ſo exactly ſet, and we generally hear ſome beating. By gently ſhifting the bridge to either ſide, this beating becomes more or leſs rapid; and when we have found in which direction the bridge muſt be moved, we can then ſlide it along till the beating ceaſe entirely, and the ſounds coaleſce into one ſound. We can ſcarcely hear the treble or octave note as diſtinguiſhable from the baſs or fundamental afforded by the other ſtring. If the notes are duly proportioned in loudneſs, we cannot hear the two as diſtinct ſounds, but a note ſeemingly the ſame with the fundamental, only more brilliant. (*N B.* It would be a great improvement of the apparatus to have a micrometer ſcrew for producing thoſe ſmall motions of the bridge.)

Having thus produced a fine octave, we can now perceive that, as we continue to ſhift the bridge from its proper place, in either direction, the beating becomes more and more rapid, changes to a violent rattling flutter, and then degenerates into a moſt diſagreeable jar. This phenomenon is obſerved in the deviation of every concord whatever from perfect harmony, and muſt be carefully kept in remembrance.

46 Harmony more ſtrict than melody.

Before we quit this concord, the octave, produced by the biſection of the pipe or ſtring, we muſt obſerve, that, with reſpect to ourſelves, the octave $c\bar{c}$ muſt beat almoſt twice in a ſecond, before we can obſerve clearly any miſ-tune in it, by ſounding the notes in ſucceſſion, or as ſteps in the ſcale of melody. We never knew any ear ſo nice as to diſcover a miſ-tuning when it beats but once in three ſeconds. We think ourſelves intitled therefore to ſay, that we are inſenſible of a temperament in melody amounting to one third of a comma; and we never knew a perſon ſenſible of a temperament half this bulk

When the imperfection of the octave is clearly ſenſible by ſounding the notes in ſucceſſion, it is extremely diſagreeable, feeling like a ſtruggle or endeavour to attain a certain note, and a failure in the attempt. This ſeems owing to the familiar ſimilarity of octaves, in the habitual talking and ſinging of men and women together. But when the notes are ſounded together, although we are not much more ſenſible of the imperfection of the harmony directly, as a failure in the ſweetneſs of the concord, we are very ſenſible of this phenomenon of beating; and any perſon who can diſtinguiſh a weak ſound from a ſtronger one, can eaſily perceive, in this indirect manner, any fraction of a comma, however minute. This makes the tuning by harmony much more exact than by melody alone. It is alſo much more accommodated to the genius of modern muſic. The ancients had favourite paſſages, which were frequently introduced into their airs, and they were ſolicitous to have theſe in good tune. It appears from paſſages in the writings of Galen, that different performers excelled chiefly in their ſkill in making thoſe occaſional temperaments which their muſic required. Our muſic is much more ſtrict, by reaſon of our harmonic accompanyments, which are an abominable noiſe when miſ-tuned in a degree, which would have paſſed with the ancients for very good melody. Ariſtoxenus ſays, that the ear cannot diſcover the error of a comma. This would now be intolerable.

47 It gives the beſt ſcale for melody.

But another advantage attends our method. We obtain, by its aſſiſtance, the moſt perfect ſcale of melody; perfect in a degree attainable only by chance by the Greeks. This is now to be our buſineſs to unfold.

48 Determination of the Vth.

II. Set the moveable bridge at 158, and ſound the two ſtrings. They will beat very diſagreeably, being plainly out of tune. Slide it gradually toward 160, and the beats will grow ſlower and ſlower; will change to a gentle and not unpleaſant undulation; and at laſt, when the bridge is at 160, will vaniſh entirely, and the two ſounds will coaleſce into one ſweet concord, in which neither of the component ſounds can be diſtinguiſhed. If the ſound given by the ſhort ſtring be now examined as a ſtep in the ſcale of melody, it will be found a fifth to the ſound of the long ſtring or fundamental note, perfectly ſatiſfactory to the niceſt ear. Thus one ſtep of the ſcale has been aſcertained.

III. Slide the bridge ſlowly along the ſtring. The beating will recommence, will become a flutter, and then a jarring noiſe; and will again change to an angry flutter, beating about eight times in a ſecond, when the bridge ſtands at 169 nearly. Puſhing it ſtill on, but very ſlowly, the flutter will become an indiſtinct jarring noiſe; which, by continuing the motion, will again become a flutter, or beat about ſix in the ſecond. The bridge is now about 171.

49 Determination of the 4th.

IV. Still continuing the motion, the flutter becomes a jarring noiſe, which continues till the bridge is near to 180, when the rapid flutter will again be heard. This will become ſlower and ſlower as we approach to 180; and when the bridge reaches that point, all beating vaniſhes, and we have a ſoft and agreeable concord, but far inferior to the former concord in that cheering ſweetneſs which characteriſes the fifth. When this note is compared with that of the fundamental ſtring as a ſtep in the ſcale of melody, it is found to correſpond to the note *fa*, or the fourth ſtep in the ſcale, and in that employment to give complete ſatisfaction to the ear.

V. Still advancing the moveable bridge toward the nut, we ſhall hear the beatings return again ; and after fluttering and degenerating to a jarring noiſe, by a very ſmall motion of the bridge, they will again be heard, will grow ſlower, accompanied with a ſort of angry expreſſion, and will ceaſe entirely when the bridge reaches the 192d diviſion of our ſcale. Here we have another concord of very peculiar character, being remarkably enlivening and gay. This ſound gives perfect ſatisfaction to the ear, if employed as the third ſtep in the ſcale of melody, being the note *mi* of that ſeries, at leaſt in all gay or cheerful airs.

50 Determination of the IIId.

51. VI. As we move the bridge from 192 to 200, we hear again the ſame beatings, which, in the immediate vicinity to 192, have a peeviſh fretful expreſſion, inſtead of the angry waſpiſh expreſſion before mentioned. When the bridge has paſſed that ſituation which produces only grating diſcordance, we hear the beatings again, and they become ſlower, and ceaſe altogether when the bridge arrives at 200. Here we have another conſonance, which muſt be called a *concord*, becauſe it is rather agreeable than otherwiſe, but ſtrongly marked by a mournful melancholy in the expreſſion. In the ſcale of melody, it forms the third ſtep in thoſe airs which expreſs lamentation or grief. It is called the *minor third*, to diſtinguiſh it from the laſt enlivening concord, which, being a larger interval, is called the *major third*.

52 Determination of the 3d.

It is well known, that theſe two thirds give the diſtinguiſhing characters to the only two modes of melodious compoſition that are admitted into modern muſic. The ſeries containing the major third is called the *major*, and that containing the minor third is called the *minor mode*. It is worthy of remark, that the fanatical preachers, in their conventicles and field ſermons, affect this mode in their harangues, which are often diſtinctly muſical, modulating entirely by muſical intervals, and keeping the whole of their chaunt in ſubordination to a fundamental or key note. This is not unnatural, when we conſider the general ſcope of their diſcourſes, namely, to inſpire melancholy and humiliating thoughts, awakening ſorrow, and the like. It is not ſo eaſy to account for the uſual whine of a beggar, who generally craves charity in the major third. This is the caſe, at leaſt, in the northern parts of this iſland.

53. If we continue to ſhift the bridge ſtill nearer to the end of the ſtring, we ſhall hear nothing but a ſucceſſion of vile diſcordant noiſes, ſomewhat leſs offenſive when the bridge is about the diviſions 213 and 216, but even there very unpleaſant.

54 Determination of the 6th.

VII. Let us therefore change our manner of proceeding a little, and again place the bridge at 160, which will give us the pleaſing concord of the fifth. Inſtead of puſhing it from that place toward the nut, let it be moved toward the wheel or bow. Without repeating what we have ſaid of the reappearance of the beatings, their acceleration, and their degenerating into a jarring diſcord, to be afterwards ſucceeded by another beating, &c. &c. we ſhall only obſerve, that when we place the bridge at 150, we have no beatings, and we hear a conſonance, which is in a ſlight degree pleaſant, and may therefore be called a *concord*. It has the other marks of a concord which we have been making ſo much uſe of ; for the beatings recommence when we ſhift the bridge to either ſide of 150. This note makes the ſixth ſtep in the deſcending ſcale of mournful melody ; that is, when we are paſſing from the acute to the graver notes, with the intention of putting an emphaſis on the third and the fundamental. Although not eminent as a concord with the fundamental alone, it has a moſt pleaſing effect when liſtened to in ſubordination to the whole ſeries, or when ſounded along with other proper accompanyments of the fundamental.

55 Determination of the VIth.

VIII. Placing the bridge at 144, we obtain another very pleaſing concord, differing in its expreſſion from any of the foregoing. We find it difficult to expreſs its character. It is greatly inferior to the fifth in ſweetneſs, and to the major third in gaiety, but ſeems to poſſeſs, in a lower degree, both of thoſe qualities. In the ſcale of cheerful melody, it is the ſixth note, which we have diſtinguiſhed by the ſyllable *la*. It is alſo uſed even in mournful melody, when we are aſcending, with the intention of cloſing with the octave.

56 Scale of the upper octave.

In ſhifting the bridge from 144 to 120, we obtain nothing but diſcordant, or at leaſt diſagreeable conſonances. And, laſtly, if we move the bridge beyond 120, to diviſions which are reſpectively the halves of thoſe numbers which produced the concords already treated of, we obtain the ſame ſteps in the ſcale of the upper octave. Thus if the bridge be at 80, we have the fifth to the octave note, or twelfth to the fundamental. If it be at 60, we obtain the double octave, &c. &c. &c.

57 Characters of the different concords.

We have perhaps been raſh in affixing certain moral or ſentimental characters to certain concords ; for we have ſeen inſtances of perſons who gave them different denominations ; but theſe were never contradictory to ours, but always expreſſed ſome ſentiment allied to that which we have aſſigned. We never met with an inſtance of a perſon capable of a little diſcriminating reflection, who did not acknowledge a manifeſt ſentimental diſtinction among the different concords which could not be confounded. We doubt not but that the Greeks, a people of exquiſite ſenſibility to all the beauties of taſte and ſentiment, paid much attention to theſe characters, and availed themſelves of them in their compoſitions. We do not think it at all unlikely, that greater effects have been produced by their muſic, which was ſtudied with this expreſs view, than have ever been produced by the modern muſic, with all the addition of harmony. We have allowed too great a ſhare of our attention to mere harmony. Our great authors are much leſs ſolicitous to compoſe an enchanting air, than to conſtruct a full ſcore of rich and well conducted harmony. We do not profeſs to be nice judges in muſical compoſition, but we may tell what we ourſelves experience. We find our minds worked up by a continuance of fine harmony into a *general* ſenſibility ; into a frame of mind which would prepare and fit us for receiving ſtrong impreſſions of moral ſentiment, if theſe were diſtinctly made. But we have ſeldom felt any diſtinct emotions excited by mere inſtrumental muſic. And when the harmonies have been merely to ſupport the performance of a voice, the words have been either ſo frittered by muſical diviſions, as to become in ſome meaſure ludicrous—or have been ſo indiſtinct, and made ſo trifling a part of the muſic, that there was nothing done to give a particular ſhape to the moral impreſſion on our mind. We have generally been ſtrongly affected by ſome of the anthems which were in vogue in former times ; and we think that we perceived the cauſe

of

npera- t of the ale of lufic. of this difference: There was a great ſimplicity in the voice parts: the ſyllables were not drawled out into long muſical phraſes, but pronounced nearly according to their proper quantities; ſo that the ſentiment of the ſpeaker was expreſſed with all the force of good declamation, and the harmony of the accompanyment then ſtrengthened the appropriate effect of the melody. We mean not to offer theſe obſervations as of much authority, but merely to mention ſome facts, and to aſſign what we felt to be their cauſes, in order to promote, in ſome degree, however inſignificant, the cultivation of muſical ſcience. With this view, we venture to ſay, that ſome of the beſt compoſitions of Knapp of York *uniformly* affect us more than the more admired anthems of Bird and Tallis. A cadence, which Knapp gives almoſt entirely to the melody, is laboured by Bird or Tallis with all the rules of art; and you have its characters of perfect or imperfect, full or diſappointed, cadences, and ſuch an apparatus of preparation and reſolution of diſcords, that you foreſee it at the diſtance of ſeveral bars, and then the part aſſigned to the voice ſeems a very trifle, and merely to fill up a blank in the harmony. Such compoſitions ſmell of the lamp, and fail of their purpoſe, that of charming the *learned* ear. But enough of this digreſſion.

58. Thus have we found a natural relation between certain ſounds ſtrongly marked by very preciſe characters. The concordance of ſound is marked by the abſence of all undulation, and the deviations from this harmony are ſhewn to be meaſurable by the frequency of thoſe undulations. We have alſo found, that the notes, which are thus harmonious along with the fundamental, are ſteps in the ſcale of natural muſic (for we muſt acknowledge melody to be the primitive muſic, dictated by nature). We have got the notes *do—mi*, *fa*, *ſol*, *la—do*, aſcertained in a way that can no longer be miſtaken.

59 ios belonging to con- s, &c. Let us now examine what phyſical or mechanical relations theſe ſounds ſtand into each other. Our monochord gives us the lengths of the ſtrings; and the diſcovery of Galileo ſhews us, that theſe are alſo the durations of the aëreal pulſes which produce the ſenſations of muſical notes. Their ratios may therefore be truly called the ratios of the ſounds. Now we ſee that the ſtrings which produce the ſounds *do ſol* are 240 and 160. Theſe are in the ratio of 3 to 2. In this manner we may ſtate all the ratios obſerved in our experiment, *viz.*

Do : *mi* have the ratio of	240 to 192, or of	5 to 4
Do : *fa*	240 : 180	4 : 3
Do : *ſol*	240 : 160	3 : 2
Do : *la*	240 : 144	5 : 3
Mi : *ſol*	192 : 160	6 : 5, = *do* : *mi*♭
Fa : *ſol*	180 : 160	9 : 8
Sol : *la*	160 : 144	10 : 9
Mi : *fa*	192 : 180	16 : 15

Here we get the ſight of all the ratios which the ingenious and unwearied ſpeculations of the Greek mathematicians enliſted into the ſervice of muſic, without being able to give a good reaſon why. The ratio 5 : 4, which their faſtidious metaphyſicians rejected, and which others wiſhed to introduce from motives of mere neceſſity to fill up a blank, is pointed out to us by one of the fineſt concords. The interval between the fourth and the fifth is, *very fortunately*, a ſtep of the ſcale.

The next ſtep *ſol la* is more important. For the ear for melody would have been very well ſatisfied with an interval equal to *fa ſol*. or 9 : 8; but if the moveable bridge be ſet at the diviſion 142$\frac{2}{9}$, correſponding to ſuch a ſtep, we ſhould have a very offenſive fluttering. It is reaſonable therefore to conclude, *from analogy*, that the interval *ſol la* does not correſpond to the ratio 9 : 8; and that 10 : 9, which is, at leaſt, equally ſatisfactory to the ear, is the proper ſtep, even in the ſcale of melody. If we conſider what may be called the ſcale of harmony, there is no room left for doubt. To enjoy the greateſt poſſible pleaſure of harmony, we muſt not only take each note as it is related to the fundamental, but alſo as it is related to other notes of the ſcale. It may chance to be convenient to aſſume, for the fundamental of our occaſional ſcale of modulation, the ſtring of the lyre which is tuned as *fa* to its proper fundamental; or it may increaſe the harmony (and we know that it does), if we accompany the note *do* with both of the notes *fa* and *la*. To have the fine concord of the major third, it is neceſſary that the interval *fa la* be equivalent to the ratio 5 : 4. Now *fa* is 180, and 5 : 4 = 180 : 144. Therefore, by making the ſtep *ſol la* equal to 9 : 8, we ſhould loſe this agreeable concord, and get diſcord in its place.

Temperament of th Scale of Muſic.

60 Obſervations on the ſtep *la*.

And thus is evinced, in oppoſition to Ariſtoxenus, the propriety of having both a major and a minor tone: the firſt expreſſed by 9 : 8, and the laſt by 10 : 9. The difference between theſe ſteps is the ratio 81 : 80, called a comma by the Greek theoriſts.

61 Determination of the VIIth. We ſtill want two ſteps of the ſcale, and two ſounds or notes correſponding to them, namely *re* and *ſi*; and we wiſh to eſtabliſh them on the ſame authority with the reſt. We ſee that this cannot be done by a concordance with the fundamental *do*. The ear ſufficiently informs us that the ſteps *do re* and *la ſi* muſt be tones, and not ſemitones, like *mi fa*. The ſenſible ſimilarity of the two tetrachords *do re mi fa* and *ſol la ſi do*, alſo teaches us that the ſtep *ſi do* ſhould be a ſemitone like *mi fa*. This ſeems to be all that mere melody can teach us. But we have little information whether we ſhall make *la ſi* a major or a minor tone. If we copy the tetrachord *do re mi fa* exactly, we ſhall make the ſtep *ſi do* like *mi fa*, and equivalent to the ratio 16 : 15. This requires the moveable bridge to be placed at 128. The ſound produced by this diviſion is perfectly ſatisfactory to the ear as a ſtep of the ſcale of melody. Moreover, our ſatisfaction is not confined to the compariſon of it with the note *do*, into which we ſlide by this gentle ſtep. It makes agreeable melody when uſed as the third to the note *ſol*. If we examine it mathematically, we find it a perfect major third to *ſol*; for *ſol* requires the 160th diviſion. Now 160 : 128 = 5 : 4, which is the ratio of the pulſes of a major third. All theſe reaſons ſeem enough to make us adopt this determination of the note *ſi*.

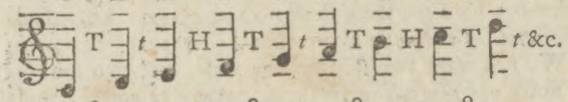
62 Determination of the IId. It remains to conſider how we ſhall divide the interval *do—mi*. It is a perfect major third. So is *fa la*, and ſo is *ſol ſi*. But in the firſt of theſe two, we have ſeen that it muſt be compoſed of a major tone with a minor tone above it; and in the ſecond we have a minor tone followed by a major tone above. We are left uncertain therefore whether *do re* ſhall reſemble *fa la* or *ſol ſi* in the poſition of its two parts. Ariſtoxenus and his followers declared the ear to be equally pleaſed with both. Ptolemy's *Syſtema Diatonicum Intenſum* makes *do re* a major tone, and other ſyſtems make it a minor. E-

even

ven in modern times it has been conſidered as uncertain; and the only reaſon which we have to offer for a preference of the major tone for the firſt ſtep is, that, ſo far as we can judge by our own feelings, the ſounds in the relation of 9 : 8 are leſs diſcordant than ſounds in the relation of 10 : 9, and becauſe all the other ſteps have been determined by means of concords with the key. We refer, for a more particular examination of the principles on which theſe arrangements are valued, to *Dr Smith's Harmonics*, Prop. I. where he ſhews how one is preferable to another, in proportion as it affords a greater number of perfect concords among the neighbouring notes, which is the favourite object in all modern muſic. Upon this principle our arrangement is by far the beſt, becauſe it admits five more concords in the octave than the other. But we have conſidered the ſubject in a different manner, merely to avail ourſelves of the phenomenon by which all the ſteps, except one, ſeem to be naturally aſcertained, and by which the connection between harmony and melody ſeems to be pointed out to us.

63. It will be convenient to repreſent the tones major and minor and the hemitone, by the ſymbols T, *t*, and H. Alſo to mark the notes by the Roman numerals, or by cyphers, according as they are the extremes of major or minor intervals. By this notation the octave may be repreſented thus:

C D E F G A B *c* *d* *e*



$\frac{8}{9}$ $\frac{9}{10}$ $\frac{15}{16}$ $\frac{8}{9}$ $\frac{9}{10}$ $\frac{8}{9}$ $\frac{15}{16}$ $\frac{8}{9}$ &c.

K II III 4 V VI VII VIII IX X &c.

The reader will remark, that the primary diviſions which we aſſigned to the repreſentation of an octave in fig. 1. by the circumference of a circle, are in conformity to this Ptolemaic partition of the octave. He will alſo be ſenſible, that the diviſion into five equal mean tones and two equal hemitones, which is expreſſed by the dotted lines, agreeing with the Ptolemaic diviſion only at C and E, is effected by biſecting the arch CE; and therefore the deviation of the ſound ſubſtituted for the Ptolemaic D is half the difference of CD and DE, that is, half a comma. The deviations therefore at F, G, A, and B, are each a quarter of a comma.

Logarithmic meaſures of the muſical intervals.

It is well known, that if the logarithm of the length of one ſtring be ſubtracted from that of another, the difference is a meaſure of the ratio between them. Therefore 30103 is the meaſure of the muſical interval called the octave, and then the meaſures of the

Comma	540 or	54
Hemitone	2803	280
Minor tone	4576	458
Major tone	5115	512
3d	7918	792
IIId	9691	969
4th	12494	1249
Vth	17609	1761
6th	20412	2041
VIth	22185	2219
VIIth	27300	2730
VIIIth	30103	3010

This is a very convenient circumſtance. If we take only the four firſt figures as integers, and make the octave conſiſt of 3010 parts, we have a ſcale more exact than the niceſt harmony requires. The circumference of a circle may be ſo divided into 301 degrees, and the moveable circle have a nonius, ſubdividing each into 10. Or it may be divided into 55,8 degrees, each of which will be a comma. Either of theſe diviſions will make it a moſt convenient inſtrument for expeditiouſly examining all temperaments of the ſcale that can be propoſed. Or a ſtraight line may be ſo divided, and repeated thrice. Then a ſliding ruler, divided in the ſame manner, and applied to it, will anſwer the ſame purpoſe. We ſhall ſee many uſeful employments of theſe inſtruments by and by.

64. Having thus endeavoured to communicate ſome plain notion of the formation and ſingular nature of that gradation of ſounds which produces all the pleaſures of muſic, and of the manner of obtaining the ſteps of this gradation with certainty and preciſion, we proceed to conſider how thoſe muſical paſſages may be performed on ſuch keyed inſtruments as the organs and harpſichords, as they are now conſtructed. Theſe inſtruments have twelve ſounds and intervals in every octave, in order that an air may be performed in any pitch; that is, taking any one of the ſounds as a key note. It is plain that this cannot be done with accuracy; for we have now ſeen that the interval *mi fa* is bigger than half of *do re* or *re mi*, &c. and therefore the intercalary ſound formerly mentioned to be inſerted between C and D, D and E, &c. will not do indiſcriminately for the ſharp of the ſound below and the flat of the ſound above it. When the tones are reduced to a mean ſize, the ear is ſcarcely ſenſible of the change in melody, and the harmony of the fifths and fourths is not greatly hurt. But when the half notes are inſerted, and employed to make up harmonious intervals, as recommended by Zarlino, the harmony is very coarſe indeed.

65 Why temperament neceſſary.

But we muſt make the reader ſenſible of the neceſſity of ſome temperament, even independent of thoſe artificial notes. Therefore

Let the ſcholar tune upwards the four Vths $c\,g$, $g\,\bar{d}$, $\bar{d}\,\bar{a}$, $\bar{a}\,\bar{\bar{e}}$, all perfect, admitting no beating whatever. This is eaſily done, either with the organ or the wheel monochord already deſcribed. Then tune downwards the perfect octaves $\bar{\bar{e}}\,\bar{e}$, $\bar{e}\,e$. Now examine the IIId $c\,e$ which reſults from this proceſs. If the inſtrument be of the pitch hitherto ſuppoſed (*c* making 240 pulſes in a ſecond), this IIId will be heard beating 15 times in a ſecond, which is a diſcordance altogether intolerable, the note *e* being too ſharp in the ratio of 81 to 80, which makes a comma. It is eaſily found, by calculation, that *e* makes $303\frac{1}{4}$ pulſes, inſtead of 300, required for the IIId to *c*.

N. B. It may not be amiſs to inform our readers, that if any concord, whoſe perfect ratio is $\frac{m}{n}$ (*m* being the greateſt term of the ſmalleſt integers expreſſing that ratio), be tempered ſharp by the fraction $\frac{p}{q}$ of a comma, and if M and N be the pulſes made by the acute and grave notes of the concord during any number of ſeconds, the number *b* of beats made in the ſame time by this concord will be $= \frac{2\,q\,m\,N}{161\,p - q}$, or $\frac{2\,q\,n\,M}{161\,p + q}$; and npera- t of the ale of ſuſic.

and if it be tempered flat, then $b = \frac{2\,q\,m\,\mathrm{N}}{161\,p+q}$, or $\frac{2\,q\,n\,\mathrm{M}}{161\,p-q}$ (*Smith's Harm.* 2d edit. p. 82, &c.)

66. It is impoſſible, therefore, to have perfect Vths and perfect IIIds at the ſame time. And it will be found, that the 3d *e g* reſulting from this proceſs, and the VIth $c\,\bar{a}$, are ſtill more diſcordant, rattling at an intolerable rate. Now the major and minor thirds, alternately ſucceeding each other, form the greateſt part of our harmonies; and the VIth is alſo a very frequent accompanyment. It is neceſſary therefore to ſacrifice ſomewhat of the perfect harmony of the Vths, in order that we may not be diſguſted with the diſcord of thoſe other harmonies: and it is this mutual accommodation, and not the changes made neceſſary by the introduction of intercalary notes, which is properly called TEMPERAMENT. It will greatly aſſiſt us in underſtanding the effects of the temperaments of the different concords, if we examine all the diviſions of the circular repreſentation of the octave and muſical ſcale given in fig. 1. by placing the index of the moveable circle on that note of the outer circle for which we want the proper harmonies, or accompanyments, which are either the IIId and Vth, or the 4th and VIth. We ſhall thus learn, in the *firſt* place, the deviations of the different perfect notes of the ſcale from the notes required for this new fundamental; and we muſt then ſtudy what effect the ſame temperament produces on the agreeableneſs of the harmony of different concords having the ſame baſs or the ſame treble, taking it for granted that the hurt to the harmony of any individual concord is proportional to its temperament.

67 w this y be ob- ed by beats.

It is in this delicate department of muſical ſcience that we think the great merit of Dr Smith's work conſiſts. We ſee that the deviation from perfect harmony is always accompanied with beats, and increaſes when they increaſe in frequency—whether it increaſes in the ſame proportion may be a queſtion. We think that Dr Smith's determination of the equality of imperfect harmony in his 13th propoſition includes every mathematical or phyſical circumſtance that appears to have any concern in it. What relates immediately to our ſenſations is, as yet, an impenetrable ſecret. The theory of beats, as delivered by this author, affords very eaſy, though ſometimes tedious, methods of meaſuring and of enſuring all the varieties which can obtain in the beating of imperfect conſonances. It appears to us therefore very unjuſt to ſay, with the late writer in the Philoſophical Tranſactions, that this obſcure volume has left the matter where it found it. The author has given us *effective* principles, although he may have been miſtaken in the application; which however we are far from affirming. Our limits will not allow us to give any account of that theory; and indeed our chief aim in the preſent article is to give a method of temperament which requires no ſcientific knowledge of the ſubject. But we could not think of loſing the opportunity of communicating, by the way, to unlearned perſons, ſome more diſtinct notions of the ſcale of muſical ſounds, and of its foundation in nature, than ſcholars uſually receive from the greater number of mere muſic maſters. The acknowledged connection of the muſical ratios with the pleaſures of harmony and melody, has (we hope) been employed in an eaſy and not obſcure manner; and the phenomena which we have faithfully narrated, ſhew plainly that, by diminiſhing the rattling undulations of tempered concords, we are certain of improving the harmony of our inſtruments. We ſhall proceed therefore on this principle for the uſe of the mere performer, but at the ſame time introducing ſome very ſimple deductions from Smith's theory, for which we expect the thanks of all ſuch readers as wiſh to ſee a little of the reaſons on which they are to proceed.

Tempera-ment of the Scale of Muſic.

68 Method in practice.

The experiment, of which we have juſt now given an account, ſhews that four conſecutive fifths compoſe a greater interval than two octaves and a major third. Yet, in the conſtruction of our muſical inſtruments of fixed ſounds, they muſt be conſidered as of equal extent; ſince we have 7 half intervals in the Vth, and 12 in the octave, and four in the IIId, four Vths contain 28, and two octaves contain 24; and theſe, with the four which compoſe a IIId, make alſo 28. It is plain, therefore, that whatever we do with the IIIds, we muſt leſſen the Vths. If therefore we keep the IIId perfect, we muſt leſſen each of the Vths by $\frac{1}{4}$th of a comma; for we learned, by the beating of the imperfect IIId *c e*, that the whole exceſs of the four Vths was a comma. Therefore the Vth *c g* muſt be flattened $\frac{1}{4}$th of a comma. But how is this to be done with accuracy? Recollect the formula given a little ago, where the number of beats b in any number of ſeconds is $= \frac{2\,q\,m\,\mathrm{N}}{161 \times p+q}$. In the preſent caſe $q = 1$, $m = 3$, $\mathrm{N} = 240$ per ſecond, and $p = 4$. Therefore the formula is $= \frac{2 \times 3 \times 240}{161 \times 4 + 1} = \frac{1440}{645} = 2{,}25$ in a ſecond, or 9 beats in four ſeconds very nearly.

In like manner, the next Vth $g\,\bar{d}$ muſt be flattened $\frac{1}{4}$th of a comma, by making it beat half as faſt again, or $13\frac{1}{2}$ beats in four ſeconds (becauſe in this Vth $\mathrm{N} = 360$). But as this beating is rather too quick to be eaſily counted, it will be better to tune downwards the perfect octave *g* G, which will reduce N to 180 for the Vth G *d*. This will give us 1,68 per ſecond, or 10 beats in 6 ſeconds very nearly.

There is another way of avoiding the employment of too quick beats. Inſtead of tuning the octave *g* G, make *c* G beat as often as *c g*. This is even more exactly an octave to *g* than can be eſtimated by a good ear. Dr Smith has demonſtrated, that when a note makes a minor concord with another note below it, and therefore a major concord with the octave to that note, it beats equally with both; but if the major concord be below, it beats twice as faſt with the octave above. Now, in the preſent caſe, *c g* is a Vth, and *c* G a 4th. For the ſame reaſon *c f* would beat twice as faſt as *c* F.

In the next place, the Vth $d\,\bar{a}$ muſt be made to beat flat 15 times in 6 ſeconds.

In like manner, inſtead of tuning upward the Vth $\bar{a}\,\bar{\bar{e}}$, tune downward the octave $\bar{a}\,a$, and then tune upward the Vth *a e*, and flatten it till it beat 15 times in 8 ſeconds.

If we take 15 ſeconds for the common period of all theſe beats, we ſhall have

The beats of $cg = 34$.
$Gd = 25$.
$\bar{d}a = 37\frac{1}{2}$.
$ae = 28$.

69. We ſhall now find ce to be a fine IIId, without any ſenſible beating; and then we proceed in the ſame way, always tuning upward a perfect Vth; and when this would lead us too high, and therefore produce too quick beating, we ſhould tune downward an octave. Do this till we reach b※, which ſhould be the ſame with $\bar{c}$, or a perfect octave above c. This will be a full proof of our accurate performance. But the beſt proceſs of tuning is to ſtop when we get to g※. Then we tune Vths downward from c, and octaves upward when the Vths would lead us too low. Thus we get cF, Ff, fb^b, $b^b \bar{b}^b$, $\bar{b}^b e^b$, and thus complete the tuning of an octave. We take this method, inſtead of proceeding upwards to $\bar{b}$※; becauſe thoſe notes marked ſharp or flat are, when tuned in this way, in the beſt relation to thoſe with which they are moſt frequently uſed as IIIds.

70 Uſe of a variable pendulum. This proceſs of temperament will be greatly expedited by employing a little pendulum, made of a ball of about two ounces weight, ſliding on a light deal rod, having at one end a pin hole through it. To prepare this rod, hang it up on a pin ſtuck into the wainſcoting, and ſlide the ball downward, till it makes 20 vibrations in 15″, by comparing it with a houſe clock. In this condition mark the rod at the upper edge of the ball. In like manner, adjuſt it for 24, 28, 32, 36, 40, 44, 48, vibrations, making marks for each, and dividing the ſpaces between them by the eye, noticing their gradual diminution. Then, having calculated the beats of the different Vths, ſet the ball at the mark ſuited to the particular concord, and temper the ſound till the beats keep pace exactly with the pendulum.

71 Abſolute number of pulſes how known. But, previous to all this, we muſt know the number of pulſes made in a ſecond by the C of our inſtrument. For this purpoſe we muſt learn the pulſes of our tuning fork. To learn this, a harpſichord wire muſt be ſtretched by a weight till it be uniſon or octave below our fork: then, by adding $\frac{1}{10}$th of the weight to what is now appended, it will be tempered by a comma, and will beat, when it is ſounded along with the fork; and we muſt multiply the beats by 80: The product is the number of pulſes required. And hence we calculate the pulſes of the C of our inſtrument when it is tuned in perfect concord with the fork.

The uſual concert pitch and the tuning forks are ſo nearly conſonant to 240 pulſes for C, that this proceſs is ſcarcely neceſſary, a quarter of a tone never occaſioning the change of an entire beat in any of our numbers.

72 Syſtem of temperament with perfect IIId. The intelligent reader cannot but obſerve, that this ſyſtem of tuning with perfect IIds, which is preferred to all others by many great maſters, is the one repreſented by our circular figure of the octave. The IIId is there perfect, and the Vth CG is deficient by a quarter of a comma. We cannot here omit taking notice of a moſt valuable obſervation of Dr Smith's on this temperament, and, in general, on any diviſion of the octave into mean tones and equal limmas.

73 Proportional variations of temperament. The octave being made up of five mean tones and two limmas, it is plain that, by enlarging the tones, we diminiſh the limmas, and that the increment of the tone is two fifths of the contemporaneous diminution of the limma. If, therefore, we employ the ſymbol v to expreſs any minute variation of this temperament, and make the increment of a mean tone $= 2v$, the contemporaneous variation which this induces on a limma will be $= -5v$; and if the tone be diminiſhed by the ſame quantity $-2v$, the limma will increaſe by the quantity $5v$. Let us ſee what are the contemporaneous changes made on all the intervals of the octave when the tone is diminiſhed by $2v$.

1. A Vth is made up of three tones and a limma. Therefore the variation of its temperament is $= -6v + 5v$, or is $= -v$. That is, the Vth is flattened from its former temperament, whatever that may have been, by the quantity $-v$. Conſequently the 4th, which is always the complement of the Vth to the octave, has its temperament ſharpened by the quantity v.

2. A IId, being a tone diſtant from the fundamental, has its temperament changed by $-2v$.

Therefore a minor 7th is raiſed by $2v$.

3. A minor 3d is made up of a tone and a limma: therefore its variation is $= -2v + 5v$, or $= 3v$.

Therefore a major VIth (its complement) loſes $-3v$.

4. A maj. IIId, or two tones, has its variation $= -4v$.

Therefore a minor 6th has its variation $= 4v$.

5. A maj. VIIth, the complement of a limma has $-5v$.

6. A tritone, or IVth. muſt have the variation $= -6v$.

Therefore the falſe 5th muſt have - - - $6v$.

74 Geometrical conſtruction founded on this. From this obſervation, Dr Smith deduces the following ſimple mathematical conſtruction: In the ſtrait line CE (fig. 2.) take the ſix equal parts Cg, gd, da, aE, Eb, bt, and draw through the points of diviſion the ſix parallel lines gG, dD, &c. Let theſe lines repreſent ſo many ſcales of the octave, ſo placed that the points C, g, d, &c. may repreſent the points C, g, d, &c. of the circular ſcale in fig. 1. where it is cut by the dotted lines repreſenting the ſyſtem of mean tones and limmas. Then, 1*ſt*, take a certain length dG on the firſt line, to the right hand of the line CE, to repreſent a quarter of a comma. G will mark the place of the perfect Vth, while g repreſents that of the mean or tempered Vth. 2*dly*, Set off dD, double of gG, in like manner, to the right hand on the ſecond parallel. This will be the place of the perfect IId to the key note C. 3*dly*, Alſo ſet off aA, on the third parallel, to the left hand, equal to gG. This will mark the place of A, the VIth to the key note C. 4*thly*, Place E on the point e, becauſe, in the ſyſtem of mean tones repreſented in fig. 1. the IIIds were kept perfect. 5*thly*, Make bB, to the right hand on the fifth line, equal to gG, to mark the place of the perfect VIIth to the key note C. And, 6*thly*, make tT, to the right hand on the ſixth line, equal to twice gG. This will ſerve for ſhewing the contemporaneous temperament of the tritone, or IVth, contained between F and B, as alſo of its complement, the falſe 5th in fig. 1.

It is evident that the temperament of all the notes of the octave, according to the above mentioned ſyſtem, are properly repreſented in this figure. The Vth is tempered flat by the quarter comma Gg; the IId is tempered flat by the half comma Dd; the VIth is tempered ſharp by a quarter comma Aa; the IIId is perfect; the VIIth is flat by a quarter comma Bb; and the 4th is ſharp by a quarter comma Gg.

75 The TEMPERER. Now, let any other ſtraight line Ct' be drawn from C acroſs theſe parallels. This will mark, by the intervals

npera-
t of the
ale of
lufic.

vals g'G, d'D, &c. the temperaments of another ſyſtem of mean tones and limmas. For it is evident, that the contemporaneous variations gg', dd', &c. from the former temperament, are in the juſt proportions to each other; gg' being $= - v$, the variation proper for the Vth, and the oppoſite temperament for its complement or 4th. In like manner, aa' is $= 3v$, the variation competent to the VIth; and Ee' is $= 4v$, the proper variation for the IIId.

In like manner, bb' is $= 5v$, the variation of the VIIth and 2d. And, laſtly, tt' is the variation $6v$ of the tritone, and its complement, the falſe fifth.

For all theſe reaſons, any ſtraight line Ce' or Ce'', drawn from C acroſs the parallels, may juſtly be called the TEMPERER.

76 This is a very uſeful conſtruction: For it is plain, that the ſounds which can be placed in our organs and harpſichords, which have only twelve keys for an octave, muſt approach to a ſyſtem of mean tones. The diviſion of the octave into twelve equal intervals is ſuch a ſyſtem of mean tones exactly. Now, in ſuch ſyſtems, when a line is drawn from C acroſs the parallels, we ſee, at one glance, not only all the temperaments of the notes with the key note, but alſo the temperaments of thoſe concords which the notes employed in full harmony make with each other. Thus, in the harmony of K — III — V, the III and V make a minor 3d with each other; and in the harmony of K — 4 -- VI, the 4 and VI make a major 3d with each other. Now the reader will eaſily ſee, that the firſt of theſe concords has its interval diminiſhed on both ſides, when the III is tempered ſharp, but only on one ſide when it is tempered flat. The mathematical reader will alſo eaſily ſee, that the contemporaneous temperament Aa' of the VIth is always equal to the ſum g'G and Ee', and that Aa' is equal to the difference of g''G and Ee''. Therefore the temperament of this ſubordinate concord, in the full harmony K — III — V, is, in all caſes, the ſame with the contemporaneous temperament of the VIth.

In like manner, he will perceive that the temperament of the ſubordinate IIId, in the harmony of K — 4 — VI, is equal to the contemporaneous temperament of the III.

We alſo ſee, in general, that the whole harmony is more hurt when the temperer lies in the angle ECK, with the IIId tempered ſharp, than when it is in the angle ACE, when the IIId is flat; and that the ſum of all the temperaments of the concords with the key is the ſmalleſt when the IIIds are perfect. This ſyſtem of mean tones, with perfect IIIds, would therefore be the beſt, if the harmony of different concords were equally hurt by the ſame temperament.

77
tain
es of
at uſe.

We do not know any thing that has been publiſhed on the ſcience of muſic that gives more general and ſpeedy inſtruction than this ſimple figure. If it be drawn of ſuch a ſize as to allow the comma EK to be divided into a number of equal parts, ſufficiently ſenſible, all trouble of calculation will be ſaved.

We would therefore propoſe to accompany this figure with proper ſcales.

The *firſt* ſcale ſhould have Gg divided into $13\frac{1}{2}$ parts. This will expreſs the logarithmic meaſures of the temperaments mentioned in n° 63. a comma being = 54.

The *ſecond* ſcale ſhould have gG divided into 36 parts. This gives the beats made in 16 ſeconds by the notes c, g, when tempered by any quantity Gg'.

Temperament of the
Scale of
Muſic.

The *third* ſcale ſhould have gG divided into 60 parts, for the beats made by the notes c, e, or the notes c, $\bar{a}$.

The *fourth* ſcale ſhould have gG divided into 72 parts. This gives the beats made by the key note C, with its minor third e^b.

The *fifth* ſcale ſhould have gG divided into 48 parts, for the beats made by the notes c, f.

The *ſixth* ſcale ſhould have gG divided into 89 parts, on which Aa' is meaſured, to get the beats of the ſubordinate concord formed by g and e in the harmony of K — III — V.

And, *laſtly*, gG, divided into 80 parts, will give the beats made by f and $\bar{a}$ in the harmony of K — 4 — VI.

78
Harmoniouſneſs,
what?

We are ignorant of the immediate efficient cauſes of the pleaſure we receive from certain conſonances, and ſhould therefore receive, with ſatisfaction, any thing that can help us to approximate to a meaſure of its degrees. We know that, in fact, the pleaſantneſs of any individual concord increaſes as the undulations called *beats* diminiſh in frequency. It is probable that we ſhall not deviate very far from the truth, if we ſuppoſe the harmoniouſneſs of an individual tempered concord to be proportional to the ſlowneſs of theſe undulations. But it by no means follows, that a tempered Vth and a IIId are equably pleaſant, each in its kind, when they beat equally ſlow. There is a difference *in kind* in the pleaſures of theſe concords: and this muſt ariſe from the peculiar manner in which the component pulſes of each concord divide each other. We are certain that this is all the difference that obtains between them in Nature. But the harmoniouſneſs here ſpoken of is the arrangement which produces this pleaſure. We are intitled to ſay, that this is equal in two given inſtances, when the arrangements are preciſely ſimilar; and when the things arranged are the ſame, nothing ſeems to remain in which the inſtances can differ.

At any rate, it is of conſequence to be able to proportion and diſtribute theſe undulations at pleaſure. They are unpleaſant; and when reinforced by uniting, muſt be more ſo. The theory puts it in our power to prevent this union: perhaps by making them very unequal; or, if this ſhould give a chance of periodical accumulation, we may find it better to make them all equal. Surely to have all this in our power is very deſirable; and this is obtained by the theory of the beats of imperfect conſonances.

79
Temperament of a
whole octave by
beats.

But we are forgetting the proceſs of tuning, and have only tuned three or four notes of our octave. We muſt tune the reſt by conſidering their relation to notes already tuned. Thus, if gc makes 36 beats in 16 ſeconds, Fc ſhould make one third leſs, or about 24 in the ſame time; becauſe N in the formula is now 160 inſtead of 240. Proceeding in this way, we ſhall tune the octave C$\overset{=}{c}$ moſt accurately as a ſyſtem of mean tones with perfect IIIds, by making the notes beat as follows. A point is put over the note that is to be tuned from the other, and $a +$, or $a -$, means that the concord is to be tempered ſharp or flat. Thus g is tuned from c,

Make	$c\dot{g}$ beat	—	36 times in 16 ſeconds
	$\dot{G}c$	+	36
	$G\dot{d}$	—	27, *i. e.* $\frac{3}{4}$ths of gc
	$c\dot{f}$	—	48

Make

Make $c\ \dot{\bar{a}}$ beat	+60 times in 16 ſeconds
$c\ \dot{e}$	0, *i. e.* a perfect IIId
$d\ \dot{f}$ ※	0
$e\ \dot{g}$ ※	0
$\bar{a}\ \dot{\bar{c}}$ ※	0
$\dot{b}^b\ f$ downward	—24, *i. e.* $\frac{8}{9}$ths of $c\,g$
$b^b\ \dot{\bar{b}}^b$	0, *i. e.* a perfect octave
$\bar{b}^b\ \dot{e}^b$ downward	—43, *i. e.* $\frac{6}{5}$ths of $c\,g$
C $\dot{\bar{c}}$	0 an octave.

Other proceſſes may be followed, and perhaps ſome of them better than the proceſs here propoſed. Thus, b^b and e^b may be tuned as perfect IIIds to *d* and *g* downwards. Alſo, as we proceed in tuning, we can prove the notes, by comparing them with other notes already tuned, &c. &c. &c.

We have directed to tune the two notes b^b and e^b by taking the leading Vth downwards. We ſhould have come at the ſame pipes in the character of *a*※ and *d*※ in the proceſs of tuning upwards by Vths. But this would not have produced preciſely the ſame ſounds, although, in our imperfect inſtruments, one key muſt ſerve for *a*※ and b^b. By tuning them as here directed, they are better fitted for the places in which they will be moſt frequently employed in our uſual modulations.

80 Another ſyſtem very fit for our inſtruments.

It may reaſonably be aſked, Why ſo much is ſacrificed in order to preſerve the IIIds perfect? Were they allowed to retain ſome part of the ſharp temperament that is neceſſary for preſerving the Vths perfect, we ſhould perhaps improve the harmony. And ſince enlarging the Vth makes the tone greater, and therefore the limma *mi fa* much ſmaller, it will bring it nearer to the magnitude of a half tone; and this will be better ſuited for its double ſervice of the ſharp of the note below, and the flat of the note above. Accordingly, ſuch a temperament is in great repute, and indeed is generally practiſed, although the VIths and the ſubordinate chords of full harmony are evidently hurt by it. Even Dr Smith recommends it as well ſuited to our defective inſtruments, and gives an extremely eaſy method of executing it by means of the beats. His method is to make the Vth and IIId beat equally faſt, along with the key, the Vth flat, and the IIId ſharp. He demonſtrates (on another occaſion), that concords beat equally faſt with the ſame baſs when their temperaments are inverſely as the major terms of their perfect ratios. Therefore draw EG, and divide it in *p*, ſo that E*p* may be to *p*G as 3 to 5. Then draw C*p*, cutting *g* G in *g'*, and EK in *e'*; and this temperer will produce the temperament we want. It will be found, that E *e'* and G *g'* are each of them 32 of their reſpective ſcales.

Fig. 2.

Therefore make $c\,g$ beat	32 times in 16 ſeconds
G c	32
G d	24
G b	24, and tune $b\ \bar{b}$
$d\ \bar{a}$	36, and tune $a\ \bar{a}$
$d\ f$ ※	36
$a\ e$	27
$a\ c$ ※	27
$e\ \bar{b}$	$40\frac{1}{2}$, proving $b\ \bar{b}$
$e\ g$ ※	$40\frac{1}{2}$
F c	$21\frac{1}{3}$, and tune F f
F a beat	$21\frac{1}{3}$, proving a
$b^b\ \underline{f}$	$28\frac{1}{2}$, and tune $b^b\ \bar{b}^b$
$e^b\ b^b$	$38\frac{1}{2}$
$c\ \bar{c}$	0.

It may be proper to add to all theſe inſtructions a caution about the manner of counting the clock while the tuner is counting the beats. If this is to continue for 16 ſeconds, let the perſon who counts the clock ſay *one* at the beat he begins with, and then telling them over *to himſelf*, let him ſay *done* inſtead of 17. Thus 16 intervals will elapſe while the tuner is counting the beats. Were he to begin to count at *one*, and ſtop when he hears ſixteen, he would get the number of beats in 15 ſeconds only.

81. We do not heſitate to ſay, that this method of tuning by beats is incomparably more exact than by the mere judgment of the ear. We cannot miſtake more than one beat. This miſtake in the concord of the Vth amounts to no more than $\frac{1}{108}$th of a comma; and in the IIId it is only $\frac{1}{180}$.

82 Practical inſtructions.

It may be objected that it is fit only for the organ and inſtruments of continued ſounds, but will not do for the quickly periſhing ſounds of the harpſichord. True, it is the only method worthy of that noble inſtrument, and this alone is a title to high regard. But farther; the accuracy attainable by it, renders it the only method fit for the examination of ſyſtems of temperament. Even for the harpſichord it is much more exact, and more certain in its proceſs, than any other. It does not proceed, by a random trial of a flattened ſeries of Vths, and a compariſon with the reſulting IIId, and a ſecond trial, if the firſt be unſatisfactory. It ſays at once, let the Vth beat ſo many times in 16 ſeconds. Even in the ſecond method, without counting, and merely by the equality of the beats of the Vth and IIId, the progreſs is eaſy. Both are tuned perfect. The Vth is then flattened a little, and the IIId ſharpened;—if the Vth beat faſter than the IIId, alter it firſt.

All difficulty is obviated by the ſimple contrivance of a variable pendulum, already deſcribed. This may be made exact by any perſon that will take a little pains; and when once made, will ſerve for every trial. When the ball is ſet to the proper number, and the pendulum ſet a ſwinging, we can come very near the truth by a very few trials.

N. B. In tuning a piano forte, which has always two ſtrings to a key, we muſt never attempt tuning them both at once; the back uniſon of both notes of the concord muſt be damped, by ſticking in a bit of ſoft paper behind it.

We hope that the inſtructions now given, and the application of them to two very reſpectable ſyſtems of temperament, are ſufficient for enabling the attentive reader to put this method of tuning ſucceſsfully in practice, and that he perceives the efficiency of it for attaining the deſired end. But before we take leave of it, we beg leave to mention another circumſtance, which evinces the juſt value of the general theory of the beats of imperfect conſonances as delivered by Dr Smith.

83 Origin of the Tartinian ſound

Theſe reinforcements of ſound, which are called *beatings*, are noiſes. If any noiſe whatever be repeated, with ſufficient frequency, at equal intervals, it becomes a muſical note, of a certain determinate pitch. If it recur 60 times in a ſecond, it becomes the note C *fa ut*, or the double octave below the middle C of our harp-

mpera-
t of the
ale of
Muſic.

harpſichords, or the note of an open pipe eight feet long. Now there is a ſimilar (we may call it the very ſame) reinforcement of ſound in every concord. Where the pulſe of one ſound of the concord biſects the pulſe of the other, the two ſounds are more uniformly ſpread: but where they coincide, or almoſt coincide, the condenſation of one undulation combines with that of the other, and there comes on the ear a ſtronger condenſation, and a louder ſound. This may be called a *noiſe*; and the equable and frequent recurrence of this noiſe ſhould produce a muſical note. If, for inſtance, *c* and *a* are ſounded together: There is this noiſe at every third pulſe of *c*, and every fifth pulſe of *a*; that is, 80 times in a ſecond. This ſhould produce a note which is a 12th below *c*, and a 17th major below *a*; that is, the double octave below *f*, which makes 320 vibrations in a ſecond. That is to ſay, along with the two notes *c* and *a* of the concord, and the compound ſound, which we call the *concord of the VIth*, we ſhould hear a third note FF in the baſs. Now this is known to be a fact, and it is the grave harmonic obſerved by Romieu and Tartini about the year 1754, and verified by all muſicians ſince that time. Tartini prized this obſervation as a moſt important diſcovery, and conſidered it as affording a foundation for the whole ſcience of muſic. We ſee that it is all included in the theory of beats publiſhed five years before, namely, in 1749; and every one of theſe grave harmonics, or Tartinian ſounds, as they have been called, are immediate conſequences of this theory. The ſyſtem of harmonious compoſition which Tartini has, with wonderful labour and addreſs, founded on it, has therefore no ſolidity. It is, however, preferable to Rameau's, becauſe it proceeds on a fact founded on the nature of muſical ſounds; whereas Rameau's is a mere whim, proceeding on a falſe aſſumption; namely, "that a muſical ſound is eſſentially accompanied by its octave, 12th, and 17th *in alto*."—This is not true, though ſuch accompanyment be very frequent, and it be very difficult to prevent it. Mr Rameau ought to have ſeen this. Are theſe acute harmonics muſical ſounds or not? He ſurely will not deny this. Therefore they, too, are eſſentially accompanied by *their* harmonics, and this abſolutely and neceſſarily *ad infinitum*; which is certainly abſurd. We ſhall have a better occaſion for conſidering this point when we deſcribe the *TRUMPET-Marigni* in a future article.

84
r Smith's
ſtem of
QUAL
ARMO-
Y.

We have taken notice of only two ſyſtems of temperament; both of them are ſyſtems of mean tones, and are in good repute as practicable methods. It would be almoſt an endleſs taſk to mention all the ſyſtems of temperament which have been propoſed. Dr Smith, aſter having, with great ingenuity, appreciated the changes of harmoniouſneſs that are induced on the different concords by the ſame temperament, and having aſſigned that proportion of temperament which renders them equally harmonious, each in its kind, gives a ſyſtem of temperament, which he calls EQUAL HARMONY. Each concord (excepting the octave) is tempered in the inverſe proportion of the product of the terms of its perfect ratio. It is very nearly equivalent to a diviſion of the octave into 50 equal parts. We do not give any farther account of it here, although we think its harmony preferable to any thing that we have ever heard. We heard it, as executed for him, and under his inſpection, by the celebrated harpſichord-maker Kirkmann, both when the inſtrument was yet in the hands of the maker, and afterwards by the ingenious author. We have alſo heard ſome excellent muſicians declare, that the organ of Trinity college chapel at Cambridge was greatly improved in its harmony by the change made on its temperament under the inſpection of Dr Smith. When we name Stanley, we preſume that the authority will not be diſputed. We mention this, becauſe the writer in the Philoſophical Tranſactions ſpeaks of this ſyſtem, with flattened major thirds, as of no value. But we do not give any farther account of it, becauſe it is not ſuited to our inſtruments, which have but twelve ſounds in the octave.

Temperament of the Scale of Muſic.

85.

The reader will pleaſe to recollect, that the great object of temperament is twofold. Firſt, to enable us to tranſpoſe muſic from one pitch to another, ſo that we may make any note of the organ the fundamental of the piece. This undoubtedly requires a ſyſtem approaching to one of mean tones, becauſe the harmony muſt be the ſame in every key. This requires temperament, becauſe a ſound muſt be occaſionally conſidered, either as the ſharp of the note below it, or the flat of the one above. This cannot produce perfect harmony, becauſe the limma of the perfect diatonic ſcale is greater than a half tone. Thus a temperament is neceſſary merely for the ſake of the melody. But, *ſecondly*, the nature of modern muſic requires every note to be accompanied, or conſidered as accompanied, with full harmony. This is, in fact, the ſame thing with modulating on every different note as a fundamental; but it requires a much cloſer attention to the perfection of the intervals, becauſe a defect or exceſs in an interval that would ſcarcely offend the ear, if the notes were heard in ſucceſſion, is quite intolerable when they are ſounded together. Here the difference between the major and minor tone is of almoſt as great moment as the difference of the limma from a ſemitone. The ſecond object, therefore, is to obtain, in the compaſs of three octaves, as many good concords of full harmony; that is, conſiſting of a fundamental with its major third and its fifth, erect or inverted, as poſſible. There is no other harmony, although our notes have frequently a different ſituation and appearance.

86
Maxims of temperament very gratuitous.

It is no wonder that, in a ſubject where we are yet to ſeek for a principle, the attempts to attain this object have been very various, and very gratuitous. The mathematicians, even in modern times, have allowed themſelves to be led away by fancies about the ſimplicity and conſequent perfection of ratios; and having no clear principle, it is no wonder that ſome of their deductions are contrary to experience. According to Euler, thoſe ratios which are moſt perfect, that is, moſt ſimple, admit of leaſt temperament. The octave is therefore infinitely perfect; for it is allowed by all, that it muſt not have the ſmalleſt temperament. A Vth muſt be leſs tempered than a IIId. Even the practical muſician thinks that he has tempered theſe two concords equally, when the offenſive quality of each is made equally ſo; but in this caſe it is demonſtrable, that the Vth has been much more tempered than the IIId. But this could not be diſcovered till we got the theory of beats.

Moſt of the mathematical muſicians adhered to ſyſtems of mean tones; or, which are equivalent to ſuch ſyſtems, giving ſimilar harmonies on every key of the

Temperament of the Scale of Muſic.

harpſichord. This is ſurely the moſt natural, and is peculiarly ſuggeſted by the tranſpoſing of muſic from one pitch to another: but they differ exceedingly, and without giving any convincing arguments, in their eſtimation of the effects of the ſame temperament on different concords. Much of this, we apprehend, ariſes from diſpoſition. Perſons of a gay diſpoſition reliſh the harmony of the IIId, and prefer a ſharp to a flat temperament of this concord. Perſons of a more penſive diſpoſition, prefer ſuch temperaments as allow the minor thirds to be more perfect.

87 Equal harmony rejected.

But there are many, eminent both as performers and as theoriſts, who reject any ſyſtem which gives the ſame harmonies on every note of the octave. They obſerve, that in the progreſs of the cultivation of muſic in Europe, the melodies of all nations have gradually approached to a certain uniformity. Certain cadences, cloſes, ſtrains, and phraſes, are becoming every day more common; and even in the conduct of a conſiderable piece of muſic, and the gradual but ſlow paſſage of the modulation from one key into another, there is a certain regularity. Nay, they add, that this cannot be greatly deviated from without becoming very offenſive. We may remain ignorant of the cauſe of this uniformity; but its exiſtence ſeems to prove that it ariſes from ſome natural principle; and therefore it ought to be complied with, and our temperaments ſhould be accommodated to it. The reſult of this uniformity in the muſic of our times is, that the modulation on ſome keys is much leſs frequent than on others, and this frequency decreaſes in a certain order. Suppoſing that we begin on C. A piece of plain muſic ſeldom goes farther than G and F. A little more fancy and refinement leads the compoſer into D, or into B^b, &c. &c. It would therefore be deſirable to adjuſt our temperaments ſo, that the harmonies in C ſhall be the beſt poſſible, and gradually leſs perfect in the order of modulation. Thus we ſhall, in our general practice, have finer harmony than if it were made equal throughout the octave; becauſe the unavoidable imperfections are thrown into the leaſt frequented places of the ſcale. The practical muſicians add to this, that by ſuch a temperament the different keys acquire characters, which fit each of them more particularly for the expreſſion of different ſentiments, and for exciting different emotions. This is very perceptible in our harpſichords as they are generally tuned. The major key of A is remarkably brilliant; that of F is as remarkably ſimple, &c.

We cannot ſay that we are altogether convinced by theſe arguments. The violin is unqueſtionably the inſtrument of the greateſt powers. A concert of inſtruments of this kind, unembarraſſed by the harpſichord, or any inſtruments incapable of occaſional temperament, is the fineſt muſic we have. The performers make no ſuch degradations of harmony, but keep it as perfect as poſſible throughout; and a violin performer is ſenſible of violence and conſtraint when he accompanies a keyed inſtrument into theſe unfrequented paths. Let him play the ſame muſic alone, and he will play it quite differently, and much more to his own ſatisfaction. We imagine, too, that much of the uniformity ſpoken of is the reſult of imitation and faſhion, and even of the temperaments that we have preferred. There is an evident diſtinction in the native muſic of different nations. An experienced muſician will know, from a few bars, whether an air is Iriſh, Scotch, or Poliſh. This diſtinction is in the modulation; which, in thoſe nations, follows different courſes, and ſhould therefore, on the ſame principle, lead to different temperaments.

With reſpect to the variety of characters given to the different keys, we muſt acknowledge the fact. We have tuned a piano forte in the uſual manner; but inſtead of beginning the proceſs with C, we began it with D. An excellent performer of voluntaries ſat down to the inſtrument, and began to indulge his rich fancy; but he was confounded at every ſtep: he thought the inſtrument quite out of tune. But when he was informed how it had been tuned, and then tried a known plain air on it, he declared it to be perfectly in tune. It is ſtill very doubtful, however, whether we ſhould not have much finer muſic, by equaliſing the harmony in the different keys, and truſting for the different expreſſion ſo much ſpoken of to a judicious mixture of other notes called *diſcords*.

88 Cauſe of this uncertainty now removed by Dr Smith's theory.

After all, the great uncertainty about the moſt proper temperament has remained ſo long undetermined, becauſe we had no method of executing with certainty any temperament that was offered to the public. What ſignifies it on what principle it may be proper to flatten a Vth one fifth of a comma, and ſharpen a VIth one-ſeventh of a comma, unleſs we are able to do both the one and the other? Till Dr Smith publiſhed the theory of beats, the monochord was the only aſſiſtance we had: but however nicely it may be divided, it is ſcarcely poſſible to make the moveable bridge ſo ſteady and ſo accurate in its motion, that it will not ſenſibly derange the tenſion of the ſtring. We have ſeen ſome very nice and coſtly monochords; but not one of them could be depended on to one eighth of a comma. Even if perfect, they give but momentary ſounds by pinching. The bow cannot be truſted, becauſe its preſſure changes the tenſion. Mr Watt's experiments with his monochord of continued ſound ſhewed this evidently. A pitch-pipe with a ſliding piſton promiſes the greateſt accuracy; but we are ſadly diſappointed, becauſe the graduation of the piſton cannot be performed by any mathematical rule. It muſt be puſhed more than half way down to produce the octave, more than one-third to produce the Vth, &c. and this without any rule yet diſcovered. Thanks to Dr Smith we can now produce an inſtrument tuned exactly, according to any propoſed ſyſtem, and then ſubmit it to the fair examination of muſicians. Even the ſpeculatiſt may now form a pretty juſt opinion of the merits of a ſyſtem, by calculating, or meaſuring by ſuch ſcales as we have propoſed, the beats produced by the tempered concords in all parts of the octave. No one who has liſtened with attention to the rattling beats of a full organ, with its twelfth and ſeſquialter ſtops all ſounding, will deny that they are hoſtile to all harmony or good muſic. We cannot be much miſtaken in preferring any temperament in proportion as it diminiſhes the number of thoſe beats. We ſhould therefore examine them on this principle alone; attending more particularly to the beats of the third major, becauſe theſe are in fact the loudeſt and moſt diſagreeable: and we muſt not content ourſelves with the beats of each concord with the fundamental of the full harmony, whether K—III—V, or K—4—VI, or K—3—V, or K—4—6, which ſometimes occurs. We muſt attend equally to the beats of the two notes

of

pera- of the le of ific. of accompanyment with each other: theſe are generally the moſt faulty.

This examination is neither difficult nor tedious. 1. Write down, in one column, the lengths of the ſtrings or diviſions of the monochord; in another write their logarithms; in a third the remainders, after ſubtracting each from the logarithm of the fundamental. 3. Have at hand a ſimilar table for the perfect diatonic ſcale. 4. Compare theſe, one by one, and note the difference, + or —, in a 4th column. Theſe are the temperaments of each note of the ſcale. 5. Compare every couple of notes which will compoſe a major or minor third, or a fifth, by ſubtracting the logarithm of the one note from that of the other. The differences are the intervals tempered. 6. Compare theſe with the perfect intervals of the diatonic ſcale, and note the differences, + or —, and ſet them down in a fifth column. Theſe are all the temperaments in the ſyſtem. 7. If we have uſed logarithms conſiſting of five decimal places, which is even more than ſufficient, conſider theſe numeral temperaments as the q of the formula given in n° 65. for calculating the beats, and then p is always = 540. Or we may make another column, in which the temperaments are reduced to ſome eaſy fraction of a comma. 9.

90 m of Young. We ſhall content ourſelves with giving one example; the temperament propoſed by Mr Young in the Philoſophical Tranſactions for 1800. It is contained in the following table.

1.	2.	3.	4.	5.		
				IIIds upward on		
C	100000	5.00000		C	135	Sharp.
C※	94723	4.97645	2355	G. F.	190	
D	89304	4.95087	4913	D. B^b	245	
E^b	83810	4.92330	7670	A. E^b	346	
E	79752	4.90174	9826	E. A^b	448	
F	74921	4.87461	12539	B. C※	494	
F※	71041	4.85151	14849	F※	540	
G	66822	4.82492	17508	3ds upward on		
G※	63148	4.80036	19964	A. E.	236	Flat.
A	59676	4.77580	22420	D. B.	291	
B^b	56131	4.74921	25079	G. F※	346	
B	53224	4.72610	27390	C. C※	448	
C	50000	4.69897	30103	F. G※	494	
				B^b. E^b	540	

Vths upward on

E^b. G※. C※. F※	perfect	Flat.
F. B^b. E. B	46	
C. G. D. A	116	

Interval of a comma - - 540
minor third - - 7918
major third - - 9691
fifth - - - 17609

The firſt column of the above table contains the ordinary deſignations of the notes. The ſecond contains the correſponding lengths of the monochord. The third contains the logarithms of column ſecond. The fourth contains the difference of each logarithm from the firſt. The next column contains, firſt, the temperaments of all the major thirds, having for their loweſt note the ſound correſponding to the letter. Thus 494, or $\frac{494}{540}$ of a comma, is the temperament of the IIId, B — D※, and C※ — F. Secondly, it contains all the minor thirds formed on the notes repreſented by the letters. The column below contains the temperaments of the Vths. *N. B.* Theſe temperaments are calculated by the author. We have found ſome of them a little different. Thus we make the temperament of C — G only 108. Below this we have ſet down the meaſures of the perfect intervals, which are to be compared with the differences of the logarithms in column third.

Temperament of the Scale of Music, Templars.

91 Syſtem of Kirnberger.

We preſume not to decide on the merits of this temperament: Only we think that the temperaments of ſeveral thirds, which occur very frequently, are much too great; and many inſtances of the 6th, which is frequent in the flat key, are ſtill more ſtrongly tempered. A temperament, however, which very nearly coincides with Dr Young's, has great reputation on the continent. This is the temperament by Mr Kirnbergher, publiſhed at Berlin in 1771, in his book called *Die Kunſt des reinen Satzes in der Muſik.* The eminent mathematician Major Templehoff has made ſome important obſervations on this temperament, and on the ſubject in general, in an eſſay publiſhed in 1775, Berlin. Dr Young's is certainly preferable.

The monochord is thus divided by Kirnbergher:

C =	1,0000	F =	7500	B^b =	5625
C※	9492	F※	7111	B	5313
D	8889	G	6667	*c*	5000
E^b	8437	G※	6328		
E	8000	A	5963		

We conclude this article (perhaps too long) by earneſtly recommending to perſons who are not mathematically diſpoſed, the ſliding ſcales, either circular or rectilineal, containing the octave divided into 301 parts; and a drawing of fig. 2. on card paper, of proper ſize, having the quarter comma about two inches, and a ſeries of ſcales correſponding to it. This will ſave almoſt the whole of the calculation that is required for calculating the beats, and for examining temperaments by this teſt. To readers of more information, we earneſtly recommend a careful peruſal of Smith's Harmonics, ſecond edition. We acknowledge a great partiality for this work, having got more information from it than from all our patient ſtudy of the moſt celebrated writings of Ptolemy, Huyghens, Euler, &c. It is our duty alſo to ſay, that we have got more information concerning the muſic of the Greeks from Dr Wallis's appendix to his edition of Porphyrius's Commentary on Ptolemy's Harmonics, than from any other work.

TEMPLARS. In the account of this order, which is publiſhed in the *Encyclopædia*, we have, with many others, ſuppoſed that the guilt of which they were accuſed at the ſuppreſſion of the order was leſs enormous than their enemies alleged. For the honour of human nature, we are ſtill unwilling to believe that this was not the caſe. Juſtice, however, compels us to admit, that the Abbé Barruel has brought together ſuch a cloud of witneſſes againſt the Templars, that we know not how to reſiſt their evidence; and that he has completely proved, that *Philip le Bel* was not influenced by avarice when he ſuppreſſed that order in France. "It has been ſaid, that he and Clement V. had concerted between them the diſſolution of the Templars. The falſity of ſuch an aſſertion is evident on the inſpection of their letters. Clement V. at firſt will give no credit

dit to the accuſations againſt the Templars; and even when he receives inconteſtable proofs from Philip le Bel, he had ſtill ſo little concerted the plan with that Prince, that every ſtep taken by the one or the other occaſions diſputes on the rights of the church or of the throne.

“ It was alſo ſaid, that the king wiſhed to ſeize on the great riches of theſe knights: but at the very commencement of his proceedings againſt the order, he ſolemnly renounced all ſhare in their riches; and perhaps no Prince in Chriſtendom was truer to his engagement. Not a ſingle eſtate was annexed to his domain; and all hiſtory bears teſtimony to the fact.

“ We next hear of a ſpirit of revenge which actuated this Prince; and during the whole courſe of this long trial, we do not hear of a ſingle perſonal offence that he had to revenge on the Templars. In their defence, not the moſt diſtant hint, either at the revengeful ſpirit, or at any perſonal offence againſt the king, is given; ſo far from it, until the period of this great cataſtrophe, the grand maſter of the order had been a particular friend of the king's, who had made him godfather to one of his children.

“ In fine, the rack and torture is ſuppoſed to have forced confeſſions from them which otherwiſe they never would have made; and in the minutes, we find the avowal of at leaſt 200 knights all made with the greateſt freedom, and without any coercion. Compulſion is mentioned but in the caſe of one perſon; and he makes exactly the ſame avowal as 12 other knights, his companions, freely made (A). Many of theſe avowals were made in councils where the biſhops begin by declaring, that all who had confeſſed through fear of the torture ſhould be looked upon as innocent, and that no Knight Templar ſhould be ſubjected to it (B). The Pope Clement V. was ſo far from favouring the king's proſecutions, that he began by declaring them all to be void and null. He ſuſpended the archbiſhops, biſhops, and prelates, who had acted as inquiſitors in France. The king accuſes the Pope in vain of favouring the Templars; and Clement is only convinced after having been preſent at the interrogatories of 72 knights at Poictiers, in preſence of many biſhops, cardinals, and legates. He interrogated them, not like a judge who ſought for criminals, but like one who wiſhed to find innocent men, and thus exculpate himſelf from the charge of having favoured them. He hears them repeat the ſame avowals, and they are freely confirmed. He deſired that theſe avowals ſhould be read to them after an interval of ſome days, to ſee if they would ſtill freely perſevere in their depoſitions. He hears them all confirmed. *Qui perſeverantes in illis, eas expreſſe et ſponte prout recitatæ fuerant approbârunt.* He wiſhed ſtill further to interrogate the grand maſter and the principal ſuperiors, *præceptores majores*, of the divers provinces of France, Normandy, Poitou, and of the Tranſmarine countries. He ſent the moſt venerable perſons to interrogate thoſe of the ſuperiors, whoſe age or infirmities hindered them from appearing before him. He ordered the depoſitions of their brethren to be read to them, to know if they acknowledged the truth of them. He required no other oath from them than to anſwer freely and without compulſion; and both the grand maſter and the ſuperiors of theſe divers provinces depoſe and confeſs the ſame things, confirm them ſome days after, and approve of the minutes of their depoſitions taken down by public notaries. Nothing leſs than ſuch precautions could convince him of his error: it was then only that he revoked his menaces and his ſuſpenſion of the French biſhops, and that he allows the king to proceed in the trials of the Templars.

“ Let ſuch pretexts be forgotten, and let us only dwell on the avowals which truth alone forced from theſe criminal knights.

“ Their depoſitions declare, that the Knights Templars, on their reception, denied Chriſt, trampled on the croſs, and ſpit upon it; that Good Friday was a day which was particularly conſecrated to ſuch outrages; that they promiſed to proſtitute themſelves to each other for the moſt unnatural crimes; that every child begotten by a Templar was caſt into the fire; that they bound themſelves by oath to obey, without exception, every order coming from the grand maſter; to ſpare neither ſacred nor prophane; to look upon every thing as lawful when the good of the order was in queſtion; and, above all, never to violate the horrible ſecrets of their nocturnal myſteries, under pain of the moſt terrible chaſtiſements (C).

“ In making their depoſitions, many of them declared they had only been forced into theſe horrors by impriſonment and the moſt cruel uſage; that they wiſhed, after the example of many of their brethren, to paſs into other orders, but that they did not dare, fearing the power and vengeance of their order; that they had ſecretly confeſſed their crimes, and had craved abſolution. In this public declaration, they teſtified, by their tears, the moſt ardent deſire of being reconciled to the church.

“ All repeat the ſame depoſition, except three, who declare they have no knowledge of the crimes imputed to their order. The Pope, not content with this information taken by men of religious orders and by French noblemen, requires that a new trial ſhould take place in Poitou before cardinals and others whom he himſelf nominates: Again, with the ſame freedom, and for the third time, the grand maſter and other chiefs, in preſence of Clement V. repeat their depoſitions. Molay even requeſted, that one of the lay brothers, who was about his perſon, ſhould be heard, and this brother confirms the declaration. During many years theſe informations were continued and renewed at Paris, in Champagne, in Normandy, in Quercy, in Languedoc, in Provence. In France alone, above 200 avowals of the ſame nature are to be found: nor did they vary in England, where, at the ſynod of London held in 1311, 78 Engliſh knights were heard, and two whole months were ſpent in taking informations and in verifying their declarations. Fifty-four Iriſh were alſo heard, and many Scotch, in their reſpective countries. It was in conſequence of theſe declarations that the order of the Templars was aboliſhed in thoſe kingdoms, and that the parliament

---

(A) *Layette*, N° 20. *Interrog. made at Caen.*

(B) See the *Council of Ravenna.* *Rubeus Hiſt. Raven.* lib. vi.

(C) See the *Vouchers brought by Dupuy*, and *Extract of the Regiſters.*

mplars, emple-man.

parliament diſpoſed of their goods (D). The ſame declarations were taken and proved in Italy, at Ravenna, at Bologna, at Piſa, and at Florence, though in all theſe councils the prelates were very ready to abſolve all thoſe knights who could ſucceed in their juſtifications.

"I would willingly aſſert (continues the Abbé), that it was the ſmaller part of the Templars who ſuffered themſelves to be carried away by ſuch abominations. Some even at Paris were declared innocent. In Italy a ſtill greater number were abſolved; of all thoſe who were judged at the councils of Mayence and Salamanca, none were condemned: and hence we may conclude, that of the 9000 houſes belonging to the order, many had not been tainted, and that whole provinces were to be excepted from the general ſtain of infamy. But the condemnations, the juridical depoſitions, the method of initiating the knights, almoſt become general; the ſecrecy of their receptions, where neither prince, nor king, nor any perſon whatever, could be preſent during the laſt half century, are ſo many teſtimonies which corroborate the divers accuſations contained in the articles ſent to the judges; that is to ſay, that at leaſt two-thirds of the order knew of the abominations practiſed without taking any ſteps to extirpate them. *Quod omnes, vel quaſi duæ partes ordinis ſcientes dictos errores corrigere neglexerint.*

"This certainly cannot mean that two thirds of the knights had equally partaken of theſe abominations. It is evident, on the contrary, that many deteſted them as ſoon as they were acquainted with them; and that others only ſubmitted to them, though initiated, after the harſheſt treatment and moſt terrible threats. Nevertheleſs, this proves, that the greateſt part of theſe knights were criminal, ſome through corruption, others through weakneſs or connivance; and hence the diſſolution of the order became neceſſary."

g. Dict.

TEMPLEMAN (Peter), M. D. the ſon of an eminent attorney at Dorcheſter in the county of Dorſet, by Mary daughter of Robert Haynes, was born March 17, 1711, and was educated at the Charter-houſe (not on the foundation), whence he proceeded to Trinity-college, Cambridge, and there took his degree of B. A. with diſtinguiſhed reputation. During his reſidence at Cambridge, by his own inclination, in conformity with that of his parents, he applied himſelf to the ſtudy of divinity, with a deſign to enter into holy orders; but after ſome time, from what cauſe we know not, he altered his plan, and applied himſelf to the ſtudy of phyſic. In the year 1736, he went to Leyden, where he attended the lectures of Boerhaave, and the profeſſors of the other branches of medicine in that celebrated univerſity, for the ſpace of two years or more. About the beginning of 1739, he returned to London, with a view to enter on the practice of his profeſſion, ſupported by a handſome allowance from his father. Why he did not ſucceed in that line was eaſy to be accounted for by thoſe who knew him. He was a man of a very liberal turn of mind, of general erudition, with a large acquaintance among the learned of different profeſſions, but of an indolent, inactive diſpoſition; he could not enter into juntos with people that were not to his liking; nor cultivate the acquaintance to be met with at tea-tables; but rather choſe to employ his time at home in the peruſal of an ingenious author, or to ſpend an attic evening in a ſelect company of men of ſenſe and learning. In this he reſembled Dr Armſtrong, whoſe limited practice in his profeſſion was owing to the ſame cauſe. In the latter end of the year 1750 he was introduced to Dr Fothergill by Dr Cuming, with a view of inſtituting a Medical Society, in order to procure the earlieſt intelligence of every improvement in phyſic from every part of Europe. At the ſame period he tells his friend, "Dr Mead has very generouſly offered to aſſiſt me with all his intereſt for ſucceeding Dr Hall at the Charter-houſe, whoſe death has been for ſome time expected. Inſpired with gratitude, I have ventured out of my element (as you will plainly perceive), and ſent him an ode." Dr Templeman's epitaph on Lady Lucy Meyrick (the only Engliſh copy of verſes of his writing that we know of), is printed in the eighth volume of the "Select Collection of Miſcellany Poems, 1781." In 1753 he publiſhed the firſt volume of "Curious Remarks and Obſervations in Phyſic, Anatomy, Chirurgery, Chemiſtry, Botany, and Medicine; extracted from the Hiſtory and Memoirs of the Royal Academy of Sciences at Paris;" and the ſecond volume in the ſucceeding year. A third was promiſed, but we believe never printed. It appears, indeed, that if he had met with proper encouragement from the public, it was his intention to have extended the work to twelve volumes, with an additional one of index, and that he was prepared to publiſh two ſuch volumes every year. His tranſlation of "Norden's Travels" appeared in the beginning of the year 1757; and in that year he was editor of "Select Caſes and Conſultations in Phyſic, by Dr Woodward," 8vo. On the eſtabliſhment of the Britiſh Muſeum, in 1753, he was appointed to the office of keeper of the reading-room, which he reſigned on being choſen, in 1760, ſecretary to the then newly inſtituted Society of Arts, Manufactures, and Commerce. In 1762, he was elected a correſponding member of the Royal Academy of Science of Paris, and alſo of the Œconomical Society at Berne. Very early in life Dr Templeman was afflicted with ſevere paroxyſms of an aſthma, which eluded the force of all that either his own ſkill, or that of the moſt eminent phyſicians then living, could ſuggeſt to him; and it continued to haraſs him till his death, which happened September 23, 1769. He was eſteemed a man of great learning, particularly with reſpect to languages; ſpoke French with great fluency, and left the character of a humane, generous, and polite member of ſociety.

Templeman, Terané.

TERANE´, a town in Egypt, ſituated on what Mr Browne calls the *left* of the moſt weſtern mouth of the Nile, at a very ſmall diſtance from the river. Its latitude is 30° 24′. The buildings are chiefly unburned brick, though there are alſo ſome of ſtone. The town and diſtrict, containing ſeveral villages, belonged, before the French invaſion, to Murad Bey, who uſually entruſted its government, and the collection of its revenue, to one of his Caſhefs. That revenue ariſes principally from natrôn (See NATRUM, *Encycl.*), found in

---

(D) Vide *Valſinger in Edvardum* II. *et Ypodigma Neuſtriæ apud Dupuy.*—*Eſſai de Fred. Nicolai.*

Terane, Terebratulæ.

in great quantities in certain lakes about thirty-five miles from Terané; and it is on account of theſe lakes only that the town is worthy of notice in this work; for though there are many columns in its neighbourhood, which indicate the ſite of ancient ſtructures, none of them have inſcriptions aſcertaining their antiquity.

The eaſtern extremity of the moſt weſtern lake Mr Browne found to be 30° 31′ North. No vegetation appears, except reeds, on the margin of the lake, which is very irregular in its form; ſo that it is not eaſy to ſay what may be the quantity of ground covered with water. It is higher in winter than in ſummer; and when it was viſited by our author, its breadth did not exceed a mile, though its length was nearly four. Towards the end of the ſummer, it is ſaid, theſe lakes are almoſt dry; and the ſpace that the water has retired from is then occupied by a thick depoſition of ſalt. Not far removed from the eaſtern extremity, a ſpring riſes with ſome force, which much agitates the reſt of the water. Cloſe to that ſpring the depth was far greater than Mr Browne's height; in other parts it was obſervable that it did not generally exceed three feet. The thermometer near this ſpring ſtood at 76, while in the open air it was 87. The more weſtern lake differs not materially from the eaſtern in ſize, form, or productions. The colour of the water in both is an imperfect red; and where the bottom is viſible, it appears almoſt as if covered with blood. Salt, to the thickneſs of five or ſix inches, lies conſtantly in the more ſhallow parts. The ſurface of the earth, near the lake, partakes more or leſs generally of the character of natrôn, and, in the parts fartheſt removed, offers to the foot the ſlight reſiſtance of ploughed ground after a ſlight froſt. The ſoil is coarſe ſand. The water of the lake, on the ſlighteſt evaporation, immediately depoſits ſalt. There is a mountain not far from the lakes, where natrôn is found in inſulated bodies, near the ſurface, of a much lighter colour than that produced in the lake, and containing a greater portion of alkali. How thick the ſubſtance of natrôn commonly is in the lake, our author did not accurately determine; but thoſe employed to collect it report, that it never exceeds a cubit, or common pike; but it appears to be regenerated as it is carried away. If ever it ſhould be brought to ſuperſede the uſe of barilla, the quantity obtainable ſeems likely to anſwer every poſſible demand.

TEREBRATULÆ (ANOMIÆ, *Lin.* ſee that article *Encycl.*) have been ſuppoſed not to exiſt now but as petrified ſhells. This, however, is a miſtake. The anomia is an inhabitant of every region, and has exiſted in every age. As many terebratulæ were caught by Perouſe's people during his voyage of diſcovery, and as Lamanon the naturaliſt thought they ſhould be conſidered as a genus by themſelves, he has given us the following deſcription of the *anomia*, or, as he calls it, *terebratula*, on the coaſt of Tartary:

The length of the ſhell varies from ſix to twenty lines, and its breadth from five to eighteen; there are, however, conſiderable varieties of proportion between different individuals, beſides thoſe ariſing from the different ages of the animal. It would be improper, therefore, to diſtinguiſh the various ſpecies of anomiæ by the proportion of their ſhells. The waving lines on the edges of the ſhell are equally defective, as diſtinctive characters; for our author obſerved in the ſame ſpecies the ſhell approaching or receding indifferently from the circular form, and, in ſome, the edges of the valves are on the ſame plane; whereas in others, one of the valves forms a ſalient angle in the middle of its curve, and the other a re-entering angle.

Terebratulæ.

The ſhell is of a moderate thickneſs, about that of a common muſcle; it is ſomewhat tranſparent, convex like the cockle: neither of the ſhells is more ſenſibly arched than the other; that, however, which has the ſpur, is rather the moſt ſo, eſpecially in the ſuperior part.

On the ſurface of the ſhell are ſeen a number of ſlight tranſverſe depreſſions, of a ſemicircular waved form, which reach the part where the ſhell ceaſes to be circular, in order to form the angle which ſupports the ſummit.

Theſe ſtriæ are covered with a very thin and ſlightly-adhering perioſteum; in ſome ſpecimens there are from one to three ſhallow broad depreſſions, radiating inſenſibly from the centre of the ſhell, and becoming more marked as they approach the edges, where they form, with the correſponding parts of the other ſhell, thoſe ſalient and re-entering angles which have been mentioned. The perioſteum is rather more firmly fixed on the latter angles than on the former.

The ſhells are equal in the rounded part of their edge, and cloſe very exactly; however, towards the ſummit, the ſpur of one of the ſhells reaches conſiderably beyond the other ſhell, conſequently they are unequal, as in oyſters.

The ſpur, or ſummit, is formed by the folding from within of the edge of the ſhell, and the elongation of its upper part. The folded edges form an oval aperture of a moderate ſize, through which the animal extends the muſcle, by means of which it attaches itſelf to other ſubſtances. This ſhell is not, therefore, perforated, as its name of terebratula would ſeem to imply, the opening not being worked in one of the ſhells, but formed by the elongation of one ſhell, the folding in of its edges, and the approach of the other ſhell. The ſummit is not pointed, but round.

The ligament, as in the oyſter, is placed between the ſummits, and does not appear on the outſide; it adapts itſelf to the pedicle of the animal. As the ſummit takes up a conſiderable part of the ſhell, the valves are only capable of opening a very little without running the riſk of being broken. It is very firm, though ſlender, and not eaſily to be diſcovered, being fixed in a ſmall groove, which is filled up when the ſhell is ſhut by the correſponding part of the oppoſite ſhell. This ligament preſerves its texture, even for a conſiderable time after the ſhell is emptied and become dry.

Oyſters are without a hinge, the teeth which form it in many other ſhells not exiſting in them. The anomia has been conſidered as an oyſter, becauſe its hinge or teeth have not been examined: they are not viſible indeed in the foſſile ſpecimens; but in opening them when alive, the teeth compoſing the hinge are ſufficiently viſible, being even much larger than in the greater part of bivalve ſhells. The foſſil terebratulæ are almoſt always found with their ſhells cloſed; whereas the other bivalves have uſually theirs either open or ſeparated: the reaſon of this ſeems to ariſe from the nature of the hinge, that of the anomia not allowing it to ſeparate, and the ligament, which is very tight, contributing to keep the two ſhells united. The teeth which form the hinge of the anomia approach very near to thoſe of the *ſpondyle*, deſcribed by M. Adanſon. In this laſt they are formed by two rounded projections, and in the anomia by the ſame a little elongated. It is above theſe teeth that the ligament is placed in the larger ſhell: there are between it and the teeth two cavities, one on each ſide, which ſerve to receive the teeth of the other valve. The teeth of the larger ſhell have, beſides, a ſlight projection, which fits into a longitudinal furrow in the other ſhell in front of the teeth.

The ſubſtance which covers the inſide of the ſhell holds, as in oyſters, a middle place between *nacre* and the interior ſubſtance of ſhells, which are deſtitute of it. The degree of its luſtre, poliſh, and thickneſs, varies with the age and circumſtances of individuals.

The colour of the teeth is always white; that of the outer ſurface of the ſhell verges more or leſs to the ochry red, eſpecially on the border. The inſide has alſo a very ſlight tint of this colour, on a varying greyiſh-white ground.

There is viſible on each ſide of the ſhell the impreſſion of two very diſtinct tendons; a circumſtance which forms a very eſſential difference between this genus and that of the oyſter: this latter having only one tendon ariſing from the middle of the body. The impreſſions of the tendon in the largeſt ſhell are oblong, ſituate near the ſummit, and hollowed; each of them has curved tranſverſe ridges, divided into two parts by a longitudinal furrow, repreſenting the wings of certain inſects. In the other valve the inſertions have a different form; their ſituation is the ſame, but they are very irregularly rounded and encompaſſed by two fulcations, which are ſeparated from each other by an intervening ridge, and then are continued in a right line towards the opening of the ſhell as far as about two thirds of its length. That part of the ſummit of the ſhell along which the pedicle of the animal paſſes, is longitudinally ſtriated in the larger ſhell, of which the middle ſtria is the deepeſt: the longitudinal ſtriæ are divided into equal parts by a tranſverſe depreſſion. There are no ſimilar marks on the other ſhell.

Our author diſſected the animal itſelf, and found what he calls the *manteau* of the anomia, formed of a very fine membrane, lining the inſide of both ſhells, and containing the body of the animal. Its origin is of the ſame breadth as the hinge of the ſhell, whence it divides into two lobes, lining both the ſhells: it forms, therefore, only a ſingle aperture, terminating at each end of the hinge, and of the ſame breadth with the interior ſurface of the ſhell: it appears to have only one trachea, which is formed by the two lobes of the manteau.

Our naturaliſt having opened the ſhell, divided the ligament as delicately as poſſible, unfixed the hinge, and detaching from the larger ſhell the lobe of the manteau, turned over the body of the animal. This operation expoſed to view the large muſcles which adhered to the ſhell; they are ſoft, membranous, and, as it were, fleſhy on the inſide, being covered with ſmall ſanguiferous glands. From the lower part of each muſcle there proceeds a pretty ſtrong tendon, which reaches to the extremity of the manteau; they run parallel to the edge of the ſhell, and at a conſiderable diſtance from each other; and are each encloſed in a ſort of flatted ſac, of the ſhape of a ribbon, which is filled with a red viſcid matter. It appears that the place of inſertion of the muſcles, as well as the muſcles themſelves, which extend along the lobe of the manteau, furniſh real blood, which is contained in three ſmall fleſhy red glandular bodies of unequal ſize, which are viſible after having taken off the muſcles; perhaps theſe conſtitute the heart of the animal.

The muſcles which are inſerted into the other ſhell are alſo divided into ſeveral parts: ſome are ſeen extending along the correſponding lobe of the manteau; many others riſe up in a kind of tuft, which is fixed into the ſhell above: ſome again ſubdivide into ſuch minute ramifications as not to allow of tracing their courſe, even with the aſſiſtance of a microſcope; but others, more apparent, contribute to the formation of the pedicle which paſſes through the opening left between the two ſhells, is connected to each of them by ſeveral fibres, and fixes itſelf to ſome external body, principally to other bivalves. The muſcles of the anomia have therefore three attachments, namely, to the inner ſurface of each ſhell, and to ſome external body.

The form of the pedicle is cylindrical, being encloſed in a muſcular ſubſtance, which contains ſeveral fibres; it is from a line to a line and a half long, and two thirds in diameter. It adheres ſo forcibly to different ſubſtances, as that the animal, and all the muſcles which contribute to the formation of the pedicle, may more eaſily be torn through than the pedicle detached from the place of its adheſion. The glutinous ſubſtance which connects them to each other, reſiſts even the heat of boiling water. It is by means of this pedicle that the animal raiſes its ſhell ſo as to be, while in the water, in a poſition inclined to the horizon. The ſmalleſt valve is always the loweſt, being that upon which the animal reſts; the ſuperior one being the larger, and ſerving as a covering. Our author thinks the animal has the power of loco-motion.

After raiſing the lobe of the manteau he obſerved the ears. They are large, compoſed of two membranaceous laminæ on each ſide, of which the ſuperior is the narrower. Theſe laminæ are connected to each other by a thin membrane, ſo as to form only a ſingle pouch. They have on their edges long fringes, which hang looſe upon the manteau; but a very remarkable circumſtance is, that their ears are ſupported by little bones like thoſe of fiſh. The form of the ears is that of an arch; they are ſeparated from each other on their lower part, where the fringes are the longeſt; ſo that the two ears on one ſide are perfectly diſtinct from thoſe on the other ſide. The commencement of the ears is at the teeth of the hinge.

Between the ears are ſituate the ſtomach, œſophagus, and mouth; the whole forming a triangle, of which the mouth is the baſe. It is placed at the ſide of the hinge, and conſiſts of a large tranſverſe opening without lips or jaw-bone. The œſophagus is very ſhort, but is capable of elongation when the animal opens its mouth. The ſtomach, which is of the ſhape of a pointed ſac, is connected by a membrane to the bones of the ear. On opening the ſtomach, he found a ſmall ſhrimp half digeſted.

At the bottom of the ſtomach is ſeen the inteſtine, of which it is, as it were, a continuation. It is extremely ſhort, not exceeding half a line in a ſhell fifteen

Terebratulæ, Ternai.

lines acroſs, and is compoſed of a very ſlender membrane. The excrements are diſcharged upon the lobes of the manteau, but they are eaſily thrown out by the motions of the two lobes.

The little bones of the ears, already mentioned, had not formerly been obſerved in any of the teſtaceous animals; whence the terebratulæ approach nearer to fiſh than the inhabitants of any other ſhell. In the anomiæ which are preſerved in cabinets, there is found only a very ſmall portion of theſe bones, whence they have obtained the improper appellations of *tongue* or *fork*, which indicate only the form of the fragments, and not their uſe.

The ſmall bones of the ears are compoſed of ſeveral pieces, the principal of which is of an oval form; it ſprings from the ſide of the hinge, of which it appears to be a continuation; thence it extends about two-thirds of the breadth of the ſhell, where it is reflected, and reſts againſt the upper part of the fork, to the branches of which it is united by a ſimple ſuperpoſition; a kind of articulation very common among the numerous ſmall bones that compoſe the heads of fiſh. The fork extends from the ſummit a little more than one-third of the breadth of the ſhell: it is formed by a pivot which divides into two long and pointed branches; theſe are remarkably brittle, and ſupport the extremities of the bones of the larger ears. The lamina, which compoſes a ſecond ſet of ears, reſts upon a curved bone, which on one ſide is attached to the inferior internal part of the bone of the larger ears, and on the other reaches to the ſide of the mouth of the animal, where it is united to another flat little bone, which is applied to a ſimilar bone on the other ſide. Theſe laſt little bones are exactly below the membrane which forms the mouth. All theſe bones are flat, very brittle, and ſurrounded with fibres and membranes. By their articulations the ears are enabled to move; they alſo ſupport the body of the animal, which touches neither of the ſhells, but remains between them as upon treſſels. The ſpace between the branches of the bones of the ears is filled up with a tranſparent firm membrane; at the baſe of the fork is a ſimilar one, and a perpendicular partition dividing the ſpace occupied by the body of the animal from the reſt of the ſhell. There are two orifices in this membrane communicating with the ſpace between the two lobes of the manteau, and which ſerves as a trachea; for we have remarked, in the deſcription of the manteau, that the two lobes are entirely ſeparated from each other, and therefore do not form a real trachea.

From this deſcription, it follows that the anomia ought to be ſeparated from the genus oyſter, ſince it has a toothed hinge, ſeveral ligaments, and an interior organization wholly different; neither ought it to be confounded with the cockle, the ſhells of which are both equal, and are deſtitute of any ſenſible perioſteum, without reckoning other differences. It has ſtill leſs analogy with the other bivalves, and therefore ought to conſtitute a peculiar genus; the ſpecies of which, both foſſil and living, are very numerous.

See Plate XLIII. where fig. 1. is a front view of a terebratula of middle ſize. Fig. 2. is a view of the internal ſtructure.—A A, laminæ of the ſuperior ears—B B, laminæ of the inferior—C, the ſtomach—D, the anus—E E, the manteau—F, the œſophagus.

Ternai.

TERNAI, the name given by Perouſe to a very fine bay which he diſcovered on the coaſt of Tartary, in Lat. 45° 13′ North, and in Long. 135° 9′ Eaſt from Paris. The bottom is ſandy, and diminiſhes gradually to ſix fathoms within a cable's length of the ſhore. The tide riſes five feet; it is high water at 8^h 15^m at full and change; and the flux and reflux do not alter the direction of the current at half a league from the ſhore.

"Five ſmall creeks (ſays La Perouſe), ſimilar to the ſides of a regular polygon, form the outline of this roadſtead; theſe are ſeparated from each other by hills, which are covered to the ſummit with trees. Never did France, in the freſheſt ſpring, offer gradations of colour of ſo varied and ſtrong a green; and though we had not ſeen, ſince we began to run along the coaſt, either a ſingle fire or canoe, we could not imagine that a country ſo near to China, and which appeared ſo fertile, ſhould be entirely uninhabited. Before our boats had landed, our glaſſes were turned towards the ſhore, but we ſaw only bears and ſtags, which paſſed very quietly along the ſea ſide. The ſame plants which grow in our climates carpeted the whole ſoil, but they were ſtronger, and of a deeper green; the greater part were in flower. Roſes, red and yellow lilies, lilies of the valley, and all our meadow flowers in general, were met with at every ſtep. Pine trees covered the tops of the mountains; oaks began only half way down, and diminiſhed in ſtrength and ſize in proportion as they came nearer the ſea; the banks of the rivers and rivulets were bordered with willow, birch, and maple trees, and on the ſkirts of the foreſts we ſaw apple and medlar trees in flower, with clumps of hazle nut trees, the fruit of which already made its appearance. Our ſurpriſe was redoubled, when we reflected on the population which overburdens the extenſive empire of China, ſo that the laws do not puniſh fathers barbarous enough to drown and deſtroy their children, and that this people, whoſe polity is ſo highly boaſted of, dares not extend itſelf beyond its wall, to draw its ſubſiſtence from a land, the vegetation of which it would be neceſſary rather to check than to encourage. At every ſtep after we had landed, we perceived traces of men by the deſtruction they had made; ſeveral trees, cut with ſharp-edged inſtruments; the remains of ravages by fire were to be ſeen in ſeveral places, and we obſerved ſome ſheds, which had been erected by hunters in a corner of the woods. We alſo found ſome ſmall baſkets, made of the bark of birch trees, ſewed with thread, and ſimilar to thoſe of the Canadian Indians; rackets for walking on the ſnow; in a word, every thing induced us to think that the Tartars approach the borders of the ſea in the ſeaſon for hunting and fiſhing; that they aſſemble in colonies at that period along the rivers; and that the bulk of the nation live in the interior of the country on a ſoil perhaps better calculated for the multiplication of their immenſe flocks and herds."

Our navigators caught in the bay vaſt quantities of fine fiſh, ſuch as cod, harp-fiſh, trout, ſalmon, herrings, and plaice; but though game was plenty on ſhore, they had no ſucceſs in hunting. The meadows, ſo delightful to the ſight, could ſcarce be croſſed; the thick graſs was three or four feet high, ſo that they found themſelves in a manner buried in it, and they were under the perpetual dread of being bitten by ſerpents, of which

which they ſaw a great number on the banks of the rivulets. They found, however, immenſe quantities of ſmall onions, ſorrel, and celery; which, together with the freſh fiſh, ſerved as antidotes againſt the ſcurvy.

TERRE-PLEIN, or TERRE-PLAIN, in fortification, the top, platform, or horizontal ſurface of the rampart, upon which the cannon are placed, and where the defenders perform their office. It is ſo called becauſe it lies level, having only a little ſlope outwardly to counteract the recoil of the cannon. Its breadth is from 24 to 30 feet; being terminated by the parapet on the outer ſide, and inwardly by the inner talus.

TERRELLA, or little earth, is a magnet turned of a ſpherical figure, and placed ſo as that its poles, equator, &c. do exactly correſpond with thoſe of the world. It was ſo firſt called by Gilbert, as being a juſt repreſentation of the great magnetic globe we inhabit. Such a terrella, it was ſuppoſed, if nicely poiſed, and hung in a meridian like a globe, would be turned round like the earth in 24 hours by the magnetic particles pervading it; but experience has ſhewn that this is a miſtake.

TETRAEDRON, or TETRAHEDRON, in geometry, is one of the five Platonic or regular bodies or ſolids, comprehended under four equilateral and equal triangles. Or it is a triangular pyramid of four equal and equilateral faces.

TETRAGON, in geometry, a quadrangle, or a figure having four angles. Such as a ſquare, a parallelogram, a rhombus, and a trapezium. It ſometimes alſo means peculiarly a ſquare.

TETRAGON, in aſtrology, denotes an aſpect of two planets with regard to the earth, when they are diſtant from each other a fourth part of a circle, or 90 degrees. The tetragon is expreſſed by the character □, and is otherwiſe called a ſquare or quartile aſpect.

THEBES, in Egypt. Having in the *Encyclopædia* given Mr Bruce's account of this ancient city, which repreſents it as having been a paltry place, ſo contrary to the deſcription of Homer, juſtice to the father of poetry requires that we here notice what has been ſaid of it by a ſubſequent traveller, who remained three days among its ruins. According to Mr Browne, "the maſſy and magnificent forms of the ruins that remain of ancient Thebes, the capital of Egypt, the city of Jove, the city with 100 gates, muſt inſpire every intelligent ſpectator with awe and admiration. Diffuſed on both ſides of the Nile, their extent confirms the claſſical obſervations, and Homer's animated deſcription ruſhes into the memory:

'Egyptian Thebes, in whoſe palaces vaſt wealth is ſtored; from each of whoſe hundred gates iſſue two hundred warriors, with their horſes and chariots.'

"Theſe venerable ruins, probably the moſt ancient in the world, extend for about three leagues in length along the Nile. Eaſt and weſt they reach to the mountains, a breadth of about two leagues and a half. The river is here about three hundred yards broad. The circumference of the ancient city muſt therefore have been about twenty-ſeven miles.

"In ſailing up the Nile, the firſt village you come to within the precincts is Kourna, on the weſt, where there are few houſes, the people living moſtly in the caverns. Next is Abuhadjadj, a village, and Karnac, a ſmall diſtrict, both on the eaſt. Far the largeſt portion of the city ſtood on the eaſtern ſide of the river. On the ſouth-weſt Medinet-Abu marks the extremity of the ruins; for Arment, which is about two leagues to the ſouth, cannot be conſidered as a part.

"In deſcribing the ruins, we ſhall begin with the moſt conſiderable, which are on the eaſt of the Nile. The chief is the Great Temple, an oblong ſquare building of vaſt extent, with a double colonnade, one at each extremity. The maſſy columns and walls are covered with hieroglyphics; a labour truly ſtupendous. 1. The Great Temple ſtands in the diſtrict called *Karnac*. 2. Next in importance is the temple at *Abuhadjadj*. 3. Numerous ruins, avenues marked with remains of ſphinxes, &c. On the weſt ſide of the Nile appear, 1. Two coloſſal figures, apparently of a man and woman, formed of a calcareous ſtone like the reſt of the ruins. 2. Remains of a large temple, with caverns excavated in the rock. 3. The magnificent edifice ſtyled the *palace of Memnon*. Some of the columns are about forty feet high, and about nine and a half in diameter. The columns and walls are covered with hieroglyphics. This ſtands at *Kourna*. 4. Behind the palace is the paſſage ſtyled *Bibân-el-Moluk*, leading up the mountain. At the extremity of this paſſage, in the ſides of the rock, are the celebrated caverns known as the ſepulchres of the ancient kings."

Though Mr Browne agrees with Pococke and Bruce, that the paſſage in Homer refers not to the gates of the city, he is yet of opinion, contrary to them, that Thebes had been a walled town. He ſays, indeed, that ſome faint remains of its ſurrounding wall are viſible at this day; and he thinks that he diſcovered the ruins of three of its gates, though he does not affirm this with abſolute confidence.

THEODOSIUS, a celebrated mathematician, flouriſhed in the times of Cicero and Pompey; but the time and place of his death are unknown. This Theodoſius, the Tripolite, as mentioned by Suidas, is probably the ſame with Theodoſius the philoſopher of Bythinia, who, Strabo ſays, excelled in the mathematical ſciences, as alſo his ſons; for the ſame perſon might have travelled from the one of thoſe places to the other, and ſpent part of his life in each of them; like as Hipparchus was called by Strabo the Bythinian, but by Ptolemy and others the Rhodian.

Biog. Dict.

Theodoſius chiefly cultivated that part of geometry which relates to the doctrine of the ſphere, concerning which he publiſhed three books. The firſt of theſe contains 22 propoſitions; the ſecond, 23; and the third, 14; all demonſtrated in the pure geometrical manner of the ancients. Ptolemy made great uſe of theſe propoſitions, as well as all ſucceeding writers. Theſe books were tranſlated by the Arabians, out of the original Greek, into their own language. From the Arabic the work was again tranſlated into Latin, and printed at Venice. But the Arabic verſion being very defective, a more complete edition was publiſhed, in Greek and Latin, at Paris 1558, by John Pena, Regius Profeſſor of aſtronomy. And Vitello acquired reputation by tranſlating Theodoſius into Latin. This author's works were alſo commented on and illuſtrated by Clavius, Heleganius, and Guarinus, and laſtly by De Chales, in his Curſus Mathematicus. But that edition of Theodoſius's Spherics, which is now moſt in uſe, was tranſlated and publiſhed by our countryman the learned Dr Barrow, Theon, Theophilanthropiſts

row, in the year 1675, illuſtrated and demonſtrated in a new and conciſe method. By this author's account, Theodoſius appears, not only to be a great maſter in this more difficult part of geometry, but the firſt conſiderable author of antiquity who has written on that ſubject.

Theodoſius, too, wrote concerning the Celeſtial Houſes; alſo of Days and Nights; copies of which, in Greek, were in the King's library at Paris. Of which there was a Latin edition, publiſhed by Peter Daſypody, in the year 1572.

THEON, of Alexandria, a celebrated Greek philoſopher and mathematician, who flouriſhed in the 4th century, about the year 380, in the time of Theodoſius the Great; but the time and manner of his death are unknown. His genius and diſpoſition for the ſtudy of philoſophy were very early improved by cloſe application to all its branches; ſo that he acquired ſuch a proficiency in the ſciences as to render his name venerable in hiſtory, and to procure him the honour of being preſident of the famous Alexandrian ſchool. One of his pupils was the admirable Hypatia, his daughter, who ſucceeded him in the preſidency of the ſchool; a truſt which, like himſelf, ſhe diſcharged with the greateſt honour and uſefulneſs. See her life, *Encycl.*

The ſtudy of Nature led Theon to many juſt conceptions concerning God, and to many uſeful reflections in the ſcience of moral philoſophy. Hence, it is ſaid, he wrote with great accuracy on Divine Providence. And he ſeems to have made it his ſtanding rule, to judge the truth of certain principles, or ſentiments, from their natural or neceſſary tendency. Thus, he ſays, that a full perſuaſion that the Deity ſees every thing we do, is the ſtrongeſt incentive to virtue; for he inſiſts, that the moſt profligate have power to refrain their hands, and hold their tongues, when they think they are obſerved, or overheard, by ſome perſon whom they fear or reſpect. With how much more reaſon then, ſays he, ſhould the apprehenſion and belief, that God ſees all things, reſtrain men from ſin, and conſtantly excite them to their duty? He alſo repreſents this belief concerning the Deity as productive of the greateſt pleaſure imaginable, eſpecially to the virtuous, who might depend with greater confidence on the favour and protection of Providence. For this reaſon, he recommends nothing ſo much as meditation on the preſence of God: and he recommended it to the civil magiſtrate as a reſtraint on ſuch as were profane and wicked, to have the following inſcription written, in large characters, at the corner of every ſtreet—GOD SEES THEE, O SINNER.

Theon wrote notes and commentaries on ſome of the ancient mathematicians. He compoſed alſo a book, intitled *Progymnaſmata*, a rhetorical work, written with great judgment and elegance; in which he criticiſed on the writings of ſome illuſtrious orators and hiſtorians; pointing out, with great propriety and judgment, their beauties and imperfections; and laying down proper rules for propriety of ſtyle. He recommends conciſeneſs of expreſſion, and perſpicuity, as the principal ornaments. This book was printed at Baſle in the year 1541; but the beſt edition is that of Leyden, in 1626, in 8vo.

THEOPHILANTHROPISTS, a ſect of deiſts, who, in September 1796, publiſhed at Paris a ſort of catechiſm or directory for ſocial worſhip, under the title of *Manuel des Theanthrophiles*. This religious breviary found favour: the congregation became numerous; and in the ſecond edition of their manual they aſſumed the leſs harſh denomination of *Theophilanthropes, i. e.* lovers of God and man. A book of hymns, a liturgy for every decade of the French year, and an homiletical ſelection of moral leſſons, are announced, or publiſhed, by their unknown ſynod. Thus they poſſeſs a ſyſtem of pious ſervices adapted to all occaſions, which ſome one of the individuals who attend reads aloud; for they object to the employment of a regular lecturer, in conſequence of their hoſtility to prieſts.—This novel ſect was countenanced by Larcveillere Lepaux, one of the Directory, and, ſoon after its formation, opened temples of its own in Dijon, and in other provincial towns. They had declamations, in the ſpirit of ſermons, which abounded with ſuch phraſes as *l'eternal geometre*, and the like, and which have long ſince been familiar to thoſe who frequent the lodges of free maſonry. Whether the ſect now exiſts, or fell at the laſt revolution which annihilated the directory, we have not learned; but a tranſlation of its *Manuel* into Engliſh, for the uſe, we ſuppoſe, of our Jacobins, was made ſo early as the year 1797. From this contemptible performance, we learn that the creed of the Theophilanthropiſts is compriſed in the four following propoſitions:

Theophilanthropiſts.

The Theophilanthropiſts believe in the exiſtence of God, and the immortality of the ſoul.

The ſpectacle of the univerſe atteſts the exiſtence of the Firſt Being.

The faculty which we poſſeſs of thinking, aſſures us, that we have, within ourſelves, a principle which is ſuperior to matter, and which ſurvives the diſſolution of the body.

The exiſtence of God, and the immortality of the ſoul, do not need long demonſtrations; they are ſentimental truths, which every one may find written in his heart, if he conſult it with ſincerity.

Thus a ſort of religious inſtinct is ſet up as the ſole foundation of piety, which every one has as much right to diſavow as another to aſſert; and the obligations of which, therefore, can in no way be ſhewn to be incumbent on thoſe to whom this novel illumination is not vouchſafed. Society, under ſuch a ſyſtem, gains no means of influencing the conduct of refractory members.

The morality of the Theophilanthropiſts is founded on one ſingle precept: *Worſhip God, cheriſh your kind, render yourſelves uſeful to your country!*

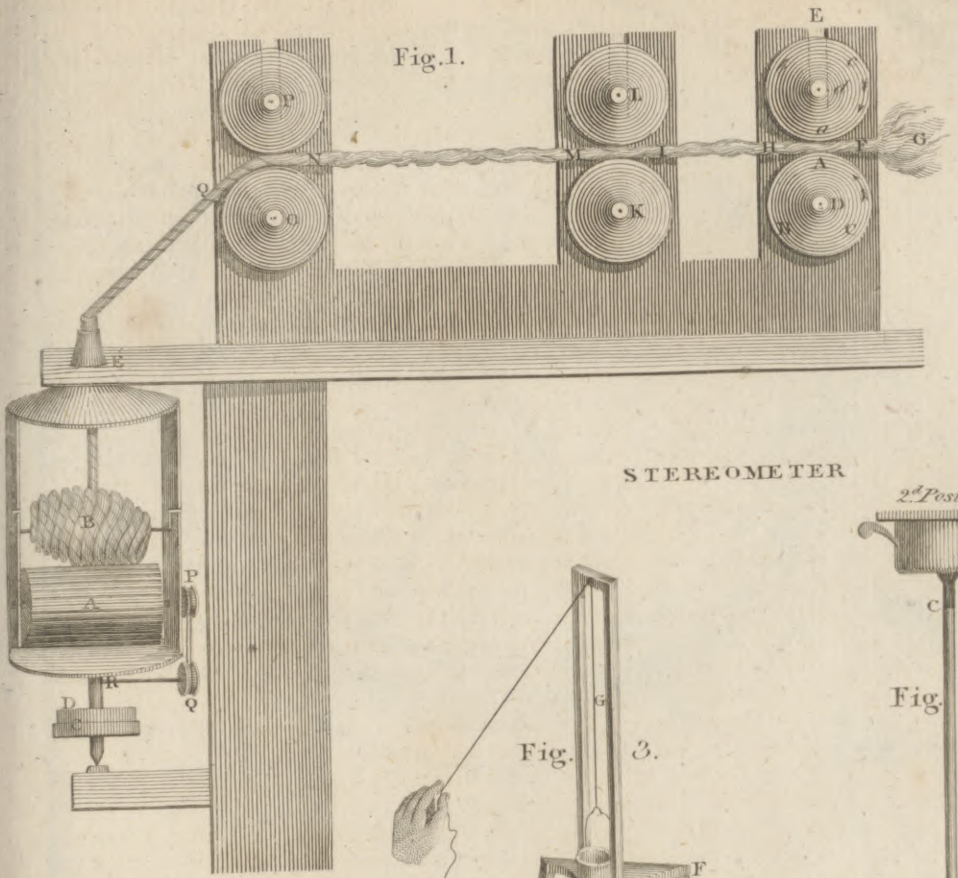
Among the duties comprehended under the denomination of cheriſhing our kind, we find that of *not lending for uſury*: the others are chiefly extracted from the goſpels, and do not interfere with the province of the civil magiſtrate. The queſtion of monogamy is not diſcuſſed.

Among the duties to our country are placed thoſe of fighting in its defence, and of paying the taxes. It was certainly prudent in the ſtateſman to ſlide theſe duties into the catalogue of his eſtabliſhed maxims of morality; and he ran thereby little riſk of provoking heretical animadverſions on his creed in France.

The following inſcriptions are ordered to be placed above the altars in the ſeveral temples or ſynagogues of the Theophilanthropiſts; but for what reaſon altars are admitted into ſuch ſynagogues we are not informed:

SPINNING PLATE XLIII.

Fig.1.



STEREOMETER

Fig. 1.

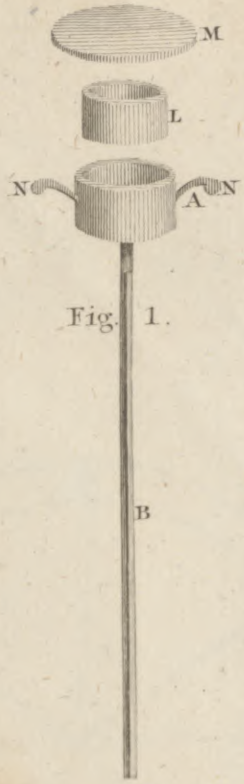


Fig. 2.

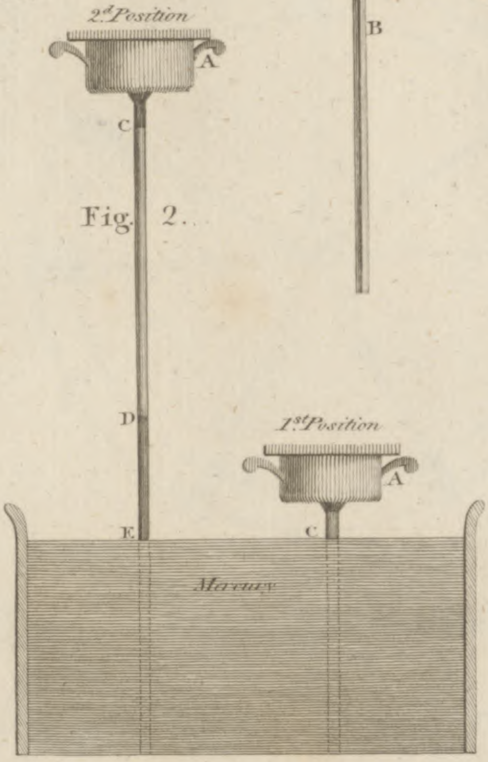
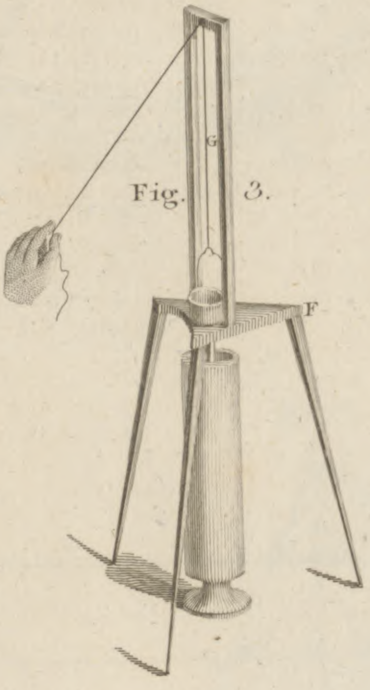


Fig. 3.



EGETABLE SUBSTANCES

Fig.1.

Fig.2.

TEREBRATULA

Fig.1.

Fig.2.

D.Lizars.Sculp!

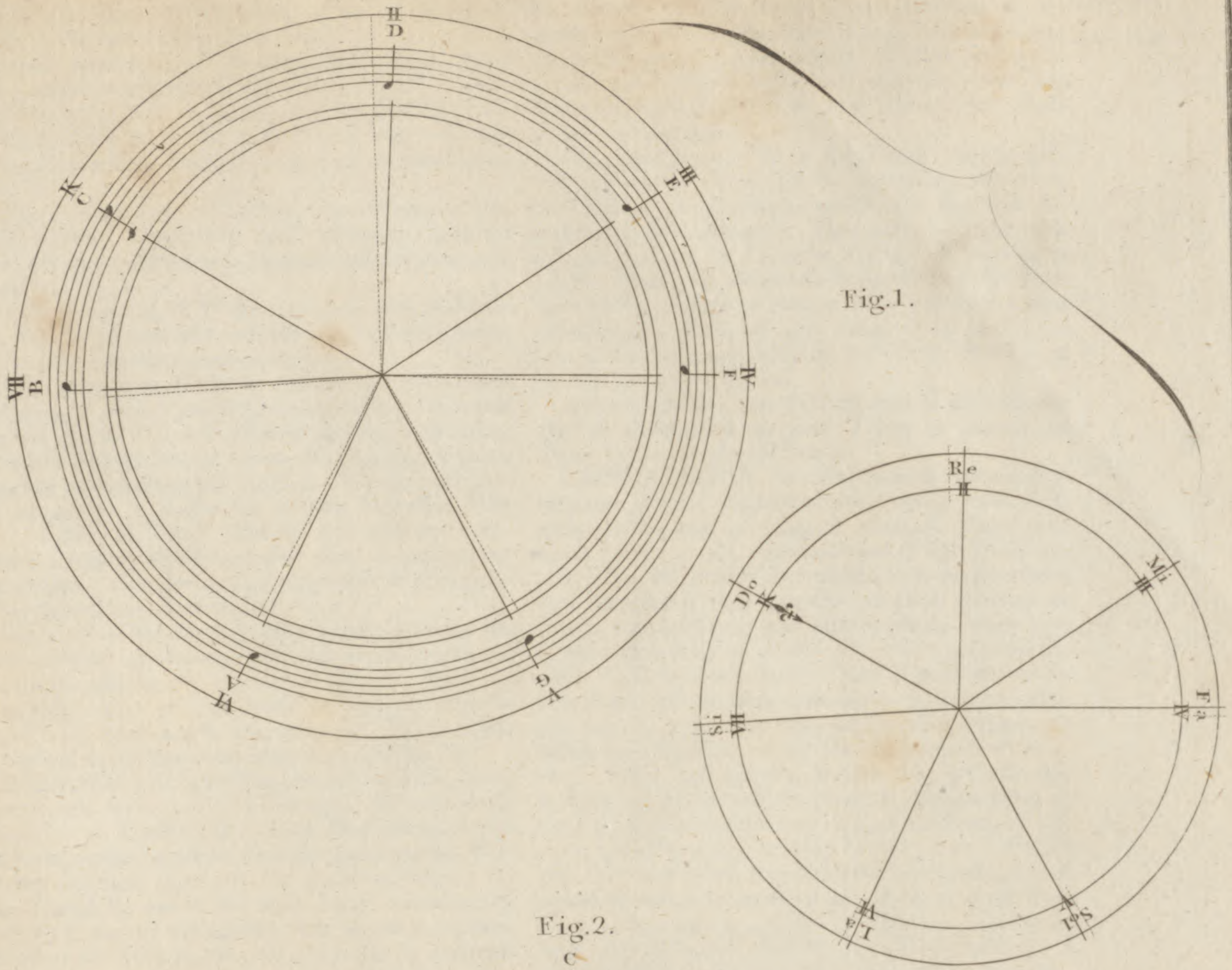
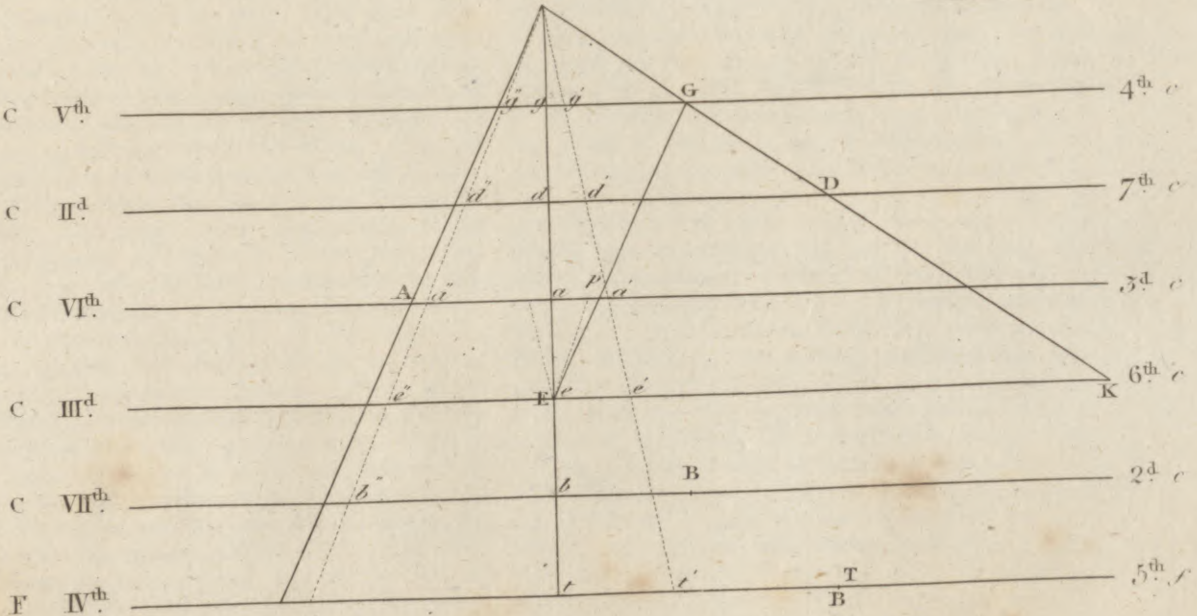


Fig.1.

Fig.2.



D Lizars Sculpt

Theophi-
anthro-
pists,
Theophi
lus.

g. Dic

Firſt inſcription, "We believe in the Exiſtence of God, in the immortality of the ſoul."

Second inſcription, "Worſhip God, cheriſh your kind, render yourſelves uſeful to the country."

Third inſcription, "Good is every thing which tends to the preſervation or the perfection of man.—Evil is every thing which tends to deſtroy or to deteriorate him."

Fourth inſcription, "Children, honour your fathers and mothers. Obey them with affection. Comfort their old age.—Fathers and mothers, inſtruct your children."

Fifth inſcription, "Wives, regard in your huſbands the chiefs of your houſes.—Huſbands, love your wives, and render yourſelves reciprocally happy."

This pentalogue is chiefly objectionable on account of the vague drift of the fifth commandment: the whole has too general a turn for obvious practical application. The introduction of ceremonies, of ſculpture, of painting, and of engraving, is forbidden. If poetry and muſic may concur to render the worſhip impreſſive, why not the other fine arts? The fine arts have never illuſtrated a country which excluded them from the public temples. Are they to be extinguiſhed in France by Theophilanthropic iconoclaſts?

At p. 28. of the Manuel, this ſurpriſing maxim occurs: *Avoid innovations!* A ſect fifteen months old grown as teſty as the church of Rome! They acknowledge, that perhaps better inſcriptions may be found; yet they forbid the exchange. They prefer *mumpſimus* to the *ſumpſimus* of genuine Chriſtianity!

THEOPHILUS, a writer and biſhop of the primitive church, was educated a Heathen, and afterwards converted to Chriſtianity. Some have imagined that he is the perſon to whom St Luke dedicates the Acts of the Apoſtles; but they are groſsly miſtaken; for this Theophilus was ſo far from being contemporary with St Luke and the apoſtles, that he was not ordained biſhop of Antioch till *anno* 170; and he governed this church twelve or thirteen years. He was a vigorous oppoſer of certain heretics of his time, and compoſed a great number of works; all of which are loſt, except three books to Autolycus, a learned Heathen of his acquaintance, who had undertaken to vindicate his own religion againſt that of the Chriſtians. The firſt book is properly a diſcourſe between him and Autolycus, in anſwer to what this Heathen had ſaid againſt Chriſtianity. The ſecond is to convince him of the falſehood of his own, and the truth of the Chriſtian religion. In the third, after having proved that the writings of the Heathens are full of abſurdities and contradictions, he vindicates the doctrine and the lives of the Chriſtians from thoſe falſe and ſcandalous imputations which were then brought againſt them. Laſtly, at the end of his work, he adds an hiſtorical chronology from the beginning of the world to his own time, to prove that the hiſtory of Moſes is at once the moſt ancient and the trueſt; and it appears from this little epitome, how well this author was acquainted with profane hiſtory. Theſe three books are filled with a great variety of curious diſquiſitions concerning the opinions of the poets and philoſophers, and there are but few things in them relating immediately to the doctrines of the Chriſtian religion. Not that Theophilus was ignorant of theſe doctrines, but, having compoſed his works for the converſion of a Pagan, he inſiſted rather on the external evidence or proofs from without, as better adapted, in his opinion, to the purpoſe. His ſtyle is elegant, and the turn of his thoughts very agreeable; and this little ſpecimen is ſufficient to ſhew that he was indeed a very eloquent man.

g. Dict.

The piece is intitled, in the Greek manuſcripts, "The books of Theophilus to Autolycus, concerning the Faith of the Chriſtians, againſt the malicious detractors of their religion." They were publiſhed, with a Latin verſion, by Conradus Geſner, at Zurich, in 1546. They were afterwards ſubjoined to Juſtin Martyr's works, printed at Paris in 1615 and 1636; then publiſhed at Oxford, 1684, in 12mo, under the inſpection of Dr Fell; and, laſtly, by Jo. Chriſt. Wolfius, at Hamburgh, 1723, in 8vo.

It is remarkable, that this patriarch of Antioch was the firſt who applied the term *Trinity* to expreſs the Three Perſons in the Godhead.

THERAPEUTÆ, ſo called from the extraordinary purity of their religious worſhip, were a Jewiſh ſect, who, with a kind of religious phrenzy, placed their whole felicity in the contemplation of the Divine nature. Detaching themſelves wholly from ſecular affairs, they transferred their property to their relations or friends, and withdrew into ſolitary places, where they devoted themſelves to a holy life. The principal ſociety of this kind was formed near Alexandria, where they lived, not far from each other, in ſeparate cottages, each of which had its own ſacred apartment, to which the inhabitant retired for the purpoſes of devotion. After their morning prayers, they ſpent the day in ſtudying the law and the prophets, endeavouring, by the help of the commentaries of their anceſtors, to diſcover ſome allegorical meaning in every part. Beſides this, they entertained themſelves with compoſing ſacred hymns in various kinds of metre. Six days of the week were, in this manner, paſſed in ſolitude. On the ſeventh day they met, clothed in a decent habit, in a public aſſembly; where, taking their places according to their age, they ſat, with the right hand between the breaſt and the chin, and the left at the ſide. Then ſome one of the elders, ſtepping forth into the middle of the aſſembly, diſcourſed, with a grave countenance and a calm of tone voice, on the doctrines of the ſect; the audience, in the mean time, remaining in perfect ſilence, and occaſionally expreſſing their attention and approbation by a nod. The chapel where they met was divided into two apartments; one for the men, the other for the women. So ſtrict a regard was paid to ſilence in theſe aſſemblies, that no one was permitted to whiſper, or even to breathe aloud; but when the diſcourſe was finiſhed, if the queſtion which had been propoſed for ſolution had been treated to the ſatisfaction of the audience, they expreſſed their approbation by a murmur of applauſe. Then the ſpeaker, riſing, ſung a hymn of praiſe to God, in the laſt verſe of which the whole aſſembly joined. On great feſtivals, the meeting was cloſed with a vigil, in which ſacred muſic was performed, accompanyed with ſolemn dancing: and theſe vigils were continued till morning, when the aſſembly, after a morning prayer, in which their faces were directed towards the riſing ſun, was broken up. So abſtemious were theſe aſcetics, that they commonly ate nothing before the ſetting ſun, and often faſted two or three days. They abſtained from wine, and their ordinary food was bread and herbs.

Much diſpute has ariſen among the learned concerning this ſect. Some have imagined them to have been Judaizing Gentiles; but Philo ſuppoſes them to be Jews, by ſpeaking of them as a branch of the ſect of Eſſenes, and expreſsly claſſes them among the followers of Moſes. Others have maintained, that the Therapeutæ were an Alexandrian ſect of Jewiſh converts to the Chriſtian faith, who devoted themſelves to a monaſtic life. But is is impoſſible; for Philo, who wrote before Chriſtianity appeared in Egypt, ſpeaks of this as an eſtabliſhed ſect. From comparing Philo's account of this ſect with the ſtate of philoſophy in the country where it flouriſhed, we conclude, that the Therapeutæ were a body of Jewiſh fanatics, who ſuffered themſelves to be drawn aſide from the ſimplicity of their ancient religion by the example of the Egyptians and Pythagoreans. How long this ſect continued is uncertain; but it is not improbable that, after the appearance of Chriſtianity in Egypt, it ſoon became extinct.

THERMOMETRIC SPECTRUM, is a name given to the ſpace in which a thermometer may be placed, ſo that it ſhall be affected by the ſun's rays refracted by a priſm. It is, in part, the ſame with the PRISMATIC SPECTRUM, which exhibits the different colours produced by the ſolar light.

The philoſophical inſtrument now called a *thermometer*, was firſt named THERMOSCOPE; and was prized by the naturaliſt, becauſe it gave him indications of the preſence and agency of fire in many caſes where our ſenſation of warmth or heat was unable to diſcover it. It was not long before it was obſerved that it alſo affords us meaſures of the changes which take place either in the quantity or the activity of the cauſe of heat, and of many other important phenomena uſually accompanied by heat. They were then called *thermometers*. But in both of theſe offices, it is ſtill a doubt whether it indicates and meaſures any real ſubſtance, a being *ſui generis*, to which we may give the name *fire*, *phlogiſton*, *caloric*, *heat*, or any other; or only indicates and meaſures certain ſtates or conditions, in which all bodies may be found, without the addition or abſtraction of any material ſubſtance.

We think that this queſtion has a greater chance now of being decided than in any former time, in conſequence of a recent and very important diſcovery made by that unwearied obſerver of the works of God, the celebrated Dr Herſchel. Being greatly incommoded when looking at the ſun, by the great heats produced in the eye-pieces of his teleſcopes, he thought that the laws of refraction enabled him to diminiſh them by a proper conſtruction of his eye-pieces. He began his attempts like a philoſopher, by examining the heat produced in the various parts of the priſmatic ſpectrum. Comparing the gradation of heat with that of illumination, he found that they did not, by any means, follow the ſame law. The illumination increaſed gradually from the violet end of the ſpectrum, where it was exceedingly faint, to the boundary of the green and yellow, where it was the moſt remarkable; and after this, it decreaſed as the illuminated object approached the red extremity of the ſpectrum. But the calorific power of the refracted light increaſed all the way from the extreme violet to the extreme red; and its laſt augmentations were conſiderable, and therefore unlike the uſual approaches of a quantity to its maximum ſtate. This made him think of placing the thermometer a little way beyond the extremity of the viſible ſpectrum. To his great aſtoniſhment, he found that the thermometer was more affected there than in the hotteſt part of the *illuminated* ſpectrum. Expoſing the thermometer at various diſtances beyond the extreme red, but in the plane of refraction, he found that it was moſt ſtrongly affected when placed beyond that extremity, about one-fifth of the whole length of the ſpectrum; from thence the calorific influence of the ſun gradually diminiſhed, but was ſtill very conſiderable, at a diſtance from the extreme red equal to three-fifths of the length of the luminous ſpectrum. Theſe firſt-ſuggeſted modes of trial appeared to Dr Herſchel to be too rude to intitle him to ſay that the warming influence did not extend ſtill farther. Indeed the inſtrument ſcarcely performed the part of a thermometer, but merely that of an indicator of heat, or a thermoſcope.

Here is a very new, and wonderful, and important, piece of information. We apprehend that all the philoſophers of Europe, as well as the unlearned of all nations, believe that the *warming* influence of the ſun, and of other luminous bodies, is conjoined with their power of *illumination*. Moſt of the philoſophers admitted the emiſſion of a matter called *light*, projected from the ſhining body, and moving with aſtoniſhing velocity, in thoſe lines which the mathematicians called *rays*, becauſe they diverged from the ſhining point, as the *radii* or ſpokes of a wheel diverge from the nave. This notion ſeems to be the ſimple ſuggeſtion of Nature; and it alſo ſeems to be the opinion entertained by Sir Iſaac Newton. His demonſtration of the laws of reflection and refraction proceeds on this ſuppoſition alone, and the particles of light are held by him to be affected by accelerating and deflecting forces, in the ſame way as a ſtone thrown from the hand is affected by gravity. Huyghens, indeed, Dr Hooke, and Euler, imagined that viſion and illumination were effected in the ſame way that hearing, and reſonance, and echo, are effected—that there is no matter projected from the ſhining body; but that we are ſurrounded by an elaſtic fluid, which is thrown into vibrations by certain tremors of the viſible object—and that thoſe vibrations of this fluid affect our eye in the ſame way as the undulation of elaſtic air, produced by the tremors of a ſtring or a bell, affect our ear. According to theſe philoſophers, a ray of viſion is merely the line which paſſes through all theſe undulations at right angles.

Theſe two opinions ſtill divide the mathematical philoſophers of Europe; but the majority, and particularly the moſt eminent for mathematical and mechanical ſcience, are (with the exception of Huyghens and Euler) on the ſide of the vulgar. This opinion has been greatly ſtrengthened of late years by the diſcoveries in chemiſtry. The influence of light on the growth of plants, the total want of aromatic oils in ſuch as grow in the dark, and their formation and appearance in the very ſame plant, along with the green colour, as ſoon as the plant is placed in the light (even that of open day without ſunſhine, or in the light of a candle), is a ſtrong indication of ſome ſubſtance being obtained from the light, abſorbed by the plant, and combined with its other ingredients. The ſame concluſion is drawn from the

the effects of the ſun's light on vegetable colours, on the nitric and nitrous acids, on mangan eſe, on the calces or oxyds of metals, and numberleſs other inſtances, which all concur in rendering it almoſt unqueſtionable that the ſun's rays, and thoſe of other ſhining bodies, may be, and daily are, combined with the other ſubſtances of which bodies are compoſed, and may be again ſeparated from them. And, ſhould any doubts remain, it would ſeem that the theory of combuſtion, fiſt conceived and imperfectly publiſhed by Dr Hooke in his *Micrography*, p. 103. and in his *Lampas*, p. 1. &c. adopted by Mayow (ſee Hooke and Mayow in this *Suppl.*), forgotten, and lately revived and confirmed by Mr Lavoiſier, removes them entirely. In the beautiful and well-contrived experiments of the laſt gentleman, the light, accompanied by its heat, which had been abſorbed in the proceſs of growth or other natural operations, re-appeared in their primitive form, and might again be abſorbed and made to undergo the ſame round of changes.

Scheele, not inferior to Newton in caution, patience, and accuracy, and attentive to every thing that occurred in his experiments, diſcovered the ſeparability of the illuminating and the warming influences of ſhining bodies. He remarked, that a plate of glaſs, the moſt colourleſs and pellucid that can be procured, when ſuddenly interpoſed between a glowing fire and the face, inſtantly cuts off the warming power of the fire, without cauſing any ſenſible diminution of its brilliancy. He followed this diſcovery into many obvious conſequences, and found them all fully confirmed by obſervation and experiment. The writer of this article, immediately on hearing of Scheele's experiments, repeated them with complete ſucceſs: but he found, that when the glaſs plate had acquired the higheſt temperature which it could acquire in that ſituation, it did not any longer intercept the heat, or at leaſt in a very ſmall and almoſt inſenſible degree. It ſeemed to abſorb the heat, till ſaturated, without abſorbing any conſiderable portion of the light.

This ſeparability of heat from light does not ſeem to have met with the attention it deſerved. Dr Scheele's untenable theories on theſe ſubjects turned away the attention of the chemiſts from this diſcovery, and the mathematical philoſophers ſeem not to have heard of it at all. The late Dr Hutton of Edinburgh was more ſenſible of its importance; and in his laſt endeavours to ſupport the falling cauſe of phlogiſton, makes frequent alluſions to it. But in his attempts to explain the curious obſervations of Meſſrs Sauſſure and Pictet, in which there are unqueſtionable appearances of radiated heat, he reaſons ſo unconſequentially, that few readers proceed farther, ſo as to notice ſeveral obſervations of facts where the illuminating and warming influences are plainly ſeparated. In all theſe inſtances, however, Dr Hutton conſiders the inviſible rays as light, but not as heat; maintaining that they are inviſible, or do not render bodies viſible, only becauſe our eyes are inſenſible to their feeble action.

It was reſerved for Dr Herſchel to put this matter beyond diſpute by theſe valuable experiments. For did the inviſibility of any of the light beyond the extreme red of the priſmatic ſpectrum ariſe from the inſenſibility of our organs, the ſpectrum would gradually fade away beyond the red; but it ceaſes abruptly. Theſe thoughts could not eſcape this attentive obſerver. He therefore examined more particularly thoſe inviſible rays, cauſing them to be reflected by mirrors, and refracted through lenſes; and, in ſhort, he ſubjected them to all the ſubſequent treatments which Newton applied to the colouring rays. He found them retain their ſpecific refrangibilities and reflexibilities with as much uniformity and obſtinacy as Newton had obſerved in the colour-making rays. They were made to paſs through lenſes while the illuminating rays were intercepted by an opaque body, and the inviſible rays were then collected into a focus. They were reflected, both by the anterior and poſterior ſurfaces of tranſparent bodies. In all theſe trials they retained their power of expanding the liquor of a thermometer, and exciting the ſenſation of heat.

Theſe trials were not confined to the ſolar light or the ſolar rays: They were alſo made on the emanations from a candle, from an open fire, and from red hot iron; then they were made with bodies not hot enough to ſhine; with the heat of a common ſtove, and the heat from iron which was not viſible in the dark. The event was the ſame in all; and it was clearly proved that heat, or the cauſe of heat, is as ſuſceptible of radiation as light is; and that this radiation is performed in both according to the ſame laws.

We look with impatience for the ſubſequent experiments of this celebrated philoſopher on this ſubject; for we conſider them as of the greateſt and moſt extenſive importance for explaining the operations of Nature. We ſee, with indiſputable evidence, that there are rays from the ſun, and other bodies, which do not illuminate. It does not follow, however, that there are rays which do not warm; for the thermometer was affected in every part of the coloured ſpectrum. Dr Herſchel ſeems to think that the power of affecting the organ of ſight depends on the particular degrees of mechanical momentum which are indicated by the different degrees of refrangibility. We confeſs that we think it unlikely that ſuch a power ſhould terminate abruptly. We do not obſerve this in analogous phenomena: the evaneſcence of our ſenſations of ſound, of muſical pitch, of heat, &c. are all gradual. We think it more likely that illuminating and warming are ſpecific effects of different things. We ſhould have entertained this opinion independent of all other experience; and we think it ſtrongly confirmed by the experiments of Dr Scheele already mentioned. We are diſpoſed therefore to believe that there are rays which illuminate, but which do not warm; and rays which warm without illuminating. We have experiments in proſpect, by which we hope to put this to the teſt.

Theſe experiments of Dr Herſchel afford another good argument for the common opinion concerning light, namely, that *it is a matter emitted from the ſhining body*, and not merely the undulations of an elaſtic medium; for if it were undulation, then, ſince there is heat in the yellow light, it would follow that a certain frequency of undulation produces both the ſenſation of heat and the ſenſation of a yellow colour. In this caſe they ſhould be inſeparable.

This follows, in the ſtricteſt manner, from the principles or aſſumptions adopted by Euler in his mechanical theory of undulations. The chromatic differences in the rays of light are affirmed to ariſe entirely from the different frequencies of the æthereal undulations; and he endeavours to ſhew that theſe differences in frequency produce a difference in refrangibility. It is evident that this reaſoning is equally concluſive with reſpect to the calorific or heating power of the rays. The light and the heat are both undulations: theſe differ only in frequency; and this frequency is indicated (according to Euler) by the refrangibility. There is a certain frequency therefore which excites the ſenſation of yellow. The ſame frequency, indicated by the ſame refrangibility, produces heat; therefore the frequency which produces this degree of heat alſo produces the ſenſation of yellow. We muſt not ſay that the momentum of the undulation may produce heat, but is inſufficient for the production of light, as a ſtring may vibrate too feebly for being heard; for we ſee, by Dr Herſchel's experiments, that, with a momentum ſufficient for making the moſt brilliant ſpectrum, there are rays (and thoſe which have the greateſt momentum) which produce heat, and yet are inviſible.

It does not follow, from any of Dr Herſchel's experiments, that the rays emitted by iron, which is not hot enough to ſhine in a dark room, have *all* the different degrees of refrangibility obſerved by him. Perhaps none of them would fall on the chromatic ſpectrum. We think, however, that this is not probable. It may be tried by collecting them to a focus by a lenſe, intercepting, however, all thoſe which are leſs refrangible than the red making rays. We truſt that the thermometer in the focus will ſtill be affected.

This is but a very imperfect account of this important diſcovery; but we thought that it would be highly intereſting to our readers. The preſs was employed on this very ſheet when we received the information from a friend, who had ſeen Dr Herſchel's Diſſertation, which will appear in the firſt volume publiſhed by the Royal Society. We truſt that the ingenious author will ſoon follow it up with the inveſtigation of the ſubject in all its conſequences.

We hope that he will examine what will reſult from mixing ſome of the inviſible rays with ſome of the coloured ones. We know that the yellow and the blue, when mixed, produce the ſenſation of green. Perhaps the inviſible rays may alſo change the appearance. We do not, however, expect this.

We alſo hope that Dr Herſchel will examine whether the inviſible rays of the ſun produce any effect on vegetable colours; whether they blacken the calces of ſilver and biſmuth, luna cornea, and decompoſe the nitrous and the oxygenated muriatic acid, &c. &c. We ſhould thus get more inſight into the nature of caloric and of combuſtion. Combuſtion may perhaps be reſtored to its rank in the phenomena of Nature, and no longer be ſunk in the general gulph of oxygenation, and thus obliterated from the memory of chemiſts. It is perhaps the moſt remarkable phenomenon of material Nature; and *fire* and burning will never go out of the language of plain men. Fire, and all its concomitants, have, in all times, been conſidered as even the *chief* objects of chemical attention; and an unlearned perſon will ſtare, when a chemiſt tells him that there is no ſuch thing, and that what he calls the burning of a piece of coal is only the making it ſour. He will perhaps ſmile; but it will not be a ſmile of aſſent.

It was one darling object of the Revolutionary Committee of Chemiſts, aſſembled at Paris in 1787, to baniſh from our minds, *by means of a new language*, all remembrance of any thing which we did not derive from the philoſophers of France. We think ourſelves in a condition to prove this by letters to this country from the ſcene of action; in which the expected victory is ſpoken of in terms of exultation, and with ſo little reſtraint, that the writer forgets that it is DR BLACK whom he is informing that *l'air fixe* and *la pauvre phlogiſtique* will ſoon be forgotten; and yet the writer was a gentleman of uncommon modeſty and worth, and ſincerely attached to Dr Black. We give this as a remarkable inſtance of the *eſprit de corps*, and of the nature and towering ambition of that nation. From this they have not ſwerved; and they hope to gain this ſummit of ſcientific dominion in the ſame way as *the ſame philoſophers* hope to baniſh Chriſtianity by means of their new kalendar. It may, however, turn out that both Dr Hooke and Mr Lavoiſier are miſtaken, when they make the oxygen gas the ſole ſource of both the light and the heat which accompany combuſtion. One of them may perhaps be furniſhed by the body which all, except the new philoſophers, call combuſtible.

The objections which may be made to the theory of Huyghens and Euler, on the acknowledged principles of mechanics, appear to us unanſwerable. Euler has never attempted to anſwer thoſe taken from the different diſperſing powers of different ſubſtances. The objections made to the Newtonian, or vulgar theory of emiſſion, are not ſuch as imply abſurdity; they are only difficulties. The chief of them, *viz.* the ſameneſs of velocity in all lights whatever, is of this kind. It is merely an improbability. But the objections to the theory of undulation, deduced from the chemical effects of light, are not leſs ſtrong than thoſe deduced from mechanical principles. It is quite inconceivable that the undulation of a medium, which pervades all bodies, ſhall produce aromatic oils in ſome, a green fæcula in others, ſhall change ſulphuric acid into ſulphur, &c. &c. No effects are produced by the undulations of air, or the tremors of elaſtic bodies, which have the moſt diſtant analogy or reſemblance to theſe.

That the ſun and other ſhining bodies emit the matter of light and heat, ſeems therefore to merit the general reception which it meets with from the philoſophers. But even of this claſs there are differences in opinion. Some imagine that light only is emitted, and that the heat which we feel is occaſioned by the action of the luminous rays on our atmoſphere, or on the ground. Were the ſun's calorific rays as denſe at the ſurface of the ſun as his luminous rays are, the heat there muſt exceed (ſay they) all that we can form any conception of. Yet we ſee, that when the nucleus of the ſun is laid bare by ſome natural operation, which, like a volcanic exploſion, throws aſide the luminous ocean which covers it to a prodigious depth, the naked parts of this nucleus are black. Therefore the intenſe heat in that place is not able to make it ſhining hot, as it does in all our experiments with intenſe heats, giving a dazzling glare. This is thought highly improbable; and it is therefore ſuppoſed that there is, primitively, no heat in the ſun's rays, but that they act on our air, or other terreſtrial matter, combining with it, and diſengaging heat from it, or producing that particular ſtate and condition which we call *heat*.

We think that Dr Herſchel's diſcovery militates ſtrongly and irreſiſtibly againſt this opinion; and ſhews, that

that whatever reaſon we have for ſaying that the ſun's rays bring light from the ſun we have the ſame authority for ſaying, that they bring heat, fire, caloric, phlogiſton, or by whatever other name we chooſe to diſtinguiſh the cauſe of warmth, expanſion, liquefaction, ebullition, &c.

We muſt either ſay that light and heat are not ſubſtances of a peculiar kind, ſuſceptible of union with the other ingredients of bodies, but merely a ſtate of undulation of an elaſtic medium, as ſound is the undulation of air; or we muſt ſay that the ſun's rays contain light and heat, in a detached ſtate, fit for appearing in their ſimpleſt form, producing illumination and expanſion, and for uniting chemically with other matter. Whichever of theſe opinions we adopt, it is pretty clear that all attempts to diſcover a difference in the weight of hot and cold bodies may be given over. In the firſt caſe, it is ſelf-evident; in the ſecond, we have abundant evidence, that if light and heat, being gravitating matter, like all other bodies, were added to, or abſtracted from bodies, in ſufficient quantity to be ſenſibly heavy, the rays of the ſun, or even the light of a candle, would occaſion inſtant deſtruction by its mere momentum; ſince every particle of radiated light and heat moves at the rate of 200,000 miles in a ſecond.

This diſcovery of Dr Herſchel's adds greatly to the probability of the opinion which we expreſſed on another occaſion, that the forces or powers of natural ſubſtances, which are the immediate cauſes of the chemical phenomena, are no way different from the mechanical forces which render bodies heavy, coherent, elaſtic, expanſive, &c.; in ſhort, that they are what we call *accelerating forces*. We deduced this from the fact, that mechanical force can be oppoſed to them, ſo as to prevent their action in circumſtances where it would otherwiſe certainly take place. Thus, by external preſſure, we can prevent that union of water and caloric which would convert it into elaſtic ſteam. We can even diſunite them again, when ſteam is already produced, by forcibly condenſing it into a ſmaller ſpace. Now, the refraction and reflection of heat are performed according to the ſame preciſe laws which we obſerve in the refraction and reflection of light; and Sir Iſaac Newton has demonſtrated that thoſe phenomena ariſe from the action of accelerating forces, whoſe direction is perpendicular to the acting ſurfaces. The matter of heat, therefore, is like other matter in its mechanical properties; and, in the motion of refraction, it is acted on and deflected, juſt as a projectile is acted on and deflected by gravity. It continues in motion till its velocity and direction are changed by deflecting forces, exerted by the particles of the tranſparent medium or the reflecting ſurface. It would take up too much room, but it is a very eaſy proceſs, to demonſtrate that this regular refraction of heat is altogether incompatible with the uſually ſuppoſed notion of caloric; namely, that it is an expanſive fluid like air, but incomparably more elaſtic: from which property very plauſible explanations have been given of the elaſticity of gaſes, ſteams, and ſuch like fluids. Every intelligent mechanician will be ſenſible, that all this ſort of chemical ſcience falls to the ground, when it is proved, by exhibition of the fact, that radiated heat is refracted in the ſame way with radiated light. We muſt look for the explanation of the immenſe exploſive force of fulminating ſilver, gold, &c. in ſome very different principles from thoſe which are now in vogue. We apprehend, too, that the very phenomenon of this refraction gives indication of forces which are ſufficiently powerful for this explanation: For when we reflect on the aſtoniſhing velocity of the ray of heat; on the minute ſpace along which it is deflected, and conſequently the time of this action, minute beyond all imagination; and when we compare theſe circumſtances with the deflection produced by gravity in the motion of a projectile—it is evident that the deflecting force of refraction muſt exceed the greateſt force that we have any knowledge of, in a greater proportion than the weight of Mount Ætna exceeds that of a particle of ſand. We would deſire Mr de la Place to ſuſpend his hopes of eſtabliſhing univerſal fataliſm, till he can reconcile theſe phenomena with his fundamental principle, "*that all forces which are diffuſed from a ſingle point, neceſſarily and eſſentially diminiſh in the inverſe duplicate ratio of the diſtances.*" Till he can do this, he had better ſtill allow, with Newton, that the ſelection of the duplicate ratio for the action of gravity (by which alone the ſolar ſyſtem can be rendered permanent and orderly) is a mark of wiſdom and benevolence. We would adviſe him to reconcile his mind to this; and perhaps, like the modeſt and admiring Newton, he may, in good time, find comfort in the thought.

It is alſo highly worthy of remark, that this refracting force, almoſt immenſe, which is ſo plainly exerted between the particles of bodies and light, when conſidered as of the ſame kind with thoſe that produce chemical union, appears abundantly ſufficient for explaining ſome of the moſt wonderful phenomena of chemiſtry; ſuch as the prodigious elaſticity of ſteam, of gunpowder, and the ſtill more aſtoniſhing exploſion of fulminating gold and ſilver. Some of the phenomena of deflected light are produced by theſe optical forces acting at diſtances ſufficiently great to admit of meaſurement; as in the Newtonian obſervations on the paſſage of light near the edges of opaque bodies. Theſe deflections enable us to compare the deflecting forces with gravity. The *refracting* force, however, is vaſtly greater than even this, as may be ſeen by the greater deflection which is produced by it; and, being exerted along a ſpace incomparably ſmaller, it muſt be greater ſtill. Here, then, are forces fully adequate to the phenomena of fulmination. And we would again deſire Mr De la Place to remark that, although theſe exploding forces are irreſiſtible, their action ſeems to vaniſh entirely beyond the limits of mathematical contact. This is plain from the fact, that thoſe exploſions do not project the fragments to great diſtances. This is remarkably the caſe in all the moſt eminent of them. Common or nitric gunpowder is perhaps the only great exception. This particular circumſtance will ſurely ſuggeſt to this eminent analyſt the *inverſe triplicate* ratio of the diſtance as more likely to explain the phenomena than his favourite law.

We truſt that our readers will not be diſpleaſed with this ſhort ſketch of Dr Herſchel's diſcovery, and the few reflections which it naturally ſuggeſted to our minds. We ſhall not be greatly ſurpriſed, although it ſhould produce a ſort of counter revolution in chemical ſcience, in conſequence of new conceptions which it may give us of the union of bodies with light and heat. The phenomena of the vegetable and animal economy ſhew that they are ſuſceptible of combination with other ſubſtances beſides the baſis of vital air. Whatever changes this may produce in the great revolution which has already taken place in chemical ſcience, they will (in our opinion) be favourable to true philoſophy; becauſe Dr Herſchel's diſcovery co-operates with other arguments of ſound mathematical reaſoning, to overturn that principle on which De la Place hopes to found his atheiſtical doctrine of fate and neceſſity. It contributes therefore to reſtore to the face of Nature that ſmiling feature of providential WISDOM which Newton had the honour of exhibiting to the view of rational men. The ſun is the ſource of light and genial warmth to a vaſt ſyſtem, which is held together, in almoſt eternal order and beauty, by a law of attraction ſelected by Infinite Wiſdom, as the only one adequate to this magnificent purpoſe.

THEVENOT (Melchiſedec), librarian to the king of France, and a celebrated writer of travels, was born at Paris in 1621, and had ſcarcely gone through his academical ſtudies, when he diſcovered a ſtrong paſſion for viſiting foreign countries. At firſt he ſaw only part of Europe; but then he took great care to procure very particular informations and memoirs from thoſe who had travelled over other parts of the globe, and out of thoſe compoſed his "Voyages and Travels."—He laid down, among other things, ſome rules, together with the invention of an inſtrument, for the better finding out of the longitude, and the declination of the needle; and ſome have thought that theſe are the beſt things in his works, ſince travels, related at ſecond-hand, can never be thought of any great authority or moment; not but Thevenot travelled enough to relate ſome things upon his own knowledge. Another paſſion in him, equally ſtrong with that for travelling, was to collect ſcarce books in all ſciences, eſpecially in philoſophy, mathematics, and hiſtory; and in this he may be ſaid to have ſpent his whole life. When he had the care of the King's library. though it was one of the beſt furniſhed in Europe, he found 2000 volumes wanting in it which he had in his own. Beſides printed books, he bought a great many manuſcripts in French, Engliſh, Spaniſh, Italian, Latin, Greek, Hebrew, Syriac, Arabic, Turkiſh, and Perſic. The marbles preſented to him by Mr Nointel, at his return from his embaſſy to Conſtantinople, upon which there are bas-reliefs and inſcriptions almoſt 2000 years old, may be reckoned among the curioſities of his library. He ſpent moſt of his time among his books, without aiming at any poſt of figure or profit: he had, however, two honourable employments; for he aſſiſted at a conclave held after the death of Pope Innocent X. and was the French king's envoy at Genoa. He was attacked with what is called a ſlow fever in 1692, and died October the ſame year, at the age of 71. According to the account given, he managed himſelf very improperly in this illneſs; for he diminiſhed his ſtrength by abſtinence, while he ſhould have increaſed it with hearty food and generous wines, which were yet the more neceſſary on account of his great age.—Thevenot's Travels into the Levant, &c. were publiſhed in Engliſh in the year 1687, folio; they had been publiſhed in French at Paris 1663, folio. He wrote alſo "L'Art de Nager," the Art of Swimming, 12mo, 1696.

THOMAS (Chriſtian) was born at Leipſic 1655, and was well educated, firſt under his father, and afterwards in the Leipſic univerſity. At firſt he acquieſced in the eſtabliſhed doctrines of the ſchools; but upon reading Puffendorf's "Apology for rejecting the Scholaſtic Principles of Morals and Law," light ſuddenly burſt upon his mind, and he determined to renounce all implicit deference to ancient dogmas. He read lectures upon the ſubject of Natural Law, firſt from the text of Grotius, and afterwards from that of Puffendorf, freely exerciſing his own judgment, and, where he ſaw reaſon, advancing new opinions. Whilſt his father was living, paternal prudence and moderation reſtrained the natural vehemence and acrimony of the young man's temper, which was too apt to break out, even in his public lectures. But when he was left to himſelf, the boldneſs with which he advanced unpopular tenets, and the ſeverity with which he dealt out his ſatirical cenſures, ſoon brought upon him the violent reſentment of theologians and profeſſors.

An "Introduction to Puffendorf," which Thomas publiſhed in the year 1687, wherein he deduced the obligation of morality from natural principles, occaſioned great offence. The following year he became ſtill more unpopular, by opening a monthly literary journal, which he intitled "Free Thoughts, or Monthly Dialogues on various Books, chiefly new;" in which he attacked many of his contemporaries with great ſeverity. The raillery of this ſatirical work was too provoking to be endured: complaints were lodged before the eccleſiaſtical court of Dreſden; the bookſeller was called upon to give up the author; and it was only through the intereſt of the Mareſchal that Thomas eſcaped puniſhment. The title of the work was now changed; but its ſpirit remained. A humorous and ſatirical life of Ariſtotle, and ſeveral other ſarcaſtic papers, kept alive the flame of reſentment, till at length it again burſt forth, on a charge brought againſt him before the ſame court by the clergy of Leipſic, for contempt of religion; but he defended himſelf with ſuch ability, that none of his adverſaries choſe to reply, and the matter was dropped.

A ſatirical review, which he wrote, of a treatiſe "On the Divine Right of Kings," publiſhed by a Daniſh divine; "A Defence of the Sect of the Pictiſts," and other eccentric and ſatirical publications, at laſt inflamed the reſentment of the clergy againſt Thomas to ſuch a degree, that he was threatened with impriſonment. To eſcape the ſtorm which thickened about him, he entreated permiſſion from the Elector of Brandenburg, in whoſe court he had ſeveral friends, that he might read private lectures in the city of Hall. This indulgence being obtained, Thomas became a voluntary exile from Leipſic. After a ſhort interval, he was appointed public profeſſor of juriſprudence, firſt in Berlin, and afterwards at Hall. In theſe ſituations, he found himſelf at full liberty to indulge his ſatirical humour, and to engage in the controverſies of the times: and as long as he lived, he continued to make uſe of this liberty in a manner which ſubjected him to much odium. At the ſame time, he perſevered in his endeavours to correct and ſubdue the prejudices of mankind, and to improve the ſtate of philoſophy. He died at Hall in the year 1728.

Beſides the ſatirical journal already mentioned, Thomas wrote ſeveral treatiſes on logic, morals, and juriſprudence; in which he advanced many dogmas contra-

Thomas, Thornton.

ry to received opinions. In his writings on phyſics, he leaves the ground of experiment and rational inveſtigation, and appears among the myſtics. His later pieces are in many particulars inconſiſtent with the former.—His principal philoſophical works are, "An Introduction to Aulic Philoſophy, or Outlines of the Art of Thinking and Reaſoning;" "Introduction to Rational Philoſophy;" "A Logical Praxis;" "Introduction to Moral Philoſophy;" "A Cure for Irregular Paſſions, and the Doctrine of Self-Knowledge;" "The new Art of diſcovering the ſecret Thoughts of Men;" "Divine Juriſprudence;" "Foundations of the Law of Nature and Nations;" "Diſſertation on the Crime of Magic;" "Eſſay on the Nature and Eſſence of Spirit, or Principles of Natural and Moral Science;" "Hiſtory of Wiſdom and Folly"

From the ſpecimen given by Dr Enfield of his more peculiar tenets (for we have read none of his books), Thomas appears to have been a man of wonderful inconſiſtency in his opinions; teaching on one ſubject rational piety and true ſcience, and on another abſurdity and atheiſm. "No other rule (he ſays) is neceſſary in reaſoning, than that of following the natural order of inveſtigation; beginning with thoſe things which are beſt known, and proceeding, by eaſy ſteps, to thoſe which are more difficult." This is perfectly conſiſtent with the foundation of the Baconian logic; and is indeed the only foundation upon which a ſyſtem of ſcience can poſſibly be built. Yet could the man, who profeſſes to proceed from a principle ſo well eſtabliſhed, gravely advance, as concluſions of ſcience, the following abſurdities: "Perception is a paſſive affection, produced by ſome external object, either in the intellectual ſenſe, or in the inclination of the will. God is not perceived by the intellectual ſenſe, but by the inclination of the will: for creatures affect the brain; but God, the heart. All creatures are in God: nothing is exterior to him. Creation is extenſion produced from nothing by the divine power. Creatures are of two kinds, paſſive and active; the former is matter, the latter ſpirit. Matter is dark and cold, and capable of being acted upon by ſpirit, which is light, warm, and active. Spirit may ſubſiſt without matter, but deſires a union with it. All bodies conſiſt of matter and ſpirit, and have therefore ſome kind of life. Spirit attracts ſpirit, and thus ſenſibly operates upon matter united to ſpirit. This attraction in man is called *love;* in other bodies, *ſympathy*. A finite ſpirit may be conſidered as a limited ſphere, in which rays, luminous, warm, and active, flow from a centre. Spirit is the region of the body to which it is united. The region of finite ſpirits is God. The human ſoul is a ray from the divine nature; whence it deſires union with God, who is love. Since the eſſence of ſpirit conſiſts in action, and of body in paſſion, ſpirit may exiſt without thought: of this kind are light, ether, and other active principles in nature." Fortunately, this jargon is as unintelligible as the categories of Kant, and the blaſphemies of Spinoza; for an account of which, the reader is referred to *Critical* PHILOSOPHY in this *Suppl.* and to SPINOZA in the *Encycl.*

Biographical Dictionary

THORNTON (Bonnel), a modern poet, the intimate friend of Lloyd and Colman, and juſtly claſſed with them in point of talents, was born in Maiden-lane, London, in the year 1724. He was the ſon of an apothecary; and being educated at Weſtminſter ſchool, was elected to Chriſt-Church, Oxford, in the year 1743. He was thus eight years ſenior to Colman, who was elected off in 1751. The firſt publication in which he was concerned was, "The Student, or Oxford and Cambridge Miſcellany," which appeared in monthly numbers; and was collected in two volumes 8vo, in 1748. Smart was the chief conductor of the work; but Thornton, and other wits of both univerſities, aſſiſted in it. He took his degree of maſter of arts in 1750; and as his father wiſhed him to make phyſic his profeſſion, he took the degree of bachelor of that faculty in 1754. In the ſame year he undertook the periodical paper called *The Connoiſſeur*, in conjunction with Colman, which they continued weekly to the 30th of September 1756. In the concluding paper, the different ages and purſuits of the two authors are thus jocularly pointed out, in the deſcription of the double author, Mr Town. "Mr Town is a fair, black, middle ſized, very ſhort man. He wears his own hair and a periwig. He is about thirty years of age (literally thirty-two), and not more than four-and-twenty. He is a ſtudent of the law and a bachelor of phyſic. He was bred at the univerſity of Oxford, where, having taken no leſs than three degrees, he looks down on many learned profeſſors as his inferiors: yet having been there but little longer than to take the firſt degree of bachelor of arts, it has more than once happened that the cenſor-general of all England has been reprimanded by the cenſor of his college, for neglecting to furniſh the uſual eſſay, or, in the collegiate phraſe, the theme of the week." Engaged in purſuits of this kind, Bonnel Thornton did not very cloſely follow the profeſſion to which his father deſtined him, but lived rather a literary life, employing his pen on various ſubjects. To the daily paper called the *Public Advertiſer*, then in high reputation, he was a frequent contributor: and he once had it in contemplation to treat with Mr Rich for the patent of Covent Garden theatre. In 1764, Mr Thornton married Miſs Sylvia Brathwaite, youngeſt daughter of Colonel Brathwaite, who had been governor of a fort in Africa. In 1766, encouraged, as he ſays himſelf, by the ſucceſs of his friend Colman's Terence, he publiſhed two volumes of a tranſlation of Plautus in blank verſe; propoſing to complete the whole if that ſpecimen ſhould be approved. Theſe volumes contained ſeven plays, of which the *Captive* was tranſlated by Mr Warner, who afterwards completed all that Thornton had left unfiniſhed; and the *Mercator* by Mr Colman. The remaining five are, the *Amphitryon*, *Miles Glorioſus*, *Trinummus*, *Aulularia*, *Rudens*. Some parts of the remaining plays which Thornton had tranſlated are preſerved by his continuator. There can be no doubt that this is the beſt way of tranſlating the old comedies, and that Thornton was well qualified for the taſk; but the work has never been in high favour with the public. Yet Warburton ſaid of it, that "he never read ſo juſt a tranſlation, in ſo pure and elegant a ſtyle." Thornton publiſhed in 1767, *The Battle of the Wigs*, as an additional canto to Garth's Diſpenſary; the ſubject of which was the diſputes then ſubſiſting between the fellows and licentiates.

The life of Thornton was not deſtined to attain any great extenſion: in the prime of his days, while he was ſurrounded by domeſtic felicity, the comforts of fortune, Thornton, Thunder.

tune, and the reſpect of ſociety, ill health came upon him; and medical aid proving inefficient, he died, of the gout in his ſtomach, May 9 1768, at only 44 years of age. His wife, a daughter, and two ſons, ſurvived him. Beſides the productions already mentioned, he wrote the papers in the Adventurer marked A; "An Ode to St Cecilia's day, adapted to the ancient Britiſh Muſic," a burleſque performance; "The Oxford Barber;" with many detached eſſays in the public papers. A few letters addreſſed to his Sylvia before they were married, diſplay great tenderneſs, expreſſed with frankneſs and eaſe. A ſmall edition of his works might, with much propriety, be preſented to the public, before it ſhall be too late to aſcertain them all. His character may be taken from his epitaph, written in Latin by his friend Dr Warton, and placed on his monument in Weſtminſter Abbey. It is to this effect: "His genius, cultivated moſt happily by every kind of polite literature, was accompanied and recommended by manners open, ſincere, and candid. In his writings and converſation he had a wonderful livelineſs, with a vein of pleaſantry peculiarly his own. In ridiculing the failings of men, without bitterneſs, and with much humour, he was ſingularly happy; as a companion, he was delightful."

1. THUNDER. There is not one of the appearances of nature which has ſo much engaged the attention of mankind as thunder. The ſavage, the citizen, and the philoſopher, have obſerved it with dread, with anxiety, and with curioſity; and the philoſopher of our times treats the others with a ſmile of condeſcenſion, while he here enjoys the fulleſt triumph of his ſuperiority.

> *Felix qui potuit rerum cognoſcere cauſas,*
> *Atque metus omnes et inevitabile fulmen*
> *Subjecit pedibus.*

But though this grand phenomenon has long engaged the curious attention of philoſophers, it is but very lately that they have been able to explain it; that is, to point out the more general law of nature of which it is a particular inſtance. Inflammable vapours had long furniſhed them with a ſort of explanation. The diſcovery of gunpowder, and ſtill more that of inflammable air, gave ſome probability to the exiſtence of extenſive ſtrata of inflammable vapours in the upper regions of the atmoſphere, which, being ſet on fire at one end, might burn away in rapid ſucceſſion, like a train of gunpowder. But the ſmalleſt inveſtigation would ſhew ſuch a diſſimilarity in the phenomena, and in the general effects, that this explanation can have no value in the eyes of a true naturaliſt. Horrid exploſion, and a blaſt which would ſweep every thing from the ſurface of the earth, muſt be the effects of ſuch inflammation. The very limited and capricious nature of the ravages made by thunder, render them altogether unlike exploſions of elaſtic fluids.

2
Thunder reſembles the electrical ſhock

No ſooner were the wonderful effects of the charged electrical phial obſerved, than naturaliſts began to think of this as exhibiting ſome reſemblance to a thunderſtroke (ſee Electricity, *Encycl.* n° 12.); but it was not till toward the year 1750 that this reſemblance was viewed in a proper light by the celebrated Franklin. In a diſſertation written that year, he delivers his opinion at large, and notices particularly the following circumſtances of ſimilarity.

Thunder in ſeveral remarkable particulars

1. The colour and crooked form of lightning, perfectly ſimilar to that of a vivid electrical ſpark between diſtant bodies, and unlike every other appearance of light. This angular, deſultory, capricious form of an electrical ſpark, and of forked lightning, is very ſingular. No two ſucceſſive ſparks have the ſame form. Their ſharp angles are unlike every appearance of motion through unreſiſting air: Such motions are always curvilineal. The ſpark is like the ſimultaneous exiſtence of the light in all its parts; and the fact is, that no perſon can poſitively ſay in which direction it moves.

2. Lightning, like electricity, always ſtrikes the moſt advanced objects—hills, trees, ſteeples.

3. Lightning affects to take the beſt conductors of electricity. Bell wires are very frequently deſtroyed by it. At Leven houſe in Fifeſhire, in 1733, it ran along a gilded moulding from one end of the houſe to the other, exploding it all the way, as alſo the tinfoil on the backs of ſeveral mirrors, and the gilding of ſcreens and leather hangings.

4. It burns, explodes, and deſtroys theſe conductors preciſely as electricity does. It diſſolves metals; melts wires; it explodes and tears to pieces bodies which contain moiſture. When a perſon is killed by lightning, his ſhoes are commonly burſt. When it falls on a wet ſurface, it ſpreads along it. The Royal William, in Louiſburgh harbour, in 1758, received a thunderſtroke, which diſſipated the maintop-gallant maſt in duſt, and came down on the wet decks in one ſpark, which ſpread over the whole deck as a ſpout of water would have done. This is quite according to electrical laws.

5. It has ſometimes ſtruck a perſon blind. Electricity has done the ſame to a chicken which it did not kill.

6. It affects the nervous ſyſtem in a way reſembling ſome of the known effects of electricity. The following is a moſt remarkable inſtance: —— Campbell, Eſq; of Succoth, in Dunbartonſhire, had been blind for ſeveral years. The diſorder was a gutta ſerena. He was led one evening along the ſtreets of Glaſgow by his ſervant Alexander Dick, during a terrible thunder ſtorm. The lightning ſometimes fluttered along the ſtreets for a quarter of a minute without ceaſing. While this fluttering laſted, Mr Campbell ſaw the ſtreet diſtinctly, and the changes which had been made in that part by taking down one of the city gates. When the ſtorm was over, his entire blindneſs returned.—We have from a friend another inſtance, no leſs remarkable. One evening in autumn he was ſitting with a gentleman who had the ſame diſorder, and he obſerved ſeveral lambent flaſhes of lightning. Their faces were turned to the parlour window; and immediately after a flaſh, the gentleman ſaid to his wife "Go, my dear, make them ſhut the white gate; it is open, you ſee." The lady did ſo, and returned; and, after a little, ſaid, "But how did you know that the gate was open?" He exclaimed, "My God! I ſaw it open, and two men look in, and go away again," (which our friend alſo had obſerved). The gentleman, on being cloſe queſtioned, could not recollect having had another glance, nor why it had not ſurpriſed him; but of the glimpſe itſelf he was certain, and deſcribed the appearance very exactly.

7. Lightning kills; and the appearances perfectly

reſemble thoſe of a mortal ſtroke of electricity. The muſcles are all in a ſtate of perfect relaxation, even in thoſe ſituations where it is uſually otherwiſe.

8. Lightning is well known to deſtroy and to change the polarity of the mariner's needle.

3
r Frank-
n diſco-
ered that
was the
me.

Dr Franklin was not contented with the bare obſervation of theſe important reſemblances. He availed himſelf of many curious diſcoveries which he had made of electrical laws. In particular, having obſerved that electricity was drawn off at a great diſtance, and without the leaſt violence of action, by a ſharp metallic point, he propoſed to philoſophers to erect a tall maſt or pole on the higheſt part of a building, and to furniſh the top of it with a fine metalline point, properly inſulated, with a wire leading to an inſulated apparatus for exhibiting the common electrical appearances. To the whole of this contrivance he gave the name of *thunder-rod*, which it ſtill retains. He had not a proper opportunity of doing this himſelf at the time of writing his diſſertation in a letter from Philadelphia to the Royal Society of London; but the contents were ſo ſcientific, and ſo intereſting, that in a few weeks time they were known over all Europe. His directions were followed in many places. In particular, the French academicians, encouraged by the preſence of their monarch, and the great ſatisfaction which he expreſſed at the repetition of Dr Franklin's moſt inſtructive experiments, which diſcovered and eſtabliſhed the theory of poſitive and negative electricity, as it is ſtill received, were eager to execute his orders, making his grand experiment, which promiſed ſo fairly to bring this tremendous operation of nature not only within the pale of ſcience, but within the management of human power.

But, in the mean time, Dr Franklin, impatient of delay, and perhaps incited by the honourable deſire of well-deſerved fame, put his own ſcheme in practice. His inventive mind ſuggeſted to him a moſt ingenious method of preſenting a point to a thunder cloud at a very great diſtance from the ground. This was by fixing his point on the head of a paper kite, which the wind ſhould raiſe to the clouds, while the wet ſtring that held it ſhould ſerve for a conductor of the electricity. We preſume that it was with a palpitating heart that Dr Franklin, unknown to the neighbours, and accompanied only by his ſon, went into the fields, and ſent up his meſſenger that was to bring him ſuch news from the heavens. He told a perſon, who repeated it in the hearing of the preſent writer, that when he ſaw the fibres of the cord raiſe themſelves up like hogs briſtles, he uttered a deep ſigh, and would have wiſhed that moment of joy to have been his laſt. He obtained but a few faint ſparks from his apparatus that day; but returned to his houſe in a ſtate of perfect happineſs, now feeling that his name was never to die. Thus did the ſoap bubble, and the paper kite, from being the playthings of children, become, in the hands of Newton, and of Franklin, the means of acquiring immortal honour, and of doing the moſt important ſervice to ſociety.

We may juſtly conſider this as one of the greateſt of philoſophical diſcoveries, and as doing the higheſt honour to the inventor; for it was not a ſuggeſtion from an accidental obſervation, but aroſe from a ſcientific compariſon of facts, and a ſagacious application of the doctrine of poſitive and negative electricity; a doctrine wholly Dr Franklin's, and the reſult of the moſt acute and diſcriminating obſervation. It was this alone that ſuggeſted the whole; and by explaining to his ſatisfaction the curious property of ſharp points, gave him the courage to handle the thunderbolt of Jove.

It is then a point fully aſcertained, that thunder and lightning are the electric ſnap and ſpark, as much ſuperior to our puny imitations as we can conceive from the immenſe extent of the inſtruments in the hands of Nature. If, ſays Dr Franklin, a conductor one foot thick and five feet long will produce ſuch ſnaps as agitate the whole human frame, what may we not expect from a ſurface of 10,000 acres of electrified clouds? How loud muſt be the exploſion? how terrible the effects?

4
Electrical
ſtates of the
atmoſ-
phere.

This diſcovery immediately directed the attention of philoſophers to the ſtate of the atmoſphere with reſpect to electricity; and in this alſo Dr Franklin led the way. He immediately erected his thunder rods; and they have been imitated all over the world, with many alterations or improvements, according to the different views and ſkill of their authors. It is needleſs to inſiſt here on their conſtruction. They have been deſcribed in the article ELECTRICITY (*Encycl.*); and any perſon well acquainted with its theory, as laid down in the *Supplementary* article ELECTRICITY, will be at no loſs to accommodate his own conſtruction to his ſituation and purpoſes.

Dr Franklin took the lead, as we have already obſerved, in this examination of the electrical ſtate of the atmoſphere. He ſeldom found it without giving ſigns of electricity, and this was generally negative. See *Phil. Tranſ.* Vol. XLVIII. p. 358. and 785.

Mr Canton repeated thoſe experiments, and found the ſame reſults; both, however, found that the electricity would frequently change from poſitive to negative, and from negative to poſitive, in very ſhort ſpaces of time, as different portions of clouds or air paſſed the thunder-rod.

5
Cautions to
be obſerved
in this exa-
mination
by a thun-
der rod.

We muſt here remark, that our acquaintance with the laws of electricity ſufficiently informs us, that the electricity of our thunder rod may frequently be of a different kind from that of the cloud which excites the appearances at our apparatus. We know that air, like glaſs, is a non-conductor; and that when it is brought into any ſtate of electricity, either by communication, or by mere induction, it will remain in that ſtate for ſome time, and that it always changes its electricity *per ſtratum*. A poſitive cloud, in the higher regions of the atmoſphere, will render the air immediately below it negative, and a ſtratum below that poſitive. If the thunder rod be in this poſitive ſtratum, it will exhibit poſitive electricity; but if the cloud be conſiderably nearer, the rod, by being in the adjoining negative ſtratum, may ſhow a negative electricity, which will exceed the poſitive electricity which the diſtant poſitive cloud would have induced on its lower end by mere poſition, had the intervening air been away. This exceſs of negative electricity muſt depend on the degree in which the ſurrounding ſtratum of air has been rendered negative. If this has been the almoſt inſtantaneous effect of the preſence of the poſitive cloud, it cannot be rendered ſo negative as to produce negative electricity in the lower

Thunder.

end of the thunder rod. But if the ſtratum of air has for ſome conſiderable time accompanied the poſitive cloud, its negative electricity has been increaſing, and ſome would remain, even if the cloud were removed. We muſt, at all times, conſider the thunder rod as affected by *all* the electricity in its neighbourhood. The diſtant poſitive cloud would at any rate render the lower end of the rod poſitive, without communication, by merely diſplacing the electricity in the rod itſelf, juſt as the north pole of a loadſtone would make the remote end of a ſoft iron rod a north pole. In like manner, the negative ſtratum of air immediately adjoining to the poſitive cloud would make the lower end of the rod negative, without communication. A poſitive ſtratum of air below this would have the contrary effect. The appearances, then, at the end of the rod, muſt be the reſult of the prevalence of one of theſe above the others; and many intervening circumſtances muſt be underſtood, before we can infer with certainty the ſtate of a cloud from the appearances at the lower end of the apparatus. It would, therefore, be a moſt inſtructive addition to a thunder rod to have an electroſcope at both ends. If they ſhew the ſame kind of electricity, we may be aſſured that it is by communication, and is the ſame with that of the ſurrounding ſtratum of air: But if they ſhew oppoſite electricities (which is generally the caſe), then we learn that it is by poſition or induction. We recommend this to the careful attention of the philoſopher.

In this way we perfectly explain an appearance which puzzled both of the above-mentioned obſervers. When a ſingle low cloud approached the rod, the electroſcope would ſhew poſitive electricity, but negative when the cloud was in the zenith, and poſitive again when it had paſſed by. We alſo learn from this the cauſe of Dr Franklin's diſappointment in his expectations of very remarkable phenomena by means of his kite. He imagined that it would be vaſtly ſuperior to the apparatus which he had recommended to the philoſophers of Europe. But the ſtring of the kite, traverſing ſeveral ſtrata in different ſtates of electricity, ſerved as a conductor between them, and he could only obtain the ſuperplus; which might be nothing, even when the clouds were ſtrongly electrified.

The moſt copious and curious obſervations on the electrical ſtate of the atmoſphere are thoſe by Profeſſor Beccaria of Turin. He had connected the tops of ſeveral ſteeples of the city by inſulated wires. He did the ſame thing at a monaſtery on a high hill in the neighbourhood. Each of theſe collected the electricity of a ſeparate ſtratum of conſiderable extent. He frequently found theſe two ſtrata in oppoſite ſtates of ſtrong electricity.

6
Beccaria's general laws of atmoſpheric electricity.

The following general obſervations are made out from a compariſon of a vaſt variety of more particular ones made in different places:

1. The air is almoſt always electrical, eſpecially in the day time and dry weather; and the electricity is generally poſitive. It does not become negative, unleſs by winds from places where it rains, ſnows, or is foggy.

2. The moiſture of the air is the conſtant conductor of its electricity in clear weather.

3. When dark or wet weather clears up, the electricity is always negative. If it has been very moiſt, and dries very faſt, the electricity is very intenſe, and diminiſhes when the air attains its greateſt dryneſs; and may continue long ſtationary, by a ſupply of air in a drying ſtate from diſtant places.

Thunde

4. If, while the ſky overcaſts in the zenith, only a high cloud is formed, without any ſecondary clouds under it, and if this cloud is not the extenſion of another which rains in ſome remote place, the electricity (if any) is always poſitive.

5. If the clouds, while gathering, are ſhaped like locks of wool, and are in a ſtate of motion among each other; or if the general cloud is forming far aloft, and ſtretches down like deſcending ſmoke, a frequent poſitive electricity prevails, more intenſe as the changes in the atmoſphere are quicker; and its intenſity predicts the great quantity of ſnow or rain which is to follow

6. When an extenſive, thin, level cloud forms, and darkens the ſky, we have ſtrong poſitive electricity.

7. Low thick fogs, riſing into dry air, carry up ſo much electricity as to produce ſparks at the apparatus. If the fog continues round the apparatus without riſing, the electricity fails.

8. When, in clear weather, a cloud paſſes over the apparatus, low and tardy in its progreſs, and far from any other, the poſitive electricity gradually diminiſhes, and returns when the cloud has gone over.

9 When many white clouds gather over head, continually uniting with and parting from each other, and thus form a body of great extent, the poſitive electricity increaſes.

10. In the morning, when the hygrometer indicates dryneſs equal to that of the preceding day, poſitive electricity obtains, even before ſunriſe.

11. As the ſun gets up, this electricity increaſes; more remarkably if the dryneſs increaſes. It diminiſhes in the evening.

12. The mid day electricity, of days equally dry, is proportional to the heat.

13. Winds always leſſen the electricity of a clear day, eſpecially if damp; therefore they do not electrify the air by friction on ſolid bodies.

14. In cold ſeaſons, with a clear ſky and little wind, a conſiderable electricity ariſes after ſunſet, at dew falling.

The ſame happens in temperate and warm weather.

If, in the ſame circumſtances, the general dryneſs of the air is leſs, the electricity is alſo leſs.

15. The electricity of dew, like that of rain, depends on its quantity. This electricity of dew may be imitated by electrifying the air of a cloſe room (not too dry), and filling a bottle with very cold water, and ſetting it in the upper part of the room. As the damp condenſes on its ſides, an electrometer will ſhew very vivid electricity.

Such a collection of obſervations, to be fit for inference, requires very nice diſcrimination. It is frequently difficult to diſcover electricity in damp air, though it is then generally ſtrongeſt; becauſe the inſulation of the apparatus is hurt by the dampneſs. To make the obſervation with accuracy, requires a portable apparatus, whoſe inſulation can be made good at all times. With ſuch apparatus we ſhall never miſs obſerving electricity in fogs, or during ſnow.

Curiou phenor non of ticklin fog.

There is a very curious phenomenon, which may be frequently obſerved in Edinburgh, and no doubt in other towns ſimilarly ſituated. In a clear day of the month

month of May, an eaſterly wind frequently brings a fog with it, which advances from the ſea in a denſe body; and when it comes up the High-ſtreet, it chills the body exceedingly, while it does not greatly affect the thermometer. Immediately before its gaining the ſtreet, one feels like a tickling on the face, as if a cobweb had fallen on it, and naturally puts up his hand, and rubs the face. We have never found this to fail, and have often been amuſed with ſeeing every perſon rubbing his face in his turn. The writer of this article has obſerved the ſame thing at St Peterſburgh, in a ſummer's evening, when a low fog came on about ten o'clock.

The general appearances of a thunder ſtorm are nearly as follow:

7
Phenomena of a thunder ſtorm.

For the moſt part the wind is gentle, or it is calm. A low denſe cloud begins in a place previouſly clear: this increaſes faſt in ſize; but this is only upwards, and in an arched form, like great bags of cotton. The lower ſurface of the cloud is commonly level, as if it reſted on a glaſs plane.

Soon after appear numberleſs ſmall ragged clouds, like flakes of cotton teazled out. Theſe are moving about in various uncertain directions, and continually changing their ragged ſhape. This change, however, is generally by augmentation. Whatever occaſions the precipitation of the diſſolved water ſeems to gain ground. As theſe clouds move about, they approach each other, and then ſtretch out their ragged arms toward each other. This is not by an augmentation, but by a real bending of theſe tatters towards the other cloud. They ſeldom come into contact; but after coming very near in ſome parts, they as plainly recede, either in whole, or by bending their arms away from each other.

But during this confuſed motion, the whole maſs of ſmall clouds approaches the great one above it: and when near it, the clouds of the lower maſs frequently coaleſce with each other before they finally coaleſce with the upper cloud: But as frequently the upper cloud increaſes without them. Its lower ſurface, from being level and ſmooth, now becomes ragged, and its tatters ſtretch down towards the others, and long arms are extended towards the ground. The heavens now darken apace, the whole maſs ſinks down; wind ariſes, and frequently ſhifts in ſqualls; ſmall clouds are now moving ſwiftly in various directions; lightning now darts from cloud to cloud. A ſpark is ſometimes ſeen co-exiſtent through a vaſt horizontal extent, of a crooked ſhape, and of different brilliancy in its different parts. Lightning ſtrikes between the clouds and the earth—frequently in two places at once. A continuation of theſe ſnaps rarifies the cloud; and in time it diſſipates. This is accompanied by heavy rain or hail; and then the upper part of the clouds is high and thin.

During this progreſs of the ſtorm, the thunder rod is ſtrongly electrified; chiefly when the principal cloud is over head. The ſtate of the electricity frequently changes from poſitive to negative—almoſt every flaſh, however diſtant, occaſions a ſudden ſtart of the electroſcope, and then a change of the electricity. When the cloud is more uniform, the electricity is ſo too.

8
Sources of atmoſpheric electricity.

The queſtion now is, In what manner does the air acquire this electricity? How come its different parts to be in different ſtates, and to retain this difference for a length of time? and how is the electric equilibrium reſtored with that rapidity, and to that extent, that we obſerve in a thunder ſtorm? For we know that air is a very imperfect conductor, and tranſmits electricity to ſmall diſtances only, and very ſlowly. We ſhall mention ſeveral circumſtances, which are known facts in electricity, and muſt frequently concur, at leaſt, with the other cauſes of this grand phenomenon.

Air is rendered electrical in a great variety of ways.

1. All operations which excite electricity in other bodies have the ſame effect on air. It is electrified by friction. When blown on any body, ſuch as glaſs, &c. that body exhibits electricity by a ſenſible electroſcope. We therefore conclude that the air has acquired the oppoſite electricity from this rubber. A glaſs veſſel, exhauſted of air, and broken in the dark, gives a loud crack, and a very ſenſible flaſh of light. An air-gun, diſcharged (without a ball) in the dark, does the ſame. Blowing on an electric with a pair of bellows never fails to excite it. In ſhort, the facts to this purpoſe are numberleſs.

2. Electricity is produced by a number of chemical operations, which are continually going on. The melting and freezing of electric bodies in contact with each other, ſuch as chocolate in its moulds, wax-candles in their moulds, ſealing-wax, &c. Nay, it is highly probable that any body, in paſſing from its fluid to its ſolid form, or the contrary, is electrical. This is the caſe when a ſolution of Glauber's ſalt, or of nitre, in water, is made to cryſtallize all at once by agitation.

The ſolution of bodies in their menſtrua is, in like manner, productive of electricity in many caſes Thus iron or chalk, while diſſolving in the ſulphuric acid, produce negative electricity in the mixture, and poſitive in the electric vapours which ariſe from them.

A moſt copious ſource of electricity is the converſion of water into elaſtic ſteam by violent heats. When this is done in a proper apparatus, the electricity of the liquid is negative, and the vapour is poſitive. But if this be accompanied by a decompoſition of the water, the liquid is ſometimes ſtrongly negative. Thus, when water evaporates ſuddenly from a red hot ſilver cup, the cup is ſtrongly negative; but if from clean red hot iron, ſo that the iron is calcined, and inflammable air produced, the iron is poſitive. If the decompoſition of the water is ſufficiently copious to do more than compenſate for the negative electricity produced by the mere expanſion of the water into ſteam, the electricity is poſitive: but not otherwiſe. Water expanded from a piece of red hot coal always gives negative electricity, and this frequently very ſtrong. Theſe experiments ſhould always be made in metalline veſſels. If made in glaſs veſſels, the glaſs takes a charge, which expends the produced electricity, and remains nearly neutral, ſo that the production of electricity is not obſerved. Theſe facts are to be found among many experiments of Mr Sauſſure. But there is here a very wide field of new inquiry, which cannot fail of being very inſtructive, and particularly in the preſent queſtion. We ſee ſome of the effects very diſtinctly in ſeveral phenomena of thunder and lightning. Thus, the great eruptions of Ætna and Veſuvius are always accompanied by forked lightnings, which are ſeen darting among the volumes of emitted ſmoke and ſteam. Here is a very copious converſion of water into elaſtic ſteam; and here alſo it is moſt reaſonable to expect a copious decompoſition of water, by the iron and coally matters, which are expoſed to the joint action of fire and water. Theſe two electricities will be oppoſite; or when not oppoſite, will not be equal: in either of which caſes, we have vaſt maſſes of ſteam in ſtates fit for flaſhing into each other.

A fact more to our purpoſe is, that if a ſilk or linen cloth, of a downy texture, be moiſtened or damped, and hung before a clear fire to dry, the fibres briſtle up, and on bringing the finger, or a metal knob, near them, they are plainly attracted by it. We found them negatively electric. This ſhews that the ſimple ſolution of water in air produces electricity. And this is the chief operation in Nature connected with the ſtate of the atmoſphere. It is thus that the watery vapours from all bodies, and particularly the copious exſudation of plants, diſappear in our atmoſphere. There can be no doubt but that the oppoſite electricity will be produced by the precipitation of this vapour; that is, by the formation of clouds in clear air. When damp, but clear air in one veſſel expands into an adjoining veſſel, from which the air has been exhauſted, a cloud appears in both, and a delicate electrometer is affected in both veſſels; but our apparatus was not fitted for aſcertaining the kind of electricity produced. Here then is another unexplored field of experiment. We got two veſſels made, having diaphragms of thin ſilk. Theſe were damped, and ſet into two tubs of water, of very different temperatures. Dry air was then blown thro' them, and came from their ſpouts ſaturated with water. The ſpouts were turned toward each other. Being of very different temperatures, the ſtreams produced a cloud upon mixing together, and a ſtrong negative electricity was produced. We even found that an electrometer, placed in a veſſel filled with condenſed air, was affected when this air was allowed to ruſh out by a large hole.

Laſtly, we know that the tourmaline, and many of the columnar cryſtals, are rendered electrical by merely heating and cooling. Nay, Mr Canton found that dry air became negative by heating, and poſitive by cooling, even when it was not permitted to expand or contract.

When water is precipitated, and forms a cloud, it is reaſonable to expect that it will have the electricity of the air from which it is precipitated. This may be various, but in general negative: For the heat by which the air was enabled to diſſolve the water made it negative; and much more the friction on the ſurface of the earth. But as heat cauſed it to diſſolve the water, cold will make it precipitate it; and we ſhould therefore expect that the air will be in the ſtate in which it was when it took up the water. But if it be cooled ſo faſt as to precipitate it in the form of rain, or ſnow, or hail, we may expect poſitive electricity. Accordingly, in ſummer, hail ſhowers always ſhew ſtrong poſitive electricity; ſo does ſnow when falling dry.

Here, then, are copious ſources of atmoſpheric electricity. The mere expanſion and condenſation of the air, and ſtill more the ſolution and precipitation of watery vapours in it, are perhaps ſufficient to account for all the inequality of electric ſtate that we obſerve in the atmoſphere.

The maſſes of air thus differently conſtituted are evidently diſpoſed in ſtrata The clouds are ſeen to be ſo. Theſe clouds are not the ſtrata, but the boundaries of ſtrata; which, from the very nature of things, are in different ſtates with reſpect to the ſuſception or precipitation of water. When two ſuch ſtrata are thus adjoining, they will ſlowly act on each other's temperature, and by mixing will form a thin ſtratum of cloud along their mutual confines. If the one ſtratum has any motion relative to the other, and be in the ſmalleſt degree diſturbed, they will mix to a greater depth in each; and this mixture will not be perfectly uniform. The extreme mobility of air will greatly increaſe this jumble of the adjoining parts of the two ſtrata, and will give the cloud a greater thickneſs. If the jumble has been very great, ſo as to puſh one of them through the other, we ſhall have great towering clouds, perhaps pervading the whole thickneſs of the ſtratum of air. We take theſe clouds to be like great foggy bladders, ſuperficially opaque where they have come into contact with the ſurrounding ſtratum of air, but tranſparent within.

9
Strata of the atmoſphere are in different ſtates of electricity, and are tranſparent.

When the wind, or ſtratum in motion, does not puſh all the quieſcent air before it, it generally gets over it, and then flows along its upper ſide, and, by a partial mixing, produces a fleecy cloud, as already deſcribed. We may obſerve here, by the way, that the motion of thoſe fleecy clouds is by no means a juſt indication of the motion of the ſtratum; it is nearly the motion compoſed of the half of the motions of the two.

10
Theſe ſtrata have ſtrata of clouds interpoſed.

This is in all probability the ſtate of the atmoſphere, conſiſting of ſtrata of clear air many hundred yards thick, ſeparated from each other by thin fleeces of clouds, which have been produced by the mixture of the two adjoining ſtrata. This is no fancy; for we actually ſee the ſky ſeparated by ſtrata of clouds at a great diſtance from each other. And we ſee that theſe ſtrata maintain their ſituations, without farther admixture, for a long time, the bounding clouds continuing all the while to move in different directions. In the year 1759, during the ſiege of Quebec, a hard gale blew one day from the weſtward, which made it almoſt impracticable to ſend a number of proviſion-boats to our troops ſtationed above the town. While the men were tugging hard at the oars againſt the wind, and hardly advancing, though the tide of flood favoured them, the French threw ſome bombs to deſtroy the boats. One of theſe burſt in the air, near the top of its flight, which was about a quarter of a mile high. The round ball of ſmoke produced by the exploſion remained in the ſame ſpot for above ſeven minutes, and diſappeared by gradual diffuſion. The lower air was moving to the eaſtward at leaſt 30 feet per ſecond.

In 1783, when a great fleet rendezvouſed in Leith Roads, the ſhips were detained by an eaſterly wind, which had blown for ſix weeks without intermiſſion. The ſky was generally clear; ſometimes there was a thin fleece of clouds at a great height, moving much more ſlowly in the ſame direction with the wind below. During the laſt eight days, the upper current was from the weſtward, as appeared by the motion of the upper clouds. High towering clouds came down the river, with a little rain; the ſtrata were jumbled, and the whole atmoſphere grew hazy and uniform; then came thunder, and heavy rain, and the wind below ſhifted to the weſtward.

Thus it is ſufficiently evinced, that the atmoſphere frequently conſiſts of ſuch ſtrata, well diſtinguiſhed from each other: their appearance and progreſs leave us no room to doubt but that they come from different quarters, and had been taken up or formed at different places, and in different circumſtances, and therefore differing in reſpect of their electrical ſtates.

11 The electric equilibrium is reſtored very ſlowly in general.

The conſequence of their continuing long together would be a gradual but ſlow progreſs of their electricity to a ſtate of equilibrium. The air is perhaps never in a perfectly dry ſtate, and its moiſture will cauſe the electricity to diffuſe itſelf gradually. It is not beyond the power of our mathematics to aſcertain the progreſs of this approximation to the electric equilibrium. We ſee ſomething very like it in the curious experiments of Beccaria with mirror plates laid together, and charged by means of a coating on the outer plates. Theſe plates were found to conſiſt of alternate ſtrata of poſitive and negative electricity, which gradually penetrated through the plates, and coaleſced till they were reduced to two ſtrata; perhaps in time the electricity would have diſappeared entirely by theſe two alſo coaleſcing. In the ſame manner there would be a ſlow transfuſion of ſenſible electricity through theſe ſtrata without any ſenſible appearances. If any collateral cauſes ſhould make a part more damp than the reſt, there would be a more briſk transference through it, accompanied with faint flaſhes of lambent lightning.

12 A rapid and extenſive reſtoration is a thunder clap.

But thunder requires a rapid communication, and a reſtoration of electric equilibrium in an inſtant, and to a vaſt extent. The means for this are at hand, furniſhed by Nature. The ſtrata of charged air are furniſhed with a coating of cloud. The lower ſtratum is coated on the underſide by the earth.

13 Manner in which this is effected by a coating of cloud.

When a jumble is made in any of the ſtrata, a precipitation of vapour muſt generally follow. Thus a conductor is brought between the electrical coatings. This will quickly enlarge, as we ſee that in our little imitations the knobs of our conductors inſtantaneouſly arrange any particles of duſt which chance to lie in the way, in ſuch a manner as to complete the line of conduct, and occaſion a ſpark to fly to a much greater diſtance than it would have leaped if no duſt had been interpoſed. We have often procured a diſcharge between two knobs which were too far aſunder, by merely breathing the damp air between them. In this manner the interpoſed cloud immediately attracts other clouds, grows ragged by the paſſage of electricity through clear air, where it cauſes a precipitation by altering the natural equilibrium of its electricity; for a certain quantity of electricity may be neceſſary for air's holding a certain quantity of vapour. Accordingly we ſee in a thunder ſtorm that ſmall clouds continually and ſuddenly form in parts formerly clear. Whatever cauſes thunder, does in fact promote this precipitation.

Theſe clouds have the electricity of the ſurrounding air, and muſt communicate it to others in an oppoſite ſtate, and within reach. They muſt approach them, and muſt afterwards recede from them, or from any that are in the ſame ſtate of electricity with themſelves. Hence their ragged forms, and the ſimilar form of the under ſurface of the great cloud; hence their continual and capricious ſhifting from place to place: they are carriers, which give and take between the other clouds, and they may become ſtepping ſtones for the general diſcharge.

If a ſmall cloud form a communication with the ground, and the great cloud be poſitive or negative, we muſt have a complete diſcharge, and all the electrical phenomena, with great violence; for this coating of vapour is abundantly complete for the purpoſe. It conſiſts of ſmall veſicles, which are ſufficiently near each other for diſcharging the whole air that is in their interſtices. A phial coated with amalgam is by no means fully coated. If we hold it between the eye and the light, we ſhall ſee that it is only covered with a number of detached points of amalgam, which looks like a cobweb. Yet this glaſs is almoſt completely diſcharged by a ſingle ſpark, the reſiduum being hardly perceptible.

14 The diſcharge is commonly between the clouds

The general ſcene of thunder is the heavens; and it is by no means a frequent caſe that a diſcharge is made into the earth. The air intervening between the earth and the loweſt coating is commonly very much confuſed in conſequence of the hills and dales, which, by altering the currents of the winds, toſs up the inferior parts, and mix them with thoſe above. This generally keeps the earth pretty much in the ſame electrical ſtate as the loweſt ſtratum of clouds.

15 Which are horizontally diſtant.

Nor are the great thunder ſtorms in general inſtances of the reſtoration of equilibrium between two ſtrata immediately incumbent on each other. They ſeem, for the moſt part, to be ſtrokes between two parcels of air which are horizontally diſtant. This, however, we do not affirm with great confidence. Our chief reaſon for thinking ſo is, that in theſe great ſtorms the ſpark or ſhaft of forked lightning is directed horizontally, and ſometimes is ſeen at once through an extent of ſeveral miles.

16 Particular account of forked lightning, and explanation of the long continued and rumbling noiſe of thunder.

The nature of this ſpark has not, we think, been properly conſidered. It is ſimply compared to a long electrical ſpark, which we conceive to be drawn thro' pure air, and is conſidered as marking the actual transference of electricity from one end to the other. But this we doubt very much. We are certain of having obſerved ſhafts of lightning at one and the ſame inſtant ſtretching horizontally, though with many capricious zigzags and lateral ſputterings, at leaſt five miles. We cannot conceive this to have been the ſtriking diſtance, becauſe the greateſt vertical diſtance of the ſtrata is not the half of this. We rather think that it is a ſimultaneous range of diſcharges, each accompanied with light, differently bright, according to the electrical capacity of the cloud into which it is made; and if there is a real transference of electric matter on this occaſion (which we do not affirm), it is only of a ſmall quantity from one cloud to the next adjoining. This we think confirmed by the ſound of thunder. It is not a ſnap, incomparably louder than our loudeſt ſnap from coated glaſs; but a long continued, rumbling, and *very unequable* noiſe. There is no doubt but that this ſnap was almoſt ſimultaneous through the whole extent of the ſpark; but its different parts are conveyed to our ear in time, and are therefore heard by us in ſucceſſion; and it is not an uniform roar, but a rumbling noiſe, unequally loud, according as the different parts of the ſnap are indeed differently loud. We ſhould hear a noiſe of the ſame kind if we ſtood at one end of a long line of ſoldiers, who diſcharged their muſquets (differently loaded) in the ſame inſtant. When any part of the ſpark is very near us, and is not very diffuſe, the ſnap begins with great ſmartneſs, and continues for ſome time, not unlike the violent tearing of a piece of ſtrong ſilk; after which it becomes more and more mellow as it comes from a greater diſtance. We do not, however, affirm, that the whole extenſive ſpark and ſnap are co-exiſtent or ſimultaneous. The cloud is, in all probability, but an indifferent conductor, and even a ſenſible time may elapſe during the propagation of the ſpark to a great diſtance. Beccaria obſerved this in a line of 250 feet of chain, lying looſely on the ground, and conſiſting of near 6000 links. He thought that it employed a full ſecond; but when the chain was gently ſtretched, the communication ſeemed inſtantaneous.

17
Obſervations on the electric ſpark.

We cannot help thinking that even the electrical ſnap between two metal knobs is of the ſame kind. Not a quantity of luminous matter which iſſues from the one and goes to the other, but a light that is excited or produced in different material interjacent particles of air or other interpoſed matter. The angular and ſputtering form is quite incompatible with the motion of a ſimple luminous point. Nay, our chemical knowledge here comes in aid, and obliges us to ſpeculate about the manner in which this light is produced. Whence does it come? It may be produced by two knobs of ice. We know that water conſiſts of vital and inflammable air, which have already emitted the light which made an ingredient of their compoſition. The ſpark therefore does not come from the ice. Is it then from the air? If ſo, perhaps water is produced, or rather ſomething elſe, for there is not always inflammable air at hand to compoſe water. Yet the transference of electricity has decompoſed the air, or has robbed it of part of its light. The remainder may not be water; but it is no longer air. Is not this confirmed by the peculiar ſmell which always accompanies electric ſparks? and the peculiar taſte, not unlike the taſte felt on the tongue when it is touched by the zinc in the experiments on GALVANISM? Even the fine pencil of light which flows from a point poſitively electrified, appears through a magnifying glaſs to conſiſt, not of luminous lines, but of lines of luminous points. And theſe points are of different brilliancy and different colour, both of which are inceſſantly changing. And be it farther obſerved, that theſe lines are curves, diverging from each other, and convex to the axis. This circumſtance indicates a mutual repulſion, ariſing, in all probability, from the expanſion of the air. And, laſtly, no ſpark nor light of any kind can be obtained in a ſpace perfectly void of air.

All theſe circumſtances concur in explaining the nature of the ſhaft of forked lightning. It is a ſeries of appearances excited in the intervening medium, and which produce ſome chemical change in it. Thunder, when it ſtrikes a houſe, always leaves a peculiar ſmell. Inflammable air has alſo a peculiar and very diſagreeable ſmell. The ſmell produced by electricity greatly reſembles the ſmell produced by ſtriking two pieces of quartz together.

18
Deluc's notion of thunder not probable.

Mr Deluc ſuppoſes that the electrical ſpark, as it is exhibited in thunder, is always accompanied by the decompoſition of air now ſo familiarly known, and that this is the origin of the deluge of rain which commonly finiſhes the ſtorm. But this is not in the ſmalleſt degree probable. The decompoſition extends ſurely no farther than where the light is ſeparated; and we ſhould no more expect a deluge of rain, even if we had inflammable air ready at hand, than we expect drops of water in our electrical experiments. Something different from water follows this decompoſition, total or partial, of the vital air; and the water which we do obſerve to accompany thunder, is no more than what we ſhould expect from the copious precipitation of water in a cloudy form. Mr Sauſſure's obſervations aſſure us, that the particles of a cloud are veſicles. Indeed no perſon who has looked narrowly at a fog, or has obſerved how large the particles are of the cloud which forms in a receiver when we ſuddenly diminiſh the denſity of the air, and who obſerves how ſlowly theſe particles deſcend, can doubt of their being hollow veſicles. We cannot perhaps explain their formation; but there they are. We can hardly conceive them receiving the commotion which accompanied the ſnap without collapſing by the agitation. Perhaps the very ceſſation of their electricity may produce this effect. They will therefore no longer float in the air, but fall, and unite, and come to the ground in rain. We may expect this rain to be copious, for it is the produce of two ſtrata of clouds. It greatly contributes to the putting an end to the ſtorm, by paſſing through the ſtrata, and helping to reſtore the equilibrium.

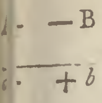
19
Why and how thunder may continue for ſome time.

One may at firſt expect that a ſingle clap of thunder will reſtore the equilibrium of any extent of clouds, and we require an explanation of their frequent repetition before this is accompliſhed. This is not difficult, and the fact is a confirmation of the above theory, which is conſiderably different from the generally received notions of the ſubject. We conſider the ſtratum of clear air as the charged electric; poſitive on one ſide, and negative on the other, and coated with conducting clouds. When the diſcharge is made, the ſtate of electricity is indeed changed through the whole ſtratum, but the equilibrium is by no means completed. The ſtratum is perhaps a quarter of a mile in thickneſs. The diſcharge does not immediately affect all this; but does it ſuperficially, leaving the reſt unbalanced. It is like the reſiduum which is left in a Leyden phial when the diſcharge has been made by means of a ſpark drawn at a diſtance. It is ſtill more like the reſiduum of the diſcharge of a Leyden phial that is coated only in patches on one ſide. Each of theſe patches diſcharge what is immediately under it and round it to a certain ſmall diſtance, but leaves a part beyond this ſtill charged. This redundant electricity gradually diffuſes itſelf into the ſpaces juſt now diſcharged; and, after ſome conſiderable time has elapſed, another diſcharge may be made. In like manner, the electricity remaining in the interior of the ſtratum diffuſes itſelf, comes within the action of the coating, and may be again diſcharged by a clap of thunder. We have a ſtill better parallel to this in Beccaria's experiments with two or more plates of glaſs laid together. After the firſt diſcharge, the internal ſurfaces will exhibit certain electricity. Lay the plates together, and, after ſome time, the electricity of the inner ſurfaces will be different, and another diſcharge may be obtained.

Magnetiſm affords the beſt illuſtration of this. If a magnet be brought near a piece of ſoft iron, lying below a paper on which iron filings are lightly ſtrewed, it will inſtantly induce a north pole on one end and a ſouth pole on the other; and this will be diſtinctly obſerved by the way in which theſe filings will arrange themſelves. But if, inſtead of ſoft iron, we place a bar of hard tempered ſteel, the ſouth pole will be but a ſmall matter removed from the north pole; but by continuing the magnet long in the ſame place, the diſtribution of magnetiſm in the piece of hard ſteel will gradually advance along the bar, and after a long time the neutral point will be almoſt in the middle of the bar, and the ſouth pole will be at the farther end. See Magnetism, in this *Suppl*

20 Moſt thun er ſtrokes re RE- URNING TROKES.

We ſaid that the clouds were the uſual ſcenes of the violent electric phenomena We imagine that the greateſt part of the thunder ſtrokes which have been felt have been of the kind which Lord Mahon, now Lord Stanhope, calls the returning ſtroke. If two clouds A and B are incumbent over the plain *a* and *b*; and if A be poſitive and B negative. the earth will be maintained in a negative ſtate at *a*, and a poſitive ſtate at *b*. If the diſcharge be now made between the clouds A and B, the electricity muſt inſtantly ruſh up through a conductor at *a*, and down through one at *b*. and each place will have a ſtroke. The ſame thing will happen if the negative cloud B is above the poſitive cloud A, but not in ſo great a degree; for the negative electricity at *a* will now be much leſs than in the other caſe, becauſe it is induced only by the prevalence of the poſitive cloud A over the more remote negative cloud B.



This returning ſtroke explains, much better than we can by any direct ſtroke, the capricious effects of thunder. A perſon at Vienna received a terrible ſhock by having his hand on a thunder-rod during a violent exploſion which he ſaw above three miles diſtant. Sparks are obſerved at thunder rods at every the moſt diſtant flaſh of lightning.

21 Beccaria's theory of thunder not juſt.

Beccaria has a different theory of thunder. He imagines that the different parts of the earth are in different ſtates of electricity, and that the clouds are the reſtoring conductors. But this does not accord with what we know of electricity. The earth is ſo good a conductor, that Dr Watſon could not obſerve any time loſt in communicating the electricity to the diſtance of more than four miles. It is very true, that the earth is almoſt always in a ſtate of very unequal, and even oppoſite, electricity in its different parts; but this ariſes from the variety of clouds ſtrongly electrified in the oppoſite way This induces electricity, or diſturbs the natural uniform diffuſion of electricity, juſt as the bringing magnets or loadſtones into the neighbourhood of a piece of iron, without touching it, renders it magnetical in its different parts. While they continue in their places, the piece of iron will be magnetical, and differently ſo in its different parts.

Such are the thoughts which occur to us on this ſubject. But we by no means affirm that we have given a full account of the procedure of Nature; we have only pointed out ſeveral neceſſary conſequences of the known laws of electricity, and of its production in the atmoſphere by means of natural operations which are continually going on. Theſe *muſt* operate, and produce an electrical ſtate of the atmoſphere greatly reſembling what we obſerve: and we have ſhewn, from the acknowledged doctrines of electricity, how this want of equilibrium may be removed, and muſt be removed, by the ſame operations of Nature. The equilibrium muſt be reſtored by means of the conducting coating furniſhed by the clouds. But theſe may be the leaſt conſiderable of Nature's reſources; and the ſubject is ſtill an unexplored field, in the examination of which we may hope to make great progreſs, in conſequence of our daily increaſing knowledge of the chemical ſtate of the atmoſphere.

22 Dr Franklin's invention of a guard againſt thunder.

Knowledge is valuable chiefly as it is uſeful. No man ever ſaw the propriety of this apothegm more ſtrongly than Dr Franklin, or more aſſiduouſly adhered to it in the courſe of a long and ſtudious life. However greatly we may admire his ſagacity, penetration, and logical diſcrimination, in the diſcoveries he has made in the ſcience of electricity, and his diſcovery of the identity of electricity and thunder, we muſt acknowledge infinitely greater obligations to him for putting it in our power to ward off the fatal, and formerly inevitable ſtroke, of this awful agent in the hands of Nature.

Dr Franklin conſiders the earth as performing the office of a conductor in reſtoring the electric equilibrium of the atmoſphere, which has been diſturbed by the inceſſant action of the unwearied powers of Nature.

He obſerves that the uſual preference will be given to the beſt conductors. In this reſpect, a metal rod far ſurpaſſes the brick, ſtone, timber, and other materials which compoſe our buildings, eſpecially when they are dry, as is uſually the caſe in the thundery ſeaſon. He therefore adviſes us to place metalline conductors in the way of the atmoſpherical electricity, in thoſe places where it is moſt likely to ſtrike, and to continue them down to the moiſt earth, at ſome depth under the ſurface. Nay, as it has been found that thunder has not in every inſtance ſtruck the higheſt parts of buildings, he adviſes to raiſe the metalline conductors to ſome conſiderable height above the building, the more certainly to invite the electricity to take this courſe.

23 Directions for conſtructing it.

To enſure ſucceſs, he obſerves that the electrical ſhock diſſipates water, and even metalline conductors, when too ſmall. He therefore adviſes to make the conductor at leaſt half an inch ſquare, none of that ſize having ever been deſtroyed, though ſmaller have, by the thunder; yet even theſe had conducted the thunder to the ground with perfect ſafety to the building.

No part of a conductor muſt terminate in the building; for the electricity accumulates exceedingly at the remote extremities of all long rods, and tends to fly off with great force, eſpecially if another conductor is near. This aids the accumulation, by acquiring at its upper end an electricity oppoſite to that of the lower end of the other: and this effect, produced by the influence of a poſitive cloud, makes the upper and negative end of the lower portion of a divided conductor draw more electricity to the lower end of the upper portion. This redundant electricity, ſtrongly attracted by the negative lower portion, flies off with great violence through the air; or if ſurrounded with any matter capable of converſion into elaſtic vapour by heat, burſts it with irreſiſtible force Thus the thunder, acting on the vane ſpindle of St Bride's ſteeple in London, ſprung from its lower end to the upper end of an iron window bar, and burſt the ſtone in which it was fixed, by expanding the moiſture into ſteam. In like manner it burſt the ſtone at the lower end of this bar, to make its way to an iron cramp which connected the oppoſite ſides of the ſteeple; from this it ſtruck to another cramp; and ſo from cramp

cramp to cramp, till it reached the gutter-leads of the church, burſting and throwing off the ſtonework in many places.

All interruptions muſt therefore be carefully avoided, and the whole muſt be made as much as poſſible one continued metal rod.

Farther, Dr Franklin, obſerving the ſingular property which ſharp points poſſeſs of drawing off the electricity in ſilence, adviſes us to finiſh our conductor with a fine point of gilt copper, which cannot be blunted by ruſt.

24
Is the thunder rod an effectual and ſafe contrivance?

But as thus raiſing the conductor, and pointing it, are ſo many invitations to the thunder to take this courſe; and as we cannot be certain that the quantity thus invited may not be more than what the rod can conduct with ſafety—it has appeared to Dr Wilſon, and other able electricians, that it will be ſafer to give abundance of conduct to what may unavoidably viſit us, without inviting what might otherwiſe have gone harmleſsly by.

This was attentively conſidered by Dr Franklin, Dr Watſon, Mr Canton, Dr Wilſon, and others, met as a committee of the Royal Society, at the deſire of the Board of Ordnance, to contrive a conductor for the powder magazine at Purfleet.

We think that the theory of induced electricity, founded on Dr Franklin's diſcoveries, and confirmed by all the later inventions of the electrophorus, condenſer, &c. will decide this queſtion in the moſt ſatisfactory manner.

25
Scientific account of the ſtate of electricity induced on a building by a thunder cloud,

When a cloud poſitively electrified comes over a building, it renders it negatively electrical in all its parts, if of conducting materials, and even the ground on which it ſtands. This effect is more remarkably produced if the ſtructure is of a tall and ſlender ſhape, like a ſteeple or a rod. Therefore the external electrical fluid is attracted by the building with greater force than if it had conſiſted of materials leſs conductive. A diſcharge will therefore be made through it in preference to any neighbouring building, becauſe it is more eminently negative. For the ſame reaſon, if there are two buildings equal and ſimilar, one of them being a good conductor, and the other being a leſs perfect one, the perfect conductor, becoming more powerfully negative, the cloud will become more ſtrongly poſitive over this houſe than over the other, and the ſtroke will be made through it.

26
And on the thunder rod.

The ſame thing muſt obtain in a perfect conductor continued from the top to the foundation of a houſe, built of worſe conducting materials. The conductor becoming more eminently negative than any other part of the building, the electric fluid will be more ſtrongly attracted by it, accumulated in its neighbourhood, and will all be diſcharged through it, ſo long as it is able to conduct.

If the building is of great extent, the proximity of one part of the building to the thunder cloud may produce an accumulation of electrical fluid in its neighbourhood, in preference to a more perfect, but remote, conductor. But when the diſtances from the cloud are not very unequal, the accumulation will always be in the neighbourhood of the perfect conductor; and this will determine the diſcharge that way. The accumulation in the neighbourhood of the rod will be ſmall indeed, when the rod is ſmall; but then it is denſe, and the whole of electric phenomena ſhew that it is the denſity, and not the quantity, of accumulation which produces the violent tendency to fly off: it is this alone which makes it impoſſible to confine electricity in a body which terminates in a ſharp point.

For the ſame reaſon, bodies of the ſame materials and ſhape will increaſe the accumulation in the adjoining part of the cloud in proportion as they are nearer to it, or more advanced beyond the reſt of the building.

And bodies of ſlender ſhape, and pointed, will produce this accumulation in their neighbourhood in a ſtill more remarkable degree, and determine the courſe of the diſcharge with ſtill greater certainty.

But it is evident that a metallic rod, no higher than the reſt of the building, may occaſion an accumulation in the adjoining part of a near thunder cloud ſufficient to produce a diſcharge, when the building itſelf, conſiſting of imperfect conductors, would not have provoked the diſcharge at all. It may therefore be doubted whether we have derived any advantage from the conductor.

27
Effect of all interruptions in the conductor.

To judge properly of this, we muſt conſider houſes as they really are, conſiſting of different materials, in very different ſhapes and ſituations; and particularly as having many large pieces of metal in their conſtruction, in various poſitions with regard to the cloud, the ground, and to each other. Suppoſe all the reſt of the building to be of non-conducting materials. When a poſitive thunder cloud comes overhead, every piece of metal in the building becomes electrical, without having received any thing as yet from the cloud; that end of each which is neareſt the cloud becoming negative, and the remote end poſitive. But, moreover, the electricity of one increaſes the electricity of its neighbour. Then the moſt elevated becomes more ſtrongly attractive at its upper end than it would have been had the others been away; and therefore produces a greater accumulation in the nearer part of the thunder cloud than it would otherwiſe have done, and it will receive a ſpark. By this its lower end becomes more overcharged, and this makes the upper end of the next more undercharged, and the ſpark is communicated to it, and ſo on to the ground; which would not have happened without this ſucceſſion of conductors. Thus it is eaſy to conceive, that the accumulation in the cloud is juſt inſufficient to produce a diſcharge—While things are in this ſtate, juſt ready to ſnap, ſhould a man chance to paſs under a bell wire, or under a luſtre hanging by a chain, his body will immediately augment the poſitive electricity of the lower end of the conductor above him, and thus will augment the negative electricity of its upper end. This again will produce the ſame effect in the conductor above it: and thus each conductor becomes more overcharged at its lower end, and more undercharged at the upper end. Before this, every thing was juſt ready to ſnap. All will now ſtrike at once. The cloud will be diſcharged through the houſe, and the man will be the ſacrifice, the whole diſcharge being made through his body. This needs no demonſtration for any well-informed electrician. Thoſe who have only ſuch a knowledge of the theory as can be gathered from the writings of Prieſtley, Cavallo, and other popular authors, may convince themſelves of the truth of what is here delivered in the following manner.

In dry weather, and the moſt favourable circumſtances for good electrical experiments, let a very large globe,

globe, ſmoothly covered with metal, and well inſulated, be as highly electrified as poſſible, without expoſing it to a rapid diſſipation. To enſure this circumſtance (which is important) let it be electrified till it begins to ſputter, and note the ſtate of the electrometer. Diſcharge this electricity, and electrify it to about half of this intenſity. Provide three or four inſulated metal conductors, about three inches long and an inch diameter, terminated by hemiſpheres, and all well poliſhed.

Having electrified the globe, as above directed, bring one of the inſulated conductors ſlowly up to it, and note its diſtance when it receives a ſpark. In doing this, take care that there be no conducting body near the remote end of the inſulated conductor. It will be beſt to puſh it gradually forward by means of a long glaſs rod. Withdraw the conductor, diſcharge its electricity, reſtore the globe to its former electricity, indicated by an electrometer, and repeat this experiment till the greateſt ſtriking diſtance is exactly diſcovered. Now ſet another of the inſulated conductors about half an inch behind the firſt, and puſh them forward together, by a glaſs rod, till a ſpark is obtained. The ſtriking diſtance will be found greater than before. Then repeat this laſt experiment, with this difference, that the two conductors are puſhed forward by taking hold of the remote one. The ſtriking diſtance will be found much greater than before. Laſtly, puſh forward the two conductors, the remote one having a wire communicating with the ground, till they are a ſmall matter *without* the ſtriking diſtance; and, leaving them in this ſituation, take any little conducting body, ſuch as a braſs ball fixed on the end of a glaſs rod, and paſs it briſkly through between the globe and the neareſt conductor, or through between the two conductors, taking care that it touch neither of them in the paſſage. It will be ſeen that, however ſwift the paſſage is made, there will be a diſcharge through all the four bodies. The inference from this is obvious and demonſtrative.

A very remarkable inſtance of this fact was ſeen at the chapel in Tottenham Court Road, London. A man, going into the chapel by the eaſt door, was killed by the thunder, which came down from the little bell-houſe, along the bell-wire, and the rod of the clock pendulum, from the end of which it leaped to ſome iron work above the door, and from thence, from nail to nail, till it reached the man's head.

This interruption of conduct, which is almoſt unavoidable in the conſtruction of any building, is the cauſe of moſt of the accidents that are recorded; for when the ends of thoſe communicating conductors are incloſed in materials of leſs conducting power, the electricity, in making its way to the next in a very denſe ſtate, never fails to explode every thing which can be converted into elaſtic vapour by heat. There is always a ſufficient quantity of moiſture in the ſtone or brickwork for this purpoſe; and moſt vegetable ſubſtances contain moiſture or other expanſible matter. The ſtone, brick, or timber, is burſt, and thrown to a conſiderable diſtance; or if kept together by a weight of wall, the wall is ſhattered. It is worth remarking that although no force whatever ſeems able to prevent this exploſion, the quantity of matter exploded is extremely ſmall; for the ſtones are never thrown to a greater diſtance than they would have been by two or three grains of gunpowder properly confined.

All theſe accidents will be prevented by giving a ſufficient uninterrupted conduct; and it is proper to make uſe of ſuch a conductor, although it may invite many diſcharges which would not otherwiſe happen. So long as the conductor is ſufficient for the purpoſe, there ſeems to be no doubt of the propriety of this maxim.

28
A thunder rod will protect even when it is not able to diſcharge the whole thunder.

But the moſt ſerious objection remains. As we are certain that theſe conductors, whether raiſed above the building or not, will produce diſcharges through them which otherwiſe would not have happened, and as we are quite uncertain whether the quantity contained in a thunder cloud may not greatly exceed what the thunder rod can conduct without being diſſipated in ſmoke, it ſeems very dangerous thus to invite a ſtroke which our conductor may not be able to diſcharge. In particular, it is reaſonable to believe that the ſtrata of electrified clouds which come near the earth loſe much of their electricity by paſſing over the ſharp points of trees, &c. while thoſe which are much higher may retain their electricity undiminiſhed, and paſs on. May it not therefore happen, that our conductor will invite a fatal ſtroke, which would have gone harmleſsly by?

The doubt is natural, and it is important.

Let us ſuppoſe a very extenſive and highly electrified cloud, in a poſitive ſtate, to come within ſuch a diſtance from a building as *juſt not to ſtrike it*, if unprovided with a conductor, but which will moſt certainly ſtrike the ſame building furniſhed with a conductor; and let the electricity be ſo great that the conductor ſhall be diſſipated in ſmoke before even a ſmall part of it is diſcharged—What will be the fate of the building? We believe that it will be perfectly ſafe.

However rapid we may ſuppoſe that motion by which electricity is communicated, it is ſtill motion, and time elapſes during the propagation. The cloud is diſcharged, not in a very inſtant, but in a very ſhort time. Part of the cloud is therefore diſcharged, while it explodes the conductor, and the electricity of the remainder is now too weak (by our ſuppoſition) to ſtrike the building no longer furniſhed with a conductor. This muſt be the caſe, however large and powerful the cloud may be, and however ſmall the conductor.

But ſuppoſe that the cloud has come ſo near as to ſtrike the building unprovided with a conductor. Then as much will be diſcharged through the building as it can conduct; and if the quantity be too great, the building will be deſtroyed: but let a conductor (tho' inſufficient) be added. The diſcharge will be made through it as long as it laſts, and the remainder only will be diſcharged through the houſe, ſurely with much leſs danger than before.

The truth of theſe concluſions from theory is fully verified by fact. When the church of Newbury in New England was ſtruck by lightning in 1755, a bell wire, no bigger than a knitting needle, conducted the thunder with perfect ſafety to the building as far down the ſteeple as the wire reached, though the ſtroke was ſo great that the wire had been exploded, and no part of it remained, but only a mark along the wall occaſioned by its ſmoke. From the termination of the wire to the ground the ſteeple was exceedingly ſhattered, and ſtones of great weight were thrown out from the foundation (where they were probably moiſter) to the diſtance of 20 and 30 feet.

Thunder.

Another remarkable inſtance happened in the ſummer palace at St Peterſburg. A Heyduk and a ſoldier of a foot regiment were ſtanding centinels at the door of the jewel-chamber: the Heyduk, with his ſcimitar reſting on his arm, was careleſsly leaning on the ſoldier, who had his muſket ſhouldered. Both were ſtruck down with lightning; and the ſoldier was killed, his left leg ſcorched, and his ſhoes burſt. The Heyduk had received no damage, but felt himſelf tripped up, as if a great dog had run againſt him. A narrow ſlip of gold lace, which was ſewed along the ſeam of his jacket and pantaloon breeches, reaching to his ſhoes, had been exploded on the left ſide. This ſeems to have been his protection. In all probability, the ſtroke came to both along the muſket (or perhaps to the Heyduk along the ſcimitar). The Heyduk had a complete, though inſufficient, conductor, and was ſafe. The ſoldier had not, and was killed. The puſh felt by the former probably aroſe from the exploſion of the lace.

It ſeems therefore plain that metalline conductors are always a protection; that advancing them above the building, increaſes their protection; and that pointing them may ſometimes enable them to diminiſh a ſtroke, by diſcharging part of the electricity ſilently.

Dr Franklin having formed all his notions of thunder from his pre-eſtabliſhed theory, and having ſeen the principal phenomena ſo conformable to it, was naturally led to expect this conformity in caſes which he could not eaſily examine preciſely by experiment. Accordingly, in his firſt diſſertation, he affirmed that a fine point always diſcharges a thunder cloud ſilently, and at a great diſtance. The analogous experiments in artificial electricity are ſo beautiful and ſo perſpicuous, that this confidence in the protecting power of fine points is not ſurpriſing: and this confidence was rendered almoſt complete by a moſt ſingular caſe which fell under his own obſervation He was awakened one night by loud cracks in his ſtair caſe, as if ſome perſon had been laſhing the wainſcoating with a great horſewhip. He thought it ſo, and got up in anger to chide the idle fool. On looking out at his chamber door, he ſaw that the diſturbance proceeded from electric exploſions at ſome interruptions of his conductor. He ſaw the electricity paſs, ſometimes in bright ſparks, producing thoſe loud thwacks, and ſometimes in a long continued ſtream of denſe white dazzling light as big as his finger, illuminating the ſtair-caſe like ſunſhine, and making a loud noiſe like a cutler's wheel. Had the cloud (ſays he) retained all this till it came within ſtriking diſtance, the conſequences would have been inconceivably dreadful. Yet not long after this he found that he had been in a miſtake; for the houſe of Mr Watt in Philadelphia, furniſhed with a finely pointed conductor, was ſtruck by a terrible clap of thunder, and the point of the conductor was melted down about two inches. This is perhaps the only inſtance on record of a finely-pointed *conductor* being ſtruck. The board room at the powder magazine at Purfleet was indeed ſtruck, though provided with a conductor; but the ſtroke was through another part of the building. St Peter's church, Cornhill, has been eight times ſtruck between 1772 and 1787; while St Michael's, in its neighbourhood, and much higher, has never had a ſtroke ſince 1772, when it was furniſhed with an excellent pointed conductor by Mr Nairne.

Thunder.

29
A pointed conductor may ſometimes be ſtruck.

Dr Franklin having ſeen the above exception to his rule, and reflected on it, acknowledges that there are caſes where a pointed conductor may be ſtruck, viz. when it ſerves as a ſtepping ſtone, to *complete* a canal of conveyance already near completed. A *ſmall* cloud may ſometimes ſerve as a ſtepping ſtone (like the man coming under a luſtre) for the electricity to come out of a great cloud, and diſcharge through the pointed conductor. Whenever it comes to the ſtriking diſtance from the conductor, it will explode at once; whereas the great cloud itſelf muſt have come nearer, and had its force gradually diminiſhed. It is remarkable that a point, employed in this way in artificial electricity, muſt be brought nearer to another body than a ball need be, before it can receive a ſtroke. The difference is about one third of the whole. Nairne found, that a ball one nine-tenths inches in diameter, exploded at the diſtance of nine inches, and a point at ſix inches diſtance.

We muſt alſo obſerve that a pointed conductor can have no advantage over a blunt one in the caſe of a returning ſtroke; which is perhaps the moſt common of any. This depends on another diſcharge, which is made perhaps at a great diſtance. This was moſt diſtinctly the caſe in the inſtance mentioned ſome time ago, of the perſon at Vienna who had a ſhock from a thunder rod by an exploſion far diſtant. This thunder rod was a very fine one, furniſhed with five gilt points.

30
Dr Franklin over-rated the protection of pointed conductors.

Still, however, this property of ſharp points was greatly over-rated by Dr Franklin, and thoſe who took all their notions of electricity from the ſimple diſcoveries of his ſagacious mind. Unfortunately Dr Franklin had not cultivated mathematical knowledge; and, ever eager after diſcovery, and ardent in all his purſuits, his wonderful penetration carried him through, and ſeldom allowed him to reſt long on falſe concluſions. He was certainly one of the greateſt *philoſophers*; and a little erudition would perhaps have brought him ſide by ſide with Newton. It was reſerved, however, for Lord C. Cavendiſh and for Æpinus, to ſubject the inveſtigations of Franklin to number and meaſure. By ſtudying what they have written on the ſubject, or even the view which we have given of their theory in the article ELECTRICITY *(Suppl.)*, the reader will be fully convinced, that a point has little or no advantage over a ball, with reſpect to a thunder cloud which is brought to the thunder rod by a briſk wind; although, when it comes ſlowly up during an almoſt perfect calm, it may diſcharge all that can be diſcharged without a ſnap. The conſtipation in a point is indeed very great, but the quantity conſtipated is moderate; and therefore its action, at any conſiderable diſtance, is but trifling. All this is fully verified by Dr Wilſon's judicious experiments in the Pantheon. He had a prodigious quantity of electrified ſurface ſuſpended there, and made a pointed apparatus come to its ſtriking diſtance with a motion which he could regulate and meaſure. And he found that with the very moderate velocity of twelve feet in a ſecond, he never failed of procuring a very ſmart ſtroke. The experiments made in the uſual way by the partiſans of ſharp points (for it became a matter of indecent party) were numberleſs, and decidedly in their favour. The great and juſt authority of Dr Franklin, who was one of the committee, procured them ſtill more conſideration, or at leaſt hindered people from ſeeing the force of Dr Wilſon's reaſoning. It is ſomewhat ſurpriſing, under.

priſing, that Dr Wilſon, a lover of mathematical learning, and a good judge, as appears from his publication of the papers of Mr Robins, did not himſelf ſee the full force of his own experiments. He had not ſurely ſtudied either Æpinus or Cavendiſh. He indeed frequently ſays, that the ſtate of the electricity in a thunder cloud, and in coated glaſs, is exceedingly different; and that the firſt extends its ſenſible influence much farther than the laſt, when both have the ſame quantity of electricity. But he ſeems not to have formed to himſelf any adequate notion of the difference. Had he done this, he would have ſeen that he has diſpoſed his great electrified ſurface very improperly. It ſhould have been collected much nearer his pointed apparatus, that this might, if poſſible, have been within the ſphere of attraction of every part of his artificial cloud. He would then have found reſults, ſome of which would have been much more favourable to his own general opinion, while others would have exhibited the peculiarities of the ſharp point in a more ſhowy manner than any thing we have ſeen.

31 hunder oud very like coat- glaſs;

Reaſoning from the true theory of coated glaſs, we ſhall learn that, when the glaſs is exceedingly thin, the accumulation of electricity, or the charge, will be exceedingly great; while the external appearance, or apparent energy, of the electricity may be hardly ſenſible, and will extend to a very ſmall diſtance. Thus, a circular plate of coated glaſs, ſix inches in diameter and one-twentieth thick, when electrified ſo as to make an electrometer diverge 50 degrees, contains about 60 times as much electricity as a braſs plate, of the ſame diameter, electrified to the ſame degree; and theſe two will have the ſame influence on an electrometer placed at a diſtance from them, and will give a ſpark nearly at the ſame diſtance. The ſpark from the coated glaſs will be bright, and will give a ſhock; while that from the braſs plate will be trifling. The cauſe of the equality of influence is, that the poſitive electricity of the one ſide of the coated glaſs is almoſt balanced by the negative electricity of the other ſide, and the unbalanced part is about $\frac{1}{59}$th of the whole. If we now take a braſs plate of 46½ inches in diameter, and electrify it to the ſame degree with the coated glaſs, we ſhall find that it will require the ſame number of turns of the machine to bring it to this ſtate, or to charge the coated glaſs. They contain the ſame quantity of electricity, and the ſpark of both will give the ſame ſhock. But this large plate will have a much wider influence: a perſon coming within ten feet of it will ſee his hair bend towards it, and feel like a cobweb on his face.

32 And the nfluence of harp points s trifling.

It may be farther demonſtrated that the power of a point to abſtract the electricity to a given degree from the large plate, is vaſtly ſmaller than its power to abſtract it to the ſame degree from the coated plate. This is different in the different degrees of the abſtraction, and cannot be expreſſed by any one number.

Thunder.

All theſe conſiderations taken together, ſhew us that the pointed conductor has little advantage over the ball in the circumſtance above-mentioned. It has, however, an advantage, and therefore ſhould be employed; and in the caſe of a calm, or very gentle progreſs of the thunder cloud, the advantage may be very great.

33 An extenſive and ſubſtantial metalline conductor is the chief ſecurity.

Thus we think the queſtion decided; and the only remaining conſideration is the quantity of metallic conduct that ſhould be given. Prudence teaches us not to ſpare, eſpecially in very lofty buildings. The conductor on the dome of St Paul's in London conſiſts of four iron ſtraps, each four inches broad and one half an inch thick. This conductor was once made red hot by a thunder ſtroke. No inſtance has been found of a rod one half an inch ſquare being exploded. The accident at Mr Watt's houſe in Philadelphia is curious. The braſs wire which terminated the rod had been ten inches long and one-fourth thick at the baſe, and two one-half inches were melted. It was unable, therefore, to conduct that ſtroke when its diameter was leſs than one-ſixteenth of an inch.

We recommend lead or copper in preference to iron. Iron waſtes by ruſt, and by exfoliating retains water, which may be dangerous by its expanſion. A ſtrap of lead, two inches broad and one fourth thick, ſtapled down to the roof or wall with braſs ſtaples, ſecures us from all riſks from neglect. An iron rod, or one faſtened with iron cramps, requires frequent inſpection, to ſee that nothing has failed or waſted by ruſt. The point or points ſhould ſurely be copper. It would be very proper to connect all the leads of the ridges, gutters, and ſpouts, with the conductor, by ſtraps of lead. This will greatly extend its protection.

A great extent of building is not ſufficiently ſecured by one conductor. And a powder magazine ſhould have ſome erected round it at a diſtance on maſts.

Maxims in a Thunder Storm.

Avoid being under trees—but be near them: do not avoid rain. When in a room, avoid the fire-ſide, which would bring you into the neighbourhood of the higheſt part of the houſe, viz. the ſtack of chimneys. The bell-wire, the grate, the fire irons – are bad neighbours. Nay, the ſoot of the chimney is not a good one, eſpecially if it has ever caked together by burning (A). Go to the middle of the room, and ſit down, if not near a luſtre, or any thing hanging from the ceiling. Avoid mirrors, or gilded mouldings.

Thunder Clouds, in phyſiology, are thoſe clouds which are in a ſtate fit for producing lightning and thunder. See the preceding article.

(A) In the terrible thunder ſtroke on Leven Houſe in Scotland, the two great ſtreams of electricity had taken the courſe of the vents which had been moſt in uſe, but not to get at the iron work, for it had branched off from the vents, at a great diſtance from the bottom. The chief conductors through the building had been various gilded mouldings, gilded leather hangings, gilded ſkreens, picture frames, and the foil of mirrors. In this progreſs the ſteps have been ſo many, and ſo capricious, that no line of progreſs can be traced, according to any principle. The thunder ſeems to have electrified at once the whole of the leaden roof, and, beſides the two main tracks along the vents, to have afterwards darted at every metal thing in its way. The loweſt point of the track was a leaden water ciſtern; which, however, received no damage; but a thick ſtone wall was burſt through to get at it.

THUS, in ſea language, a word uſed by the pilot in directing the helmſman or ſteerſman to keep the ſhip in her preſent ſituation when ſailing with a ſcant wind, ſo that ſhe may not approach too near the direction of the wind, which would ſhiver her ſails, nor fall to leeward, and run farther out of her courſe.

TIBERIAS (anc geog.), the laſt town of Galilee, ſituated on the ſouth ſide of the lake Tiberias; built by Herod the Tetrarch, and called *Tiberias* in honour of the Emperor Tiberius; diſtant 30 ſtadia from Hippus, 60 from Gadara, and 120 from Scythopolis: whence it appears to have been at no great diſtance from where the Jordan runs out of the lake. It is a number of times mentioned by St John the Evangeliſt. Pliny places it on the weſt extremity of the lake, commending the ſalubrity of its hot waters. Jerome ſays, the ancient name was *Chennereth;* which, if true, will account for the name of the lake.

TIERRA del Fuego, ſeveral iſlands at the ſouthern extremity of America. They take their name from a volcano on the largeſt of them. They are all very barren and mountainous; but from what Mr Forſter ſays, in his Voyage to the South Sea, the climate does not appear to be ſo rigorous and tempeſtuous as it is repreſented in Anſon's Voyage. Upon the lower grounds and iſlands, that were ſheltered by the high mountains, Mr Forſter found ſeveral ſorts of trees and plants, and a variety of birds. Among the trees was Winter's bark-tree, and a ſpecies of *arbutus*, loaded with red fruit of the ſize of ſmall cherries, which were very well taſted. In ſome places there is alſo plenty of celery. Among the birds was a ſpecies of duck, of the ſize of a gooſe, which ran along the ſea with amazing velocity, beating the water with its wings and feet. It had a grey plumage, with a yellow bill and feet, and a few white quill-feathers. At the Falkland iſlands it is called a *loggerhead-duck*. Among the birds are alſo plenty of geeſe and falcons. The rocks of ſome of the iſlands are covered with large muſcle-ſhells, the fiſh of which is well flavoured. The natives of this country are ſhort in their perſons, not exceeding five feet ſix inches at moſt, their heads large, their faces broad, their cheek bones prominent, and their noſes flat. They have little brown eyes, without life; their hair is black and lank, hanging about their heads in diſorder, and beſmeared with train-oil. On the chin they have a few ſtraggling ſhort hairs inſtead of a beard. The whole aſſemblage of their features forms the moſt loathſome picture of miſery to which human nature can poſſibly be reduced. Thoſe which Mr Forſter ſaw had no other clothing than a ſmall piece of ſeal ſkin, which hung from their ſhoulders to the middle of their back, being faſtened round the neck with a ſtring: the reſt of their body was perfectly naked. Their natural colour ſeems to be an olive brown, with a kind of gloſs, reſembling that of copper; but many of them diſguiſe themſelves with ſtreaks of red paint, and ſometimes, though ſeldom, with white. Their whole character is a ſtrange compound of ſtupidity, indifference, and inactivity. They have no other arms than bows and arrows; and their inſtruments for fiſhing are a kind of fiſh-gigs. They live chiefly on ſeals fleſh, and like the fat oily part moſt. There is no appearance of any ſubordination among them; and their mode of life approaches nearer to that of brutes than that of any other nation.

TILLANDSIA, the large barren WILD PINE of the Weſt Indies; a genus of the monogynia order, belonging to the hexandria claſs of plants. It is called *Caragatua* by Father Plumier, and is a paraſitic plant, and ought perhaps, in ſtrict propriety, to be denominated an *aquatic:* for although it is ſuſpended in the air among the branches of lofty trees, to whoſe boughs it is faſtened by its numerous roots; yet it is not indebted to thoſe boughs, like the miſletoe and other paraſitic plants, for nouriſhment, but merely for ſupport; provident Nature having, in a very extraordinary manner, ſupplied this with other means to preſerve its exiſtence: For the leaves, which much reſemble thoſe of the pine-apple, but are larger, ſurround this plant in a circular manner; each leaf being terminated near the ſtalk with a hollow bucket, which contains about half a pint of water. It is by theſe numerous ſmall reſervoirs of water that the roots, as well as every other part of this plant, are ſupplied with nouriſhment without the help of any earth. The flouriſhing condition of this plant, as well as the great growth of fig-trees, upon barren rocks, ſhews that water is of greater uſe to vegetation than earth.

One contrivance of Nature in this vegetable, ſays Dr Sloane, is truly admirable. The ſeed is crowned with many long downy threads, not only that it may be carried everywhere by the wind, but that by thoſe threads, when driven through the boughs, it may be held faſt, and ſtick to the arms and prominent parts of the barks of trees. So ſoon as it ſprouts or germinates, although it be on the under part of a bough, its leaves and ſtalks riſe perpendicular or erect: if they aſſumed any other direction, the ciſtern or reſervoir juſt mentioned, made of the hollow leaves, could not hold water, which is neceſſary to the life and nouriſhment of the plant. In ſcarcity of water this reſervoir is uſeful, not to the plant only, but to men, and even to birds and all ſorts of inſects, which come thither in troops, and ſeldom go away without refreſhment.

To the ſame purpoſe, Dampier, in his Voyage to Campeachy, relates, "that the wild pine has leaves that will hold a pint and a half or quart of rain-water, which refreſhes the leaves, and nouriſhes the roots. When we find theſe pines, we ſtick our knives into the leaves, juſt above the root; and the water guſhing out, we catch it in our hats, as I myſelf have frequently done, to my great relief."

TIMÆUS, a Greek hiſtorian, the ſon of Andronicus, who was eminent for his riches and excellent qualities, was born at Tauromenium in Sicily, and flouriſhed in the time of Agathocles. He wrote ſeveral books, and among the reſt an hiſtory of his own country; but they are all loſt.

TIMÆUS, a famous Pythagorean philoſopher, was born at Locres in Italy, and lived before Plato. There is ſtill extant a ſmall treatiſe of his on Nature and the Soul of the World, written in the Doric dialect. This treatiſe, which is to be found in the works of Plato, furniſhed that great philoſopher with the ſubject of his treatiſe intitled *Timæus*.

TINNING, the covering or lining of any thing with melted tin, or with tin reduced to a very fine leaf. Looking-glaſſes are foliated or *tinned* with thin plates of beaten tin, by a proceſs deſcribed under the title FOLIATING, *Encycl.*

Kettles, ſauce-pans, and other kitchen utenſils, which are uſually made of copper, are tinned by the following proceſs: The ſurface to be tinned, if of new copper, ſhould firſt be cleaned or ſcoured with ſalt and ſulphuric acid (vitriolic acid) diluted with water. This, however, is not always done; ſome workmen contenting themſelves with ſcouring it with ſand perfectly dry, or with ſcales of iron. Powdered roſin is then ſtrewed over it; and when the veſſel or utenſil is conſiderably heated, melted tin is poured into it, and rubbed with flax coiled hard over the ſurface to be coated. This tin may be either pure, ſuch as that known by the name of *grain-tin;* or a compoſition conſiſting of two parts of tin and one of lead. For very obvious reaſons, we ſhould certainly prefer the pure tin; but the generality of workmen give the preference to the compoſition, becauſe the ſurface coated with it appears more brilliant. The tin is not always put into the veſſel in a liquid ſtate; for ſome workmen ſtrew it in ſmall pieces over the ſurface to be coated, and then heat the veſſel till the tin melt, when they rub it as formerly.

In tinning old veſſels which have been tinned before, the proceſs is ſomewhat different. In theſe caſes, the ſurface is firſt ſcraped with an inſtrument proper for the purpoſe, or ſcoured with the ſcales of iron, which may be always found in a blackſmith's ſhop: it is then ſtrewed over with ſal ammoniac in powder, inſtead of roſin, or an infuſion of ſal ammoniac in ſtale urine is boiled in it till the urine be evaporated, and it is then tinned with pure tin; the compoſition of tin and lead being in this caſe never uſed. The tin, while liquid, is rubbed into the ſurface with a piece of ſal ammoniac, inſtead of a bundle of flax. When iron veſſels are to be tinned, they are firſt cleaned with muriatic acid, after which the proceſs is the ſame as in the tinning of old copper.

In the year 1785, Mr John Poulain of Mortlake, Surrey, obtained a patent for the diſcovery of a new compoſition for tinning veſſels, eſpecially ſuch as are uſed for culinary purpoſes. This compoſition conſiſts of grain tin one pound, good malleable iron one ounce and a half, platinum one drachm, ſilver one pennyweight, gold three grains: the whole muſt be well fuſed together in a crucible, with one ounce of pounded borax, and two ounces of pounded glaſs, and then caſt in ſmall ingots. The compoſition, to be fit for uſe, muſt be heated and put in a metal mortar, alſo heated over a fire, and well pounded with a heated metal peſtle; when it is well pounded, make an ingot of it, by putting it on the fire in a mould made of iron plate, in which mould the compoſition muſt be well ſtirred and let to cool; then it is fit for uſe. To apply the compoſition, firſt tin the utenſil or veſſel with grain-tin and ſal ammoniac, as is uſually done in the common way of tinning; clean well the tinned part of the metal utenſil or veſſel, and then apply a coat of the compoſition with ſal ammoniac, as is uſually done in the common way of tinning; and when the compoſition is well ſpread, let it cool; then make it a little red-hot in all its parts, to neal it, and plunge the metal utenſil or veſſel, while yet hot, in cold water; then, with a ſharp ſcraper, ſcrape and rub off the rough or grumous particles of the compoſition applied on the metal utenſil or veſſel, and ſcour it well with ſand. The ſame operation muſt be repeated for every coat of the compoſition that is applied; two coats of the compoſition are quite ſufficient for culinary utenſils or veſſels, and a thin coat of grain tin may be applied over the laſt coat of the compoſition, to ſmooth it. The author adds, that his compoſition may be employed for covering or plating the ſurfaces of all materials made of copper, braſs, iron, and other metals or mixtures of metals, and that it ſhould be applied with a charcoal fire in preference to any other fire. All this may be true, and it may be a very valuable coating to copper; but the ſcarcity, high price, and infuſibility of platinum, muſt for ever prevent it from coming into very general uſe.—We think that even the *Enamelling of Veſſels for the Kitchen* muſt be more common. See that article in this *Supplement.*

The following proceſs is leſs expenſive, whilſt the coating given by it is exceedingly durable, adds ſtrength to the copper veſſel, and ſecures it much longer than the common tinning from the action of acids:

When the veſſel has been prepared and cleaned in the uſual manner, it muſt be roughened on the inſide by being beat on a rough anvil, in order that the tinning may hold better, and be more intimately connected with the copper. The proceſs of tinning muſt then be begun with perfectly pure grained tin, having an addition of ſal ammoniac inſtead of the common colophonium or reſin. Over this tinning, which muſt cover the copper in an even and uniform manner throughout, a ſecond harder coat muſt be applied, as the firſt forms only a kind of medium for connecting the ſecond with the copper. For this ſecond tinning you employ pure grained tin mixed with zinc in the proportion of two to three, which muſt be applied alſo with ſal ammoniac ſmooth and even, ſo that the lower ſtratum may be entirely covered with it. This coating, which, by the addition of the zinc, becomes pretty hard and ſolid, is then to be hammered with a ſmoothing hammer, after it has been properly rubbed and ſcoured with chalk and water; by which means it becomes more ſolid, and acquires a ſmooth compact ſurface.

Veſſels and utenſils may be tinned in this manner on both ſides. In this caſe, after being expoſed to a ſufficient heat, they muſt be dipped in the fluid tin, by which means both ſides will be tinned at the ſame time.

As this tinning is exceedingly durable, and has a beautiful colour, which it always retains, it may be employed for various kinds of metal inſtruments and veſſels which it may be neceſſary to ſecure from ruſt.

TINPLATE, called in Scotland *White iron,* is a thin plate of iron covered with tin, to which it is united by chemical affinity. See Chemistry, n° 122. *Suppl.*

TIPRA, the name of certain mountainous diſtricts to the eaſtward of Bengal, inhabited by a people of very ſingular manners. As every thing which contributes a ſingle fact to the hiſtory of human nature is intereſting to the philoſopher, the reader will be pleaſed with the following account of the religion, laws, and manners of theſe people, taken from the 2d volume of the *Aſiatic Reſearches.*

Though they acknowledge one Creator of the univerſe, to whom they give the name of Pa'tiya'n, they believe that a deity exiſts in every tree, that the ſun and moon are gods, and that whenever they worſhip thoſe ſubordinate divinities Pátiyán is pleaſed. This is very ſimilar to the religious creed of ancient Greece and Rome, differing only with reſpect to creation, which, in the proper ſenſe of the word, the Greeks and Romans ſeem not to have admitted.

If any one of theſe mountaineers, called in the memoir Cucis, put another to death, the chief of the tribe, or other perſons who bear no relation to the deceaſed, have no concern in puniſhing the murderer; but if the murdered perſon have a brother or other heir, he may take blood for blood; nor has any man whatever a right to prevent or oppoſe ſuch retaliation.

When a man is detected in the commiſſion of theft or other atrocious offence, the chieftain cauſes a recompenſe to be given to the complainant, and reconciles both parties; but the chief himſelf receives a cuſtomary fine, and each party gives a feaſt of pork or other meat to the people of his reſpective tribe.

In ancient times, it was not a cuſtom among them to cut off the heads of the women whom they found in the habitations of their enemies; but it happened once that a woman aſked another, why ſhe came ſo late to her buſineſs of ſowing grain? ſhe anſwered, that her huſband was gone to battle, and that the neceſſity of preparing food and other things for him had occaſioned her delay. This anſwer was overheard by a man at enmity with her huſband; and he was filled with reſentment againſt her, conſidering, that as ſhe had prepared food for her huſband for the purpoſe of ſending him to battle againſt his tribe, ſo in general, if women were not to remain at home, their huſbands could not be ſupplied with proviſion, and conſequently could not make war with advantage. From that time it became a conſtant practice to cut off the heads of the enemy's women, eſpecially if they happen to be pregnant, and therefore confined to their houſes; and this barbarity is carried ſo far, that if a Cuci aſſail the houſe of an enemy, and kill a woman with child, ſo that he may bring two heads, he acquires honour and celebrity in his tribe, as the deſtroyer of two foes at once.

As to the marriages of this wild nation, when a rich man has made a contract of marriage, he gives four or five head of *gayáls* (the cattle of the mountains) to the father and mother of the bride, whom he carries to his own houſe: Her parents then kill the *gayáls;* and having prepared fermented liquors and boiled rice with other eatables, invite the father, mother, brethren, and kindred of the bridegroom to a nuptial entertainment. When a man of ſmall property is inclined to marry, and a mutual agreement is made, a ſimilar method is followed in a lower degree; and a man may marry any woman except his own mother. If a married couple live cordially together, and have a ſon, the wife is fixed and irremoveable; but if they have no ſon, and eſpecially if they live together on bad terms, the huſband may divorce his wife, and marry another woman.

They have no idea of heaven or hell, the reward of good, or the puniſhment of bad, actions; but they profeſs a belief, that when a perſon dies, a certain ſpirit comes and ſeizes his ſoul, which he carries away; and that whatever the ſpirit promiſes to give at the inſtant when the body dies, will be found and enjoyed by the dead; but that if any one ſhould take up the corſe and carry it off, he would not find the treaſure.

The food of this people conſiſts of elephants, hogs, deer, and other animals; of which if they find the carcaſes or limbs in the foreſts, they dry them, and eat them occaſionally.

When they have reſolved on war, they ſend ſpies, before hoſtilities are begun, to learn the ſtations and ſtrength of the enemy, and the condition of the roads; after which they march in the night, and two or three hours before daylight make a ſudden aſſault with ſwords, lances, and arrows: if their enemies are compelled to abandon their ſtation, the aſſailants inſtantly put to death all the males and females, who are left behind, and ſtrip the houſes of all their furniture; but ſhould their adverſaries, having gained intelligence of the intended aſſault, be reſolute enough to meet them in battle, and ſhould they find themſelves overmatched, they ſpeedily retreat and quietly return to their own habitations. If at any time they ſee a ſtar very near the moon, they ſay, "to-night we ſhall undoubtedly be attacked by ſome enemy;" and they paſs that night under arms with extreme vigilance. They often lie in ambuſh in a foreſt near the path, where their foes are uſed to paſs and repaſs, waiting for the enemy with different ſorts of weapons, and killing every man or woman who happens to paſs by: in this ſituation, if a leech, or a worm, or a ſnake, ſhould bite one of them, he bears the pain in perfect ſilence; and whoever can bring home the head of an enemy, which he has cut off, is ſure to be diſtinguiſhed and exalted in his nation. When two hoſtile tribes appear to have equal force in battle, and neither has hopes of putting the other to flight, they make a ſignal of pacific intentions, and, ſending agents reciprocally, ſoon conclude a treaty; after which they kill ſeveral head of *gayáls*, and feaſt on their fleſh, calling on the ſun and moon to bear witneſs of the pacification: but if one ſide, unable to reſiſt the enemy, be thrown into diſorder, the vanquiſhed tribe is conſidered as tributary to the victors; who every year receive from them a certain number of *gayáls*, wooden diſhes, weapons, and other acknowledgments of vaſſalage. Before they go to battle, they put a quantity of roaſted *álus* (eſculent roots like potatoes), and paſte of rice-flour, into the hollow of bamboos, and add to them a proviſion of dry rice with ſome leathern bags full of liquor: then they aſſemble, and march with ſuch celerity, that in one day they perform a journey ordinarily made by letter-carriers in three or four days, ſince they have not the trouble and delay of dreſſing victuals. When they reach the place to be attacked, they ſurround it in the night, and at early dawn enter it, putting to death both young and old, women and children, except ſuch as they chooſe to bring away captive: they put the heads, which they cut off, into leathern bags; and if the blood of their enemies be on their hands, they take care not to waſh it off When after this ſlaughter they take their own food, they thruſt a part of what they eat into the mouths of the heads which they have brought away, ſaying to each of them, "Eat, quench thy thirſt, and ſatisfy thy appetite; as thou haſt been ſlain by my hand, ſo may thy kinſmen be ſlain by my kinſmen!" During their journey, they have uſually two ſuch meals; and every watch, or two watches, they ſend intelligence of their proceedings to their families. When any one of them ſends word that he has cut off the head of an enemy, the people of his family, whatever be their age or ſex, expreſs great delight,

light, making caps and ornaments of red and black ropes; then filling ſome large veſſels with fermented liquors, and decking themſelves with all the trinkets they poſſeſs, they go forth to meet the conqueror, blowing large ſhells, and ſtriking plates of metal, with other rude inſtruments of muſic. When both parties are met, they ſhow extravagant joy, men and women dancing and ſinging together; and if a married man has brought an enemy's head, his wife wears a head-dreſs with gay ornaments, the huſband and wife alternately pour fermented liquor into each other's mouths, and ſhe waſhes his bloody hands with the ſame liquor which they are drinking. Thus they go revelling, with exceſſive merriment, to their place of abode; and having piled up the heads of their enemies in the court yard of their chieftain's houſe, they ſing and dance round the pile; after which they kill ſome *gayáls* and hogs with their ſpears; and having boiled the fleſh, make a feaſt on it, and drink the fermented liquor. The richer men of this race faſten the heads of their foes on a bamboo, and fix it on the graves of their parents, by which act they acquire great reputation. He who brings back the head of a ſlaughtered enemy, receives preſents from the wealthy of cattle and ſpirituous liquor; and if any captives are brought alive, it is the prerogative of thoſe chieftains, who were not in the campaign, to ſtrike off the heads of the captives. Their weapons are made by particular tribes; for ſome of them are unable to fabricate inſtruments of war.

In regard to their civil inſtitutions; the whole management of their houſehold affairs belongs to the women; while the men are employed in clearing foreſts, building huts, cultivating land, making war, or hunting game and wild beaſts. Five days (they never reckon by months or years) after the birth of a male child, and three days after that of a female, they entertain their family and kinſmen with boiled rice and fermented liquor; and the parents of the child partake of the feaſt. They begin the ceremony with fixing a pole in the court yard; and then killing a *gayál* or a hog with a lance, they conſecrate it to their deity; after which all the party eat the fleſh and drink liquor, cloſing the day with a dance and with ſongs. If any one among them be ſo deformed, by nature or by accident, as to be unfit for the propagation of his ſpecies, he gives up all thought of keeping houſe, and begs for his ſubſiſtence, like a religious mendicant, from door to door, continually dancing and ſinging. When ſuch a perſon goes to the houſe of a rich and liberal man, the owner of the houſe uſually ſtrings together a number of red and white ſtones, and fixes one end of the ſtring on a long cane, ſo that the other end may hang down to the ground; then, paying a kind of ſuperſtitious homage to the pebbles, he gives alms to the beggar; after which he kills a *gayál* and a hog, and ſome other quadrupeds, and invites his tribe to a feaſt: the giver of ſuch an entertainment acquires extraordinary fame in the nation, and all unite in applauding him with every token of honour and reverence.

When a *Cúci* dies, all his kinſmen join in killing a hog and a *gayál*; and, having boiled the meat, pour ſome liquor into the mouth of the deceaſed, round whoſe body they twiſt a piece of cloth by way of ſhroud: all of them taſte the ſame liquor as an offering to his ſoul; and this ceremony they repeat at intervals for ſeveral days. Then they lay the body on a ſtage, and kindling a fire under it, pierce it with a ſpit and dry it; when it is perfectly dried, they cover it with two or three folds of cloth, and, encloſing it in a little caſe within a cheſt, bury it under ground. All the fruits and flowers that they gather within a year after the burial they ſcatter on the grave of the deceaſed: but ſome bury their dead in a different manner; covering them firſt with a ſhroud, then with a mat of woven reeds, and hanging them on a high tree. Some, when the fleſh is decayed, waſh the bones, and keep them dry in a bowl, which they open on every ſudden emergence; and, fancying themſelves at a conſultation with the bones, purſue whatever meaſures they think proper; alleging that they act by the command of their departed parents and kinſmen. A widow is obliged to remain a whole year near the grave of her huſband; where her family bring her food: if ſhe die within the year, they mourn for her; if ſhe live, they carry her back to her houſe, where all her relations are entertained with the uſual feaſt of the *Cúcis*.

If the deceaſed leave three ſons, the eldeſt and the youngeſt ſhare all his property; but the middle ſon takes nothing: if he have no ſons, his eſtate goes to his brothers; and if he have no brothers, it eſcheats to the chief of the tribe.

TIRESIAS, a famous ſoothſayer of antiquity, was the ſon of Everes and the nymph Chariclo. Pherecydes ſays, that Minerva being accidentally ſeen by Tireſias, as ſhe was bathing with Chariclo in the fountain of Hippocrene, the goddeſs was enraged, and declared that he ſhould ſee nothing more: on which he inſtantly loſt his ſight; but afterwards received from the goddeſs ſuperior endowments. Others ſay, that Juno ſtruck him ſtone-blind for deciding a caſe between Jupiter and her, to her diſſatisfaction; for which Jupiter gave him the faculty of divination: He was the moſt celebrated prophet in the Grecian annals. Ulyſſes is ordered by Circe to conſult him in the ſhades.

> There ſeek the Theban bard depriv'd of ſight,
> Within irradiate with prophetic light.

But, beſides the honour done to him by Homer, Sophocles makes him act a venerable and capital part in his tragedy of Oedipus. Callimachus aſcribes to Minerva the gift of his ſuperior endowments; the pre-eminence of his knowledge is likewiſe mentioned by Tully in his firſt book of Divination. And not only Tireſias is celebrated by Diodorus Siculus, but his daughter Daphne, who, like her father, was gifted with a prophetic ſpirit, and was appointed prieſteſs at Delphos. She wrote many oracles in verſe, from whence Homer was reported to have taken ſeveral lines, which he interwove in his poems. As ſhe was often ſeized with a divine fury, ſhe acquired the title of *ſibyl*, which ſignifies "enthuſiaſt." She is the firſt on whom it was beſtowed: in aftertimes this denomination was given to ſeveral other females that were ſuppoſed to be inſpired, and who uttered and wrote their predictions in verſe; which verſe being ſung, their function may be juſtly ſaid to unite the prieſthood with prophecy, poetry, and muſic.

TISRI, or Tizri, in chronology, the firſt Hebrew month of the civil year, and the 7th of the eccleſiaſtical or ſacred year. It anſwered to part of our September and October.

Tithing-Men || Tombuctoo.

TITHING-MEN, are now a kind of petty conſtables, elected by pariſhes, and ſworn in their offices in the court-leet, and ſometimes by juſtices of the peace, &c. There is frequently a tithing-man in the ſame town with a conſtable, who is, as it were, a deputy to execute the office in the conſtable's abſence; but there are ſome things which a conſtable has power to do, that tithing men and head-boroughs cannot intermeddle with. When there is no conſtable of a pariſh, his office and the authority of a tithing man ſeems to be all one under another name.

TITHONUS, in fabulous hiſtory, the ſon of Laomedon king of Troy, and the brother of Priamus; was beloved by Aurora, who carried him to Delos, thence to Ethiopia, and at laſt to heaven, where ſhe prevailed on the Deſtinies to beſtow upon him the gift of immortality; but forgot to add that of youth, which could only render the preſent valuable. At length Tithonus grew ſo old that he was obliged to be rocked to ſleep like an infant; when Aurora, not being able to put an end to his miſery by death, transformed him into a graſshopper; which renews its youth by caſting his ſkin, and in its chirping retains the loquacity of old age.

TITLE FOR ORDERS, in the church of England, is an aſſurance of being employed and maintained as an officiating clergyman in ſome cathedral or parochial church, or other place of Divine worſhip. And, by the 33*d Canon*, "no one is to be ordained but in order to be a curate or incumbent, or to have ſome miniſter's place in ſome church, or except he be fellow, conduct, or chaplain, in ſome college in one of the univerſities, or be maſter of arts of five years ſtanding, and live there at his own coſt." By the ſame canon, the biſhop who ordains a clerk without title, is bound to keep him till he prefer him to ſome eccleſiaſtical living.

TOD OF WOOL, is mentioned in the ſtatute 12 Carol. II. c. 32. as a weight containing 2 ſtone, or 28 pounds.

TOMBUCTOO, a large city in North Africa, and capital of a kingdom of the ſame name. It has for ſome years paſt been the great object of European reſearch, being one of the principal marts for that extenſive commerce which the Moors carry on with the Negroes. The hopes of acquiring wealth in this purſuit, and zeal for propagating their religion, have filled this extenſive city with Moors and Mahomedan converts; the king himſelf, and all the chief officers of ſtate are Moors; and they are ſaid to be more ſevere and intolerant in their principles than any other of the Mooriſh tribes in this part of Africa. Mr Park was informed, by a venerable old Negro, that when he firſt viſited Tombuctoo, he took up his lodging at a ſort of public inn, the landlord of which, when he conducted him into his hut, ſpread a mat on the floor, and laid a rope upon it; ſaying, "if you are a Muſſulman, you are my friend, ſit down; but if you are a Kafir, you are my ſlave; and with this rope I will lead you to market." The reigning ſovereign of Tombuctoo, when Mr Park was in Africa, was named *Abu Abrahima*. He was reported to poſſeſs immenſe riches, and his wives and concubines were ſaid to be clothed in ſilk, and the chief officers of ſtate live in conſiderable ſplendour. The whole expence of his government is defrayed by a tax upon merchandize, which is collected at the gates of the city.

Tomſook, Tooth-ache.

Of that city very little is known with accuracy, as it has never been viſited by any European. It is the largeſt on the Niger, Houſſa only excepted; and probably contains from 60,000 to 80,000 inhabitants In ſome of the Gazetteers, its houſes are ſaid to be built in the form of bells; but they are probably ſuch buildings as thoſe of SEGO, which ſee in this *Supplement*. Tombuctoo, according to Major Rennel, is in 16° 30′ N Lat. and 1° 33′ E. Long. from Greenwich.

TOMSOOK, in the language of Bengal, a bond.

TOOTH-ACHE, a well known-excruciating pain (ſee *Encycl.*), for the alleviation, and even the cure of which, many ſpecifics have been offered to the public. Of one of the moſt extraordinary of theſe, there is an account, in a ſmall work publiſhed at Florence in 1794, by profeſſor Gerbi, who gives the deſcription of an inſect, a kind of *curculio*, which, from its property of allaying the tooth-ache, has received the epithet of *antiodontalgicus*, and which is found on a ſpecies of thiſtle, *carduus ſpinoſiſſimus*. The flowers of this thiſtle, when analyſed, gave the acid of galls, the muriatic acid, oxalat of lime, extractive matter, and a very little reſin. On the bottom of the calyx, which ſupports the flowers, there are often found excreſcences like the gall nut, which are at firſt ſpheroidal, afterwards cylindric, and at length aſſume the figure of two hemiſpheres: they conſiſt of the like component parts with the flowers, but contain more reſin, and far more oxalat of lime; as the gall apple of the oak, according to the experiments of M. Branchi, which are here mentioned, contains more of the acid of galls than the bark and other parts of the oak, in which he could diſcover no ſulphuric acid. The inſect, according to the author's obſervations, eats not only the parenchyma, but alſo the veſſels and fibres of the leaves. The egg, before the worm makes its appearance, is nouriſhed by the ſap of the plant, and of the above excreſcences, in which it reſides, by means of the attractive power that the egg poſſeſſes for certain vegetable juices and ſubſtances. The excreſcences ariſe by the accumulation of a ſolid ſubſtance, which is precipitated from the nouriſhing juices of the thiſtle, diminiſhed by nouriſhing the egg and the worm. This inſect, the eggs of which are depoſited in theſe excreſcences, is, together with the *curculio* of the centaury, a new ſpecies. It is of a longiſh figure; covered below with ſhort yellow hair, and above with golden yellow velvety ſpots. Its corſlet is variegated with ſpecks; and the covering of its wings with ſpecks and ſtripes. It has a ſhort proboſcis, and ſhews ſome likeneſs to the *curculio villoſus* of Geoffroy. Its larva repreſents a ſort of ichneumon. By chemical analyſis it exhibits ſome traces of common ſalt; by diſtillation with a ſtrong dry heat, ſome volatile lixivious ſalts; and it contains, beſides theſe, ſome gelatinous, and a little ſebaceous and ſlimy extractive matter. If about a dozen or fifteen of theſe inſects, when in the ſtate of larva, or even when come to perfection, be bruiſed and rubbed ſlowly between the fore-finger and the thumb, until they have loſt their moiſture, and if the painful tooth, where it is hollow, be touched with that finger, the pain ceaſes, ſometimes inſtantaneouſly. This power or property the finger will retain for a year, even though it be often waſhed and uſed. A piece of ſhamoy leather will ſerve equally well with the finger. Of 629 experiments, 401 were attended with complete ſucceſs. In two of theſe caſes, the hollow teeth aroſe from ſome fault in the juices: in the reſt they were merely local. If the gums are inflamed, the remedy is of no avail.

To the truth of this tale the reader will give what credit he pleaſes; but it is ſurely very difficult to believe, that a living finger, continually perſpiring, can retain for a year the moiſture imbibed from this inſect. But it ſeems there are other inſects which have the property of curing the tooth ache; ſuch as the *carabus chryſocephalus* of Roſſi; the *carabus ferrugineus* of Fabricius; the *coccinella ſeptem punctata* (the lady bird); the *chryſomela populi*, and the *chryſomela ſanguinolenta*. It would appear, therefore, that this property belongs to various kinds of the *coleoptera*.

The idea of theſe inſects being endowed with the property of curing the tooth-ache is not confined to Italy; for Dr Hirſch, dentiſt to the court of Weimar, aſſerts (*Verkundiger*, September 24, 1798) that he employed them with the happieſt effect, except in ſome caſes where his patients were females. He ſays, that he took that ſmall inſect, found commonly among corn, *coccinella ſeptem punctata*, and bruiſed it between his fingers. He then rubbed the fingers with which he had bruiſed it, till they became warm at the points, and touched with them the unſound parts of the gums, as well as the diſeaſed tooth. Dr Hirſch adds, that he made the ſame experiment a few days after with equal ſucceſs, though he had not bruiſed a new inſect with his fingers. He ſeems to think that, to inſure the efficacy of the proceſs, the inſect ſhould be alive; becauſe, when dead, its internal parts, in which he preſumes the virtue chiefly reſides, become dried up, leaving only the wings and an empty ſhell; and therefore propoſes to phyſicians to turn their attention to the finding out of ſome method for preſerving the virtue of the inſect, ſo that its efficacy may be in full vigour throughout the year.

Beſides theſe beetles, charcoal has been recommended as an anodyne in the tooth-ache; but whether it operates merely by filling the hollow of the tooth, and thereby preventing the acceſs of atmoſpheric air to the nerve, or by any of its ſingular and hitherto unknown qualities, ſeems not to have been well aſcertained.

TOR, a town of Aſia, in Arabia Petræa, ſeated on the Red Sea, with a good harbour, defended by a caſtle. There is a handſome Greek convent, in whoſe garden are fountains of bitter water, which they pretend are thoſe rendered ſweet by Moſes, by throwing a piece of wood into them. Some think that this town is the ancient Elana. E. Long. 31. 25. N. Lat. 28. 0.

TORELLI (Joſeph), was born at Verona on the 4th of November 1721. His father Lucas Torelli, who was a merchant, dying while young Torelli was but an infant, he was left entirely to the care of his mother Antonia Albertini, a Venetian lady of an excellent character. After receiving the firſt rudiments of learning, he was placed under the Ballerini, who, obſerving the genius of the boy, prevailed upon his mother to ſend him to complete his education at Patavia. Here he ſpent four years entirely devoted to ſtudy, all his other paſſions being abſorbed by his thirſt for knowledge.

The unſullied innocence of his life, and the prudence and gravity of his conduct, ſoon attracting the attention of his maſters, they not only commended him with eagerneſs, but performed to him the part of parents, converſed with him familiarly about their reſpective ſciences, and read over to him privately the lectures which they had to deliver. This was the caſe particularly with Hercules Dondinus, under whom Torelli ſtudied juriſprudence. But he by no means confined himſelf to that ſcience alone. The knowledge which he acquired was ſo general, that upon whatever ſubject the converſation happened to turn, he delivered his ſentiments upon it in ſuch a manner that one would have thought he had beſtowed upon it his whole attention.

After receiving the degree of Doctor, he returned home to the enjoyment of a conſiderable fortune; which putting it into his power to chooſe his own mode of living, he determined to devote himſelf entirely to literary purſuits. He reſolved, however, not to cultivate one particular branch to the excluſion of every other, but to make himſelf maſter of one thing after another, as his humour inclined him; and he was particularly attentive to lay an accurate and ſolid foundation. Tho' he declined practiſing as a lawyer, he did not, on that account, relinquiſh the ſtudy of law. The Hebrew, Greek, Latin, and Italian languages, occupied much of his time. His object was to underſtand accurately the two firſt, and to be able to write and ſpeak the two laſt with propriety and elegance. Beſides theſe languages, he learned French, Spaniſh, and Engliſh. On the laſt, in particular, he beſtowed uncommon pains; for he was peculiarly attached to the Britiſh nation, and to Britiſh writers, whom he peruſed with the greateſt attention; not merely to acquire the language, but to imbibe alſo that force and loftineſs of ſentiment for which they are ſo remarkable. Nay, he even began an Italian tranſlation of Paradiſe Loſt.

He likewiſe made himſelf acquainted with ethics, metaphyſics, and polemical divinity; to which laſt ſubject he was induced to pay attention by the cuſtom of his country. With ancient hiſtory he was very familiarly acquainted, calling in to his aſſiſtance, while engaged in that ſtudy, the aids of chronology, geography, and criticiſm. This laſt art, indeed, by means of which what is counterfeit may be diſtinguiſhed from what is genuine, what is interpolated from what is uncorrupted, and what is excellent from what is faulty, he carried about with him as his counſellor and his guide upon all occaſions.

The theory of *muſic* he ſtudied with attention, preferring thoſe powerful airs which make their way into the ſoul, and rouſe the paſſions at the pleaſure of the muſician. His knowledge of *pictures* was held in high eſtimation by the artiſts themſelves, who were accuſtomed to aſk his opinion concerning the fidelity of the deſign, the harmony of colours, the value of the picture, and the name of the painter. He himſelf had a collection, not remarkably ſplendid indeed, but exceedingly well choſen. *Architecture* he ſtudied with ſtill greater attention, becauſe he conſidered it as of more real utility. Nor did he neglect the purſuits of the *antiquarian*, but made himſelf familiarly acquainted with coins, gems, medals, engravings, antique veſſels, and monuments. Indeed ſcarce any monumental inſcriptions were engraved at Verona which he had not either compoſed or corrected. With the *antiquities* of his own country he was ſo intimately acquainted, that every perſon of eminence, who viſited Verona, took care to have him in their company when they examined the curioſities of the city.

But theſe purſuits he conſidered merely as amuſements; mathematics and the belles lettres were his ſerious ſtudies. Theſe ſtudies are, in general, conſidered as incompatible; but Torelli was one of the few who could combine the gravity of the mathematician with the amenity of the muſes and graces, and who handle the compaſs and the plectrum with equal ſkill. Of his progreſs in mathematics, ſeveral of his treatiſes, and eſpecially his edition of Archimedes, publiſhed ſince his death by the univerſity of Oxford, are ſufficient proofs. Nor was his progreſs in the more pleaſing parts of literature leſs diſtinguiſhed. In both theſe ſtudies he was partial to the ancients, and was particularly hoſtile to the poetry and the literary innovations of the French.

Nothing could be purer or more elegant than his Latin ſtyle, which he had acquired at the expence of much time and labour. His Latin tranſlation of Archimedes is a ſufficient proof of this, and is indeed really wonderful, if we conſider that the Romans, being far inferior to the Greeks in mathematical knowledge, their language was of neceſſity deſtitute of many neceſſary words and phraſes. He wrote the Italian language with the claſſic elegance of the 14th and 15th centuries. Witneſs his different works in that language, both in proſe and verſe. He tranſlated the whole of Æſop's Fables into Latin, and Theocritus, the *Epithalamium* of Catullus, and the *comedy* of Plautus, called *Pſeudolus*, into Italian verſe. The two firſt books of the Æneid were alſo tranſlated by him with ſuch exactneſs, and ſo much in the ſtyle of the original, that they may well paſs for the work of Virgil himſelf.

His life, like his ſtudies, was drawn after the model of the ancient ſages. Frugal, temperate, modeſt, he exhibited a ſtriking contraſt to the luxurious manners of his age. In religion he adhered ſtrictly, though not ſuperſtitiouſly, to the opinions of his anceſtors. He was firm to his reſolutions, but not fooliſhly obſtinate; and ſo ſtrict an obſerver of equity, that his probity would have remained inviolate, even though there had been no law to bind him to juſtice. He never married, that he might have leiſure to devote himſelf, with leſs interruption, to his favourite ſtudies. Every one readily found admiſſion to him, and no man left him without being both pleaſed and inſtructed; ſuch was the ſweetneſs of his temper, and the readineſs with which he communicated information. He adhered with great conſtancy to his friendſhips. This was particularly exemplified in the caſe of Clemens Sibiliatus, who has favoured the world with the life of Torelli. With him he kept up the cloſeſt connection from a ſchool boy till the day of his death. He was peculiarly attached likewiſe to many men of diſtinction, both in Italy and Britain. He died in Auguſt 1781, in the 70th year of his age.

The following is a complete liſt of his works, his edition of Archimedes excepted, which was not publiſhed till after his death:

1. "Lucubratio Academica, ſivi Somnium Jacobi Pindemontii, &c." Patavii, 1743.—2. "Animadverſiones in Hebraicum Exodi Librum et in Græcum lxx Interpretationem;" Veronæ, 1744.—3. "De principe Gulæ incommodo, ejuſque remedio, Libri duo;" Coloniæ Agrippinæ, 1744.—4. "De Probabili Vitæ Morumque Regula;" Coloniæ, 1747.—5. "Li due primi Canti dell' Iliade (di Scipione Maffei) e li due primi dell' Eneide di Giuſeppe Torelli tradotti in verſi Italiani;" Verona, 1749.—6. "Gli ſteſſi due canti dell' Eneide riſtampati ſoli lo ſteſſo anno per lo ſteſſo Ramanzini."—7. "Scala de Meriti a capo d'anno Trattato Geometrico;" Verona, 1751.—8. "De Nihilo Geometrico, lib. 2.;" Veronæ, 1758.—9. "Lettera intorno a due paſſi del Purgatorio di Dante Alighiero;" *ib.* 1760.—10. "Della Denominazione del corrente anno volgarmente detto 1760 in Bologna per Lelio della Volpe."—11. "Il pſeudolo. Comedia, &c. e ſi aggiunge la traduzione d'alcuni Idilli di Teocrito e di Moſco;" Firenze, 1765.—12. "Inno a Maria Virgine nella Feſtivita della ſua Concezione;" Verona, 1766.—13. "Lettera a Miladi Vaing-Reit premeſſa al libro che ha per titalo xii. lettere Ingleſi, con altra lettera all'autore della ſuddetta;" Verona, 1767.—14. "Elegia di Tommaſo Gray, Poeta Ingleſe, in un Cimetero Campeſtre in verſi Italiani rimati;" Verona, 1767.—15. "Geometrica;" Veronæ, 1769.—16. "Demonſtratio antiqui Theorematis de motuum commixtione;" Veronæ, 1774.—17. "Lettera ſupra Dante contro il Signor di Voltaire;" Verona, 1781.—18. "Poemetto di Catullo su le Nozze di Peleo e Tetite, ed un Epitalamio dello ſteſſo;" 1781.—19. "Œſopi Fabulæ."—20. "Teocrito tradotto, in verſi Toſcani."—21. "Elementi d'Euclide tradotti nell'idioma Italiano."—22. "Elementorum Proſpectivæ, libri duo."

TORPEDO, or Cramp-fish, has been deſcribed under the generic title Raja; and an attempt made to explain its electrical phenomena in the article Electricity, n° 258, &c. (Both theſe articles are in the *Encyclopædia*). From ſome late diſcoveries, however, of Volta and others, the ſhock given by the torpedo appears much more analogous to the ſhock of Galvaniſm than to that of common electricity; and even the electrical organs of the fiſh ſeem to reſemble the apparatus with which thoſe diſcoveries in galvaniſm were made.

In the 63d volume of the Philoſophical Tranſactions, Mr Hunter deſcribes the electric organ of the torpedo as conſiſting of a number of columns, varying in their length from an inch and a half to a quarter of an inch, with diameters about two-tenths of an inch. The number of columns in each organ of the torpedo which he preſented to the Royal Society was about 470; but in a very large torpedo which he diſſected, the number of columns in one organ was 1182. Theſe columns were compoſed of films parallel to the baſe of each; and the diſtance between each partition of the columns was $\frac{1}{150}$th of an inch. From theſe facts, the reader will find the anomalies of torpedinal electricity (ſuppoſing it the ſame with common electricity) accounted for in a very ingenious and philoſophical manner by Mr Nicholſon, at p. 358 of the firſt volume of his valuable Journal. We paſs on, however, to point out the reſemblance between it and the lately diſcovered phenomena in galvaniſm.

Take any number of plates of copper, or, which is better, of ſilver, and an equal number of tin, or, which is much better, of zinc, and a like number of diſcs, or pieces

pieces of card, or leather, or cloth (A), or any porous ſubſtance capable of retaining moiſture. Let theſe laſt be ſoaked in pure water, or, which is better, ſalt and water, or alkaline leys. The ſilver or copper may be pieces of money. Build up a pile of theſe pieces; namely, a piece of ſilver, a piece of zinc, and a piece of wet card: then another piece of ſilver, a piece of zinc, and a piece of wet card: and ſo forth, in the ſame order (or any other order, provided the pieces ſucceed each other in their turn), till the whole number intended to be made uſe of is builded up. The inſtrument is then completed.

In this ſtate it will afford a perpetual current of the galvanic influence through any conductor communicating between its upper and lower plates; and if this conductor be an animal, it will receive an electrical ſhock as often as the touch is made, by which the circuit is completed. Thus if one hand be applied to the lower plate, and the other to the upper, the operator will receive a ſhock, and that as often as he pleaſes to lift his finger and put it down again.

This ſhock reſembles the weak charge of a battery of immenſe ſurface; and its intenſity is ſo low that it cannot make its way through the dry ſkin. It is therefore neceſſary that a large ſurface of each hand ſhould be well wetted, and a piece of metal be graſped in each, in order to make the touch; or elſe that the two extremities of the pile ſhould communicate with ſeparate veſſels of water, in which the hands may be plunged.

The commotion is ſtronger the more numerous the pieces. Twenty pieces will give a ſhock in the arms, if the above precautions be attended to. One hundred pieces may be felt to the ſhoulders. The current acts on the animal ſyſtem while the circuit is complete, as well as during the inſtant of commotion, and the action is abominably painful at any place where the ſkin is broken.

That this influence, whatever it may be, has a ſtriking reſemblance to the repeated ſhocks given by the torpedo, is obvious; but what it really is in itſelf muſt be aſcertained, if it can be aſcertained at all, by future experiments. Mr Nicholſon indeed, from whoſe Journal we have taken this account of Volta's apparatus and its effects, ſeems confident that theſe effects proceed from an electrical ſtream or current; but this mode of operation is quite foreign from all the laws of electricity known to us. The galvanic influence in this apparatus appears to move perpetually in a circle; to which we are acquainted with no fact in electricity that is at all ſimilar. Galvaniſm, too, ſeems capable of accumulation, even while ſurrounded by conducting ſubſtances, which is quite inconſiſtent with all that we *diſtinctly* know of electricity and its laws.

That the energy of the apparatus, however, is the effect of an electric ſtream or current, our ingenious author thinks proved by the condenſer with which Sig. Volta aſcertained the kind of the electricity, and obtained its ſpark. He finds the action ſtrongeſt, or moſt pungent, on wounds on the minus ſide of the apparatus, or where the wounds give out electricity; a fact alſo obſervable in the common electric ſpark.

The theory of the learned inventor ſeems to be, that it is a property of ſuch bodies as differ in their power of conducting electricity, that when they are brought into contact they will occaſion a ſtream of the electric matter. So that if zinc and ſilver be made to communicate immediately by contact, there will be a place of good conducting energy; and if they be made to communicate mediately by means of water, there will be a place of inferior conducting energy: and wherever this happens, there will be a ſtream or current produced in the general ſtock of electricity. This is not deduced as the conſequence of other more ſimple facts; but is laid down as a general or ſimple principle grounded on the phenomena. If ſo, is it not a *petitio principii?* That ſuch bodies as zinc and ſilver, when properly diſpoſed, produce a ſtream or current, or ſomething analogous to a ſtream or current, in the galvanic fluid, follows indeed indiſputably from the phenomena; but it by no means follows from the ſame phenomena that galvaniſm is electricity; for electricity ſeems ſubject to different laws. See ELECTRICITY and THUNDER, both in this *Supplement*.

It muſt be acknowledged that the diſcovery of the galvanic ſhock and ſpark, and of the apparent exiſtence of two oppoſite ſtates of galvaniſm correſponding to poſitive and negative electricity, conſiderably increaſe the analogy; which, in the article GALVANISM, *Suppl.* we have admitted to be very ſtriking: but ſuppoſing no fallacy in any of Volta's experiments, we do not think that theſe diſcoveries amount to any thing like a demonſtration of the concluſions which have been drawn from them. It is by no means certain that light is eſſentially connected with the electric fluid; for we know that it is not eſſentially connected with heat: (See *THERMOMETRICAL Spectrum*, in this *Suppl.*) The flaſh, for example, of lightning may be merely an extrication of light, in conſequence of the action of electricity upon the atmoſphere in its paſſage, or on the bodies upon which it impinges; and there are many inſtances of a ſimilar extrication, as in the colliſion of two pieces of flint, where neither electricity nor galvaniſm were ever ſuſpected to have any ſhare in producing the phenomenon. Why may not the progreſs of the galvanic fluid have a ſimilar effect in this inſtance with that of electricity, though the two fluids be eſſentially different between themſelves? But we have more to ſay on this ſubject.

Meſſrs Nicholſon and Carliſle conſtructed an apparatus ſimilar to that of Volta, which gave them a ſhock as before deſcribed, and a very acute ſenſation wherever the ſkin was broken. Their firſt reſearch was directed to aſcertain that the ſhock they felt was really an electrical phenomenon. For this purpoſe the pile was placed upon Bennett's gold leaf electrometer, and a wire was then made to communicate from the top of the pile to the metallic ſtand or foot of the inſtrument; ſo that the circuit of the ſhock would have been thro' the leaves, if they had diverged; but no ſigns of electricity appeared. Recourſe was then had to the revolving doubler; of which the reader will find an account in our Supplementary article ELECTRICITY,

---

(A) Woollen or linen cloth appear to be more durable, and more ſpeedily ſoaked, than card.

nº 203. The doubler had been previouſly cleared of electricity by twenty turns in connection with the earth. The negative divergence was produced in the electrometer. Repeated experiments of this kind ſhewed that the ſilver end was in the minus, and the zinc end in the plus ſtate.

Here a pile of 17 half crowns, with a like number of pieces of zinc, and of paſteboard ſoaked in ſalt water, though it gave a ſevere ſhock, exhibited no ſymptoms of electricity till aſſiſted by the doubler. Will it be ſaid that this aroſe from want of intenſity in the galvanic ſhock? We can only reply, that a much leſs intenſe ſhock of electricity would have produced a ſenſible divergence in the inſtrument without the doubler. What was the cauſe of this difference? We have, however, no doubt but that electricity was concerned in this phenomenon; for we have ſhewn elſewhere (ſee Thunder, *Suppl.)*, that either *electricity* is produced, or the equilibrium of the electrical fluid diſturbed, by every chemical ſolution; and we ſhall ſee immediately that chemical ſolutions are perpetually going on in Volta's apparatus.

Very early in the courſe of this experiment, the contacts being made ſure by placing a drop of water upon the upper plate, Mr Carliſle obſerved a diſengagement of gas round the touching wire. This gas, though very minute in quantity, evidently ſeemed to have the ſmell afforded by hydrogen when the wire of communication was ſteel. This, with ſome other facts, led Mr Nicholſon to propoſe to break the circuit by the ſubſtitution of a tube of water between two wires. They therefore inſerted a braſs wire through each of two corks inſerted in a glaſs tube of half an inch internal diameter. The tube was filled with New River water, and the diſtance between the points of the wires in the water was one inch and three quarters. This compound diſcharger was applied ſo that the external ends of its wire were in contact with the two extreme plates of a pile of 36 half crowns, with the correſpondent pieces of zinc and paſteboard. A fine ſtream of minute bubbles immediately began to flow from the point of the lower wire in the tube which communicated with the ſilver, and the oppoſite point of the upper wire became tarniſhed, firſt deep orange, and then black. On reverſing the tube, the gas came from the other point, which was now loweſt; while the upper, in its turn, became tarniſhed and black. Reverſing the tube again, the phenomena again changed their order. In this ſtate the whole was left for two hours and a half. The upper wire gradually emitted whitiſh filmy clouds, which, towards the end of the proceſs, became of a pea-green colour, and hung in perpendicular threads from the extreme half inch of the wire, the water being rendered ſemiopaque by what fell off, and in a great part lay, of a pale green, on the lower ſurface of the tube, which, in this diſpoſition of the apparatus, was inclined about forty degrees to the horizon. The lower wire, of three quarters of an inch long, conſtantly emitted gas, except when another circuit, or complete wire, was applied to the apparatus; during which time the emiſſion of gas was ſuſpended. When this laſt mentioned wire was removed, the gas re-appeared as before, not inſtantly, but after the lapſe of four beats of a half ſecond clock ſtanding in the room. The product of gas, during the whole two hours and a half, was two-thirtieths of a cubic inch. It was then mixed with an equal quantity of common air, and exploded by the application of a lighted waxed thread.

Meſſrs Nicholſon and Carliſle had been led, by their reaſoning on the firſt appearance of hydrogen, to expect a decompoſition of the water; but it was with no little ſurprize that they found the hydrogen extricated at the contact with one wire, while the oxygen fixed itſelf, in combination with the other wire, at the diſtance of almoſt two inches. This new fact ſtill remains to be explained, and ſeems, ſays Mr Nicholſon, to point at ſome general law of the agency of electricity in chemical operations. Does it not as naturally ſuggeſt a ſuſpicion that galvaniſm is not electricity; eſpecially as we are informed, by Mr Cruickſhank of Woolwich, that Meſſrs Nicholſon and Carliſle diſcovered, that "galvaniſm decompoſes water with much greater facility than electricity, and with phenomena ſomewhat different?" What the particular differences are, he does not ſay; but we learn from Mr Nicholſon himſelf, that from the general tenor of his experiments, it appears to be eſtabliſhed, that the decompoſition of water by galvaniſm is more effectual the leſs the diſtance is between the wires, but that it ceaſes altogether when the wires are in contact.

Mr Nicholſon concludes his memoir with mentioning conciſely the effects of a pile of 100 half crowns, and a chemical incident, which appears to be the moſt remarkable of thoſe which he has yet obſerved.

The pile was ſet up with pieces of green woollen cloth ſoaked in ſalt water. It gave ſevere ſhocks, which were felt as high as the ſhoulders. The tranſition was much leſs forcible through a number of perſons, but it was very perceptible through nine. The ſpark was frequently viſible when the diſcharge was made in the dark, and a gleam of light was alſo, in ſome inſtances, ſeen about the middle of the column at the inſtant of the exploſion. The aſſiſtants were of opinion that they heard the ſnap.

The extrication of the gaſes was rapid and plentiful by means of this apparatus. When copper wires were uſed for the broken circuit, with muriatic acid diluted with 100 parts of water in the tube, no gas, nor the leaſt circulation of the fluid was perceived, when the diſtance of the wires was two inches. A ſhort tube, with two copper wires very near each other in common water, was made part of the circuit, and ſhewed, by the uſual phenomena, that the ſtream of electricity was rapidly paſſing. The wires in the muriatic acid were then ſlided within the third of an inch of each other. For the ſake of brevity he avoids enumerating the effects which took place during ſeveral hours, and ſimply ſtates, that the minus wire gave out ſome hydrogen during an hour; while the plus wire was corroded, and exhibited no oxyd; but a depoſition of copper was formed round the minus, or lower wire, which began at its lower end: that no gas whatever appeared in this tube during two hours, though the depoſition was going on, and the ſmall tube ſhewed the continuance of the electric ſtream; and that the depoſition, at the end of four hours, formed a ramified metallic vegetation, nine or ten times the bulk of the wire it ſurrounded.

In this experiment, it appeared that the influence of electricity increaſing the oxydability of the upper wire, and affording naſcent hydrogen from the lower, cauſed the latter to act as the precipitant of a ſolution of one and the ſame metal.

Mr Nicholſon, we ſee, continues to call it electricity with the utmoſt confidence, as if it could not poſſibly be any thing elſe; and yet he ſays that the galvanic ſhock is much leſs forcible when paſſed through a number of perſons than when paſſed only through one. This, we believe, does not hold in the ſhocks of common electricity; and the difference probably ariſes from the cuticle obſtructing the paſſage of the one and not of the other. Volta himſelf ſays, that *this* electricity, for he too is deſirous to prove it electricity, does not diffuſe itſelf through the air. It is ſo univerſally known that very dry air is no conductor of electricity, that he muſt mean, on this occaſion, air not uncommonly dry; otherwiſe the non-diffuſion of *this* electricity through air would not diſtinguiſh it, as he ſeems to admit it does, from common electricity. But what occaſions this diſtinction, if the two electricities be the ſame?

Lieutenant-colonel Haldane, well known in the ſcientific world, made experiments with Volta's pillar, both in a horizontal and in a vertical poſition. With a large pillar, placed vertically, he obtained very weak ſigns of electricity. He connected the apparatus with the conductor of an electrical machine, and found the effect rather impeded than aſſiſted by the common electric ſtream. He placed the plate of Bennet's electrometer in the circuit, without producing electric ſigns. He found that the galvanic apparatus, placed between the outſide and inſide of a jar, prevented its charging, and that it is alſo capable of conducting the charge, though not rapidly: and, on the whole, from the very minute exhibition of the attractive and repellent powers, while the cauſticity, the ſhock, and the oxydation, are ſo very powerful, he cannot be perſuaded that electricity is the principal agent, though ſome might be generated, or diſengaged, during the operation of the apparatus.

This is exactly our own opinion, which is ſtrongly corroborated by the reſults of ſome very curious experiments made by Mr Cruickſhank of Woolwich. Theſe experiments our limits permit us not to detail. They were made with a view to aſcertain the nature and relative proportions of the gaſes obtained from water and other fluids by this influence; and the author thinks himſelf authoriſed to conclude from them:

1. That hydrogen gas, mixed with a very ſmall proportion of oxygen and ammonia, is ſomehow diſengaged at the wire connected with the ſilver extremity of the machine; and that this effect is equally produced, whatever the nature of the metallic wire may be, provided the fluid operated upon be pure water.

2. That where metallic ſolutions are employed inſtead of water, the ſame wire which ſeparates the hydrogen revives the metallic calx, and depoſits it at the extremity of the wire in its pure metallic ſtate; in this caſe no hydrogen gas is diſengaged. The wire employed for this purpoſe may be of any metal.

3. That of the earthy ſolutions, thoſe of magneſia and argil only are decompoſed by the ſilver wire; a circumſtance which ſtrongly favours the production of ammonia.

4. That when the wire connected with the zinc extremity of the pile conſiſts either of gold or platinum, a quantity of oxygen gas, mixed with a little azote and nitrous acid, is diſengaged; and the quantity of gas thus obtained is a little better than $\frac{1}{3}$d of the hydrogen gas ſeparated by the ſilver wire at the ſame time.

5. That when the wire connected with the zinc is ſilver, or any of the imperfect metals, a ſmall portion of oxygenous gas is likewiſe given out; but the wire itſelf is either oxydated or diſſolved, or partly oxydated and partly diſſolved: indeed, the effect in this caſe produced upon the metal is very ſimilar to that of the concentrated nitrous acid, where a great deal of the metal is oxydated, and but a ſmall quantity held in ſolution.

6. That when the gaſes obtained by gold or platinum wires are collected together and exploded over mercury, the whole nearly diſappears and forms water, with probably a little nitrous acid; for there was always a thick white vapour perceived for ſome time after the exploſion. The reſiduary gas, in this caſe, appeared to be azote.

In reflecting on theſe experiments, it would appear that in ſome of them the water muſt be decompoſed: but how this can be effected is by no means ſo eaſily explained. For example, it ſeems extremely myſterious how the oxygen ſhould paſs ſilently from the extremity of the ſilver wire to that of the zinc wire, and there make its appearance in the form of gas. It is to be obſerved, likewiſe, that this effect takes place which ever way the wires are placed, and whatever bends may be interpoſed between their extremities, provided the diſtance be not too great. On conſidering theſe facts more minutely, it appeared to Mr Cruickſhank that the eaſieſt and ſimpleſt mode of explanation would be, to ſuppoſe that the galvanic influence (whatever it may be) is capable of exiſting in two ſtates, that is, in an oxygenated and deoxygenated ſtate; that when it paſſes from metals to fluids containing oxygen, it ſeizes their oxygen, and becomes oxygenated; but when it paſſes from the fluid to the metal again, it aſſumes its former ſtate, and becomes deoxygenated. Now when water is the fluid interpoſed, and the influence enters it from the ſilver ſide deoxygenated (and we ſuppoſe that it always paſſes from the deoxygenated to the oxygenated ſide), it ſeizes the oxygen of the water, and diſengages the hydrogen, which accordingly appears in the form of gas*; but when the influence enters the zinc wire, it parts with the oxygen, with which it had formerly united; and this either eſcapes in the form of gas, unites with the metal to form an oxyd, or, combined with a certain portion of water, &c. may, according to the German chemiſts, form nitrous acid. When a metallic ſolution is the interpoſed fluid, the effect produced may be explained in two ways; but the ſimpleſt is to ſuppoſe that the influence, in paſſing from the ſilver wire, ſeizes the oxygen of the metallic calx, and afterwards depoſits it on entering the zinc one. In this caſe no gas ſhould appear at the ſilver wire; but when a perfect metal is employed, oxygen ſhould be diſengaged from the zinc wire: and this, as has been already mentioned, is exactly what takes place.

What our author conſiders as the ſtrongeſt argument in favour of this hypotheſis, and what we conſider as an argument equally ſtrong to prove that galvaniſm differs eſſentially from electricity, is, that all fluids which do not contain oxygen, are incapable of tranſmitting the galvanic fluid, ſuch as alcohol, æther, the fat, and eſſential oils, as he has proved by direct experiment ; but on the contrary, that all thoſe which do contain oxygen conduct it more or leſs readily, as all aqueous fluids, metallic ſolutions, and acids, more eſpecially the concentrated ſulphuric acid ; which it decompoſes. In this laſt inſtance, the oxygen produced can hardly be aſcribed to the decompoſition of water ; for this acid, when properly concentrated, does not contain any ſenſible quantity. By this theory alſo we can readily explain the oxydation of the zinc plates in the machine ; where the fluid in paſſing from the different pairs of plates appears to be alternately oxygenated and deoxygenated. Although I am not (ſays Mr Cruikſhank) by any means entirely ſatisfied with this hypotheſis, yet as it is the only one by which I can explain the different phenomena, it was thought adviſable to throw it out, merely with a view to induce others to reaſon upon the ſubject, and to incite them to make experiments, by which alone truth can be aſcertained.

We approve heartily of his conduct. It is for the ſame reaſon, and not to maintain at all hazards any preconceived opinion of our own, that we have urged every objection that occurs to us againſt the hypotheſis of the identity of galvaniſm and electricity. Theſe fluids or influences appear to us to differ eſſentially ; but ſtill we admit that future experiments and future reaſonings *may remove* our objections, which, however, ought never to be loſt ſight of *till* they be removed. If ingenious men, adopting implicitly the hypotheſis of Volta and Mr Nicholſon, ſhall inſtitute a ſet of experiments to aſcertain the laws of the galvanic influence, they will be very apt to make their experiments ſupport their hypotheſis, inſtead of employing them as guides to the temple of truth. Mr Nicholſon ſays, that in all the experiments made by him and Mr Carliſle, the action of the inſtrument was freely tranſmitted through the uſual conductors of electricity (meaning, we ſuppoſe, metals and watery fluids), but that it was ſtopped by glaſs and other non-conductors. We have experienced the ſame thing, and ſo far we acknowledge a ſtriking reſemblance between galvaniſm and electricity ; but, on the other hand, we have never been able to make any accumulation of galvaniſm by means of coated electrics, whilſt Mr Cruickſhank found that the galvanic influence cannot be tranſmitted through alcohol, ether, or eſſential oils. In theſe inſtances, the difference between galvaniſm and electricity ſeems to be as ſtriking as the reſemblance is in the others. Indeed theſe differences between the one and the other are ſo many and ſo great, that M. Fabbroni attributes the phenomena of galvaniſm not to electricity, but to a chemical operation ; to the tranſition of oxygen into a combination, and to the formation of a new compound. He had obſerved, in repeating the common experiment, that if he wiped his tongue as accurately as poſſible, the ſenſation of taſte excited by the two metals was ſo diminiſhed as to be hardly diſtinguiſhed. The ſaliva, or ſome other moiſture, muſt therefore be of ſome importance in this phenomenon. He afterwards inſtituted a ſet of very proper experiments; from which it appeared to him that an evident chemical action takes place in the operations of galvaniſm, and that it is unneceſſary to ſeek farther for the nature of the new ſtimulus. Galvaniſm (he ſays) is manifeſtly a combuſtion or oxydation of the metals ; and the ſtimulating principle may be either the caloric which is diſengaged, or the oxygen which paſſes into new combinations ; or the new metallic ſalt ; but which of theſe he has not aſcertained.

Without adopting or rejecting theſe concluſions, we recommend them to the attention of our chemical readers ; for it is only by expert and ſcientific chemiſts that we expect the nature and properties of galvaniſm to be aſcertained. In the mean time, it is proper to obſerve, that the pile of Volta continues in order for about three days, and ſcarcely three ; and that on account of the corroſion of the fæces of the zinc, it is neceſſary to renew them previous to each conſtruction of the pile. This may be done by ſcraping or grinding, or by cleaning them with diluted muriatic acid.

To avoid the trouble of conſtantly repiling the pieces of ſilver and zinc, Mr Cruickſhank conſtructed a kind of trough of baked wood, 26 inches in length, 1.7 inches deep, and 1.5 inches wide ; in the ſides of this trough grooves were made oppoſite to each other, about the tenth of an inch in depth, and ſufficiently wide to admit one of the plates of zinc and ſilver when ſoldered together ; three of theſe grooves were made in the ſpace of one inch and three tenths, ſo that the whole machine contained 60 pair of plates. A plate of zinc and ſilver, each 1.6 inches ſquare, well cemented together, were introduced into each of theſe grooves or notches, and afterwards cemented into the trough by a compoſition of roſin and wax, ſo perfectly that no water could paſs from one cell to the other, nor between the plates of zinc and ſilver. This circumſtance muſt be ſtrictly attended to, elſe the machine will be extremely imperfect. When all the plates were thus ſecured in the trough, the interſtices or cells formed by the different pairs of plates were filled with a ſolution of the muriat of ammonia, which here ſupplied the place of the moiſtened papers in the pile, but anſwered the purpoſe much better. It is hardly neceſſary to obſerve, that in fixing the zinc and ſilver plates, they muſt be placed regularly, as in the pile, *viz.* alternately zinc and ſilver, the ſilver plate being always on the ſame ſide. When a communication was made between the firſt and laſt cell, a ſtrong ſhock was felt in the arms, but ſomewhat different from that given by the pile, being quicker, leſs tremulous, and bearing a greater reſemblance to the common electrical ſhock. He conſtructed two of theſe machines, which contained in all 100 pair of plates ; theſe when joined together gave a very ſtrong ſhock, and the ſpark could be taken in the day-time at pleaſure ; but what ſurpriſed him not a little, was the very ſlender power which they poſſeſſed in decompoſing water : in this reſpect they were certainly inferior to a pile of 30 pair, although ſuch a pile would not give a ſhock of one third the ſtrength.

This apparatus retained its power for many days, and would in all probability have retained it much longer, had not the fluid got between the dry ſurfaces of the metals. To remedy this defect, he ſoldered the zinc and ſilver plates together, and found that this method anſwers very well. The zinc plates may be cleaned at any time, by filling the different cells for a few minutes with the dilute muriatic acid. Although this apparatus may not entirely ſuperſede the pile, eſpecially if it ſhould be found to decompoſe water, &c. but ſlowly, yet in other reſpects it will no doubt be found very convenient and portable.

If this article be thought long, and if we appear to have loſt ſight of our original ſubject, the *Torpedo*, we have

have only to plead in excuſe for our conduct, that whilſt we could not avoid pointing out the reſemblance between the ſhock given by the torpedo and that by Volta's apparatus, we felt it a kind of duty to embrace the only opportunity that we ſhall have of laying before our readers the additional information reſpecting the phenomena of GALVANISM which we have received ſince the publication of that article. Theſe phenomena are yet new, and they are unqueſtionably important; indeed ſo very important, that to us it appears neither impoſſible, nor even improbable, that to the galvanic agency of metals and minerals may be attributed volcanoes and earthquakes.

TOUCAN, or AMERICAN GOOSE, is one of the modern conſtellations of the ſouthern hemiſphere, conſiſting of nine ſmall ſtars.

TRACTORS, METALLIC. See PERKINISM in this *Suppl.*

TRACTRIX, in geometry, a curve line, called alſo CATENARIA; which ſee, *Encycl.* and ARCH, *Suppl.*

TRADESCANT (John), an ingenious naturaliſt and antiquary, was, according to Anthony Wood, a Fleming or a Dutchman. We are informed by Parkinſon, that he had travelled into moſt parts of Europe, and into Barbary; and from ſome emblems remaining upon his monument in Lambeth church yard, it plainly appears that he had viſited Greece, Egypt, and other eaſtern countries. In his travels, he is ſuppoſed to have collected, not only plants and ſeeds, but moſt of thoſe curioſities of every ſort which, after his death, were ſold by his ſon to the famous Elias Aſhmole, and depoſited in his muſeum at Oxford. When he firſt ſettled in this kingdom cannot, at this diſtance of time, be aſcertained. Perhaps it was at the latter end of the reign of Queen Elizabeth, or the beginning of that of King James I. His print, engraven by Hollar before the year 1656, which repreſents him as a perſon very far advanced in years, ſeems to countenance this opinion. He lived in a great houſe at South Lambeth, where his muſeum was frequently viſited by perſons of rank, who became benefactors thereto: among theſe were King Charles I. (to whom he was gardener), Henrietta Maria his Queen, Archbiſhop Laud, George Duke of Buckingham, Robert and William Cecil, Earls of Saliſbury, and many other perſons of diſtinction. John Tradeſcant may therefore be juſtly conſidered as the earlieſt collector (in this kingdom) of every thing that was curious in natural hiſtory, viz. minerals, birds, fiſhes, inſects, &c. He had alſo a good collection of coins and medals of all ſorts, beſides a great variety of uncommon rarities. A catalogue of theſe, publiſhed by his ſon, contains an enumeration of the many plants, ſhrubs, trees, &c. growing in his garden, which was pretty extenſive. Some of theſe plants are, if not totally extinct, at leaſt become very uncommon, even at this time: though this able man, by his great induſtry, made it manifeſt, in the very infancy of botany, that there is ſcarce any plant extant in the known world that will not, with proper care, thrive in this kingdom.

When his houſe at South Lambeth, then called *Tradeſcant's Ark*, came into Aſhmole's poſſeſſion, he added a noble room to it, and adorned the chimney with his arms, impaling thoſe of Sir William Dugdale, whoſe daughter was his third wife; where they remain to this day.

It were much to be wiſhed, that the lovers of botany had viſited this once famous garden before, or at leaſt in the beginning of the preſent century. But this ſeems to have been totally neglected till the year 1749, when Dr Watſon and the late Dr Mitchell favoured the Royal Society with the only account now extant of the remains of Tradeſcant's garden.

When the death of John Tradeſcant happened is not known; no mention being made thereof in the regiſter-book of Lambeth church.

TRAJECTORY, a term often uſed, generally for the path of any body, moving either in a void, or in a medium that reſiſts its motion; or even for any curve paſſing through a given number of points. Thus Newton, Princip. lib. 1. prop. 22. propoſes to deſcribe a trajectory that ſhall paſs through five given points.

TRAITOR's ISLAND, one of the Archipelago called *NAVIGATOR's Iſlands*, in the South Sea (See that article, *Suppl.*). It is low and flat, with only a hill of ſome height in the middle; and is divided into two parts by a channel, of which the mouth is about 150 toiſes wide. It abounds with bannanas, yams, and the fineſt cocoa nuts, which Perouſe ſays he ever ſaw. About twenty canoes approached the French ſhips without dread, traded with a good deal of honeſty, and never refuſed, like the natives of the archipelago of Navigators, to give their fruit before they were paid for it; nor, like them, did they give a preference to beads over nails and pieces of iron. They ſpoke, however, the ſame language, and had the ſame ferocious look; their dreſs, their manner of tatowing, and the form of their canoes, were the ſame; nor could we (ſays the author) doubt that they were one and the ſame people: they differed, indeed, in having univerſally two joints cut off from the little finger of the left hand; whereas, in the iſlands of Navigators, I only perceived two individuals who had ſuffered that operation. They were alſo of much lower ſtature, and far leſs gigantic make; a difference proceeding, no doubt, from the ſoil of theſe iſlands, which being leſs fertile, is conſequently leſs favourable to the expanſion of the human frame.

TRAMMELS, in mechanics, an inſtrument uſed by artificers for drawing ovals upon boards, &c. One part of it conſiſts of a croſs with two grooves at right angles; the other is a beam carrying two pins, which ſlide in thoſe grooves, and alſo the deſcribing pencil. All the engines for turning ovals are conſtructed on the ſame principles with the trammels: the only difference is, that in the trammels the board is at reſt, and the pencil moves upon it; in the turning engine, the tool, which ſupplies the place of the pencil, is at reſt, and the board moves againſt it. See a demonſtration of the chief properties of theſe inſtruments by Mr Ludlam, in the *Phil. Tranſ.* vol. lxx. p. 378, &c.

TRANSFORMATION, in geometry, is the changing or reducing of a figure, or of a body, into another of the ſame area, or the ſame ſolidity, but of a different form. As, to tranſform or reduce a triangle to a ſquare, or a pyramid to a parallelopipedon.

TRANSFORMATION of Equations, in algebra, is the changing equations into others of a different form, but of equal value. This operation is often neceſſary, to prepare equations for a more eaſy ſolution.

TRANSLATION, in literature, is a matter of ſo much importance, that no other apology can be made for the very imperfect manner in which it is treated in the *Encyclopædia*, than a candid declaration that it was impoſſible to enter at all upon the ſubject within the narrow limits to which we were then reſtricted by the proprietors of the work. The fundamental laws of tranſlation, which we gave from Dr Campbell of Aberdeen, we believe indeed to be unexceptionable; but the queſtion is, how are theſe laws to be obeyed?

In order that a tranſlator may be enabled to give a complete tranſcript of the ideas of the original work, it is almoſt needleſs to obſerve, that he muſt poſſeſs a perfect knowledge of both languages, *viz.* that of his author, and that into which he is to tranſlate; and that he muſt have a competent acquaintance with the ſubject of which his author treats. Theſe propoſitions we conſider as ſelf evident; but if any of our readers ſhall be of a different opinion, we refer them to an *Eſſay on the Principles of Tranſlation*, publiſhed 1797 by Cadell and Davies, London, where they will find our doctrine very clearly illuſtrated. It may be proper to add, that ſuch a knowledge of the Greek and Latin languages as merely enables a man to read them with eaſe and entertainment to himſelf, is by no means ſufficient to qualify him for tranſlating every Greek and Latin book, even though it treats of a ſubject with which he has a general acquaintance. The religious rites and ceremonies of the Greeks and Romans, as well as the radical words of their language, were derived from the Eaſt; and he who is an abſolute ſtranger to oriental literature, will be very liable to miſtake occaſionally the ſenſe of Greek and Roman authors who treat of religious ſubjects. We could illuſtrate the truth of this poſition by quotations from ſome of the moſt admired modern tranſlations of the Greek Scriptures, which we have no heſitation to ſay fall very ſhort of the authoriſed verſion in accuracy as well as in elegance. The divines employed by King James to tranſlate the Old and New Teſtaments were profoundly ſkilled in the learning, as well as in the languages, of the Eaſt; whilſt ſome of thoſe who have preſumed to improve their verſion ſeem not to have poſſeſſed a critical knowledge of the Greek tongue, to have known ſtill leſs of the Hebrew, and to have been abſolute ſtrangers to the dialect ſpoken in Judea in the days of our Saviour, as well as to the manners, cuſtoms, and peculiar opinions of the Jews ſects. Neither metaphyſical acuteneſs, nor the moſt perfect knowledge of the principles of tranſlation in general, will enable a man who is ignorant of theſe things to improve the authoriſed verſion either of the Goſpels or the Epiſtles; for ſuch a man knows not accurately, and therefore cannot give a complete tranſcript of the ideas of the original work.

But ſuppoſing the tranſlator completely qualified with reſpect to knowledge, it becomes a queſtion, whether he may, in any caſe, add to or retrench the ideas of his author? We are ſtrongly inclined to think, that, in no caſe, it is allowable to take ſuch liberties; but the ingenious and elegant eſſayiſt, whoſe work on the principles of tranſlation we muſt always quote with reſpect, is of a different opinion. "To give a general anſwer (ſays he) to this queſtion, I would ſay, that this liberty may be uſed, but with the greateſt caution. It muſt be further obſerved, that the ſuperadded idea ſhall have the moſt neceſſary connection with the original thought, and actually increaſe its force. And, on the other hand, that whenever an idea is cut off by the tranſlator, it muſt be only ſuch as is an acceſſory, and not a principle, in the clauſe or ſentence. It muſt likewiſe be confeſſedly redundant, ſo that its retrenchment ſhall not impair or weaken the original thought. Under theſe limitations, a tranſlator may exerciſe his judgment, and aſſume to himſelf, in ſo far, the character of an original writer"

Of the judicious uſe, as he thinks it, of this liberty, the author quotes many examples, of which we ſhall ſelect three, as well calculated to illuſtrate our own ideas of the ſubject.

In the firſt book of the Iliad, Achilles, having reſolved, though indignantly, to give up Briſeis, deſires Petroclus to deliver her to the heralds of Agamemnon:

> Ὡς φατο· Πατροκλης δε φιλω επεπειθεθ' ἑταιρῳ·
> Εκ δ' αγαγε κλισιης Βρισηιδα καλλιπαρηον,
> Δωκε δ' αγειν· τω δ' αυτις ιτην παρα νηας Αχαιων·
> Ἡ δ' ακεους' ἁμα τοισι γυνη κιεν· *Ilias*, A. 345.

> Patroclus now th' unwilling beauty brought;
> She in ſoft ſorrows, and in penſive thought,
> Paſt ſilent, as the heralds held her hand,
> And oft look'd back, ſlow moving o'er the ſtrand.
> POPE.

Our author thinks, and we heartily agree with him, that the amplification in the three laſt lines of this verſion highly improves the effect of the picture; but we cannot conſider this amplification as a new idea ſuperadded. It was the object of Homer to inform his countrymen, that Briſeis went with the heralds *unwillingly*. This he does by the words ἡ δ' ακευσ' ἁμα τοισι γυνη κιεν· and it is by no means improbable, that the rhythmical movement of the verſe may have preſented to the ancient Greeks the image of the lady walking ſlowly and reluctantly along. This image, we are ſure, is not produced by a literal tranſlation of the Greek words into Engliſh; and therefore it was Pope's duty, not to add to the ideas of the original, but, by amplification, to preſent to his own countrymen the picture which Homer, by the ſuperiority of the Greek language and rhythm, had preſented to his.

In the ninth book of the Iliad, where Phœnix reminds Achilles of the care he had taken of him while an infant, one circumſtance, extremely mean, and even diſguſting, is found in the original:

> ——— ὁτε δη σ' επ' εμοισιν εγω γουνασσι καθισσας
> Οψου τ' ασαιμι προταμων, και οινον επισχων·
> Πολλακι μοι κατεδευσας επι στηθεσσι χιτωνα,
> Οινου αποβλυζων εν νηπιεη αλεγεινη.

The literal verſion of theſe lines is indeed very groſs: "When I placed you before my knees, I crammed you with meat, and gave you wine, which you often vomited upon my boſom, and ſtained my clothes, in your troubleſome infancy:" but we cannot agree with our author, that the Engliſh reader is obliged to Pope for having altogether ſunk this nauſeous image. What is, or ought to be, our object in reading Homer? If it be merely to delight our ear with ſonorous lines, and pleaſe our fancy with grand or ſplendid images, the tranſlator certainly did right in keeping out of view this diſguſting picture of ſavage life; but when he did ſo, he cannot be ſaid to have given a complete tranſcript of his author's ideas. To pleaſe ourſelves, however, with ſplendid images, is not our only object when ſtudying the

the works of the ancient poets. Another, and in our opinion a more important object, is to acquire a lively notion of ancient manners; and if ſo, Pope groſsly miſleads the mere Engliſh reader, when, inſtead of the beaſtly image of Homer, he preſents him with the following ſcene, which he may daily meet with in his own family, or in the families of his friends:

> Thy infant breaſt a like affection ſhow'd,
> Still in my arms, an ever pleaſing load;
> Or at my knee, by Phœnix would'ſt thou ſtand,
> No food was grateful but from Phœnix hand:
> I paſs my watchings o'er thy helpleſs years,
> The tender labours, the compliant cares.

This is a picture of the domeſtic manners of Great Britain in the 18th century, and not of Greece in the heroic ages.

In the beginning of the eighth book of the Iliad, Homer puts into the mouth of Jove a very ſtrange ſpeech, ſtuffed with braggart vaunting and ludicrous images. This, as our author obſerves, is far beneath the dignity of the thunderer; but it is only beneath the dignity of the thunderer as our habits and modes of thinking compel *us* to conceive ſuch a being. The thunderer of the Greeks was a notorious adulterer and ſodomite, whoſe moral character ſinks beneath that of the meaneſt of our bravos; and as he had dethroned his father, and waged for ſome time a doubtful war with certain *earthly* giants, it does not appear to us that the boaſting ſpeech which Homer puts into his mouth is at all unſuitable to his acknowledged attributes. But whether it be or not, was not the tranſlator's concern. Homer, when he compoſed it, certainly thought it not unworthy of the thunderer; and whatever Pope's opinion might be, he had no right to ſubſtitute his own notions of propriety for thoſe of his author. The mythological tales of the poets, and more eſpecially of Homer and Heſiod, conſtituted, as every one knows, the religious creed of the vulgar Greeks (ſee POLYTHEISM, n° 33. *Encycl.*); and this circumſtance makes it doubly the duty of a tranſlator to give, on ſuch ſubjects, a fair tranſcript of his author's ideas, that the mere Engliſh reader, for whom he writes, may know what the ancients really thought of the objects of their idolatrous worſhip. This Pope has not done in the ſpeech under conſideration; and has therefore, in our opinion, deviated widely from the firſt and moſt important of the three general laws of tranſlation. Johnſon has apologized, we think ſufficiently, for many of Pope's embelliſhments of his author; but he has not attempted to make an apology for ſuch embelliſhments as alter the ſenſe. We cannot indeed conceive a pretence upon which it can ever be allowable in a tranſlator to add to the ideas of his author, to retrench, or to vary them. If he be tranſlating hiſtory, and find his author advancing what he *believes* to be falſe, he may correct him in a note; but he has no right to make one man utter, as his own, the belief or the ſentiments of another, when that belief, and thoſe ſentiments, are *not* his own. If he be tranſlating a work of ſcience, he may likewiſe correct the errors of his author in notes, as Dr Clerke corrected thoſe of Rohault; but no man has a right to give to a Rohault the ſcience of a Newton. The tranſlator of a poem may certainly employ amplification to place in a ſtriking light the images or the ſentiments of the original work; but he muſt not alter thoſe images or ſentiments ſo as to make that appear grand or elegant in the verſion, which is mean or diſguſting in the original. On every occaſion on which he takes ſuch liberties as theſe, he ceaſes to be a tranſlator, and becomes a faithleſs paraphraſt.

The ſecond general law of tranſlation, though certainly leſs important, is perhaps more difficult to be obſerved than the firſt. We have ſtated it in theſe words: (See TRANSLATION, *Encycl.*) "The ſtyle and manner of the original ſhould be preſerved in the tranſlation;" but it is obvious, that this cannot be done by him who poſſeſſes not ſufficient taſte and judgment to aſcertain with preciſion to what claſs the ſtyle of the original belongs. "If a tranſlator fail in this diſcernment, and want this capacity, let him be ever ſo thoroughly maſter of the ſenſe of his author, he will preſent him through a diſtorting medium, or exhibit him in a garb that is unſuitable to his character." It would obviouſly be very improper to tranſlate the elegantly ſimple language of Cæſar into rounded periods like thoſe of *The Rambler*, or the Orations of Cicero into the language of Swift.

The chief characteriſtic of the hiſtorical ſtyle of the ſacred Scriptures is its ſimplicity; and that ſimplicity is, for the moſt part, well preſerved in the authoriſed verſion. It is, however, loſt in many of the modern verſions. Caſtalio's, for inſtance, though intitled to the praiſe of elegant latinity, and though, in general, faithful to the ſenſe of the original, yet exhibits numberleſs tranſgreſſions of the law which is now under conſideration. Its ſentences are formed in long and intricate periods, in which many ſeparate members are artfully combined; and we obſerve a conſtant endeavour at claſſical phraſeology and ornamented diction, inſtead of the beautiful ſimplicity of the original.

The verſion of the Scriptures by Arias Montanus is, in ſome reſpects, a contraſt to that of Caſtalio. By adopting the literal mode of tranſlation, Arias undoubtedly intended to give as faithful a picture as he could, both of the ſenſe and of the manner of the original. Not attending to the peculiar idioms of the Hebrew, Greek, and Latin tongues, which, in ſome reſpects, are very different from each other, he has, by giving to his Latin the combination and idioms of the two firſt of theſe languages, ſometimes made the ſacred writers talk abſurdly. In Latin, as every ſchool-boy knows, two negatives make an affirmative, whilſt in Greek they add force to the negation. χωρις εμου ου δυνασθε ουδεν ſignifies, "Without me ye can do nothing," or, "Ye cannot *poſſibly* do any thing;" but Arias has tranſlated the words *ſine me non poteſtis facere nihil*, *i. e.* "without me ye cannot do nothing," or, "ye *muſt* do ſomething," which is directly contrary to the meaning of our Lord. It is not therefore by tranſlating literally or verbally that we can hope to preſerve the ſtyle and manner of the original.

To expreſs in florid or elevated language the ideas of an author who writes himſelf in a ſimple ſtyle, is not to give in the verſion a juſt picture of the original; but to attempt, for the ſake of verbal accuracy, to introduce into one language the peculiar idioms or conſtruction of another, is ſtill worſe, as in this mode of tranſlation the ſenſe, as well as the manner of the original, is loſt. The rule obviouſly is to uſe, in the verſion, the words and phraſeology which we have reaſon to believe that the author would himſelf have uſed, had he been maſter of the language into which we are tranſlating his ideas. Thus, if we are to tranſlate into Engliſh a piece of elegantly ſimple Greek or Latin, we muſt make ourſelves completely maſter of the author's meaning, and, neglecting the Greek or Latin *idioms*, expreſs that meaning in elegantly ſimple Engliſh. We need not add, that when the language of the original is florid or grand, if that ſtyle be ſuited to the ſubject, the language of the tranſlation ſhould be florid or grand likewiſe; but care muſt always be taken that perſpicuity be not ſacrificed to ambitious ornaments of any kind; for ornaments which obſcure the ſenſe are worſe than uſeleſs.

If theſe reflections be juſt, it is obvious that a poem cannot be properly tranſlated into proſe. The mere ſenſe may doubtleſs be thus transferred from one language into another, as has generally been done by Macpherſon in his hobbling verſion of the Iliad, and perhaps more completely by a late tranſlator of Anacreon; but in ſuch a verſion, the ſtyle and manner of the original muſt neceſſarily be loſt. Of this the following accurate proſe tranſlation of Anacreon's ninth ode (on a dove) is a ſtriking inſtance:

"O lovely Pigeon! whence, whence do you fly? Whence, ſpeeding through the air, do you breathe, and diſtil ſo many perfumes? Who is your maſter? For it concerns me to know. 'Anacreon ſent me to a youth, —to Bathyllus, at preſent the prince, and diſpoſing of all things Venus ſold me, receiving a little hymn in return. And I ſerve Anacreon in ſuch tranſactions as theſe: and now I carry his letters, ſuch as you ſee: and he affirms, that he will immediately make me free. But I will remain a ſervant with him although he may diſmiſs me: For wherefore does it behove me to fly, both over mountains, and fields, and to perch on trees, devouring ſome ruſtic food? Now indeed I eat bread, ſnatching it from the hands of Anacreon himſelf; and he gives to me the wine to drink which he drinks before me; and having drunk, I perhaps may dance, and cover my maſter with my wings: then going to reſt, I ſleep upon the lute itſelf. You have it all;—begone: you have made me more talkative, O mortal! than even a jay *."

How inferior is the general effect of this piece of proſe to that of the well-known poetical verſions of Addiſon and Johnſon? and yet the mere *ideas* of the original are perhaps more faithfully tranſcribed by this anonymous writer than by either of thoſe elegant tranſlators. The emotions indeed excited by the original are not here brought into view.

The third general law of tranſlation is ſo nearly allied to the ſecond, that we have very few directions to give for the obſervation of it. He who, in his verſion, preſerves the ſtyle and manner of the original, as we have endeavoured to ſhew that they *ought* to be preſerved, will, of courſe, give to the tranſlation the eaſe of original compoſition. The principal difficulty that he has to encounter in this part of his taſk, will occur in the tranſlating of idiomatical and proverbial phraſes. Hardly any two languages are conſtructed preciſely in the ſame way; and when the ſtructure of the Engliſh language is compared with that of the Greek and Latin, a remarkable difference between the ancient and modern tongues is found to pervade the whole. This muſt occaſion very conſiderable difficulty; but it is a difficulty which will be removed by a due obſervance of the former law, which directs the tranſlator to make his author ſpeak Engliſh in ſuch a ſtyle to Engliſhmen as he ſpoke his own tongue to his own countrymen, and of courſe to uſe the Engliſh idiom with Engliſh words. But what is to be done with thoſe proverbial phraſes of which every language has a large collection, and which allude to local cuſtoms and manners?

The ingenious author of the Eſſay ſo often quoted, very properly obſerves, in anſwer to this queſtion, that the tranſlation is perfect when the tranſlator employs, in his own language, an idiomatic phraſe correſponding to that of the original. "It is not (ſays he) poſſible perhaps to produce a happier inſtance of tranſlation by correſponding idioms, than Sterne has given * in the tranſlation of Slawkenbergius's tale. *Nihil me penitet hujus naſi*, quoth Pamphagus; that is, "My noſe has been the making of me." *Nec eſt cur pœniteat*; that is, "How the deuce ſhould ſuch a noſe fail?" *Miles peregrini in faciem ſuſpexit!* "The centinel looked into the ſtranger's face. Never ſaw ſuch a noſe in his life!"

"As there is nothing (continues our author) which ſo much conduces both to the eaſe and ſpirit of compoſition as a happy uſe of idiomatic phraſes, there is nothing which a tranſlator, who has a moderate command of his own language, is ſo apt to carry to an extreme." Of this he gives many ſtriking examples from Echard's tranſlations of Terence and Plautus, for which we muſt refer the reader to the Eſſay itſelf. He obſerves, likewiſe, that in the uſe of idiomatic phraſes, a tranſlator frequently forgets both the country of his original author, and the age in which he wrote; and while he makes a Greek or Roman ſpeak French or Engliſh, he unwittingly puts into his mouth alluſions to the manners of modern France or England. This, to uſe a phraſe borrowed from painting, may be termed an offence againſt the *coſtume*. The proverbial expreſſion βατραχῳ ὑδωρ, in Theocritus, is of ſimilar import with the Engliſh proverb, *to carry coals to Newcaſtle*; and the Scotch, *to drive ſalt to Dyſart*; but it would be a groſs impropriety to uſe either of theſe expreſſions in the tranſlation of an ancient claſſic. Of ſuch improprieties our author points out many inſtances both in French and Engliſh tranſlations of the claſſics; and he might have increaſed the number by quotations from Blackwell's Memoirs of the Court of Auguſtus, where, inſtead of Roman ſenators and their wives, we meet with modern gentlemen and ladies, with *ſecretaries at war*, *paymaſters*, *commiſſary generals*, and *lord high admirals*. It is true the memoirs of the court of Auguſtus is no tranſlation; but with reſpect to coſtume, it is neceſſarily ſubject to the laws of tranſlation.

Offences againſt coſtume are often committed by the uſe of improper words as well as of improper phraſes. To introduce into dignified and ſolemn compoſition words aſſociated with mean and ludicrous ſubjects, is equally a fault in an original author and in a tranſlator; and it is obviouſly improper, in the tranſlation of works of very high antiquity, to make uſe of words which have but lately been admitted into the language of the tranſlator. Faults of this kind are very frequent in Dr Geddes's tranſlation of the Bible, as when the *paſſover* is called the *ſkipover*; the tabernacle of the congregation,

---

* The Odes of Anacreon, tranſlated into Engliſh proſe, printed at York, 1796.

* Triſtram Shandy.

tion, the *convention-tent;* and a burnt-offering, a *holocauſt.* The firſt of theſe expreſſions preſents to the imagination an image profanely ludicrous; the ſecond, brings into our view the French Convention, which, we ſuſpect, occupied no ſmall portion of the Doctor's thoughts, when they ſhould have been wholly employed on the ſacred text; and the word *holocauſt,* which muſt be unintelligible to the mere Engliſh reader, is, in the mind of every man of letters, cloſely aſſociated with the abominable rites performed at the ſacrifices of the ancient heathens. But it is needleſs to point out faults of this kind in a work which is open to more ſerious objections, and which, we truſt, ſhall never be generally read. We are ſorry that truth compels us to ſay, that the novel expreſſions introduced by Dr Campbell into his verſion of the goſpels—ſuch as *confluence* for multitude, and *reign* for kingdom—are, to ſay the beſt of them, no improvements of the authoriſed verſion. We will not rank them with Dr Geddes's innovations, becauſe we will not claſs the great author of the *Diſſertation on Miracles* with a paradoxical Chriſtian of no communion; but we do not think that Dr Campbell's laurels were freſhened on his brow by the tranſlation of the Goſpels.

We ſhall conclude this article with the following reflections, taken from the Eſſay which has been ſo often quoted:

"If the order in which we have claſſed the three general laws of tranſlation be their juſt and natural arrangement, which, we preſume, will hardly be denied, it follows, that, in every caſe where it is neceſſary to make a ſacrifice of one of theſe laws to another, a due regard ought to be paid to their rank and comparative importance. When the genius of the original language differs much from that of the tranſlation, it is often neceſſary to depart from the author's manner in order to convey a faithful picture of his ſenſe; but it would be highly prepoſterous to depart, in any caſe, from the ſenſe, for the ſake of imitating the manner. Equally improper would it be, to ſacrifice either the ſenſe or manner of the original, if theſe can be preſerved conſiſtently with purity of expreſſion, to a fancied eaſe or ſuperior gracefulneſs of compoſition; and it is certain that the ſenſe may always be preſerved, though to purity of expreſſion the manner of the original muſt ſometimes be ſacrificed."

TRAPEZOID, ſometimes denotes a trapezium that has two of its ſides parallel to each other; and ſometimes an irregular ſolid figure, having four ſides not parallel to each other.

TRAVERSE, in gunnery, is the turning a piece of ordnance about, as upon a centre, to make it point in any particular direction.

TRAVERSE, in fortification, denotes a trench with a little parapet, ſometimes two, one on each ſide, to ſerve as a coverfrom the enemy that might come in flank.

TRAVERSE, in a wet foſs, is a ſort of gallery, made by throwing ſauciſſons, joiſts, faſcines, ſtones, earth, &c. into the foſs, oppoſite the place where the miner is to be put, in order to fill up the ditch, and make a paſſage over it.

TRAVERSE alſo denotes a wall of earth, or ſtone, raiſed acroſs a work, to ſtop the ſhot from rolling along it.

TRAVERSE alſo ſometimes ſignifies any retrenchment, or line fortified with faſcines, barrels, or bags of earth, or gabions.

TRAVESTY, or burleſque tranſlation, is a ſpecies of writing which, as it partakes, in a great degree, of original compoſition, is not to be meaſured by the laws of ſerious tranſlation. It conveys neither a juſt picture of the ſentiments, nor a faithful repreſentation of the ſtyle and manner of the original; but pleaſes itſelf in exhibiting a ludicrous caricatura of both. It diſplays an overcharged and groteſque reſemblance, and excites our riſible emotions by the incongruous aſſociation of dignity and meanneſs, wiſdom and abſurdity. This aſſociation forms equally the baſis of traveſty and of ludicrous parody, from which it is no otherwiſe diſtinguiſhed than by its aſſuming a different language from the original. In order that the mimickry may be underſtood, it is neceſſary that the writer chooſe, for the exerciſe of his talents, a work that is well known, and of great reputation. Whether that reputation is deſerved or unjuſt, the work may be equally the ſubject of burleſque imitation. If it has been the ſubject of general, but undeſerved praiſe, a parody or a traveſty is then a fair ſatire on the falſe taſte of the original author and his admirers, and we are pleaſed to ſee both become the objects of a juſt caſtigation. The *Rehearſal*, *Tom Thumb*, and *Crononhotonthologos*, which exhibit ludicrous parodies of paſſages from the favourite dramatic writers of the times, convey a great deal of juſt and uſeful criticiſm. If the original is a work of real excellence, the traveſty or parody detracts nothing from its merit, nor robs the author of the ſmalleſt portion of his juſt praiſe. We laugh at the aſſociation of dignity and meanneſs; but the former remains the excluſive property of the original, the latter belongs ſolely to the copy. We give due praiſe to the mimical powers of the imitator, and are delighted to ſee how ingeniouſly he can elicit ſubjects of mirth and ridicule from what is grave, dignified, pathetic, or ſublime.

But this ſpecies of compoſition pleaſes only in a ſhort ſpecimen. We cannot bear a lengthened work in traveſty. The incongruous aſſociation of dignity and meanneſs excites riſibility chiefly from its being unexpected. Cotton's and Scarron's Virgil entertain but for a few pages: the compoſition ſoon becomes tedious, and at length diſguſting. We laugh at a ſhort exhibition of buffoonery; but we cannot endure a man who, with good talents, is conſtantly playing the fool.

TREACLE (ſee *Encycl.*) or MELASSES, is a ſubſtance very wholeſome, but of a taſte diſagreeably ſweet. Methods have accordingly been propoſed for purifying it, ſo as that it may, on many occaſions, ſupply the place of refined ſugar, which has long been at a price which a great number of poor perſons cannot afford to pay for what muſt now be conſidered as a neceſſary of life. The following is the proceſs for purifying treacle, given by the M. Cadet (Devaux) in the *Feuille du Cultivateur*, founded upon experiments made by Mr Lowitz of Peterſburgh:

Take of treacle 24 lbs. of water 24 lbs. of charcoal, thoroughly burnt, 6 lbs. Bruiſe the charcoal groſsly, mix the three ſubſtances in a caldron, and let the mixture boil gently upon a clear wood-fire. After it has boiled for half an hour, pour the liquor through a ſtraining-bag, and then replace it upon the fire, that the ſuperfluous water may be evaporated, and that the treacle may be brought to its original conſiſtence. There is little or no loſs by this operation, as 24 lbs. of treacle give nearly the ſame quantity of ſyrup.

This proceſs has been repeated in the large way, and has ſucceeded: the treacle is ſenſibly ameliorated, ſo that it may be uſed for many diſhes; nevertheleſs, thoſe with milk, and the fine or aromatic *liqueurs*, are not near ſo good as with ſugar.

TREBISOND, a large, populous, and ſtrong town of Turkey in Aſia, in the province of Jenich, with a Greek archbiſhop's ſee, a harbour, and a caſtle. It is ſeated at the foot of a very ſteep hill. The walls are ſquare and high, with battlements; and are built with the ruins of ancient ſtructures, on which are inſcriptions not legible. The town is not populous; for there are more woods and gardens in it than houſes, and theſe but one ſtory high The caſtle is ſeated on a flat rock, with ditches cut therein. The harbour is at the eaſt end of the town, and the mole built by the Geneoſe is almoſt deſtroyed. It ſtands on the Black Sea, 104 miles north weſt of Erzerum, and 440 eaſt of Conſtantinople. E. Lon. 40° 25′. N. lat. 40° 45′.

TREE. Under this title (*Encycl.*) we gave an account of the method recommended by Meſſrs Forſyth and Hitt for curing injuries and defects in trees. The actual cautery is employed in Cevennes, and in the department de l'Allier, in France, for ſtopping the progreſs of rottenneſs in large trees. When they perceive that this very common and deſtructive diſeaſe begins to make ſome progreſs in the cheſnut-tree, by excavating its trunk, they collect heath, and other combuſtible vegetables, and burn them in the very cavity, till the ſurface is completely converted into a coal. It ſeldom happens that the tree periſhes by the effect of this operation, and it is always found that this remedy ſuſpends the progreſs of the decay. It is practiſed in the ſame manner, and with ſimilar ſucceſs, on the white oak. When we compare the effects of the actual cautery on the animal ſyſtem, in ſimilar diſeaſes, a new reſemblance is ſeen between the diſeaſes which affect the organic beings of both kingdoms, as well as between the remedies by which they may be oppoſed.—*Nicholſon's Journal.*

TRIANGLE, Arithmetical, a kind of numeral triangle, or triangle of numbers, being a table of certain numbers diſpoſed in form of a triangle. It was ſo called by Paſcal; but he was not the inventor of this table, as ſome writers have imagined, its properties having been treated of by other authors ſome centuries before him, as is ſhewn in Dr Hutton's Mathematical Tracts, vol. i. p. 69. &c.

The form of the triangle is as follows:

1					
1	1				
1	2	1			
1	3	3	1		
1	4	6	4	1	
1	5	10	10	5	1
1	6	15	20	&c.	
1	7	21	&c.		
1	8	&c.			
1	9				
1					

And it is conſtructed by adding always the laſt two numbers of the next two preceding columns together, to give the next ſucceeding column of numbers.

The firſt vertical column conſiſts of units; the ſecond, a ſeries of the natural numbers 1, 2, 3, 4, 5, &c.; the third, a ſeries of triangular numbers 1, 3, 6, 10, &c.; the fourth, a ſeries of pyramidal numbers, &c. The oblique diagonal rows, deſcending from left to right, are alſo the ſame as the vertical columns. And the numbers taken on the horizontal lines are the co-efficients of the different powers of a binomial. Many other properties and uſes of theſe numbers have been delivered by various authors, as may be ſeen in the Introduction to Hutton's Mathematical Tables, pages 7, 8, 75, 76, 77, 89, ſecond edition.

TRIANGULAR Compasses, are ſuch as have three legs or feet, by which any triangle, or three points, may be taken off at once. Theſe are very uſeful in the conſtruction of maps, globes, &c.

Triangular Numbers, are a kind of polygonal numbers; being the ſums of arithmetical progreſſions, which have 1 for the common difference of their terms.

Thus, from theſe arithmeticals 1 2 3 4 5 6,
are formed the triangular numbers 1 3 6 10 15 21,
or the third column of the arithmetical triangle abovementioned.

The ſum of any number n of the terms of the triangular numbers, 1, 3, 6, 10, &c. is =

$$\frac{n^3}{6}+\frac{n^2}{2}+\frac{n}{3}, \text{ or } \frac{n}{1}\times\frac{n+1}{2}\times\frac{n+2}{3}$$

which is alſo equal to the number of ſhot in a triangular pile of balls, the number of rows, or the number in each ſide of the baſe, being n.

The ſum of the reciprocals of the triangular ſeries, infinitely continued, is equal to 2; viz.

$$1+\frac{1}{3}+\frac{1}{6}+\frac{1}{10}+\frac{1}{15}, \text{ \&c.} = 2.$$

For the rationale and management of theſe numbers, ſee *Malcolm's Arith.* book 5. ch. 2.; and *Simpſon's Algeb.* ſec. 15.

TRIESTE, a ſmall, but ſtrong and ancient ſeaport of Italy, in Iſtria, on the gulph of Venice, with a biſhop's ſee. It is beautifully ſituated on the ſide of a hill, about which the vineyards form a ſemicircle. The ſtreets are narrow; but there is a large ſquare, where they keep the annual fair. The harbour is ſpacious, but not good; becauſe it is open to the W. and S. W. winds. The inhabitants have a good trade in ſalt, oil, almonds, iron, &c. brought from Laubach; and they make good wines. The cathedral, and the late Jeſuits church, are the two beſt buildings. It belongs to the Houſe of Auſtria, and is eight miles north of Capo d'Iſtria, and 80 north-eaſt of Venice. E. Long. 14. 4. N Lat. 45. 56.

TRINITARIANS (Order of), was inſtituted at Rome in the year 1198, under the pontificate of Innocent III. the founders whereof were John de Matha and Felix de Valois. His Holineſs gave them permiſſion to eſtabliſh this order for the deliverance of captives, who groaned under the tyranny of the infidels: he gave them as a habit a white gown, ornamented with a red and blue croſs. After the death of the two founders, Pope Honorious III. continued the order; and their rule was approved by his ſucceſſor Clement IV. in 1367. At firſt they were not permitted to eat fleſh; and when they travelled, were to ride only upon aſſes. But their rule was corrected and mitigated by the biſhop of Paris, and the abbots of St Victor and St Genevieve, who allowed them to eat any kind of food, and to uſe horſes. This order poſſeſſed, at one time, about 250 convents in 13 different provinces: ſix of which were in France; namely, France, Normandy, Picardy, Champaine, Languedoc, and Provence; three in Spain, viz. New Caſtile, Old Caſtile, and Arragon; one in Italy, and one in Portugal. There was formerly the province of England, where this order had 43 houſes; that of Scotland, where it had nine; and that of Ireland, where it had 52; beſides a great number of monaſteries in Saxony, Hungary, Bohemia, and other countries. The convent of Cerfroy in France was head of the order. It is impoſſible for us to ſay what is now the ſtate of the order, which can have no viſible exiſtence in France, and is probably ſuppreſſed even in Italy.

TRIONES, in aſtronomy, a ſort of conſtellation, or aſſemblage of ſeven ſtars in the Urſa Major, popularly called *Charles's Wain.*—From the *ſeptem triones* the north pole takes the denomination *ſeptentrio*.

TRIPOLI of Syria is, according to Mr Browne, by no means ſo populous a place as we were led to repreſent it in the *Encyclopædia*. It is indeed, he ſays, a city of ſome extent, ſituated about a mile and a half from the ſea; but inſtead of ſixty, he eſtimates its population at about ſixteen thouſand. The air is rendered unwholeſome by much ſtagnant water. The town is placed on a ſlight elevation, the length conſiderably exceeding the breadth. On the higheſt ground, to the ſouth, is the caſtle, formerly poſſeſſed by the earls of Tripoli; it is large and ſtrong. Hence is viſible a part of mount Libanus, the ſummit of which is covered with ſnow. The gardens in the vicinity are rich in mulberry and other fruit trees. The city is well built, and moſt of the ſtreets are paved.

Here is found a number of Mohammedan merchants, ſome of the richeſt and moſt reſpectable in the empire. Silk is the chief article of commerce.

The *miri*, or fixed public revenue paid by Tripoli to Conſtantinople, is only about L.1000 Sterling, 20 purſes, a-year. Syria at preſent contains only four Paſhaliks, Damaſcus, Aleppo, Acré, and Tripoli; the laſt of which is the ſmalleſt in territory and power. Our author obſerved no antiquities at Tripoli; but the country round it is noted for producing the beſt tobacco in Syria.

TRISECTION, the dividing a thing into three equal parts. The term is chiefly uſed in geometry, for the diviſion of an angle into three equal parts. The *triſection of an angle* geometrically, is one of thoſe great problems, whoſe ſolution has been ſo much ſought for by mathematicians for 2000 years paſt; being, in this reſpect, on a footing with the famous quadrature of the circle, and the duplicature of the cube.

TRISTAN d'Acunha, the largeſt of three iſlands which were viſited by Lord Macartney and his ſuite on the 31ſt of December 1792. The other two are diſtinguiſhed by the names of *Inacceſſible* and *Nightingale* iſlands. "Inacceſſible (as Sir Eraſmus Gower obſerved) ſeems to deſerve that name, being a high, bluff, as well as apparently barren plain, about nine miles in circumference, and has a very forbidding appearance. There is a high rock detached from it at the ſouth end. Its latitude is 37° 19′ ſouth; its longitude 11° 50′ weſt from Greenwich. This rude-looking ſpot may be ſeen at 12 or 14 leagues diſtance. Nightingale iſland is irregular in its form, with a hollow in the middle, and is about ſeven or eight miles in circumference, with ſmall rocky iſles at its ſouthern extremity. It is deſcribed as having anchorage on the north-eaſt ſide. Its latitude is 37° 29′ ſouth; and longitude 11° 48′ weſt from Greenwich. It may be ſeen at ſeven or eight leagues diſtance. The largeſt of theſe three iſlands, which comparatively may be called the great iſle of *Triſtan d'Acunha*, is very high, and may be ſeen at 25 leagues diſtance. It ſeems not to exceed in circumference 15 miles. A part of the iſland towards the north riſes perpendicularly from the ſea to a height apparently of a thouſand feet or more. A level then commences, forming what among ſeamen is termed *table land*, and extending towards the centre of the iſland; from whence a conical mountain riſes, not unlike in appearance to the Peak of Teneriffe, as ſeen from the bay of Santa Cruz. Boats were ſent to ſound and to examine the ſhore for a convenient place to land and water. In conſequence of their report, the Lion (a ſhip of 64 guns) ſtood in, and came to anchor in the evening on the north ſide, in 30 fathoms water, one mile from the ſhore; the bottom black ſand with ſlime; a ſmall rock, off the weſt point, bearing ſouth weſt by ſouth, juſt open with the weſtern extremity of the iſland; a caſcade, or fall of water, emptying itſelf upon the beach, ſouth by eaſt. All the ſhore, from the ſouthern point to the eaſtern extremity, appears to be clear of danger, and ſteep, except the weſt point, where there are breakers about two cables length, or near 500 yards from the ſhore. The ſhip, when anchored, was overſhadowed by the dark maſs of that portion of the iſland whoſe ſides ſeemed to riſe, like a moſs grown wall, immediately from the ocean. On the right the elevation was leſs rapid, and between the riſing part and the ſea was left a flat, of ſome extent, covered with ſedge-graſs, interſperſed with ſmall ſhrubs, which, being perfectly green, looked from the ſhip like a pleaſant meadow, watered by a ſtream that fell, afterwards, from its banks upon the beach. The officers, who went aſhore, reported, that the caſks might be filled with freſh water by means of a long hoſe, without moving them from the boats. The landing place thereabouts was alſo deſcribed as being ſafe, and ſuperior to any other that had been examined. From the plain, the land roſe gradually towards the central mountain, in ridges covered with trees of a moderate ſize and height. The coaſt abounded with ſea lions and ſeals, penguins and albatroſſes. One of the latter was brought on board, his wings meaſuring ten feet from tip to tip; but others are ſaid to have been found much larger. The coaſt was covered with a broad ſea-weed, ſeveral fathoms long, and deſervedly by naturaliſts termed *gigantic fucus*. Some good fiſh was caught with the hook and line.

"The accident of a ſudden guſt, by which the anchor was in a few hours driven from its hold, and the ſhip forced out to ſea, prevented the iſland from being explored, as was intended. It is probable that had the Lion anchored in 20, inſtead of 30 fathoms water, the anchor would have held firmly. Some advantage was obtained, however, from coming to this place. The juſt poſition of thoſe iſlands, in reſpect to their longitude, was aſcertained, by the mean of ſeveral time-pieces, to be about two degrees to the eaſtward of the place where they are laid down in charts, taken from obſervations made at a period when the inſtruments for this purpoſe were leſs accurate than at preſent. The ſpot where the Lion anchored was determined, by good meridional obſervations, and by accurate time-pieces, to be 37° 6′ ſouth latitude, and 11° 43′ weſt longitude from Greenwich. The compaſs had ſeven degrees of variation weſtward from the pole. Fahrenheit's thermometer ſtood at 67 degrees. It was uſeful alſo to have aſcertained, that a ſafe anchorage, and plenty of good water, were to be found here. Theſe iſlands are certainly worthy of a more particular inquiry; for they are not 50 leagues from the general track of veſſels bound to China, and to the coaſt of Coromandel, by the outer paſſage. In war time, an excellent rendezvous might be ſettled there, for ſhips that wanted no other ſupply but that of water. When circumſtances require particular diſpatch, it is practicable to come from England to Triſtan d'Acunha without ſtopping in the way, and afterwards to the end of the voyage to India or China."

Theſe iſlands are ſeparated by a ſpace of about fifteen hundred miles from any land to the weſtward or northward of them. They are ſituated in that part of the ſouthern hemiſphere, in the neighbourhood of which a continent, to balance the quantity of land in the northern hemiſphere, was once expected to be found, but where it has been ſince diſcovered that there is none. Of what extent, however, the baſes of theſe iſlands are under the ſurface of the ſea, cannot be aſcertained ; or whether they may, or may not,' be ſufficient to make up for the defect of land appearing above water. Navigators report, that to the eaſtward of them are other ſmall iſlands, differing not much in latitude, ſuch as Gough and Alvarez iſlands, and the Marſouines ; as well as extenſive ſhoals, lying due ſouth of the moſt ſoutherly point of Africa, and extending eaſterly ſeveral degrees. That all theſe together form a chain, ſome of ſubaqueous, and ſome of ſuperaqueous mountains, but all connected by their roots, is perhaps a conjecture leſs improbable, than that they ſhould ſeparately ariſe, like tall columns, from the vaſt abyſs.

A ſettlement in Triſtan d'Acunha is known to have been twice in the contemplation of adventurers, but not as yet to have been carried into execution. One had the project of rendering it a mart for the change of the light manufactures of Hindoſtan, ſuited to hot climes, for the ſilver of the Spaniſh ſettlements in South America ; in the route between which places it is conveniently ſituated. The other plan meant is only as a ſuitable ſpot for drying and preparing the furs of ſea lions and ſeals, and for extracting the ſpermaceti of the white or long-noſed whale, and the whale-bone and oil of the black ſpecies. Whales of every kind were ſeen ſporting about Triſtan d'Acunha, particularly near the ſetting of the ſun; and the ſword-fiſh likewiſe made its appearance occaſionally.—*Sir George Staunton's Account of the Embaſſy to China.*

TRITON, in zoology, a genus belonging to the order of vermes molluſca. The body is oblong ; the tongue is ſpiral ; it has twelve tentacula, ſix on each ſide, the hindmoſt ones having claws like a crab. There is but one ſpecies, found in holes of rocks about the ſhore.

TROTTER (Mrs Catharine), was the daughter of Captain David Trotter, a Scotch gentleman. He was a commander in the royal navy in the reign of Charles II. and at his death left two daughters, the youngeſt of whom, Catharine, our celebrated author, was born in London, Auguſt 1679. She gave early marks of her genius ; and learned to write, and alſo made herſelf miſtreſs of the French language, by her own application and diligence, without any inſtructor ; but ſhe had ſome aſſiſtance in the ſtudy of the Latin grammar and logic, of which latter ſhe drew up an abſtract for her own uſe. The moſt ſerious and important ſubjects, and eſpecially religion, ſoon engaged her attention.—But notwithſtanding her education, her intimacy with ſeveral families of diſtinction of the Romiſh perſuaſion, expoſed her, while very young, to impreſſions in favour of that church ; which not being removed by her conferences with ſome eminent and learned members of the church of England, ſhe embraced the Romiſh communion, in which ſhe continued till the year 1707. In 1695, ſhe produced a tragedy called *Agnes de Caſtro*, which was acted at the theatre-royal when ſhe was only in her 17th year. The reputation of this performance, and the verſes which ſhe addreſſed to Mr Congreve upon his Mourning Bride, in 1697, were probably the foundation of her acquaintance with that celebrated writer. Her ſecond tragedy, *Fatal Friendſhip*, was acted in 1698, at the new theatre in Lincoln's-Inn-Fields. This tragedy met with great applauſe, and is ſtill thought the moſt perfect of her dramatic performances. Her dramatic talents not being confined to tragedy, ſhe brought upon the ſtage, in 1701, a comedy called *Love at a loſs*, or *Moſt votes carry it.* In the ſame year ſhe gave the public her third tragedy, entitled the *Unhappy Penitent*, acted at the theatre royal in Drury-lane. But poetry and dramatic writing did not ſo far engroſs the thoughts of our author but that ſhe ſometimes turned them to ſubjects of a very different nature ; and diſtinguiſhed herſelf in an extraordinary manner in defence of Mr Locke's writings ; a female metaphyſician being a remarkable phenomenon in the republic of letters.

She returned to the exerciſe of her dramatic genius in 1703, and fixed upon the revolution of Sweden, under Guſtavus Erickſon, for the ſubject of a tragedy. This tragedy was acted, in 1706, at the Queen's theatre in the Hay-Market. In 1707, her doubts concerning the Romiſh religion, which ſhe had ſo many years profeſſed, having led her to a thorough examination of the grounds of it, by conſulting the beſt books on both ſides of the queſtion, and adviſing with men of the beſt judgment, the reſult was a conviction of the falſeneſs of the pretenſions of that church, and a return to that of England, to which ſhe adhered during the remainder of her life. In 1708, ſhe was married to the Rev. Mr Cockburn, then curate of St Dunſtan's in Fleet-ſtreet, but he afterwards obtained the living of Long-Horſely, near Morpeth in Northumberland. He was a man of conſiderable abilities ; and, among ſeveral other things, wrote an account of the Moſaic Deluge, which was much approved by the learned.

Mrs Cockburn's remarks upon ſome writers in the controverſy concerning the foundation of moral duty and moral obligation, were introduced to the world, in Auguſt 1743, in the Literary Journal, intitled *The Hiſtory of the Works of the Learned.* The ſtrength, clearneſs, and vivacity ſhewn in her remarks upon the moſt abſtract and perplexed queſtions, immediately raiſed the curioſity of all good judges about the concealed writer ; and their admiration was greatly increaſed when her ſex and advanced age were known. Dr Rutherforth's Eſſay on the Nature and Obligations of Virtue, publiſhed in May 1744, ſoon engaged her thoughts ; and notwithſtanding the aſthmatic diſorder which had ſeized her many years before, and now left her ſmall intervals of eaſe, ſhe applied herſelf to the confutation of that elaborate diſcourſe, and finiſhed it with a ſpirit, elegance, and perſpicuity equal, if not ſuperior, to all her former writings.

The loſs of her huſband in 1748, in the 71ſt year of his age, was a ſevere ſhock to her ; and ſhe did not long ſurvive him, dying on the 11th of May 1749, in her ampet arine.

71ſt year, after having long ſupported a painful diſorder with a reſignation to the Divine will, which had been the governing principle of her whole life, and her ſupport under the various trials of it.

Her works are collected into two large volumes 8vo, by Dr Birch; who has prefixed to them an account of her life and writings.

TRUMPET Marine, or Marigny. This is a ſtringed inſtrument, invented in the 16th century by an Italian artiſt Marino or Marigni, and called a *trumpet*, becauſe it takes only the notes of the trumpet, with all its omiſſions and imperfections, and can therefore execute only ſuch melodies as are fitted for that inſtrument. It is a very curious inſtrument, though of ſmall muſical powers, becauſe its mode of performance is totally unlike that of other ſtringed inſtruments; and it deſerves our very particular attention, becauſe it lays open the mechaniſm of muſical ſounds more than any thing we are acquainted with; and we ſhall therefore make uſe of it in order to communicate to our readers a philoſophical theory of muſic, which we have already treated in detail as a liberal or ſcientific art.

Plate XLV.

The trumpet marine is commonly made in the form of a long triangular pyramid, ABCD, fig. A. on which a ſingle ſtring EFG is ſtrained over a bridge F by means of the finger pin L. At the narrow end are ſeveral frets 1, 2, 3, 4, 5, &c. between E and K, which divide the length EF into aliquot parts. Thus E 1 is $\frac{1}{32}$ of EF, E 2 is $\frac{1}{31}$, and ſo on. The bow is drawn lightly acroſs the cord at H, and the ſtring is ſtopped by preſſing it with the finger immediately above the frets, but not ſo hard as to make it touch the fret. When the open ſtring is ſounded, it gives the fundamental note. If it be ſtopped, in the way now deſcribed, at $\frac{1}{3}$d of its length from E, it yields the 12th of the fundamental; if ſtopped at $\frac{1}{4}$th, it gives the double octave; if at $\frac{1}{5}$th, it gives the 17th major, &c. In ſhort, it always gives the note correſponding to the length of the part between the fret and the nut E. The ſounds reſemble thoſe of a pipe, and are indeed the ſame with thoſe known by the name *harmonics*, and now executed by every performer on inſtruments of the viol or violin ſpecies. But in order to increaſe the noiſe, the bridge F is conſtructed in a very particular manner. It does not reſt on the ſound-board of the inſtrument through its whole breadth, but only at the corner *a*, where it is firmly fixed. The other extremity is detached about $\frac{1}{100}$ of an inch from the ſound-board; and thus the bridge, being made to tremble by the ſtrong vibration of the thick cord, rattles on the ſound-board, or on a bit of ivory glued to it. The uſual way in which this motion is procured, is to have another ſtring paſſing under the middle of the bridge in ſuch a manner that, by ſtraining it tight, we raiſe the corner *b* from the ſound-board to the proper height. This contrivance increaſes prodigiouſly the noiſe of the inſtrument, and gives it ſomewhat of the ſmart ſound of the trumpet, tho' very harſh and coarſe. But it merits the attention of every perſon who wiſhes to know any thing of the philoſophy of muſical ſounds, and we ſhall therefore ſay as much on the ſubject as will conduce to this effect.

Galileo, as we have obſerved in the article Temperament, *Suppl.* was the firſt who diſcovered the real connection between mathematics and muſic, by demonſtrating that the times of the vibrations of elaſtic cords of the ſame matter and ſize, and ſtretched by equal weights, are proportional to the lengths of the ſtrings. He inferred from this that the muſical pitch of the ſound produced by a ſtretched cord depended ſolely on the frequency of the vibrations. Moreover, not being able to diſcover any other circumſtance in which thoſe ſounds phyſically reſembled each other, and reflecting that all ſounds are immediately produced by agitations of air acting on the ear, he concluded that each vibration of the cord produced a ſonorous pulſe in the air, and therefore that the pitch of *any* ſound whatever depended on the frequency of the aerial pulſes. In this way alone the ſound of a ſtring, of a bell, of an organ pipe, and the bellow of a bull, may have the ſame pitch. He could not, however, demonſtrate this in any caſe but the one above mentioned. But he was encouraged to hope that mathematicians would be able to demonſtrate it in all caſes, by his having obſerved that the ſame proportions obtained in organ pipes as in ſtrings ſtretched by equal weights. But it required a great progreſs in mechanical philoſophy, from the ſtate in which Galileo found it, before men could ſpeculate and reaſon concerning the pulſes of air, and diſcover any analogy between them and the vibrations of a ſtring. This analogy, however, was diſcovered, and its demonſtration completed, as we ſhall ſee by and by. In the mean time, Galileo's demonſtration of the vibrations of elaſtic cords became the foundation of all muſical philoſophy. It muſt be thoroughly underſtood before we can explain the performance of the trumpet marine.

Trumpet Marine.

The demonſtration of Galileo is remarkable for that beautiful ſimplicity and perſpicuity which diſtinguiſh all the writings of that great mechanician, and it is the elementary propoſition in all mechanical treatiſes on muſic. Few of them indeed contain any thing more; but it is extremely imperfect, and is juſt only on the ſuppoſition that all the matter of the ſtring is collected at its middle point, and that the reſt of it has elaſticity without *inertia*. This did not ſuit the accurate knowledge of the laſt century, after Huyghens and Newton had given the world a taſte of what might be done by proſecuting the Galilean mechanics. When a muſical cord has its middle point drawn aſide, and it is ſtrained into the ſhape of two ſtrait lines, if it be let go, it will be obſerved not to vibrate in this form. It may eaſily be ſeen in the extremity of its excurſions, where it reſts, before it return by its elaſticity. The reaſon is this (ſee fig. B.) When the middle point C of the cord is drawn aſide, and the cord has the form of two ſtraight lines AC, CB, this point C, being pulled in the directions CA, CB, at once, is really accelerated in the direction CD, which biſects the angle ACB; and if it were then detached from the reſt of the material cord, it would move in that direction. But any other point *f* between C and B has no accelerating force whatever acting on it. It is equally pulled in the directions *f* C and *f* B. The particle C therefore is obliged to drag along with it the inert matter of the reſt of the cord; and when it has come to any intermediate ſituation *c*, the cord cannot have the form of two ſtraight lines A *c*, *c* B, with the particle *f* ſituated in *f*. This particle will be left ſomewhat behind, as in φ, and the cord will have a curved form A *c* φ B; and in this form it will vibrate, going to the other ſide, and aſſuming, not the rectilineal form ADB, but the curved form

A δ B.

A *f* B. That every particle of the curve A $e\,c'f$ B is now accelerated toward the axis AB is evident, becauſe every part is curved, and the whole is ſtrained toward A and B, which tends to ſtraighten every part of it. But in order that the whole may arrive at the axis in one moment, and conſtitute a ſtraight line AB, it is evidently neceſſary that the accelerating force on every particle be as the diſtance of the particle from that point of the axis at which it arrives. It is well known to the mathematician that the accelerating force by which any particle is urged towards a rectilineal poſition, with reſpect to the adjoining particles, is proportional to the curvature. Our readers who are not familiar with ſuch diſcuſſions, may ſee the truth of this fundamental propoſition by conſidering the whole of A c B as only a particle or minute portion of a curve, magnified by a microſcope. The force which ſtrains the curve may be repreſented by c A or AE. Now it is well known (and is the foundation of Galileo's demonſtration) that the ſtraining force is to the force with which c is accelerated in the direction c E as A c to c D, or as AE to c D, or as AE to twice c E. Now c E is the meaſure of the curvature of A c B, being its deflection from a right line. Therefore when the ſtraining force is the ſame all over the curve, the accelerating force, by which any portion of it tends to become ſtraight, is proportional to the curvature of that portion. And if r be the radius of a circle paſſing through A, c, and B, and coinciding with this element of a curve, it is plain that $c\text{D} : c\text{A} = c\text{A} : r$, or that the radius of curvature is to the element c A as the extending force to the accelerating force; and $c\text{D} = \frac{c\text{A}^2}{r}$; and is inverſely as r, or directly as the curvature.

Hence we ſee the nature of that curve which a muſical chord muſt have, in order that all its parts may arrive at the axis at once. The curvature at c muſt be to the curvature at f as E c to $g\,f$. But this may not be enough. It is farther neceſſary that when c has got half way to E, the curvature in the different points of the new curve into which the cord has now arranged itſelf, be alſo, in every point, proportional to the diſtance from the axis. Now this *will* be the caſe if the extreme curve has been ſuch. For, taking the cord in any other ſucceſſive ſhape, the diſtance which each point has gone in the ſame moment muſt be proportional to the force which impelled it; therefore the remaining diſtances of all the points from the axis will have the ſame proportions as before. And the geometrical and evident conſequence of this is, that the curvatures will alſo be in the ſame proportion.

Therefore a cord that is once arranged in this form will always preſerve it, and will vibrate like a cycloidal pendulum, performing its oſcillations in equal times, whether they be wide or narrow. Therefore ſince this perfect iſochroniſm of vibrations is all that is wanted for preſerving the ſame muſical pitch or tone, this cord will always have the ſame note.

This propoſition was the diſcovery of Dr Brooke Taylor, one of the ornaments of our country *, and is publiſhed in his celebrated work *Methodus Incrementorum*. The inveſtigation, however, and the demonſtration in that work, are ſo obſcure and ſo tedious that few had patience to peruſe them. It was more elegantly treated afterwards by the Bernoullis and others. The curve got the name of the *Taylorean curve;* and is conſidered by many eminent mathematicians as a trochoid, *viz.* the curve deſcribed by a point in the nave or ſpoke of a wheel while the wheel rolls along a ſtraight line. But this is a miſtake, although it is allied to the trochoid in the ſame manner that the figure of ſines is allied to the cycloid. Its phyſical property intitles it to the name of the HARMONICAL CURVE. As this curve is not only the foundation of all our knowledge of the vibration of elaſtic cords, but alſo furniſhes an equation which will lead the mathematician through the whole labyrinth of aereal undulations, and be of uſe on many other occaſions; and as the firſt mathematicians have, through inattention, or through enmity to Dr Taylor, affected to conſider it as the trochoid already well known to themſelves—we ſhall give a ſhort account of its conſtruction and chief properties, ſimplified from the elegant deſcription given by Dr Smith in his Harmonics.

Let SDTV, QERP (fig. C.), be circles deſcribed round the centre C. Draw the diameters QCR, ECP, cutting each other at right angles. From any point G in the exterior circle draw the radius GC, cutting the interior circle in F, draw KHFI parallel to QCR, and make HI, HK, each equal to the arch EG. Let this be done for every point of the quadrantal arch EGR. The points I, K, are in the harmonic curve; that is, the curve AKDIB paſſing through the points K and I, determined by this conſtruction, has its curvature in every point K proportional to the diſtance KN from the baſe AB.

To demonſtrate this, draw FL perpendicular to the axis, and join EL. Take another point g in the outer circle indefinitely near to G. Draw $g\,c$, cutting the inner circle in f, and $f\,h$ and $f\,l$ perpendicular to DC, CT, and join E l. Then ſuppoſe two lines K m', K m' perpendicular to the curve in K and k. They muſt meet in m, the centre of the equicurve circle. Draw KN n' perpendicular to the baſe, and $m'\,n'$ parallel to it, and join $k\,n$ Laſtly, draw XL x perpendicular to EL.

It is plain that k O, the difference of HK and $h\,k$, is equal to G g, the difference of GE and g E, and that KO is equal to F r, and L l to $r\,f$. Alſo, becauſe ELX is a right angle, $\text{EX} = \frac{\text{EL}^2}{\text{EC}}$.

We have $\text{F}r : \text{F}f = \text{CL} : \text{CF}, = \text{CL} : \text{CD}.$
$\text{F}f : \text{G}g = \text{CD} : \text{CE}.$
Therefore $\text{F}r : \text{G}g$, or $\text{KO} : \text{O}k = \text{CL} : \text{CE}.$

The triangles ECL and kOK are therefore ſimilar, as are alſo kOK and K$n\,m$, and conſequently ECL and K$n\,m$; and becauſe EC is parallel to Kn, EL is parallel to Km. For the ſame reaſon $k\,m$ is parallel to El, and the triangles E$l\,x$ and mKk are ſimilar, and

$\text{L}x : \text{K}k = \text{LE} : \text{K}m,$
and $\text{L}x : \text{K}k = \text{EC} : \text{K}n.$ But farther,
$\text{L}x : \text{L}l = \text{CE} : \text{CL}$
$\text{L}l : \text{F}f = \text{KN} : \text{CD}$, being $= \text{FL} : \text{FC}$
$\text{F}f : \text{G}g = \text{CD} : \text{CE}$, being $= \text{F}f : k\text{O}$
$\text{G}g : \text{K}k = \text{CE} : \text{CL}$, being $= \text{KO} : \text{K}k.$
Therefore $\text{L}x : \text{K}k = \text{KN} \times \text{CE} : \text{EL}^2, = \text{KN} : \text{EX}.$
Therefore $\text{KN} : \text{EX} = \text{LE} : \text{K}m$, and $\text{K}m = \frac{\text{EX} \cdot \text{LE}}{\text{KN}}$,
and $\text{KN} : \text{EX} = \text{CE} : \text{K}n$, and $\text{K}n = \frac{\text{EX} \cdot \text{CE}}{\text{KN}}$.

In

---

* See his Life, Encycl

In the very narrow vibrations of muſical cords, CD is exceedingly ſmall in compariſon with CE, ſo that EX·EL, or EX·CE, may, without ſenſible error, be taken for CE^2, and then we obtain K*m* or K*n* (which hardly differ) $= \frac{CE^2}{KN}$, and therefore the curvature is proportional to KN. The ſmall deviation from this ratio would ſeem to ſhew that this conſtruction does not give the harmonic curve with accuracy. But it is not ſo. For it will be found that although the curvature is not as KN, it is ſtill proportional to the ſpace which any particle K muſt really deſcribe in order to arrive at the axis. Theſe paths are lines whoſe curvatures diminiſh as they approach to DC.

We ſee, *1ſt*, that the baſe ACB of the curve is equal to the ſemicircular arch QER.

2d, Alſo that the tangent KZ in any point K is perpendicular to EL.

3d. We learn that the curvature at A and B is nothing, for in theſe two points KN is nothing.

4th, The radius of curvature at D is preciſely $= \frac{CE^2}{CD}$.

Therefore, as the ſtring approaches the axis, and CD diminiſhes, the curvature diminiſhes in the ſame proportion. The vibrations therefore are performed like thoſe of a pendulum in a cycloid, and are iſochronous, whether wide or narrow, and therefore the muſical pitch is conſtant.

This is not ſtrictly true, becauſe in the wide vibrations the extenſion or extending force is ſomewhat greater. Hence it is that a ſtring when violently twanged ſounds a little ſharper at the beginning. Dr Long made a harpſichord whoſe ſtrings were ſtretched by weights, by which this imperfection was removed.

It is proper to exhibit the curvature at D in terms of the length AB, and of the greateſt excurſion *c* D. Therefore let *c* be the circumference of a circle whoſe diameter is 1. Let AB the length of the cord be = L, and let CD the $\frac{1}{2}$ breadth of the vibration be B.

We had a little ago $Dm = \frac{CE^2}{CD}$, but $c : 1 = AB : CE$, and $CE = \frac{AB}{c}$, and $cE^2 = \frac{ABc}{c^2}$. Therefore $Dm = \frac{AB^2}{c^2 \times CD}, = \frac{L^2}{9{,}87CD}$ nearly.

We can now tell the number of vibrations made in a ſecond by a ſtring. This we obtain by comparing its motion, when impelled by the accelerating force which acts on it, with its motion when acted on by its weight only. Therefore let L be the length of a ſtring, and W its weight, and let E be the ſtraining weight, or extending force. Let *f* be the force which accelerates the particle D *d* of the cord, and *w* the weight of that particle, while W is the weight of the whole cord. Let *z* be the ſpace which the particle D *d* would deſcribe during the time of one vibration by the uniform action of the force *f*, and let S be the ſpace which it would deſcribe in the ſame time by its weight *w* alone. Then (DYNAMICS, *Suppl.* n° 103. cor. 6) the time in which *f* would impel the particle D *d* along $\frac{1}{2}$ DC, is to the time of one vibration as $1 : c$. And $\frac{1}{2}$ DC is to *z* as the ſquare of the time of deſcribing $\frac{1}{2}$ DC, is to the ſquare of the time of deſcribing *z*; that is, $1 : c^2 = \frac{1}{2} DC : 2z$, and $c^2 . DC = 2z$.

Trumpet Marine.

Now, by the property of the harmonic curve,

$$AB : Dm = 2z : AB$$

But $Dm : Dd = E : f$

And $Dd : AB = w : W$

Therefore $2z \cdot E \cdot w = AB \cdot f \cdot W$

And $f : w = 2z \times E : AB \times W$

But $w : f = 2S : 2z$

Therefore $2S \times E = AB \times W$

And $2E : W = AB : S$.

That is, a muſical cord, extended by a force E, performs one vibration DCV in the time that a heavy body deſcribes a ſpace S, which is to the length of the cord as its weighr is to twice the extending force.

Now let *g* be the ſpace through which a heavy body falls in one ſecond, and ſet the time of a vibration (eſtimated in parts of a ſecond) be T. We have

$$AB : S = 2E : W$$

$$S : g = T^2 : 1^2$$

Therefore $AB : g = 2E \cdot T^2 : W$

And $AB \times W = T^2 \times 2E \times g$

Therefore $T^2 = \frac{AB \times W}{2g.E}$, and $T = \sqrt{\frac{AB \times W.}{2g.E}}$

Let *n* be the number of vibrations made in a ſecond,

$$n = \frac{1}{T}, = \sqrt{\frac{2g.E}{AB.W}} = \sqrt{\frac{2gE}{L.W}}.$$

If the length of the cord be meaſured in feet, 2 *g* is very nearly 32. If in inches, 2 *g* is 386, more nearly. Therefore $n = \sqrt{\frac{32E}{L \cdot W}}$ or $\sqrt{\frac{386E}{L \cdot W}}$. This may eaſily be compared with obſervation. Dr Smith hung a weight of 7 pounds, or 49,000 grains, on a braſs wire ſuſpended from a finger pin, and ſhortened it till it was in perfect uniſon with the double octave below the open ſtring D of a violin. In this ſtate the wire was 35,55 inches long, and it weighed 31 grains.

Now $\sqrt{\frac{384 \times 49000}{35{,}55 \times 31}} = 130{,}7 = n$. This wire, therefore, ought to make 130,7 vibrations in a ſecond. Dr Smith proceeded to aſcertain the number of aereal pulſes made by this ſound, availing himſelf of the theory of the beats of tempered conſonances invented by himſelf. On his fine chamber organ he tuned upwards the perfect fifths DA, A *e*, *e b*, and then tuned downward the perfect 6th *e d*. Thus he obtained an octave to D, which was too ſharp by a comma, and he found that it beat 65 times in 20 ſeconds. Therefore the number of vibrations was $\frac{65}{20}$ 81, or 263,25. Theſe were complete pulſes or motions from D to V and back again, and therefore contained $526\frac{1}{2}$ ſuch vibrations as we have now been conſidering. The double octave below ſhould make $\frac{1}{4}$th of this, or 131,6, which is not a complete vibration more than the above theory requires: more accurate coincidence is needleſs.

This theory is therefore very completely eſtabliſhed, and it may be conſidered as one of the fineſt mechanical problems which has been ſolved in this century. We mention it with the greater minuteneſs, becauſe the merit of Dr Taylor is not ſufficiently attended to. Mr Rameau, and the other great theoriſts in muſic, make no mention of him; and ſuch as have occaſion to ſpeak of the abſolute number of vibrations made by any muſical note, always quote Mr Sauveur of the French academy,

demy. This gentleman has written ſome very excellent diſſertations on the theory of muſic, and Sir Iſaac Newton in his *Principia* often quotes his authority. He has given the actual determination of the number of vibrations of the note C, obtained in a manner ſimilar to that practiſed by Dr Smith on his chamber organ, and which agrees extremely well with that meaſure. But Mr Sauveur has alſo given a mechanical inveſtigation of the problem, which gives the ſame number of vibrations that he obſerved. We preſume that Rameau and others took the demonſtration for good; and thus Mr Sauveur paſſes on the Continent for the diſcoverer of this theorem. But it was not publiſhed till 1716, though read in 1713; whereas Dr Taylor's demonſtration was read to the Royal Society in May 1714. But this demonſtration of Mr Sauveur is a mere paralogiſm, where errors compenſate errors; and the aſſumption on which he proceeds is quite gratuitous, and has nothing to do with the ſubject. Yet John Bernoulli, from enmity to Taylor and the Engliſh mathematicians, takes not the leaſt notice of this ſophiſticated demonſtration, accommodated to the experiment, and ſo devoid of any pretenſions to argument that this ſevere critic could not but ſee its falſity.

Sauveur was one of the firſt who obſerved diſtinctly that remarkable fact which Mr Rameau made the foundation of his muſical theory, *viz.* that a full muſical note is accompanied by its octave, its twelfth, and its ſeventeenth major. It had been caſually obſerved before, by Marſennus, by Perrault, and others; but Sauveur tells diſtinctly how to make the obſervation, and affirms it to be true in all deep notes. Rameau aſſerts it to be univerſally and neceſſarily true in all notes, and the foundation of all muſical pleaſure.

It had been diſcovered before this time, that not only a full note cauſed its uniſon to reſound, but alſo that a 12th, being ſounded near any open ſtring, the ſtring *reſounded* to this 12th. It does the ſame to a 15th, a 17th major, a 22d, &c.

Dr Wallis added a very curious circumſtance to this obſervation. Two of his pupils, Mr Noble and Mr Pigott, in 1673, amuſing themſelves with theſe reſonnances, obſerved, that if a ſmall bit of paper be laid on the ſtring of a violin which is made to reſound to its uniſon, the paper is thrown off: a proof that the ſtring reſounded by really vibrating, and that it is thrown into theſe vibrations by the pulſes of the air produced by the other ſtring. In like manner the paper is thrown off when the ſtring reſounds to its octave. But the young gentlemen obſerved, that when the paper was laid on the middle point of the ſtring, it remained without agitation, although the ſtring ſtill reſounded. They found the ſame thing when they made the ſtring reſound to its 12th: papers laid on the two points of diviſion lay ſtill, but were thrown off when laid on any other place. In ſhort, they found it a general rule, that papers laid on any points of diviſion correſponding to the note which was reſounded, were not agitated.

Dr Wallis (the greateſt theoriſt in muſic of the laſt century) juſtly concluded that theſe points of the reſounding ſtring were at reſt, and that the intermediate parts were vibrating, and producing the notes correſponding to their lengths.

From this Mr Sauveur, with great propriety, deduced the theory of the performance of the trumpet marine, the vielle, the clavichord, and ſome other inſtruments.

When the ſtring of the trumpet marine is gently ſtopped at $\frac{1}{2}$, and the bow drawn lightly acroſs it at H (fig. A), the full vibration at the finger is ſtopped; but the ſtring is thrown into vibrations of ſome kind, which will either be deſtroyed or may go on. It is of importance to ſee what circumſtance will permit their continuance.

Suppoſe an elaſtic cord put into the ſituation ABCDE (fig. D), ſuch that AB, BC, CD, DE, are all equal, and that BCD is a ſtraight line. Let the point C be made faſt, and the two points B and D be let go at once. It is evident that the two parts will immediately vibrate in two harmonical curves A*b*C and CDE, which will change to ABC and C*d*E, and ſo on alternately. It is alſo evident that if a line FCG be drawn touching the curve ABC, it will alſo touch the curve CDE; and the line which touches the curve A*b*C in C, will alſo touch the curve C*d*E. In every inſtant the two halves of the cord will be curves which have a common tangent in the point C. The undoubted conſequence of this is, that the point C will not be affected by theſe vibrations, and its fixure may be taken away. The cord will continue to vibrate, and will give the ſound of the octave to its fundamental note.

The condition, then, which muſt be implemented, in order that a ſtring may reſound to its octave, or take the ſound of its octave, is ſimply this, that its two parts may vibrate equally in oppoſite directions. This is evidently poſſible; and when the bow is drawn acroſs the ſtring of the trumpet marine at H, and irregular vibrations are produced in the whole ſtring, thoſe which happen to be in one direction on both ſides of the middle point, where it is gently ſtopped by the finger, will deſtroy each other, and the conſpiring ones will be inſtantly produced, and then every ſucceeding action of the bow will increaſe them.

The ſame thing muſt happen if a ſtring is gently ſtopped at one-third of its length; for there will be the ſame equilibrium of forces at the two points of diviſion, ſo that the fixures of theſe points may be removed, and the ſtring will vibrate in three parts, ſounding the 12th of the fundamental.

We may obſerve, by the way, that if the bow be drawn acroſs the ſtring at one of the points of diviſion, correſponding to the ſtopping at the other end of the ſtring, it will hardly give any diſtinct note. It rattles, and is intolerably harſh. The reaſon is plain: The bow takes ſome hold of the point C, and drags it along with it. The cord on each ſide of C is left behind, and therefore the two curves cannot have a common tangent at C. The vibrations into which it is thus jogged by the bow deſtroy each other.

We now ſee why the trumpet marine will not ſound every note. It will ſound none but ſuch as correſpond to a diviſion of the ſtring into a number of equal parts, and its note will be in uniſon with a ſtring equal to one of thoſe parts. Therefore it will *firſt* of all ſound the fundamental, by its whole length;

2. Its octave, correſponding to - $\frac{1}{2}$ its length
3. The 12th, - - - $\frac{1}{3}$
4. The 15th, or double octave, - $\frac{1}{4}$
5. The 17th, - - - $\frac{1}{5}$
6. The 19th, - - - $\frac{1}{6}$

7. The

7. The 21ſt, which is not in the diatonic ſcale of our muſic, - $\frac{1}{7}$ its length.
8. The triple octave, or 22d, - $\frac{1}{8}$
9. The 23d, or 2d in the ſcale of the triple octave - - - $\frac{1}{9}$
10. The 24th, or 3d in this ſcale, $\frac{1}{10}$
11. The 25th, a falſe 4th of this ſcale, $\frac{1}{11}$
12. The 26th, a perfect 5th of this ſcale, $\frac{1}{12}$
13. The 27th, a falſe 6th of ditto, $\frac{1}{13} = \frac{3}{39}$ or $\frac{3}{40}$
14. The 28th, a falſe 7th minor, - $\frac{1}{14}$
15. The 28th, a perfect 7th major, $\frac{1}{15}$
16. The quadruple octave, - $\frac{1}{16}$

Thus we ſee that this inſtrument will not execute all muſic, and indeed will not complete any octave, becauſe it will neither give a perfect 4th nor 6th. We ſhall preſently ſee that theſe are the very defects of the trumpet.

This ſingular ſtringed inſtrument has been deſcribed in this detail, chiefly with the view of preparing us for underſtanding the real trumpet. The **Vielle, Savoyarde**, or **Hurdygurdy**, performs in the ſame manner. While the wheel rubs one part of the ſtring like a bow, the keys gently preſs the ſtrings, in points of aliquot diviſion, and produce the harmonic notes.

It is to prevent ſuch notes that the part of harpſichord wires, lying between the bridge and the pins, are wrapped round with liſt. Theſe notes would frequently diſturb the muſic.

Laſtly on this head, the Æolian harp derives its vaſt variety of fine ſounds from this mode of vibration. Seldom do the cords perform their fundamental or ſimple vibrations. They are generally ſounding ſome of the harmonies of their fundamentals, and give us all this variety from ſtrings tuned in uniſon.

Trumpet, Muſical, is a wind inſtrument which ſounds by preſſing the cloſed lips to the ſmall end, and forcing the wind through a very narrow aperture between the lips. This is one of the moſt ancient of muſical inſtruments, and has appeared in all nations in a vaſt variety of forms. The conch of the ſavage, the horn of the cowherd and of the poſtman, the bugle horn, the lituus and tuba of the Romans, the military trumpet, and the trombone, the *cor de chaſſe* or French horn—are all inſtruments winded in the ſame manner, producing their variety of tones by varying the manner and force of blowing. The ſerpent is another inſtrument of the ſame kind, but producing part of its notes by means of holes in the ſides.

Although the trumpet is the ſimpleſt of all muſical inſtruments, being nothing but a long tube, narrow at one end and wide at the other, it is the moſt difficult to be explained. To underſtand how ſonorous and regulated undulations can be excited in a tube without any previous vibration of reeds to form the waves at the entry, or of holes to vary the notes, requires a very nice attention to the mechaniſm of aereal undulations, and we are by no means certain that we have as yet hit on the true explanation. We are certain, however, that theſe aereal undulations do not differ from thoſe produced by the vibration of ſtrings; for they make ſtrings reſound in the ſame manner as vibrating cords do. Galileo, however, did not know this argument for his aſſertion that the muſical pitch of a pipe, like that of a cord, depended on the frequency alone of the aereal undulations; but he thought it highly probable, from his obſervations on the ſtructure of organs, that the notes of pipes were related to their lengths in the ſame manner as thoſe of wires, and he expreſsly makes this remark. Newton, having diſcovered that ſound moved at the rate of about 960 feet per ſecond, obſerved that, according to the experiments of Mr Sauveur, the length of an open pipe is half the length of an aereal pulſe. This he could eaſily aſcertain by dividing the ſpace deſcribed by ſound in a ſecond by the number of pulſes.

Daniel Bernoulli, the celebrated promoter of the Newtonian mechanics, diſcovered, or at leaſt was the firſt who attentively marked, ſome other circumſtances of reſemblance between the undulations of the air in pipes and the vibrations of wires. As a wire can be made, not only to vibrate in its full length, ſounding its fundamental note, but can alſo be made to ſubdivide itſelf, and vibrate like a portion of the whole, with points of reſt between the vibrating portions, when it gives one of its harmonic notes; ſo a pipe cannot only have ſuch undulations of air going on within it as are competent to the production of its fundamental note, but alſo thoſe which produce one of its harmonic notes. Every one knows that when we force a flute, by blowing too ſtrongly, it quits its proper note, and gives the octave above. Forcing ſtill more, produces the 12th. Then we can produce the double octave or 15th, and the 17th major, &c. In ſhort, by attending to ſeveral circumſtances in the manner of blowing, all the notes may be produced from one very long pipe that we produce from the trumpet marine, and in preciſely the ſame order, and with the ſame omiſſions and imperfections. This alone is almoſt equivalent to a proof that the mechaniſm of the undulations of air in a pipe are analogous to that of the vibrations of an elaſtic cord. Having with ſo great ſucceſs inveſtigated the mechaniſm of the partial vibrations of wires, and alſo another kind of vibrations which we ſhall mention afterwards, incomparably more curious and more important in the philoſophy of muſical ſounds, Mr Bernoulli undertook the inveſtigation of thoſe more myſterious motions of air which are produced in pipes; and in a very ingenious diſſertation, publiſhed in the Memoirs of the Academy of Paris for 1762, &c. he gives a theory of them, which tallies in a wonderful manner with the chief phenomena which we obſerve in the wind inſtruments of the flute and trumpet kind. We are not, however, ſo well ſatisfied with the truth of his *aſſumptions* reſpecting the ſtate of the air, and the preciſe form of the undulations which he aſſigns to it; but we ſee that, notwithſtanding a probability of his being miſtaken in theſe circumſtances (it is with great deference that we preſume to ſuppoſe him miſtaken), the chief propoſitions are ſtill true; and that the changes from note to note muſt be produced in the order, tho' perhaps not in the preciſe manner, aſſigned by him.

It is by no means eaſy to conceive, with clearneſs, the way in which muſical undulations are excited in the various kinds of trumpets. Many who have reputation as mechanicians, ſuppoſe that it is by means of vibrations of the lips, in the ſame manner as in the hautboy, clarionette, and reed pipes of the organ, where the air, ſay they, is put in motion by the trembling reed. But this explanation is wrong in all its parts; even in the reed-pipes of an organ, the air *is not* put in motion by the reeds. They are indeed the *occaſions* of its muſical undulation, but they do not *immediately impel* it into thoſe waves. This method (and indeed all methods but the vibrations of wires, bells, &c.) of producing ſound is little underſtood, though it is highly worthy of notice, being the origin of animal voice, and becauſe a knowledge of it would enable the artiſts to entertain us with ſounds hitherto unknown, and thus add conſiderably to this gift of our Bountiful Father, who has ſhewn, in the ſtructure of the larynx of the human ſpecies, that he intended that we ſhould enjoy the pleaſures of muſic as a *laborum dulce lenimen*. He has there placed a micrometer apparatus, by which *after* the other muſcles have done their part in bringing the glottis nearly to the tenſion which the intended note requires, we can eaſily, and inſtantly, adjuſt it with the utmoſt nicety.

We truſt, therefore, that our readers will indulge us while we give a very curſory view of the manner in which the tremulous motion of the glottis, or of a reed in an organ pipe, produces the ſonorous undulations with a conſtant or uniform frequency, ſo as to yield a muſical note.

If we blow through a ſmall pipe or quill, we produce only a whizzing or hiſſing noiſe. If, in blowing, we ſhut the entry with our tongue, we hear ſomething like a ſolid blow or tap, and it is accompanied with ſome faint perception of a muſical pitch, juſt as when we tap with the finger on one of the holes of a flute when all the reſt are ſhut. We are then ſenſible of a difference of pitch according to the length of the pipe; a longer pipe or quill giving a graver ſound. Here, then, is like the *beginning* of a ſonorous undulation. Let us conſider the ſtate of the air in the pipe: It was filled by a column of air, which was moving forward, and would have been ſucceeded by other air in the ſame ſtate. This air was therefore nearly in its ſtate of natural denſity. When the entry is ſuddenly ſtopped by the tongue, the included air, already in motion, continues its motion. This it cannot do without growing rarer, and then it is no longer a balance for the preſſure of the atmoſphere. It is therefore retarded in its motion, totally ſtopped (being in a rarefied ſtate), and is then preſſed back again. It comes back with an accelerated motion, and recovers its natural denſity, while the ſtate of rarefaction goes forward through the open air like any other aereal pulſe. Its motions are ſomewhat, but not altogether, like that of a ſpiral wire, which has been in like manner moving uniformly along the pipe, and has been ſtopped by ſomething catching hold of its hindermoſt extremity. This ſpring, when thus catched behind, ſtretches itſelf a little, then contracts *beyond* its natural ſtate, and then expands again, quivering ſeveral times. It can be demonſtrated that the column of air will make but one quiver. Suppoſe this accompliſhed in the hundredth part of a ſecond, and that at that inſtant the tongue is removed for the hundredth part of a ſecond, and again applied to the entry of the pipe. It is plain that this will produce ſuch another pulſe, which will join to the former one, and force it out into the air, and the two pulſes together will be like two pulſes produced by the vibration of a cord. If, inſtead of the tongue, we ſuppoſe the flat plate of an organ-reed to be thus alternately applied to the hole and removed, at the exact moments that the renewals of air are wanted, it is plain that we ſhall have *ſonorous* undulations of *uniform* frequency, and therefore a muſical note. This is the way in which reeds produce their effect, not by *impelling* the air into alternate ſtates of motion to and fro, and alternate ſtrata of rarefied and condenſed air, but by giving them time to acquire this ſtate by the combination of the air's elaſticity with its progreſſive motion.

The adjuſtment of the ſucceeding puff of air to the pulſe which precedes it, ſo that they may make one ſmooth and regular pulſe, is more exact than we have yet remarked; for the ſtoppage of the hole not only *occaſions* a rarefaction *before it*, but by checking the air which was juſt going to enter, makes a condenſation *behind the door* (ſo to ſpeak); ſo that, when the paſſage is again opened, the two parcels of air are fitted for ſupporting each other, and forming one pulſe.

Suppoſe, in the next place, that the reed, inſtead of completely ſhutting the hole each time, only half ſhuts it. The ſame thing muſt ſtill happen, although not in ſo remarkable a degree. When the paſſage is contracted, the ſupply is diminiſhed, and the air now in the pipe muſt rarefy, by advancing with its former velocity. It muſt therefore retard; by retarding, regain its former denſity; and the air, not yet got into the pipe, muſt condenſe, &c. And if the paſſage be again opened or enlarged in the proper time, we ſhall have a complete pulſe of condenſed and rarefied air; and this muſt be accompanied by the beginning of a muſical note, which may be continued like the former.

This will be a ſofter or more mellow note than the other; for the condenſed and rarefied air will not be ſo ſuddenly changed in their denſities. The difference will be like the difference of the notes produced by drawing a quill along the teeth of a comb, and that produced by the equally rapid vibrations of a wire. For let it be remarked here, that muſical notes are by no means confined, as theoriſts commonly ſuppoſe, to the regular cycloidal agitations of air, ſuch as are produced by the vibrations of an elaſtic cord; but that any crack, ſnap, or noiſe whatever, when repeated with ſufficient frequency, becomes *ipſo facto* a muſical ſound, of which we can tell the pitch or note. What can be leſs muſical than the ſolitary cracks or ſnaps made by a ſtiff door when very ſlowly opened? Do this briſkly, and the creak changes to a chirp, of which we can tell the note. The ſounds will be harſh or ſmooth, according as the ſnaps of which they are compoſed are abrupt or gradual.

This diſtinction of ſounds is moſt ſatisfactorily confirmed by experiment. If the tongue of the organ reed is quite flat, and if, in its vibrations, it apply itſelf to the whole margin of the hole at once, ſo as completely to ſhut it (as is the caſe in the oldfaſhioned regal ſtop of the organ), the note is clear, ſmart, and harſh or hard: but if the lips of the reed are curved, or the tongue properly bent backward, ſo that it applies itſelf to the edges of the hole *gradatim*, and never completely ſhuts the paſſage, the note may have any degree of mellow ſweetneſs. This remark is worth the attention of the inſtrument-makers or organ builders, and enables them to vary the VOICE of the organ at pleaſure. We only mention it here as introductory to the explanation of the ſounds of the trumpet.

We truſt that the reader now perceives how the air, proceeding along a pipe, may be put in the ſtate of alternate ſtrata of condenſed and rarefied air, the particles, in the mean time, proceeding along the pipe with a very moderate velocity; while the *ſtate of undulation* is propagated at the rate of eleven or twelve hundred feet in a ſecond; juſt as we may ſometimes ſee a ſtream of water gliding gently down a canal, while a wave runs along its ſurface with much greater rapidity.

It will greatly aſſiſt the imagination, if we compare theſe aërial undulations with the undulations of water in an open canal. While the water is flowing ſmoothly along, ſuppoſe a ſluice to be thruſt up from the bottom quite to the ſurface, or beyond it. This will immediately cauſe a depreſſion on the lower ſide of the ſluice, by the water's going along the canal, and a heaping up of the water on the other ſide. By properly timing the motion of this ſluice up and down, we can produce a ſeries of connected waves. If the ſluice be not puſhed up to the ſurface but only one-half way, there will be the ſame ſucceſſion of waves, but much ſmoother, &c. &c.

It is in this ſtate, though not by ſuch means, that the air is contained in a ſounding trumpet. It is not brought into this ſtate by any tremor of the lips. The trumpeter ſometimes feels ſuch a tremor; but whenever he feels it, he can no longer ſound his note. His lips are painfully tickled, and he muſt change his manner of winding.

When blowing with great delicacy and care, the deepeſt notes of a French horn, or trombone, we ſometimes can feel the undulations of the air in the pipe diſtinctly fluttering and beating againſt the lips; and it is difficult to hinder the lips from being affected by it: but we feel plainly that it is not the lips which are fluttering, but the air before them. We feel a curious inſtance of this when we attempt to whiſtle in concert. If our accompanier intonates with a certain degree of incorrectneſs, we feel ſomething at our own lips which makes it impoſſible to utter the intended note. This happens very freqnently to the perſon who is whiſtling the upper note of a greater third. In like manner, the undulations in a pipe react on the reed, and check its vibrations. For if the dimenſions of a pipe are ſuch that the undulations formed by the reed cannot be kept up in the pipe, or do not ſuit the length of the pipe, the reed will either not play at all, or will vibrate only in ſtarts. This is finely illuſtrated by a beautiful and inſtructive experiment. Take a ſmall reed of the *vox humana* ſtop of an organ, and ſet it in a glaſs foot, adapted to the windbox of the organ. Inſtead of the common pipe above it, fix on it the ſliding tube of a ſmall teleſcope. When all the joints are thruſt down, touch the key, and look attentively to the play of the reed. While it is ſounding, draw out the joints, making the pipe continually longer. We ſhall obſerve the reed thrown into ſtrange fits of quivering, and ſometimes quite motionleſs, and then thrown into wide ſonorous vibrations, according as the *maintainable* pulſe is commenſurate or not with the vibrations of the reed. This plainly ſhews that the air is not impelled into its undulations by the reed, but that the reed accommodates itſelf to the undulations in the pipe.

We acknowledge that we cannot explain with diſtinctneſs in what manner the air in a trumpet is firſt put into muſical undulations. We ſee that it is only in very long and ſlender tubes that this can be done. In ſhort tubes, of conſiderable diameter, like the cowherd's horn, we obtain only one or two very indiſtinct notes, of which it is difficult to name the pitch; and this requires great force of blaſt; whereas, to bring out the deep notes of the French horn, a very gentle and well regulated blaſt is neceſſary. The form of the lips, combined with the force of the blaſt, form all the notes. But this is in a way that cannot be taught by any deſcription. The performer learns it by habit, and *feels* that the inſtrument leaps into its note without him, when he gradually varies his blaſt, and continues ſounding the ſame note; although he, in the mean time, makes ſome ſmall change in his manner of blowing. This is owing to what Mr Bernoulli obſerved. The tube is ſuited only to ſuch pulſes, and can only maintain ſuch pulſes as correſpond to aliquot parts of its length; and when the embouchure is very nearly, but not accurately, ſuited to a particular note, that note *forms itſelf* in the tube, and, reacting on the lips, brings them into the form which can maintain it with eaſe. We have a proof of this when we attempt to ſound the note correſponding to one ſeventh of the length. Not having a diſtinct notion of this note, which makes no part of our ſcale of melody, we cannot eaſily prepare for it in the way that habit teaches us to prepare for the others: whereas, from what we ſhall ſee preſently, the notes *one-ſixth* and *one eighth* are both familiar to the mind, and eaſily produced. When, therefore, we attempt to produce the note *one-ſeventh*, we ſlide, againſt our will, into the *one ſixth* or *one-eighth*.

Nor can we completely illuſtrate the formation of muſical pulſes by waves in water. A canal is equally ſuſceptible of every height and length of progreſſive waves; whereas we ſee that a certain length of tube will maintain only certain determined pulſes of air.

We muſt therefore content ourſelves for the preſent with having learned, by means of the reed pipes, how the air may exiſt progreſſively in a tube, in an alternate ſtate of condenſation and rarefaction; and we ſhall now proceed to conſider how this ſtate of the air is related to the length of the tube. And here we can do no more than give an outline of Mr Bernoulli's beautiful theory of flutes and trumpets, but without a mathematical examination of the particular motions. We can, however, ſhew, with ſufficient evidence, how the different notes are produced from the ſame tube. It requires, however, a very ſteady attention from the reader to enable him to perceive how the different portions of this air act on each other. We truſt that this will now be given.

The conditions which muſt be implemented, in order to maintain a muſical pulſe, are two: 1. That the vibrations of the different plates of air be performed in equal times, otherwiſe they would all mix and confound each other. 2. That they move all together, all beginning and all ending at the ſame inſtant. It does not appear that any other ſtate of vibration can exiſt and be maintained.

The column of air in a tube may be conſidered as a material ſpring (having weight and inertia). This ſpring is compreſſed and coiled up by the preſſure of the atmoſphere. But in this coiled ſtate it can vibrate in its different parts, as a long ſpiral wire may do, though preſſed a little together at the ends. It is evident that the air within a pipe, ſhut at both ends, may be placed in ſuch a ſituation, *in a variety of ways*, that it will vibrate in every part, in the ſame manner as a chord of the ſame length and weight, ſtrained by a force equal to the preſſure of the atmoſphere. Thus, in the ſhut pipe AB (fig. 1.), ſuppoſe a harmonic curve ACB, or

Plate XLV.

a wire of the ſame weight with the air, throwing itſelf into the form of this curve. The force which impels the point C to the axis is to that which impels the point c as CE to $c\,e$. Now, ſuppoſe the air in this pipe divided into parallel ſtrata or plates, croſſing the tube like diaphragms. In order that theſe may vibrate in the ſame manner (not acroſs the tube, but in the direction of its axis), all that is neceſſary for the moment is, that the exceſs of the preſſure of the ſtratum $d\,d$ above that of the ſtratum $f\,f$ may be to the exceſs of the preſſure of DD above that of FF as $c\,e$ to CE. In this caſe, the ſtratum $c\,e$ will be accelerated in the direction $e\,f$, and the ſtratum EE is accelerated in the ſame direction, and in the due proportion. Now this may be done in an infinite variety of ways for a ſingle moment. It depends, not on the abſolute denſity, but on the *variation* of denſity; becauſe the preſſure by which a particle of air is urged in any direction ariſes from the *difference* of the diſtances of the adjoining particles on each ſide of it. But in order to *continue* this vibration, or in order that it may obtain at once in the whole pipe, this variation of denſity muſt continue, and be according to ſome connected law. This circumſtance greatly limits the ways in which the vibration may be kept up. Mr Bernoulli finds that the iſochroniſm and ſynchroniſm can be maintained in the following manner, and in no other that he could think of:

Let AB (fig. 2.) be a cylindrical pipe, ſhut at A, and open at B. Then, in whatever manner the ſound is produced in the pipe, the undulations of the contained air muſt be performed as follows: Let $a\,a$ be a plate of air. This plate will approach to, and recede from, the ſhut end A, vibrating between the ſituations $b\,b$ and $c\,c$, the whole vibration being $b\,c$, and the plate will vibrate like a pendulum in a cycloid. The greater we ſuppoſe the excurſions $a\,b$, $a\,c$, the louder will the ſound be; but the duration of them all muſt be the ſame, to agree with the fact that the tone remains the ſame. The motion will be accelerated in approaching to $a\,a$ from either ſide, and retarded in the receſs from it. Let us next conſider a plate $\alpha\,\alpha$, more remote from A. It muſt make ſimilar vibrations from the ſituation $\beta\,\beta$ to the ſituation $\gamma\,\gamma$. But theſe vibrations muſt be greater in proportion as the plate is farther from A. It cannot be conceived otherwiſe: For ſuppoſe the plate $\alpha\,\alpha$ to make the *ſame* excurſions with $a\,a$, and that the reſt do the ſame. Then they will all retain the ſame diſtances from each other; and thus there will be no force whatever acting on any particles to make them vibrate. But if every particle make excurſions proportional to its diſtance from A, the *variation* of denſity will, in any inſtant, be the ſame through the whole pipe, and each particle in the vibrating plate $\beta\,\beta$ will be accelerated or retarded in proportion to its diſtance from A; while the accelerations and retardations over all will, in any inſtant, be proportional to the diſtance of each particle from its place of reſt. All this will appear to the mathematician, who attentively conſiders any momentary ſituation of the particles. In this manner all the particles will ſupport each other in their vibrations.

It follows from this deſcription that the air in the tube is alternately rarefied and condenſed. But theſe changes are very different in different parts of the tube. They muſt be greateſt of all at A; becauſe, while all the plates approach to A, they concur in condenſing the air immediately adjoining to A; while the air in $a\,a$ and $\alpha\,\alpha$ is leſs condenſed by the action of the plates beyond it. The air at B is always of its natural denſity, being in equilibrio with the ſurrounding air. At B, therefore, there is a ſmall parcel of air, of its natural denſity, which is alternately going in and out.

This account is confirmed by many facts. If the bottom of the pipe be ſhut by a fine membrane, ſtretched acroſs it like a drum-head, with a wire ſtretched over it, either externally or internally, in the ſame manner as the catgut is ſtretched acroſs the bottom of a drum, it will be thrown into ſtrong vibrations, making a very loud noiſe, by rattling againſt the croſs wire. The ſame thing happens if the membrane be paſted over a hole cloſe to the bottom, leaving a ſmall ſpace round the edge of the hole without paſte, ſo that the membrane may play out and in, and rattle on the margin of the hole. This alſo makes a prodigious noiſe. Now, if the membrane be paſted on a hole far from the bottom, the agitations will be much fainter; and when the hole is near the mouth of the pipe, there will be none.—When a pipe has its air agitated in this manner, it is giving the loweſt note of which it is ſuſceptible.

Let us next conſider a pipe open at both ends. Let CB (fig. 3.) be this pipe. It is plain that, if there be a partition A in the middle, we ſhall have two pipes AB, AC, each of which may undulate in the manner now deſcribed, if the undulations in each be in oppoſite directions. It is evidently poſſible, alſo, that theſe undulations may be the ſame in point of ſtrength in both, and that they may begin in the ſame inſtant. In this caſe, the air on each ſide of the partition will be in the ſame ſtate, whether of condenſation or rarefaction, and the partition A itſelf will always be in equilibrio. It will perfectly reſemble the point C of the muſical cord BFCGH (fig. 6.), which is in equilibrio between the vibrating forces of its two parts. In the pipe, the plates of air on each ſide are either both approaching it, or both receding from it, and the partition is either equally ſqueezed from both ſides, or equally drawn outwards. Conſequently this partition may be removed, and the parcels of air on each ſide will, in any inſtant, ſupport each other. There ſeems no other way of conceiving theſe vibrations in open pipes which will admit of an explanation by mechanical laws. The vibrations of all the plates muſt be obtained without any mutual hinderance, in order to produce the tone which we really hear; and therefore ſuch vibrations are impreſſed by Nature on each plate of air.

But if this explanation be juſt, it is plain that this pipe CB muſt give the ſame note with the pipe AB (fig. 2.) of half the length, ſhut at one end. But the ſound, being doubled, with perfect conſonance, muſt be clear, ſtrong, and mellow. Now this is perfectly agreeable to obſervation; and this fact is an unequivocal confirmation of the juſtneſs of the theory. If we take a ſlender pipe, about ſix inches long and one half of an inch wide, ſhut at one end, and ſound it by blowing acroſs its mouth, as we whiſtle on the pipe of a key, or acroſs a hole that is cloſe to the mouth, and formed with an edge like the ſound-hole of a German flute, we ſhall get a very diſtinct and clear tone from it. If we now take a pipe of double the length, open at both ends, and blow acroſs its mouth, we obtain the ſame note, but more clear and ſtrong. And the note produced by blowing acroſs the mouth is not changed by a hole made exactly in the middle, in reſpect of its muſical pitch, although it is greatly hurt in point of clearneſs and ſtrength. Alſo a membrane at this hole is ſtrongly agitated. All this is in perfect conformity to this mechaniſm.

Thus we have, in a great meaſure, explained the effect of an open and a ſhut pipe. The ſhut pipe is always an octave graver than an open pipe of the ſame length; becauſe the open pipe is in uniſon with a ſhut pipe of half the length.

Let AC (fig. 4.) be a pipe ſhut at both ends. We may conſider it as compoſed of two pipes AB, BC, ſtopped at A and C, and open at B. Undulations may be performed in each half, preciſely as in the pipe AB of fig. 2.; and they will not, in the ſmalleſt degree, obſtruct each other, if we only ſuppoſe that the plates in each half are vibrating at once in the *ſame* direction. The condenſation in AB will correſpond with the rarefaction in BC, and the middle parcel B will maintain its natural denſity, vibrating to, and again acroſs the middle; and two plates $a\,a$, $\alpha\,\alpha$, which are equally diſtant from B, will make equal excurſions in the ſame direction.

We may produce ſound in this pipe by making an opening at B. Its note will be found to be the ſame with that of BC of fig. 2. or of AB of fig. 2.

In the next place, let a pipe, ſhut at one end, be conſidered as divided into any odd number of equal parts, and let them be taken in pairs, beginning at the ſtopped end, ſo that there may be an odd one left at the open end. It is plain that each of theſe pairs may be conſidered as a pipe ſtopped at both ends, as in fig. 4.

For the partitions will, of themſelves, be in equilibrio, and may be removed, and vibrations may be maintained in the whole, conſiſtent with the vibration of the odd part at the open end; and theſe vibrations will all ſupport each other, and the plates of air which are at the points of diviſion will remain at reſt. Conceive the pipe AB of fig. 2. to be added to the pipe AC of fig. 4. the part A of the firſt being joined to A of the other. Now, ſuppoſe the vibrations to be performed in both, in ſuch a manner that the ſimultaneous undulations on each ſide of the junction may be in oppoſite directions. It is plain that the partition will be in equilibrio, and may be removed; and the plate of air will perform the ſame office, being alternately the middle plate of a condenſed and of a rarefied parcel of air. The two pipes CA, AB will together give the ſame note that AB would have given alone, but louder.

In like manner may another pipe, equal to AC, be joined to the ſhut end of this compound pipe, as in fig. 5. and the three will ſtill give the ſame note that AB would have done alone.

And in the ſame manner may any number of pipes, each equal to AC, be added, and the whole will give ſtill the ſame note that AB would have given alone.

Hence it legitimately follows, that if the undulations can be once begun in this manner in a pipe, it may give either the ſound competent to it, as a ſingle pipe AB (fig. 2.); or it may give the ſound competent to a pipe of $\frac{1}{3}$d, $\frac{1}{5}$th, $\frac{1}{7}$th, &c. of its length; the undulations in each part AB, BC, CD, maintaining themſelves in the manner already deſcribed. This ſeems the only way in which they can be preſerved, both iſochronous and ſynchronous.

It is known that the graveſt tones of pipes are as the lengths of the pipes, or the frequency of the undulations are inverſely as their lengths. (This will be *demonſtrated* preſently). Therefore theſe acceſſory tones ſhould be as the odd numbers 3, 5, 7, &c. and the whole tones, including the fundamental, ſhould form the progreſſion of the odd numbers 1, 3, 5, 7, &c.

This is abundantly confirmed by experiment. Take a German flute, and ſtop all the finger-holes. The flute, by gradually forcing the blaſt, will give the fundamental, the 12th, the 17th, the 21ſt, &c. (A).

Again, let AD (fig. 6.) repreſent the length of a pipe. Conſtruct on AD an harmonic curve AEBFCGHD, in ſuch a manner that HD may be $\frac{1}{2}$ AB, $= \frac{1}{2}$ BC, $= \frac{1}{2}$ CH. The ſmall ordinates $m\,n$ will expreſs the total excurſion of the plates of air at the points m, m, &c. and thoſe ordinates which are above the axis will expreſs excurſions on one ſide of the place of reſt, and the ordinates below will mark the excurſions in the oppoſite directions, in the ſame manner as if this harmonic curve were really a vibrating cord. Theſe excurſions are nothing in the points A, B, C, H, and are greateſt at the points E, F, G, D, where the little maſs of air retains its natural denſity, and travels to and again, condenſing the air at B, or rarefying it, according as the parcels E and F are approaching to or receding from each other. The points A, B, C, H, may be called NODES, and the parts E, F, G, D, may be called BIGHTS or LOOPS. This repreſents very well to the eye the motion of the plates of air. The denſity and velocity need not be minutely conſidered at preſent. It is enough that we ſee that when the denſity is increaſing at A, by the approach of the parcel E, it is diminiſhing at B by the receſs of E and F; and increaſing at C, by the approach of F and G, and diminiſhing at H, by the receſs of G. In the next vibration it will be diminiſhing at A and C, and increaſing at B and H. And thus the alternate nodes will be in the ſame ſtate, and the adjoining nodes in oppoſite ſtates.

The reader muſt carefully diſtinguiſh this motion from

(A) A little reflection will teach us that theſe tones will not be perfectly in the ſcale. A certain proportion between the diameter and length of the pipe produces a certain tone. Making the pipe wider or ſmaller flattens or ſharpens this tone a little, and alſo greatly changes its clearneſs. Organ builders, who have tried every proportion, have adopted what they found beſt. This requires the diameter to be about $\frac{1}{11}$th or $\frac{1}{12}$th of the length. Therefore, when we cauſe the ſame pipe to ſound different notes, we neglect this proportion; and the notes are falſe, and even very coarſe, when we produce one correſponding to a very ſmall portion of the pipe. For a ſimilar reaſon, Mr Lambert found that, in order to make his pitch pipe ſound the octave to any of its notes, it was not ſufficient to ſhorten its capacity one-half by puſhing down the piſton; he found that the part remaining muſt be leſs than the part taken off by a fixed quantity $1\frac{5}{11}$ inches. Or, the length which gave any note being x, the length for its octave muſt be $\frac{x - 1\frac{5}{11}}{2}$.

Muſical Trumpet.

from the undulatory motion of a pulſe, inveſtigated by Newton, and deſcribed in the article ACOUSTICS, *Encycl.* That undulation is going on at the ſame time, and is *a reſult* of what we are now conſidering, and the cauſe of our hearing this undulation. The undulation we are now conſidering is the original agitation, or rather it is the SOUNDING BODY, as much as a vibrating ſtring or bell is; for it is not the trumpet that we hear, but the air trembling in the trumpet. The trumpet is performing the office, not of the ſtring, but of the pin and bridge on which the ſtring is ſtrained. This is an important remark in the philoſophy of muſical ſounds.

There is yet another ſet of notes producible from a pipe beſides thoſe which follow in the order of frequency 1, 3, 5, 7, &c.

Suppoſe a pipe open at both ends, ſounding by blowing acroſs the end, and undulating, as already deſcribed, with a node in the middle A (fig. 3.) If we ſtill expreſs the fundamental note of the pipe AB of fig. 2. by 1, it is plain that the fundamental of an open pipe of the ſame length will have the frequency of its undulations expreſſed by 2; becauſe an open pipe of twice the length of AB (fig 2.) will be 1, the two pipes AB (fig. 2.), and CB (fig. 3.), being in uniſon.

But this open pipe may be made to undulate in another manner; for we have ſeen that AB of fig. 2. joined to CA of fig. 4. may ſound altogether when the partition A is removed, ſtill giving the note of AB (fig. 2.) Let ſuch another as AB (fig. 2.) be added to the end C, and let the partition be removed. The whole may ſtill undulate, and ſtill produce the ſame note; that is, a pipe open at both ends may ſound a note which is the fundamental of a pipe like AB (fig. 2.), but only one-fourth of its length. The pipe CB of fig. 3. may thus be ſuppoſed to be divided into four equal parts, CE, EA, AF, FB, of which the extreme parts EC and FB contain undulations ſimilar to thoſe in AB (fig. 2.); and the two middle parts contain undulations like thoſe in CA (fig. 4.) The partitions at E and F may be removed, becauſe the undulations in EC and EA will ſupport each other, if they are in oppoſite directions; and thoſe in FB and FA may ſupport each other in the ſame manner.

It muſt here be remarked, that in this ſtate of undulation the direction of the agitations at the two extremities is the ſame; for in the middle piece EF the particles are moving one way, condenſing the air at E, while they rarefy it at F. Therefore, while the middle parcel is moving from E towards F, the air at B muſt be moving towards F, and the air at C muſt be moving from E. In ſhort, the air at the two extremities muſt, in every inſtant, be moving in the oppoſite direction to that of the air in the middle.

In like manner, if the pipe CB of fig. 3. be divided into ſix parts, the two extreme parts may undulate like AB of fig. 2. and the four inner parts may undulate like two pipes, ſuch as CA of fig. 4. and the whole will give the ſound which makes the fundamental of a pipe of one-ſixth of the length, or having the frequency 6.

We may remark here, that the ſimultaneous motion of the air at the extremities is in oppoſite directions, whereas in the laſt caſe it was in the ſame direction. This is eaſily ſeen; for as the partition which is between the two middle pieces muſt always be in equilibrio, the air muſt be coming in or going out at the extremities together. This circumſtance muſt give ſome ſenſible difference of character to the ſounds 4 and 6. In the one, the agitations at each end of the tube are in the ſame direction, and in the other they are in the oppoſite. Both produce pulſes of ſound which are conveyed to the ear. Thus we ſee that the air in a pipe open at both ends may undulate in two ways. It may undulate with a node in the middle, giving the note of AB (fig. 2.), or of its 3d, 5th, 7th, &c. paſt; and it may undulate with a loop or bight in the middle, ſounding like $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{6}$, &c of AB, fig. 2.

Muſical Trumpet.

In like manner may this pipe produce ſounds whoſe frequency are expreſſed by 8, 10, &c. and proceed as the even numbers

This ſtate of agitation may be repreſented in the ſame way that we repreſented the ſounds 1, 3, 5, &c. by conſtructing on AM (fig. 7.) an harmonic curve, with any number of nodes and loops. Divide the parts AF, FD, DE, EM, equally in C, O, P, B. CB will correſpond to the pipe, and the ordinates to the curve GFHDLEN will expreſs the excurſions of the plates of air.

If the pipe gives its fundamental note, its length muſt be repreſented by CO, and the undulations in it will reſemble the vibrations of part CO of a cord, whoſe length AD is equal to 2CO, and which has a node in F.

If the pipe is ſounding its octave, it will be repreſented by CP, and its undulations will reſemble the vibrations of a cord CP, whoſe length AE is $\frac{1}{2}$ of CP, having nodes at F and D, &c. &c.

We can now ſee the poſſibility of ſuch undulations exiſting in a pipe as will be permanent, and produce all the variety of notes by a mere change in the manner of blowing, and why theſe notes are in the order of the natural numbers, preciſely as we obſerve to happen in winding the trumpet or French horn. We have, *1ſt*, the fundamental expreſſed by 1; then the octave 2; then the 12th, 3; the double octave 4; then the third major of that octave 5, or 17th of the fundamental; then the octave of the 12th, or the 5th of this double octave, = 6. We then jump to the triple octave 8, without producing the intermediate ſound correſponding to $\frac{1}{7}$th of the pipe. With much attention we can hit it; and it is a fact that a perſon void of muſical ear ſtumbles on it as eaſily as on any other. But the muſician, finding this ſound begin with hum, and his ear being grated with it, perhaps thinks that he is miſtaking his embouchure, and he ſlides into the octave. After the triple octave, we eaſily hit the ſounds correſponding to $\frac{1}{9}$ and $\frac{1}{10}$, which are the 2d and 3d of this octave. The next note $\frac{1}{11}$ is ſharper than a juſt 4th. We eaſily produce the note 12, which is a juſt 5th; 13 is a falſe 6th; 14 is a ſound of no uſe in our muſic, but eaſily hit; 15 and 16 give the exact 7th and 8th of this octave.

Thus, as we aſcend, we introduce more notes into every octave, till at laſt we can nearly complete a very high octave; but in order to do this with ſucceſs, and tolerable readineſs, we muſt take an inſtrument of a very low pitch, that we may be able nearly to fill up the ſteps of the octave in which our melody lies. Few players can make the French horn or trombone ſound its real fundamental, and the octave is generally miſtaken for it. The proof of this is, that moſt players can give uſical umpet.

give the 5th of the loweſt note that they are able to produce; whereas the 5th of the real fundamental cannot be uttered. Therefore that loweſt note is not the fundamental, but the octave to the fundamental.

Few performers can ſound even this ſecond octave on a ſhort inſtrument, ſuch as the ordinary military trumpet; and what they imagine to be the fundamental ſound of this inſtrument is the double octave above it. This appears very ſtrange; and it may be aſked, how we know what is really the fundamental note of a trumpet? The anſwer to this is to be obtained only by demonſtrating, on mechanical principles, what is the frequency of undulation correſponding to a given length of pipe. This is a propoſition equally fundamental with its correſponding one in the theory of muſical cords; but we have reſerved it till now, becauſe many readers would ſtop ſhort at ſuch an inveſtigation, who are able to underſtand completely what we have now delivered concerning the muſic of the trumpet.

Suppoſe therefore a pipe ſhut at both ends, and that the whole weight of the contained air is concentrated in its middle point, the reſt retaining its elaſticity without inertia; or (which is a more accurate conception), let the middle point be conceived as extending its elaſticity to the two extremities of the pipe, being repelled from each by a force inverſely as the diſtance. Let the length of this pipe be L. This may alſo expreſs the weight of the middle plate of air, which will always be proportional to the length of the pipe, becauſe all is ſuppoſed to be concentrated there. Let E be the elaſticity of the air. This muſt be meaſured by the preſſure of the atmoſphere, or by the weight of the column of mercury in the barometer. Perhaps the rationale of this will be better conceived by ſome readers by conſidering E as the height of a homogeneous atmoſphere. Then it is plain that E is to L as the weight of this atmoſpheric column to the weight of the column of the ſame air which fills the pipe whoſe length is L. Then it is alſo plain that E is to L as the external preſſure; and conſequently, as the elaſticity which ſupports that preſſure is to the weight or inertia of the matter to be moved. Let this middle plate or diaphragm be withdrawn from its place of reſt to the very ſmall diſtance a. The elaſticity or repulſion will be augmented on one ſide and diminiſhed on the other; and the difference between them is the only force which impels the diaphragm toward the middle point, and cauſes it to vibrate, or produces the undulation. It is plain that the repulſion on one ſide is $\frac{\frac{1}{2}L}{\frac{1}{2}L-a}\times E$, or $\frac{L}{L-2a}E$ $\left(\text{for } \frac{1}{2}L-a:\frac{1}{2}L=E:\frac{\frac{1}{2}LE}{\frac{1}{2}L-a}\right)$, and the repulſion on the other ſide is $\frac{\frac{1}{2}L}{\frac{1}{2}L+a}\times E$, or $\frac{L}{L+2a}E$. The difference of theſe repulſions is $E\times L\times\frac{4a}{L^2-4a^2}$. But as we ſuppoſe a exceedingly ſmall in compariſon with L, this difference, or the accelerating force, may ſafely be expreſſed by $E\frac{4a}{L}$, or $4a\frac{E}{L}$.

Hence we deduce, in the firſt place, that the undulations will be iſochronous, whether wide or narrow; becauſe the accelerating force is always proportional to the diſtance a from the middle point.

Muſical Trumpet.

Now, let a pendulum, whoſe quantity of matter is L, and length a, be ſuppoſed to vibrate in a cycloid by the force $\frac{4a}{L}E$, or $\frac{4E}{L}a$. It muſt perform its vibrations in the ſame time with the plate of air; becauſe the moving force, the matter to be moved, and the ſpace along which they are to be ſimilarly impelled, are the ſame in both caſes. Let another pendulum, having the ſame quantity of matter L, vibrate by its weight L alone. In order that theſe two pendulums may vibrate in equal times, their lengths muſt be as the accelerating forces. Therefore we muſt have $\frac{4E}{L}a:L=a:\frac{aL^2}{4Ea}$, $=\frac{L^2}{4E}$, which is therefore the length of the ſynchronous pendulum.

Now, a cord without weight and inertia, but loaded with the weight L at its middle point, and ſtrained by a weight E, and drawn from the axis to the diſtance a, is preciſely ſimilar in its motion to the diaphragm we are now conſidering, and muſt make its oſcillations in the ſame time.

This is applicable to any number of plates of air, by ſubſtituting in the cord a loaded point for each of the plates; for when the caſe is thus changed, both in the pipe and the cord, the ſpace to be paſſed over by the plate of air bears the ſame proportion to a, which is paſſed over by the whole air concentrated in the middle point, which the ſpace to be paſſed over by the correſponding loaded point of the cord bears to that paſſed over by the whole matter of the cord concentrated in the middle point; and the ſame equality of ratios obtains in the accelerating forces of the plate of air and the correſponding loaded point of the cord. Suppoſe, then, a pipe divided into 2, 3, 4, &c. equal parts, by 1, 2, 3, diaphragms, each of which contains the air of the intervening portion of the pipe, the whole weight L being equally divided among them. If there be but one diaphragm, its weight muſt be L; if two, the weight of each muſt be $\frac{1}{2}$ L; if three, the weight of each muſt be $\frac{1}{3}$ L; and ſo on for any number.

By conſidering this attentively, we may infer, without farther inveſtigation, what will be the undulations of all the different plates of air in a pipe ſtopped at both ends. We have only to compare it with a cord ſimilarly divided and loaded. Increaſe the number of loaded points, and diminiſh the load on each, continually—it is evident that this terminates in the caſe of a ſimple cord, with its matter uniformly diffuſed; and a ſimple pipe, with its air alſo uniformly diffuſed over its whole length.

Therefore, if we take an elaſtic cord, and ſtretch it by ſuch a weight that the extending weight may bear the ſame proportion to the accelerating force acting on the whole matter concentrated in its middle point, which the elaſticity of the air bears to its accelerating force acting on the whole matter concentrated at the mouth of an open pipe, ſounding its fundamental note, the cord and the air will vibrate in the ſame time. Moreover, ſince the proportion between the vibrations of a cord ſo conſtituted, and thoſe of a cord having its matter uniformly diffuſed, is the ſame with the proportion between the undulations in a pipe ſo conſtituted, and thoſe of a pipe in which the air is uniformly diffuſed—it is plain that the vibrations of the cord and of the pipe

pipe in their natural ſtate will alſo be performed in equal times.

We look on this as the eaſieſt way of obtaining a diſtinct perception of the authority on which we reſt our knowledge of the abſolute number of undulations of the air in a pipe of given length. It may be obtained directly; and Daniel Bernoulli, Euler, and others, have given very elegant ſolutions of this problem, without having recourſe to the analogy of the vibrations of cords and undulations of a column of air. But it requires more mathematical knowledge than many readers are poſſeſſed of who are fully able to follow out this analogical inveſtigation.

Let us therefore compare this theory with experiment. What we call an open pipe of an organ is the ſame which we, in this theory, have conſidered as a pipe open at both ends; for the opening at the foot, which the organ builders call the VOICE of the pipe, is equivalent to a complete opening. The aperture, and the ſharp edge which divides the wind, may be continued all round, and the wind admitted by a circular ſlit, as is repreſented in fig. 10. We have tried this, and it gives the moſt brilliant and clear tones we ever heard, far exceeding the tones of the organ. An open organ pipe, therefore, when ſounding its fundamental note, undulates with one node in its middle, and its undulations are analogous, in reſpect of their mechaniſm, with the vibrations of a wire of the ſame length, and the ſame weight, with the column of air in the pipe, and ſtretched by a weight equal to that of a column of the ſame air, reaching to the top of a homogeneous atmoſphere, or equal to the weight of a column of mercury as high as that in the barometer.

Dr Smith (ſee *Harmonics*, 2d edit. p. 193) found that a braſs wire, whoſe length was 35,55 inches, and weight 31 troy grains, and ſtretched by 7 pounds avoirdupois, or 49000 grains, was in perfect uniſon with an open organ pipe whoſe length was 86,4 inches.

Now 86,4 inches of this wire weighs 75,34 grains. When the barometer ſtands at 30 inches, and the thermometer at 55° (the temperature at the time of the experiment), the height of a homogeneous atmoſphere is 332640 inches. This has the ſame proportion to the length of the pipe which the preſſure of the atmoſphere has to the weight of the column of air contained in the pipe.

Now 86,4 : 332640 = 75,34 : 290060. This wire, therefore, ſhould be ſtretched (if the theory be juſt) by 290060 grains, in order to be uniſon with the other wire, and we ſhould have $35,55^2 : 86,4^2 = 49000 : 290060$
But, in truth, - $35,55^2 : 86,4^2 = 49000 : 289430$
The difference is - - - - - 630
The error ſcarcely exceeds $\frac{1}{300}$, and does not amount to an error of one vibration in a ſecond.

We muſt therefore account this theory as accurate, ſeeing that it agrees with experiment with all deſirable exactneſs.

We may alſo deduce from it a very compendious rule for determining the abſolute number of aereal pulſes made by an open pipe of any given length. When conſidering the vibrations of cords, we found that the number of vibrations made in a ſecond is $\sqrt{\frac{386E}{LW}}$, where E is the extending weight, W the weight of the cord, and L its length. Let H be the height of a homogeneous atmoſphere. We have its weight $= \frac{HW}{L}, = E$. Therefore ſubſtituting $\frac{HW}{L}$ for E in the above formula, we have the number of aereal pulſes made per ſecond $= \sqrt{\frac{386H}{L^2}}$, or $= \frac{\sqrt{386H}}{L}$. Now $\sqrt{386H}$, computed in inches, is 11331. Therefore, if we alſo meaſure the length of the pipe L in inches, the pulſes in a ſecond are $= \frac{11331}{L}$. Thus, in the caſe before us, $\frac{11331}{86,4} = 131,12$, or this pipe produces 131 pulſes in a ſecond. Dr Smith found by experiment that it produced 130,9, differing only about $\frac{1}{6}$th of a pulſe.

We ſee that the pitch of a pipe depends on the height of the homogeneous atmoſphere. This may vary by a change of temperature. When the air is warmer it expands, and the weight of the induced column is leſſened, while it ſtill carries the ſame preſſure. Therefore the pitch muſt riſe. Dr Smith found his organ a full quarter tone higher in ſummer than in winter. The effect of this is often felt in concerts of wind inſtruments with ſtringed inſtruments. The heat which ſharpens the tone of the firſt flattens the laſt. The harpſichord ſoon gets out of tune with the horns and flutes.

Sir Iſaac Newton, comparing the velocity of ſound with the number of pulſes made by a pipe of given length, obſerved that the length of a pulſe was twice the length of the open pipe which produced it. Divide the ſpace paſſed over in a ſecond by the number of pulſes, and we obtain the length of each pulſe. Now it was found that a pipe of 21,9 inches produced 262 pulſes. The velocity of ſound (as computed by the theory on which our inveſtigation of the undulations in pipes proceeds) is 960 feet. Now $\frac{960 \times 12}{262} = 44$ inches very nearly, the half of which is 22, which hardly differs from 21,9. The difference of this theoretical velocity of ſound, and its real velocity 1142 feet per ſecond, remains ſtill to be accounted for. We may juſt obſerve here, that when a pipe is meaſured, and its length called 21,9, we do really allow it too little. The voice-hole is equivalent to a portion, not inconſiderable of its length, as appears very clearly from the experiments of Mr Lambert on a variable pitch pipe, and on the German flute, recorded in the Berlin Memoirs for 1775. He found it equivalent to $\frac{1}{8}$th; and this is ſufficient for reconciling theſe meaſures of a pulſe with the real velocity of ſound.

The determination which we have given of the undulations of air in an organ pipe is indirect, and is but a ſketch of the beautiful theory of Daniel Bernoulli in which he ſtates with accuracy the preciſe undulation of each plate of air, both in reſpect of poſition, denſity, velocity, and direction of its motion. It is a pleaſure to obſerve how the different equations coincide with thoſe which expreſs the vibrations of an elaſtic cord. But this would have taken up much room, and would not have been ſuited to the information of many curious readers, who can eaſily follow the train of reaſoning which we have employed.

Mr Bernoulli applies the ſame theory to the explanation

nation of the undulations in flutes, or inſtruments whoſe ſounds are modified by holes in the ſides of the pipe. But this is foreign to our purpoſe of explaining the muſic of the trumpet. We ſhall only obſerve, that a hole made in that part of a pipe where a node ſhould form itſelf, in order to render practicable the undulations competent to a particular note, prevents its formation, and in its place we only get ſuch undulations (and their correſponding ſounds) as have a loop in that place. The intelligent reader will perceive that this ſingle circumſtance will explain almoſt every phenomenon of flutes with holes; and alſo the effects of holes in inſtruments with a reed voice, ſuch as the hautboy or clarionette.

We now ſee that the ſound or muſical pitch of a pipe is inverſely as its length, in the ſame manner as in ſtrings. And we learn, by comparing them, that the ſound of a trumpet has the ſame pitch with an open organ pipe of the ſame length. A French horn, 16 feet long, has the ſound C *fa ut*, which is alſo the ſound of an open flute-pipe of that length.

The TROMBONE, great trumpet, or SACKBUT, is an old inſtrument deſcribed by Merſennus and other authors of the laſt century. It has a part which ſlides (air-tight) within the other. By this contrivance the pitch can be altered by the performer as he plays. This is a great improvement when in good hands; becauſe we can thus correct all the falſe notes of the trumpet, which are very offenſive, when they occur in an emphatical or holding note of a piece of muſic. We can even employ this contrivance for filling up the blanks in the lower octaves.

We muſt not take leave of this ſubject without taking notice of another diſcovery of Mr Bernoulli's, which is exceedingly curious, and of the greateſt importance in the philoſophy of muſic.

Artiſts had long ago obſerved that the deep notes of muſical inſtruments are ſometimes accompanied by their harmonic ſounds. This is moſt clearly perceived in bells, ſome of which give theſe harmonics, particularly the 12th, almoſt as ſtrong as the fundamental. Muſicians, by attending more carefully to the thing, ſeem now to think that this accompaniment is univerſal. If one of the fineſt ſounding ſtrings of the baſes of a harpſichord be ſtruck, we can hear the 12th very plainly as the ſound is dying away, and the 17th major is the laſt ſound that dies away on the ear This will be rendered much more ſenſible, if we divide the wire into five parts, and at the points of diviſion tie round it a thread with a faſt knot, and cut the ends off very ſhort. This makes the ſtring falſe indeed by the unequal loading; but, by rendering thoſe parts ſomewhat leſs moveable by this additional matter, the portions of the wire between theſe points are thus jogged, as it were, into ſecondary vibrations, which have a more ſenſible proportion to the fundamental vibration. This is ſtill more ſenſible in the ſound of the ſtrings of a violincello when ſo loaded; but we muſt be careful not to load them too much, becauſe this would ſo much retard the fundamental vibration, without retarding the ſecondary vibrations, that both cannot be maintained together. (*N. B.* This experiment always produces a beat in the ſound).—Liſtening to a fine ſounding flute-pipe of the organ, we can alſo very often perceive the ſame thing. Mr Rameau, and moſt other theoriſts in muſic, now aſſert that this is the eſſence of a muſical ſound, and *neceſſarily* exiſts in all of them, diſtinguiſhing them from harſh noiſes. Rameau has made this the foundation of his ſyſtem of muſic, aſſerting that the pleaſure of harmony reſults from the ſucceſsful imitation of this harmony of Nature. (ſee MUSIC, *Encycl.*). But a little logic ſhould convince theſe theoriſts that they muſt be miſtaken. If a note is muſical becauſe it has theſe accompaniments, and by this compoſition alone is a muſical note, what are theſe harmonics? Are they muſical notes? This is granted. Therefore they have the ſame compoſition; and a muſical note muſt conſiſt at once of every poſſible ſound; yet we know that this would be a jarring noiſe. A little mathematics, too, or mechanics, would have convinced them. A ſimple vibration is ſurely a moſt poſſible thing, and therefore a ſimple ſound. No, ſay the theoriſts; for though the vibration of the cord may be ſimple, it produces ſuch undulations in the air as excite in us the perception of the harmonics. But this is a mere aſſertion, and leaves the queſtion undecided. Is not a ſimple undulation of the air as poſſible as the ſimple vibration of a cord?

It is, however, a very curious thing, that almoſt all muſical ſounds really have this accompaniment of the octave, 12th, double octave, and 17th major; for theſe are the harmonics that we hear.

The jealouſy of Leibnitz and of John Bernoulli, and their unfriendly thoughts reſpecting all the Britiſh mathematicians, made John Bernoulli do every thing in his power to leſſen the value of Dr Taylor's inveſtigation of the vibration of a muſical cord. Taylor gave him a good opportunity. Perhaps a little vain of his inveſtigation of this abſtruſe matter, he thought too much of it. He affirmed that the harmonic curve was the eſſential form of a ſtring giving a muſical note. This was denied, without knowing at firſt whether it was true or falſe. But as the analytic mathematics improved, it was at length found that there are an infinity of forms into which an elaſtic cord can be thrown, which are conſiſtent both with iſochronous vibrations, whether wide or narrow, and alſo with the condition of the whole cord becoming a ſtraight line at once. Euler, D'Alembert, and De la Grange, have proſecuted this matter with great ingenuity, and it is one of the fineſt problems of the preſent day.

Daniel Bernoulli, of a very different caſt of mind from his illuſtrious friends, admired both Newton and Taylor; and ſo far from wiſhing to eclipſe Dr Taylor by the additions he had made to his theory, tried whether he could not extend Taylor's doctrine as far as the author had ſaid. When he took a review of what he had done while explaining the partial vibrations of muſical cords, he thought it very poſſible that while a cord is vibrating in three portions, with two nodes or points of reſt, and ſounding the 12th to its fundamental, it might at the ſame time be alſo vibrating as a ſimple cord, and ſounding its fundamental note. It was poſſible, he thought, that the three portions might be vibrating between the four points with a triple frequency, while the two middle nodes were vibrating acroſs the ſtraight line between the two pins; and thus the vibrating cord might be a moveable axis, to which the rapid vibrations of the three parts might always be referred. This was very ſpecious; and when a little more attentively conſidered, became more probable: for if the cord ApBqCrD (fig. 8.) be vibrating as a 12th to its fundamental AD, the points B and C are in equilibrio. If therefore theſe two points be laid hold of by hooks, and be drawn aſide to β and γ, while the ſtring is yet vibrating, this ſhould not hinder the vibrations. If the hooks be annihilated in an inſtant, the whole ſhould vibrate between A and D; and this ſhould be in a way very different from the ſimple vibration. The queſtion now is, will the cord *continue* to vibrate with the loops $\beta s \gamma$, $\beta q \gamma$, &c. in the 900th part of a ſecond (for inſtance), while the whole ſtring vibrates from A$\beta\gamma$D to A$\beta'\gamma'$D in the 300th part of a ſecond? or will it at once acquire the form of the ſimple harmonic curve? The caſe in which it is moſt likely to take the latter mode of vibration is when the points β and γ are let go at the inſtant that each portion of the ſtring is in the middle of its vibration, and therefore forms the line A$\beta\gamma$D. But a moment's conſideration will ſhew us that it cannot do this; for at that inſtant the point v, for inſtance, which had come from q, is moving outwards with a moſt rapid motion, and therefore will continue to go outward, while β and γ are approaching the axis. The point w, on the contrary, is at this moment approaching the axis with a motion equally rapid. They cannot therefore all come to the axis at once, and the vibration muſt differ greatly from a ſimple one. On the other hand, let it be ſuppoſed that both ſpecies of vibrations can be preſerved, and that, at the moment of letting go the points β and γ, the cord has the form A$m\beta q\gamma n$D. Then, when β and γ have come to B and C, having made $\frac{1}{2}$ a vibration, the point m will be in the axis, having made a vibration downward, and a half vibration upwards. q, in like manner, is in the axis, having made a whole vibration upwards, and half a vibration downwards. n is like m. Thus the whole comes to the axis at once; and in ſuch a manner, that if the points B and C were inſtantly ſtopped, the three portions would continue their partial vibrations without any new effort. The reſult of this compound vibration muſt be a compound pulſe of air, which will excite in us the perception of the fundamental ſound and of its 12th. The conſequence will be the ſame if the points β and γ are ſtopped any where ſhort of the axis; and therefore (ſaid Bernoulli) the ſtring will really vibrate ſo if not ſtopped at all.

But this was refuſed by Euler, who obſerved that in the points β and γ of contrary flexure, having no curvature, there can be no accelerating force. This cauſed Bernoulli to attempt a direct inveſtigation, examining minutely the curvatures and accelerating forces in the different points.

He had the pleaſure of finding that the accelerating forces ariſing from the curvature in every point, were preciſely ſuch as would produce the accelerations neceſſary in thoſe points for performing the motion that was required. And he exhibited the equations expreſſive of the ſtate of the cord in all theſe points. And, on the faith of theſe equations, he reſtored the Taylorean curve to the rank which its inventor had given it; and he aſſerted that in every muſical vibration the cord was diſpoſed in a harmonical curve either ſimple or compound. He farther ſhewed that the equations which Euler and D'Alembert had given for the muſical cord (at leaſt in the caſes which they had publiſhed) were included in his equations, and that their equations only exhibited its momentary ſtates, while his own equations ſhewed the phyſical connection of them all; which is, that the whole cord forms a harmonic curve between the two fixed pins, while its different portions form ſubordinate harmonic curves on the firſt as an axis. Euler and D'Alembert, although they acknowledge this in the particular caſes which they had taken as examples, on account of their ſimplicity, ſtill inſiſt that no ſubordinate harmonic vibrations can correſpond to all the ſtates of an elaſtic cord which their equations exhibit as iſochronous and permanent. Mr Bernoulli's death put an end to the controverſy, and the queſtion (conſidered as a general theory) is perhaps ſtill undecided. It may very probably be true, that as a ſimple vibration may be permanent which never has the form of the ſimple harmonic deſcribed by Dr Taylor, ſo a vibration may exiſt compounded of ſuch vibrations, and therefore not expreſſible by any equation deduced from the Taylorean curve.

But, in the mean time, Mr Bernoulli has made the moſt beautiful diſcovery in mechanics which has appeared in the courſe of the preſent century, and has explained the moſt curious phenomenon of continued ſounds, *viz.* the *almoſt univerſal* accompaniment of the harmonic notes of any fundamental ſound. For this *ſuſceptibility* of compounded variation is not confined to a 12th, but is equally demonſtrable of every other harmonic. Nay, it is evident that the ſame ſimple vibration of a cord may furniſh a moveable axis to more than one harmonic. For as the ſimple vibration can have a ſubordinate harmonic vibration ſuperinduced upon it, ſo may this compounded vibration have another ſuperinduced on it, and ſo on to any degree of compoſition. And farther, as Mr Bernoulli has ſhewn the complete analogy between the accelerations of the different points of an elaſtic cord and of the correſponding plates of a column of air, it legitimately follows that all the conſequences which we can eaſily deduce, reſpecting the vibrations of an elaſtic cord, may be affirmed reſpecting the undulations of a column of air in a pipe. Therefore this accompaniment of the harmonics muſt not be confined to the muſic of ſtrings and bells, but equally obtains in the muſic of wind inſtruments. And thus the doctrine becomes univerſal.

Mr Bernoulli did not think it enough to ſhew that theſe compound vibrations are poſſible. He endeavours to ſhew that this accompaniment muſt be frequent. He illuſtrates this very prettily, by ſuppoſing that a toothed wheel is turned round, and rubs with its teeth on an elaſtic cord. If the ſucceſſive dropping of the teeth keep exactly pace with ſuch vibrations as the cord can take and maintain by its elaſticity, theſe will certainly be formed on it. If the intervals do not *exactly* correſpond, a little reflection will ſhew that the agitation which the cord acquires will approximate to thoſe which it can maintain; and, if when they are exactly ſo in any place of it, and the wheel be in that inſtant removed, this vibration will remain and diffuſe itſelf throught he reſt of the cord; ſo that the very laſt dying quiver (ſo to ſpeak) will be a harmonic. Every *harmonic* agitation tends, by the very nature of the thing, to continue, while thoſe that are incompatible really *do* deſtroy each other; and the very laſt muſt be the remainder or ſuperplus of ſuch as could continue,

PLATE XLV.

Fig. 1.

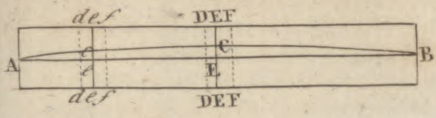



Fig. 2.

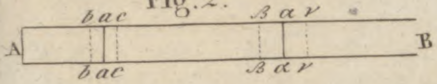


Fig. 3.

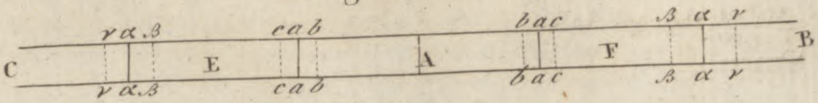


Fig. 4.

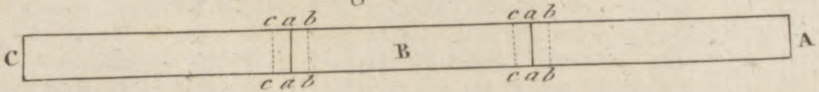


Fig. 5.

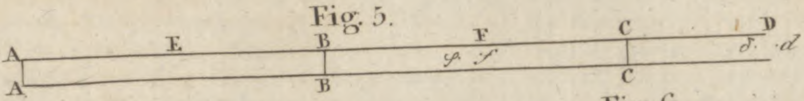


Fig. 6.

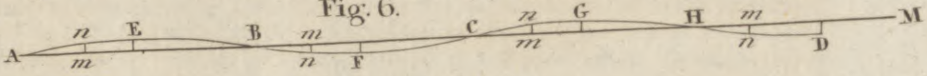


Fig. 7.

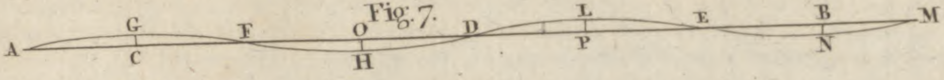


Fig. 8.

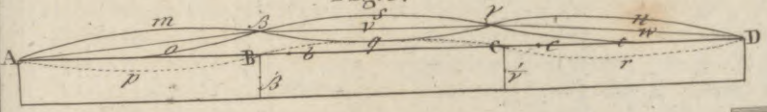


Fig. 9.

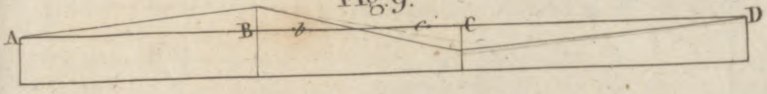
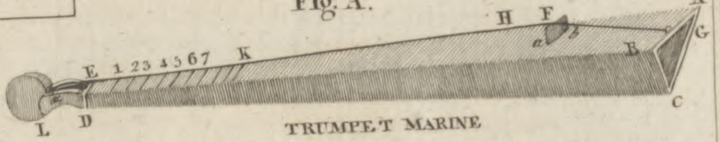


Fig. 10.

Fig. A.



TRUMPET MARINE

Fig. C.

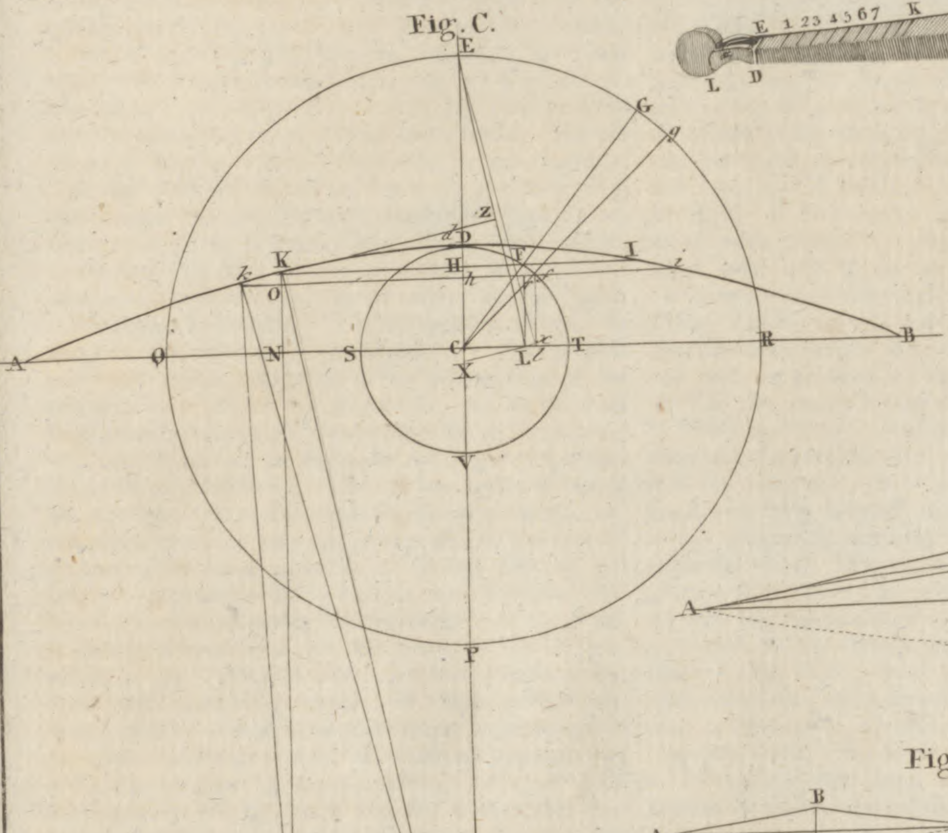


Fig. B.

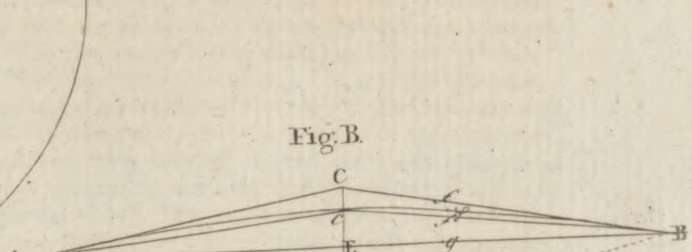
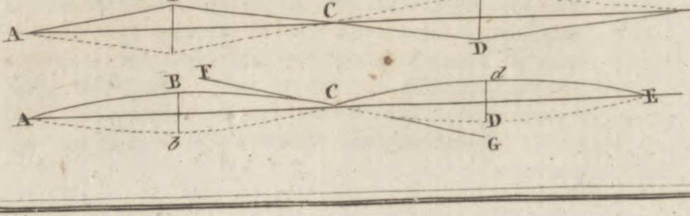


Fig. D



D. Lizars sculp.

over thoſe which deſtroyed each other. Accordingly, the harmonic notes of wires are always moſt diſtinctly heard as the ſound is dying away.

There is no occaſion now to ſay any thing about the fallacy of Rameau's *Generation Harmonique* as a theory of muſical pleaſure. Our harmonies pleaſe us, not becauſe a ſound is accompanied by its harmonics, but becauſe harmonics pleaſe. His principle is therefore a tautology, and gives no inſtruction whatever. His theory is a very *forced* accommodation of this principle to the practice of muſicians, and taſte of the Public. He is exceedingly puzzled in the caſe of the *ſousdominante*, or 4th of the ſcale, and the 6th where there is no reſonnance. He ſays that theſe notes, "fremiſſent, quoiqu' elles ne reſonnent pas." But this miſleads us. They do not reſound; becauſe a 4th and a 6th cannot be produced at all by dividing the cord. They tremble; becauſe the falſe 4th and falſe 6th are very near the true ones, and the true 4th and 6th would both tremble and reſound if they were made falſe. A ſtring will both tremble and reſound, if very nearly true, as any one obſerves the 12th and 17th on a harpſichord tremble and reſound very ſtrongly, though they are tempered notes. The whole theory is overturned at once by tuning the 4th falſe, ſo as to correſpond to an aliquot diviſion of the cord. It will then reſound; and if this had happened to be agreeable, it would have been catched at as the ſouſdominant.

The phyſical cauſe of the pleaſure of harmonic ſounds is yet to ſeek, as much as our choice of thoſe notes for melody which give us the beſt harmony (ſee TEMPERAMENT, *Suppl.*). We have no heſitation in ſaying that, with reſpect to our choice, the two are quite independent. Thouſands enjoy the higheſt pleaſure from melody who never heard a harmonious ſound. All the untaught ſingers, and all ſimple nations, are examples. They not only fix on certain intervals as the ſteps of their tunes, but are diſguſted when other ſteps are taken. Nor do we heſitate, for the very ſame reaſons, to ſay that the rules of accompaniment are dependent on the cantus or air, and by no means on the fundamental baſs of Rameau. The dependence aſſumed by him, as the rule of accompaniment, would, if properly adhered to, according to his own notions of the comparative values of the harmonics, lead to the moſt fantaſtic airs imaginable, always jumping by large intervals, and altogether incompatible with graceful muſic. The rules of modulation which he has ſqueezed out of his principle, are nothing but forced, very forced, accommodations of a very vague principle to the current practice of his contemporaries. They do not ſuit the primitive melodies of many nations, and they have cauſed theſe national muſics to degenerate. This is acknowledged by all who are not perverted by the prevailing habits. We have heard, and could write down, ſome moſt enchanting lullabies of ſimple peaſant women, poſſeſſed of muſical ſenſibility, but far removed, in the cool ſequeſtered vale of life, from all opportunities of ſtealing from our great compoſers. Some of theſe lullabies never fail to charm, even the moſt erudite muſician, when ſung by a fine flexible voice: but it would puzzle Mr Rameau to accompany them *ſecundum artem*.

We conclude this ſubject by deſcribing a moſt beautiful and inſtructive experiment.

Mr Watt, the celebrated engineer, was amuſing himſelf (about the year 1765) with organ building, and invented a monochord of continued ſound, by which he could tune an organ with mathematical preciſion, according to any propoſed ſyſtem of temperament. It conſiſted of a covered ſtring of a violincello, ſounding by the friction of an ivory wheel. The inſtrument did not anſwer Mr Watt's purpoſe, by reaſon of the dead harſhneſs of its tone, and a flutter in the ſtring by the unequal action of the wheel. But Mr Watt was amuſed by obſerving the ſtring frequently taking, of its own accord, points of diviſion, which remained fixed, while the reſt was in a ſtate of ſtrong vibration. The inſtrument came into the poſſeſſion of the writer of this article. He ſoon ſaw that it gave him an opportunity of making all the experiments which Bernoulli could only relate. When the ſtring was kept in a ſtate of ſimple vibration, by a very uniform and gentle motion of the wheel, if its middle point was then gently touched with a quill, this point immediately ſtopped, but the ſtring continued to vibrate in two parts, ſounding the octave: And this it continued to do, however ſtrong the vibrations were rendered afterwards by increaſing the preſſure and velocity of the wheel. The ſame thing happened if the ſtring was gently touched at one third. It inſtantly divided itſelf into three parts, with two nodes, and ſounded the 12th. In the ſame manner the double octave, the 17th, and all other harmonics, were produced and maintained.

But the prettieſt experiment was to put ſomething ſoft, ſuch as a lock of cotton, in the way of the wide vibrations of the cord, at one third and two-thirds of its length, ſo as to diſturb them when they became very wide. When this was done, the ſtring inſtantly put on the appearance of fig. 8. performing at once the full vibration competent to its whole length, and the three ſubordinate vibrations, correſponding to one-third of its length, and ſounding the fundamental and the 12th with equal ſtrength. In this manner all the different accompaniments were produced at pleaſure, and could be continued, even with ſtrong ſounds. And it was amuſing to obſerve, when the wheel was ſtrongly preſſed to the ſtring, and the motion violent, the nodes would form themſelves on various parts of the ſtring, running from one part to another. This was always accompanied with all the jarring ſounds which correſponded to them.

When the ſtring was making very gentle, ſimple vibrations, and the wheel hardly touching it, if a violincello was made to ſound the 12th very ſtrongly in its neighbourhood, the ſtring inſtantly divided itſelf, and vibrated in uniſon, frequently retaining its ſimple vibration and fundamental tone. We recommend this experiment to every perſon who wiſhes to make himſelf well acquainted with the mechaniſm of muſical ſounds. He will ſee, in a moſt ſenſible and convincing manner, how a ſingle ſtring of the Æolian harp gives us all the changes of harmony, ſliding from one ſound to another, according as it is affected in its different parts by an irregular breeze of wind. The writer of this article has attempted to regulate theſe ſweet harmonic notes, and to introduce them into the organ. His ſucceſs has been very encouraging, and the ſounds far exceed in pathetic ſweetneſs any that have yet been produced by that noble inſtrument. But he has not yet brought them fully under command, nor made them ſtrong enough for any thing but the ſofteſt chamber muſic. Other

Muſical Trumpet, Tſchirnhaus.

neceſſary occupations prevent him from giving the attention to this ſubject that it deſerves. He recommends it therefore to the muſical inſtrument makers as richly deſerving their notice. His general method was this: A wooden pipe is made, whoſe ſection is a double ſquare. A partition in the middle divides it into two pipes, along ſide of each other. One of them communicates with the foot and wind cheſt, and is ſhut at the upper end. The other is open at the upper, and ſhut at the lower end. In the partition there is a ſlit almoſt the whole length, and the ſides of this ſlit are brought to a very ſmooth chamfered or feather edge. A fine catgut is ſtrained in this ſlit, ſo as almoſt to touch the ſides. It is evident that when the wind enters one pipe by the foot, it paſſes through the ſlit into the other, and eſcapes at the top, which is open. In its paſſage it forces the catgut into motion, and produces a muſical note, having all the ſweetneſs of the Æolian harp. The ſtrength of ſound may be increaſed by increaſing the body of air which is made to undulate. This was done by uſing, inſtead of catgut, very narrow ſilk tape or ribband varniſhed: but the unavoidable raggedneſs of the edges made the ſounds coarſe and wheeſing. Flat ſilver wire was not ſufficiently elaſtic; flat wire, uſed for watch balance ſprings, was better, but ſtill very weak ſounded. Other methods were tried, which promiſed better. A thin round plate of metal, properly ſupported by a ſpring, was ſet in a round hole, made in another plate not ſo thin, ſo as juſt not to touch the ſides. The air forced through this hole made the ſpring plate tremble, dancing in and out, and produced a very bold and mellow ſound.—This, and ſimilar experiments, are richly worth attention, and promiſe great additions to our inſtrumental muſic.

TSCHIRNHAUS (Ehrenfred Walther Von), a name well known in the republic of letters, and one of the ornaments of the laſt century, was born April 10. 1651, at Kiſlingſwald near Gorlitz in Upper Luſatia. His father was Erneſt Chriſtopher Von Tſchirnhaus, Baron Kiſlingſwald and Stoltzberg, and Obernſchonfeld, privy counſellor, and in various offices of rank under the Electors George I. and II. of Saxony, the firſt of whom honoured him with the diſtinction of the gold chain and portrait, as a mark of his ſenſe of his merits and ſervices. The mother of the young Von Tſchirnhaus was Maria Stirling, daughter of *Baro a Stirling et Achil*, Stirling of Achil, or Achyle, in Scotland, an old and reſpectable family, as appears by an epitaph which the Duke Chriſtian, brother of the Elector George II. inſcribed on the tomb of Johan Albert Stirling of Achil, in the cathedral of Marckſburg. This gentleman had been preſident of the ſenate of the electorate, privy counſellor, director of the impoſts, and maſter of horſe to the Prince, and had, by his faithful and uſeful ſervices, acquired his higheſt eſteem.

E. W. Von Tſchirnhaus was born, as has been obſerved, at Kiſlingſwald, the uſual reſidence of the family, and poſſeſſed by it during more than 300 years. The family came originally from Bohemia, and appears to have been conſiderable, ſeeing that, from the earlieſt accounts of it in Luſatia, the Barons of Kiſlingſwald are generally found in the moſt reſpectable civil offices.

The figure which Baron Von Tſchirnhaus, the ſubject of this relation, has made in the ſcientific and political world, makes it ſuperfluous to ſay that his early years were well employed. Quick apprehenſion, a clear perception of the ſubject of his thoughts, and the moſt ardent and inſatiable thirſt for knowledge, diſtinguiſhed him during his academical education. When 17 years of age, he was ſent to Leyden. In 1672 all ſtudy was interrupted in Holland by the din of war; and Mr Von Tſchirnhaus left the univerſity for the camp. His knowledge in mathematics, mechanics, and all phyſical ſcience, found ample room in the military ſervice for ſhewing the importance of thoſe ſciences; and Tſchirnhaus ſo diſtinguiſhed himſelf by his ſervice in this way, that Baron Nieuland, a general officer of great merit, and at the ſame time an accompliſhed ſcholar, took delight in puſhing him into every ſervice where he could ſhew himſelf and his talents.

Tſchirnhaus.

After two years ſervice, he returned to his father's; but finding little to intereſt him in the life of a mere country gentleman, and ſtill burning with the ſame thirſt of knowledge, he prevailed on his father to allow him to travel. His younger brother George Albrecht Von Tſchirnhaus, Baron Obernſchonfeld, which he inherited from his grandfather Stirling, loved him with the warmeſt affection, and ſupplied him liberally with what was required for his appearance everywhere in a manner becoming his rank, and for fully gratifying his curioſity. He uſed often to ſay, "Sorry was I to loſe the company of my dear brother, and I ſometimes wiſhed to accompany him; but not having his thirſt for knowledge, I knew that his love for me would debar him of much happineſs, which I ſhould thus have obſtructed." *Felices animæ!* He went to Holland, from thence into England, France, Italy, Sicily, Malta, Greece.—Returning through the Tyrol, he met his brother at Vienna, where both were in great favour at the court of Leopold Wherever he went, he made himſelf acquainted with the moſt eminent in all departments of ſcience, living with them all in the mutual exchange of diſcoveries and of kind offices. In Holland he was intimate with Huyghens and Hudde; in England, with Newton, Wallis, Halley, and Oldenburgh; in France, among a people who more ſpeedily contract acquaintance, there was not a man of note with whom he did not cultivate an active acquaintance—and, fortunately, Leibnitz then lived at Paris: in Italy, he was particular careſſed by Michaeli, ſoon after Cardinal; and was in the cloſeſt correſpondence with Kircher. His enjoyments, however, were derived ſolely from the communications of the moſt eminent; his curioſity was directed to every thing, and wherever he ſaw an ingenious artiſan, he was eager to learn from him ſomething uſeful. In 1682, when at Paris for the third time, he communicated to his friends his celebrated theory of the cauſtic curves, which marked him out as a valuable acquiſition, and he was elected a member of the Royal Academy of Sciences, which was then reformed by the great miniſter Colbert, and the moſt illuſtrious in all nations were picked out for its ornaments. There he found himſelf ſeated with Leibnitz, Huyghens, John Bernoulli, &c.

After twelve years employed in viſiting Europe, he returned home: but after a ſhort ſtay, went to Flanders, and prepared to publiſh his work, intitled *Medicina Mentis*; of which the ſubject may almoſt be gueſſed, from the way in which he had exerciſed his own mind. Having the moſt exalted notions of the intellectual and moral

moral nature of man, he thought that the continual ſupply of information was as neceſſary as the continual ſupply of food. And his great principle was TO ENLIGHTEN. This work was committed to the care of ſome friends, and did not appear till 1687, at Amſterdam. A ſecond edition appeared at Leipſic in 1695.

Finding now that his moderate fortune was inſufficient for the great public projects he had in view, he ſought for aſſiſtance, and endeavoured to make friends by frequenting the court of the Elector at Dreſden. He ſoon became a favourite of his Princes, George the II. and III. and was appointed to active offices of great reſponſibility. By the orders and encouragement of the Elector, then king of Poland, he introduced into his native country the firſt manufacture of glaſs; and his project ſoon throve to ſuch a degree, that not only Saxony was ſupplied, but they even began to export the finer kinds of white glaſs for windows; in which manufacture Saxony ſtill excels. It was in the courſe of experiments for improving this manufacture that Tſchirnhaus made the celebrated great burning glaſſes which ſtill bear his name. He made two of theſe lenſes, and gave one to the Emperor, and the other to the Academy of Paris. He was eager to improve the art of forming and poliſhing optical glaſſes; and in the proſecution of the theory on which their performance depends, he made ſome beautiful diſcoveries in the department of pure geometry. It is well known that all the ſciences are allied, and of a family, and that eminence in one is ſeldom attainable without the aſſiſtance of others. His preſent purſuits led him to the ſtudy of chemiſtry, which he proſecuted with the ſame ardour which he exhibited in every thing he undertook. But all the while, mathematics, and eſpecially geometry, was his favourite ſtudy; and he was anxious to make the ſame advances in the general paths of mathematical inveſtigation which he thought he had made in the general laws of material nature. He apprehended that only bye paths were yet known, and that many things were yet inacceſſible; becauſe we had not yet found out the great roads from which thoſe branches were derived. He was of Des Cartes's opinion, that the true road in mathematics muſt be an eaſy one, except in caſes which were, in their own nature, complicated. Very early, therefore, he began writing on mathematical ſubjects, always continuing his general views of the ſcience, and his endeavours to ſyſtematiſe the ſtudy; but, at the ſame time, beſtowing a very particular attention on any branch which chanced to intereſt him: each of theſe his epiſodical ſtudies in mathematics deſerves the name of a department of the ſcience. This is the caſe with his theory of cauſtic curves, with his method of tangents, and his attempt to free Leibnitz's calculus from all conſideration of infiniteſimal quantities. Mr Tſchirnhaus ſeldom gave himſelf any trouble with a particular problem. In all his mathematical performances, there is an evident connection with ſomething which he conſidered as the great whole of the ſcience; and the manner of treating the different queſtions is plainly accommodated to a ſyſtem in his thoughts. This he intended as the third part of the Medicina Mentis; and, having nearly completed the ſecond, he had propoſed theſe as the occupation of the enſuing winter (1708-9). But his death, which may be called premature, has deprived the world of theſe, and other beneficent and uſeful labours.

Mr Von Tſchirnhaus was of the moſt mild and gentle diſpoſition, as was well known to all who enjoyed his acquaintance. This diſpoſition was ſo eminent in him, that ſcarcely any perſon ever ſaw him angry, or even much ruffled in his temper. He forgave injuries frankly and heartily, and often ſtood the friend (unknown) of thoſe who had wronged him. By ſuch conduct, he changed ſome enmities into the moſt ſteady and affectionate friendſhips. As an inquirer and an inventor, he had contentions with other claimants, and ſome diſputes about the legitimacy of his methods; as, for example, with Nicholas Fatio Duiller, who attacked Tſchirnhaus's method of tangents; and Preſtet and Rolle, who found fault with his expreſſion of equations of the third degree. But theſe were all friendly debates, and never carried him beyond the limits of gentlemanly behaviour. He began to diſpute with Ozanam about a quadratrix; but on being merely told that he was miſtaken, by P. Souciet, he immediately acknowledged his error, and corrected it.

Many original and important mathematical performances of Mr Von Tſchirnhaus are to be ſeen in the Leipſic Acts, in the Memoirs of the Academy of Sciences at Paris, and other literary journals. His happy generaliſation of Dr Barrow's theorem for the focus of a ſlender pencil of rays after reflection or refraction, and the theory of cauſtic curves, in which this terminates, both conſtitutes one of the moſt elegant branches of optical ſcience, and affords a rich harveſt of very curious and unexpected geometrical truths. The manner in which he notices the rough way in which his firſt and ſole miſtake in this theory was pointed out, is perhaps incomparable as an example of gentlemanlike reprehenſion, and is a leſſon for literati of all deſcriptions, highly valuable on account of the ſoft way in which it falls, while it is convincing as a mathematical theorem.

Tſchirnhaus was the diſcoverer of the ſubſtance of which the celebrated Saxon porcelain is made, and of the manner of working it up; by which he eſtabliſhed a manufacture highly profitable to his country, and has given us the fineſt pottery in the world. He never wearied in ſpreading uſeful knowledge; and the ſhops of our artiſans of almoſt all kinds were ſupplied with books of inſtructions and patterns, many of them written by Mr Von Tſchirnhaus, or under his inſpection. Uſeful books of all kinds were tranſlated out of foreign languages at his expence. Men of genius in the arts were enabled, through the encouragement of himſelf and his friends, and often by his pecuniary aſſiſtance, to bring their talents before the public eye. In ſhort, he ſeemed at all times to prefer the public good to his own; and never felt ſo much pleaſure as when he could promote ſcience or the uſeful arts. He was as it were ſtimulated to this by an innate propenſity. And as he was more deſirous of *being* than of *appearing* the accompliſhed man, he was in no concern what notice others took of his ſervices to the public. He even repreſents the deſire of fame as hoſtile to the improvement either of ſcience or morality, in his *Medicina Mentis*; a work which is acknowledged by all who knew him to be a picture of his own amiable mind. He lightly eſteemed riches; and knew not what

Tſchirnhaus.

uſe they were of, except for providing the neceſſaries of life, and the means of acquiring knowledge. In perfect conformity to this maxim, he modeſtly, and with elegant reſpect, refuſed the ample preſents made him by his affectionate ſovereign; and when he was added to his cabinet council, he received the diploma, but begged and obtained to be free from the title. And when he preſented his great burning glaſs to the Emperor, and got from him the dignity and inſignia of Baron of the Empire, he pleaded for leave to decline it, requeſting to keep the chain and portrait, which he always wore under his veſt. He expended a very great portion of the ample revenue left him by his father in the ſervice of his country, by promoting the uſeful arts and ſciences.

Mr Von Tſchirnhaus venerated truth above all things; ſaying, that thoſe who thought any thing comparable with it were not the ſons of God, but ſtep-children, and that the love of truth is the ruling affection in every man of a worthy heart. In a letter to an intimate friend, he ſaid that, by the age of five-and-twenty, he had completely ſubdued the love of glory, of riches, and of worldly pleaſures; and that at no time he had found it difficult to repreſs vanity, becauſe he was every day conſcious of having acted worſe than he was certain that he might and ſhould have done. He felt himſelf humbled in the ſight of the All-perfect Judge.

Nor was all this the vain boaſt of a man averſe to buſineſs, and poſſeſſed of an ample fortune, which permitted him, without inconvenience, to pleaſe his fancy in ſtudy, and in helping others with what to himſelf was ſuperfluous. Such a character, though rare, may exiſt, without being the object of much reſpect. No: Mr Tſchirnhaus was really a philoſopher of the true ſtoïc ſect, in reſpect of fortitude of mind, while a good Chriſtian in modeſty and diffidence. In the laſt five years of his life he bore up under troubles, and embarraſſments, and misfortunes in his family, which would have tried the mind of Cato himſelf. But in the midſt of theſe ſtorms he was unſhaken, and preſerved his ſerenity of mind. He was even ſenſible of this being a rare gift of Providence, and uſed frequently to expreſs his thankfulneſs for a treaſure ſo precious. He felt deeply his relation to the Author of Nature, and rejoiced in thinking himſelf ſubject to the providence of God. He ſaid that he was fully perſuaded that he would meet with perfect juſtice, and would therefore ſtrive to perform his own part to the utmoſt of his power, that his future condition might be the more happy, and that he might in the mean time enjoy more ſatisfaction on reflecting on his own conduct. His lot, he ſaid, was peculiarly fortunate: having ſuch thirſt for novelty, he would have been unhappy without an affluent fortune; and his own enjoyments encouraged neither vice nor idleneſs in himſelf or in the miniſters to his pleaſures.

This amiable perſon was of a conſtitution not puny, but not robuſt, and he had hurt it by too conſtant ſtudy. He feared no diſeaſe; thinking that he had a cure or an alleviation for all but one, namely, the ſtone and gravel. He had a dread of this, and laboured to find a preventative or a remedy. He thought that he had alſo done a great deal here; and deſcribes in his *Medicina Corporis* a preparation of whey, which he ſaid he uſed with great advantage to his health. But his precautions were in vain: He was attacked with the gravel, which, after three months ſuffering, brought on a ſuppreſſion of urine. The phyſicians ſaw that his end approached; and finding him diſregard their preſcriptions, they quitted him. He treated himſelf (it is ſaid judiciouſly) for ſome time, and with ſome appearance of ſucceſs; but at laſt he ſaw death not far off. He dictated a letter to his Sovereign, thanking him for all his favours and kindneſs, and recommended his children to his protection. He never fretted nor complained; but frequently, with gliſtening eyes, expreſſed his warmeſt thanks to Providence for the wonderful track of good fortune and of happineſs that he had enjoyed; and ſaid that he alſo felt ſome ſatisfaction in the conſciouſneſs that ſome of this was owing to his own prudent conduct. He poſſeſſed his entire faculties to the laſt moment; and when he felt his ſpirit juſt about to depart, his laſt words were, "*Iö triumphé—Victoria!*" No longer able to ſpeak, he made ſigns for what he wanted; and a little after, ſhutting his eyes, as if to ſleep, he gently, and without a groan, yielded up his ſpirit, about four o'clock in the morning of the 11th of October 1708, aged 56.

His funeral was performed in a manner becoming his rank, and the body conveyed to the family vault. The Elector (King of Poland) defrayed the expence; for he would not allow his family to have any thing to do with the funeral of a man of ſo public a character, and ſo univerſally beloved.

The account of ſuch a life as that of Baron Von Tſchirnhaus would, at all times, make a pleaſant and uſeful impreſſion. In theſe our times, in the end of the 18th century, after ſociety has availed itſelf of all the acquiſitions in ſcience and art, furniſhed by that ardent age of the world which this gentleman contributed to adorn; in an age when we boaſt of illumination unparalleled in hiſtory, and of improvements almoſt amounting to perfection; and in particular, of an emancipation from the prejudices which had obſcured our view of the chief good, and ſtifled public ſpirit—now, when we are ſo full of knowledge that it is running over on all hands, in volumes of inſtruction, how to make the world one happy family; in theſe bright days of philanthropiſm, can the public records of Europe exhibit a ſuperior character to that of Mr Von Tſchirnhaus, either in reſpect of wiſdom or of diſpoſition? Was he not a philanthropiſt, a ſincere lover of mankind? Was he not wiſe, in employing his great acquired knowledge as the means of direct and active beneficence, by limiting his exertions to the extent of thoſe circles where his own efforts would be effective? He did not write books, teaching others how to do good: he taught it by example; being determined that his own wiſhes to ſee men happier ſhould not fail by the want of ſuch wiſhes in others, even after he ſhould inſtruct them. He never allowed his inſatiable curioſity for freſh diſcoveries to interfere with the immediate turning to the good of his own country the knowledge he had already acquired. He probably never thought of improving the ſituation of the Chineſe or the Mexicans, finding that it required all his ample fortune, and all the intereſt and influence he could acquire, to do the good he wiſhed in Saxony. We doubt not but that he was equally attentive to the

ſtill

Tſchirnhaus, Tſhamie.

ſtill narrower circle of duties formed by his own family. We ſee that he was a dearly beloved brother; which could hardly be without his alſo being a loving brother and a dutiful ſon. The nature of the diſtreſſes which he experienced in his family, and the manner in which he behaved under them, ſhew him to have been an eminent Chriſtian moraliſt. With a modeſty that is unmatched by any one of the thouſands who have poured out inſtructions uponus during the laſt ten years, and a gracefulneſs which characteriſes the gentleman, his *Medicina Mentis* is offered to public notice, merely as an experimental proof that a certain way of thinking and acting is productive of internal quiet of mind; of great mental enjoyment, both moral and intellectual; and of peace, and the good will of thoſe around us: and that it did, in fact, produce a dutiful and comfortable reſignation to the unavoidable trials of human life. He pretends not to be greatly ſuperior in wiſdom to his neighbours, but merely tells how things ſucceeded with himſelf. He did not ſcruple, however, to publiſh to the world diſcoveries in ſcience, in which he had got the ſtart of others during that buſy period of ſcientific occupation: and theſe diſcoveries in mathematics were highly prized by the firſt men of the age; nor will the name of Tſchirnhaus, or his cauſtic curves, ever be forgotten.

We felt ourſelves obliged to the friend who took notice of the omiſſion of this gentleman's name, ſo eminent in the mathematical world, in the courſe of our alphabet; but when we looked into the Memoirs of the Academy of Paris for 1709 for ſome account of him, what we there ſaw appeared ſuch a continual panegyric, that we could not take it as a fair picture of any real character. Looking about for more impartial information, we found in the *Acta Eruditorum*, Leipſ. 1709, the account of which the foregoing is an abſtract, except a particular or two which we have copied from an account in the Literary Journal of Breſlaw, by Count Herberſtein, whom we can ſcarcely ſuſpect of undue partiality, becauſe he had ſome diſputes with Mr Von Tſchirnhaus on mathematical ſubjects. May we not ſay, "the memory of this man is ſweet!"

TSHAMIE, the Indian name of a tree in the Northern Circars of Hindoſtan. It grows, ſays Dr Roxburgh, to be a pretty large tree, is a native of moſt parts of the coaſt, chiefly of low lands at a conſiderable diſtance from the ſea, and may be only a variety of *proſopis ſpicigera*, for the thorns are in this ſometimes wanting; flowers during the cold and beginning of the hot ſeaſons. *Trunk* tolerably erect, bark deeply cracked, dirty aſh colour. *Branches* irregular, very numerous, forming a pretty large ſhady head. *Prickles* ſcattered over the ſmall branches; in ſome trees wanting. *Leaves* alternate, generally bipinnate, from two to three inches long; pinnæ from one to four, when in pairs oppoſite, and have a gland between their inſertions. *Leaflets* oppoſite, from ſeven to ten pair, obliquely lanced, ſmooth, entire, about half an inch long, and one-ſixth broad. *Stipules* none. *Spikes* ſeveral, axillary, filiform, nearly erect. *Bracts* minute, one-flowered, falling. *Flowers* numerous, ſmall, yellow, ſingle, approximated. *Calyx* below, five-toothed. *Filaments* united at the baſe. *Anthers* incumbent, a white gland on the apex of each, which falls off ſoon after the flower expands. *Style* crooked. *Stigma* ſimple. *Legume* long, pendulous, not inflated. *Seeds* many, lodged in a brown meally ſubſtance.

Tucker.

The pod of this tree is the only part uſed. It is about an inch in circumference, and from ſix to twelve long; when ripe, brown, ſmooth, and contains, beſides the ſeeds, a large quantity of a brown meally ſubſtance, which the natives eat; its taſte is ſweetiſh and agreeable; it may therefore be compared to the Spaniſh *algaroba*, or locuſt tree. (*Ceratonia ſiliqua*, Linn.)

In compliance with Dr Kœnig's opinion, Dr Roxburgh calls this tree a *proſopis*; but as he thinks the antheral glands give it a claim to the genus *adenanthera*, we have retained the Indian name till its botanical claſſification ſhall be aſcertained by thoſe who have greater authority in the ſcience than we lay claim to.

TUCKER (Abraham), Eſq; a curious and original thinker, was a gentleman of affluent fortune, and author of "The Light of Nature purſued," 9 vols 8vo; of which the five firſt volumes were publiſhed by himſelf in 1768, under the aſſumed name of "Edward Search, Eſq;" and the four laſt after his death, in 1777, as "The poſthumous Work of Abraham Tucker, Eſq; publiſhed from his manuſcript as intended for the preſs by the author." Mr Tucker lived at Betchworth-caſtle, near Dorking, in Surrey; an eſtate which he purchaſed in the early part of his life. He married the daughter of Edward Barker, Eſq; by whom he had two daughters; one of whom married Sir Henry St John, and died in his lifetime; the other ſurvived, and now lives at Betchworth-caſtle. He loſt his eyeſight a few years before his death, which happened in 1775. To deſcribe him as a neighbour, landlord, father, and magiſtrate, it would be neceſſary to mention the moſt amiable qualities in each. It is unneceſſary to add, that he was very ſincerely regretted by all who had the pleaſure of his acquaintance, and who ſtood connected with him in any of thoſe relations.

Tucker (Joſiah, D. D.), well known as a political and commercial writer, was born at Langhorn, in Caermarthenſhire, in the year 1712. His father was a farmer, and having a ſmall eſtate left him at or near Aberyſtwith, in Cardiganſhire, he removed thither; and perceiving that his ſon had a turn for learning, he ſent him to Ruthin ſchool, in Denbighſhire, where he made ſo reſpectable a progreſs in the claſſics, that he obtained an exhibition at Jeſus College, Oxford. It is generally underſtood that ſeveral of his journeys to and from Oxford were performed on foot, with a ſtick on his ſhoulder, and bundle at the end of it. Thus it might be ſaid by him, as by Simonides, "*Omnia mea mecum porto.*"

At the age of 23 he entered into holy orders, and ſerved a curacy for ſome time in Glouceſterſhire. About 1737 he became curate of St Stephen's church in Briſtol, and was appointed minor-canon in the cathedral of that city. Here he attracted the notice of Dr Joſeph Butler, then Biſhop of Briſtol, and afterwards of Durham, who appointed Mr Tucker his domeſtic chaplain. By the intereſt of this prelate Mr Tucker obtained a probendal ſtall in the cathedral of Briſtol; and on the death of Mr Catcott, well known by his treatiſe on the Deluge, and a volume of excellent ſermons, he became rector of St Stephen. The inhabitants of that pariſh conſiſt

conſiſt chiefly of merchants and tradeſmen; a circumſtance which greatly aided his natural inclination for commercial and political ſtudies.

When the famous bill was brought into the Houſe of Commons for the naturalization of the Jews, Mr Tucker, conſidering the meaſure rather as a merchant or politician than as a Chriſtian divine, wrote in defence of it with a degree of zeal which, to ſay no more, was at leaſt indecent in a man of his profeſſion. As ſuch it was viewed by his brethren of the clergy, and by his pariſhioners; for, while the former attacked him in pamphlets, newſpapers, and magazines, the latter burnt his effigy dreſſed in canonicals, together with the letters which he had written in defence of the naturalization.

In the year 1753 he publiſhed an able pamphlet on the "Turkey Trade;" in which he demonſtrates the evils that reſult to trade in general from chartered companies. At this period Lord Clare (afterward Earl Nugent) was returned to Parliament for Briſtol; which honour he obtained chiefly through the ſtrenuous exertions of Mr Tucker, whoſe influence in his large and wealthy pariſh was almoſt deciſive on ſuch an occaſion. In return for this favour, the Earl procured for him the deanery of Glouceſter, in 1758, at which time he took his degree of doctor in divinity. So great was his reputation for commercial knowledge, that Dr Thomas Hayter, afterwards Biſhop of London, who was then tutor to his preſent majeſty, applied to Dr Tucker to draw up a diſſertation on this ſubject for the peruſal of his royal pupil. It was accordingly done, and gave great ſatisfaction. This work, under the title of "The Elements of Commerce," was printed in quarto, but never publiſhed.

Dr Warburton, who became Biſhop of Glouceſter in the year 1760, thinking very differently from Dr Tucker of the proper ſtudies of a clergyman, as well as of the project for naturalizing the Jews, ſaid once to a perſon who was praiſing the Elements of Commerce, that "his Dean's trade was religion, and religion his trade." This ſarcaſm, though not perhaps groundleſs, was certainly too ſevere; for ſome of the Dean's publications evince him to have devoted part of his time at leaſt to the ſtudy of theology, and to have been a man of genuine benevolence.

In the year 1771, when a ſtrong attempt was made to procure an abolition of ſubſcription to the 39 articles, Dr Tucker came forward as an able and moderate advocate of the church of England. About this time he publiſhed "Directions for Travellers;" in which he lays down excellent rules, by which gentlemen who viſit foreign countries may not only improve their own minds, but turn their obſervations to the benefit of their native country.

The Dean was an attentive obſerver of the American conteſt. He examined the affair with a very different eye from that of a party man, or an intereſted merchant; and he diſcovered, as he conceived, that both ſides would be better off by an abſolute ſeparation. Mr Burke's language in the Houſe of Commons, in conſequence of his publiſhing this opinion, was harſh, if not illiberal. In his famous ſpeech on the American taxation bill, April the 13th, 1774, he called the Dean of Glouceſter the advocate of the court faction, though it is well known that the court diſapproved of the propoſal as much as the oppoſition. This attack rouſed the Dean to reſentment; and he publiſhed a letter to Mr Burke; in which he not only vindicates the purity of his own principles, but retorts upon his adverſary in very forcible and ſarcaſtic terms. He afterwards ſupported Lord Nugent's intereſt in Briſtol againſt that of Mr Burke, and was certainly very inſtrumental in making the latter loſe his election.

When the terrors of an invaſion were very prevalent in 1779, Dr Tucker circulated, in a variety of periodical publications, ſome of the moſt ſenſible obſervations that were ever made on the ſubject, in order to quiet the fears of the people. In 1781 he publiſhed, what he had printed long before, "A Treatiſe on Civil Government," in which his principal deſign is to counteract the doctrines of Locke and his followers. The book made a conſiderable noiſe, and was very ſharply attacked by ſeveral writers on the democratic ſide of the queſtion, particularly by Dr Towers and Dr Dunbar of Aberdeen. This laſt gentleman acted a part which, if not diſhonourable, was at leaſt uncommon. The Dean had thrown off thirty copies of his work long before he publiſhed it; and theſe he ſent to different men of eminence, that he might avail himſelf of their animadverſions before he ſhould ſubmit it to the public at large. Principal Campbell of Aberdeen received one copy for this purpoſe; and Dr Dunbar having by him been favoured with a peruſal of it, inſtead of ſending his objections privately to the author, publiſhed ſevere remarks on it in a work which he had then in the preſs. Thus was the anſwer to the Dean of Glouceſter's Treatiſe on Government publiſhed before that treatiſe itſelf; but Dr Dunbar was no match for Dr Tucker.

In the year 1782 our author cloſed his political career with a pamphlet intitled "*Cui Bono?*" in which he balances the profit and loſs of each of the belligerent powers, and recapitulates all his former poſitions on the ſubject of war and colonial poſſeſſions. His publications ſince that period conſiſted of ſome tracts on the commercial regulations of Ireland, on the exportation of woollens, and on the iron trade. In 1777 he publiſhed ſeventeen practical ſermons, in one volume octavo. In the year 1778, one of his pariſhioners, Miſs Pelloquin, a maiden lady of large fortune and moſt exemplary piety, bequeathed to the Dean her dwelling houſe in Queen Square, Briſtol, with a very handſome legacy, as a teſtimony of her great eſteem for his worth and talents. In the year 1781 the Dean married a lady of the name of Crowe, who reſided at Glouceſter.

It ſhould be recorded to his praiſe, that though enjoying but very moderate preferment (for to a man of no paternal eſtate, or other eccleſiaſtical dignity, the Deanery of Glouceſter is no very advantageous ſituation), he was notwithſtanding a liberal benefactor to ſeveral public inſtitutions, and a diſtinguiſhed patron of merit. The celebrated John Henderſon of Pembroke-college, Oxford, was ſent to the univerſity, and ſupported there, at the Dean's expence, when he had no means whatever of gratifying his ardent deſire for ſtudy. We ſhall mention another inſtance of generoſity in this place, which reflects the greateſt honour upon the Dean. About the year 1790 he thought of reſigning his rectory in Briſtol, and, without communicating his deſign to any other perſon, he applied to the Chancellor, in whoſe

whoſe gift it is, for leave to quit it in favour of his curate, a moſt deſerving man, with a large family. His Lordſhip was willing enough that he ſhould give up the living, but he refuſed him the liberty of nominating his ſucceſſor. On this the Dean reſolved to hold the living himſelf till he could find a fit opportunity to ſucceed in his object. After weighing the matter more deliberately, he communicated his wiſh to his pariſhioners, and adviſed them to draw up a petition to the Chancellor in favour of the curate. This was accordingly done, and ſigned by all of them, without any exception, either on the part of the diſſenters or others. The Chancellor being touched with this teſtimony of love between a clergyman and his people, yielded at laſt to the application; in conſequence of which the Dean cheerfully reſigned the living to a ſucceſſor well qualified to tread in his ſteps. Since that time he reſided chiefly at Glouceſter, viewing his approaching diſſolution with the placid mind of a Chriſtian, conſcious of having done his duty both to God and man. He died in November 1799. The following we believe to be a tolerably correct liſt of his works.

Theological and Controverſial.—1. A Sermon, preached before the Governors of the Infirmary of Briſtol, 1745. 2. Letters in behalf of the Naturalization of the Jews. 3. Apology for the Church of England, 1772. 4. Six Sermons, 12mo, 1773. 5. Letter to Dr Kippis on his Vindication of the Proteſtant Diſſenting Miniſters. 6. Two Sermons and Four Tracts. 7. View of the Difficulties of the Trinitarian, Arian, and Socinian Syſtems, and Seventeen Sermons, 1777.

Political and Commercial.—8. A pamphlet on the Turkey Trade. 9. A brief View of the Advantages and Diſadvantages which attend a Trade with France. 10. Reflections on the Expediency of Naturalizing foreign Proteſtants, and a Letter to a Friend on the ſame Subject. 11. The Pleas and Arguments of the Mother Country and the Colonies ſtated. 12. A Letter to Mr Burke. 13. Quere, Whether a Connection with, or Separation from, America, would be for national Advantage? 14. Anſwers to Objections againſt the Separation from America. 15. A Treatiſe on Civil Government. 16. *Cui Bono?* 17. Four Letters on national Subjects. 18. Sequel to Sir William Jones on Government. 19. On the Diſpute between Great Britain and Ireland. 20. Several Papers under the Signature of Caſſandra, &c. on the Difficulties attendant on an Invaſion. 21. A Treatiſe on Commerce (Mr Coxe, in his Life of Sir Robert Walpole, ſays that this was printed, but never publiſhed.)

Miſcellaneous.—22. Directions for Travellers. 23. Cautions againſt the Uſe of Spirituous Liquors. 24. A Tract againſt the Diverſions of Cock-fighting, &c.

TULIPOMANIA, the very proper name given to a kind of gambling traffic in *tulip roots*, which prevailed in Holland and the Netherlands during ſome part of the 17th century. It was carried on to the greateſt extent in Amſterdam, Haerlem, Utrecht, Alkmaar, Leyden, Rotterdam, Hoorn, Enkhuyſen, and Meedenblick; and roſe to the greateſt height in the years 1634, 1635, 1636, and 1637. Munting, who, in 1696, wrote a book of 1000 pages folio on the ſubject, has given a few of the moſt extravagant prices, of which we ſhall preſent the reader with the following For a root of that ſpecies called the *Viceroy*, the after-mentioned articles, valued as below, were agreed to be delivered.

		Florins.
2	laſts of wheat	448
4	ditto rye	558
4	fat oxen	480
8	fat ſwine	240
12	fat ſheep	120
2	hogſheads of wine	70
4	tons beer	32
2	ditto butter	192
1000	pounds of cheeſe	120
	a complete bed	100
	a ſuit of clothes	80
	a ſilver beaker	60
	Sum	2500

Theſe tulips afterwards were ſold according to the weight of the roots. Four hundred perits* of Admiral Lieſken coſt 4400 florins; 446 ditto of Admiral Von der Eyk, 1620 florins; 106 perits Schilder coſt 1615 florins; 200 ditto Semper Auguſtus, 5500 florins; 410 ditto Viceroy, 3000 florins, &c. The ſpecies Semper Auguſtus has been often ſold for 2000 florins; and it once happened that there were only two roots of it to be had, the one at Amſterdam and the other at Haerlem. For a root of this ſpecies, one agreed to give 4600 florins, together with a new carriage, two grey horſes, and a complete harneſs. Another agreed to give twelve acres of land for a root: for thoſe who had not ready money, promiſed their moveable and immoveable goods, houſe and lands, cattle and clothes. A man, whoſe name Munting once knew, but could not recollect, won by this trade more than 60,000 florins in the courſe of four months. It was followed not only by mercantile people, but alſo by the firſt noblemen, citizens of every deſcription, mechanics, ſeamen, farmers, turf-diggers, chimney-ſweeps, footmen, maid-ſervants, and old clothes-women, &c. At firſt, every one won and no one loſt. Some of the pooreſt people gained in a few months houſes, coaches, and horſes, and figured away like the firſt characters in the land. In every town ſome tavern was ſelected which ſerved as a change, where high and low traded in flowers, and confirmed their bargains with the moſt ſumptuous entertainments. They formed laws for themſelves, and had their notaries and clerks.

To get poſſeſſion of fine flowers was by no means the real object of this trade, though many have ſaid that it was, and though we have known ſome individuals in Scotland, who, led away by what they thought the faſhion, have given ten guineas for a tulip root. During the time of the tulipomania, a ſpeculator often offered and paid large ſums for a root which he never received, and never wiſhed to receive. Another ſold roots which he never poſſeſſed or delivered Oft did a nobleman purchaſe of a chimney-ſweep tulips to the amount of 2000 florins, and ſold them at the ſame time to a farmer; and neither the nobleman, chimney ſweep, or farmer, had roots in their poſſeſſion, or wiſhed to poſſeſs them Before the tulip ſeaſon was over, more roots were ſold and purchaſed, beſpoke, and promiſed to be delivered, than in all probability were to be found in the gardens of Holland; and when Semper Auguſtus

---

* A *perit* is a ſmall weight leſs than a grain.

was not to be had, which happened twice, no ſpecies perhaps was oftener purchaſed and ſold. In the ſpace of three years, as Munting tells us, more than ten millions were expended in this trade in only one town of Holland.

To underſtand this gambling traffic, it may be neceſſary to make the following ſuppoſition. A nobleman beſpoke of a merchant a tulip root, to be delivered in ſix months, at the price of 1000 florins. During theſe ſix months the price of that ſpecies of tulip muſt have riſen or fallen, or remained as it was. We ſhall ſuppoſe that, at the expiration of that time, the price was 1500 florins; in that caſe, the nobleman did not wiſh to have the tulip, and the merchant paid him 500 florins, which the latter loſt and the former won. If the price was fallen when the ſix months were expired, ſo that a root could be purchaſed for 800 florins, the nobleman then paid to the merchant 200 florins, which he received as ſo much gain; but if the price continued the ſame, that is, 1000 florins, neither party gained or loſt. In all theſe circumſtances, however, no one ever thought of delivering the roots or of receiving them. Henry Munting, in 1636, ſold to a merchant at Alkmaar, a tulip root for 7000 florins, to be delivered in ſix months; but as the price during that time had fallen, the merchant paid, according to agreement, only 10 *per cent.* "So that my father (ſays the ſon) received 700 florins for nothing; but he would much rather have delivered the root itſelf for 7000." The term of theſe contracts was often much ſhorter, and on that account the trade became briſker. In proportion as more gained by this traffic, more engaged in it; and thoſe who had money to pay to one, had ſoon money to receive of another; as at faro, one loſes upon one card, and at the ſame time wins on another. The tulip dealers often diſcounted ſums alſo, and transferred their debts to one another; ſo that large ſums were paid without caſh, without bills, and without goods, as by the Virements at Lyons. The whole of this trade was a game at hazard, as the Miſſiſſippi trade was afterwards, and as ſtock jobbing is at preſent. The only difference between the tulip trade and ſtock-jobbing is, that at the end of the contract the price in the latter is determined by the Stock Exchange; whereas in the former it was determined by that at which moſt bargains were made. High and low priced kinds of tulips were procured, in order that both the rich and the poor might gamble with them; and the roots were weighed by perits, that an imagined whole might be divided, and that people might not only have whole, but half and quarter lots. Whoever is ſurpriſed that ſuch a traffic ſhould become general, needs only to reflect upon what is done where lotteries are eſtabliſhed, by which trades are often neglected, and even abandoned, becauſe a ſpeedier mode of getting fortunes is pointed out to the lower claſſes.

At length, however, this trade fell all of a ſudden. Among ſuch a number of contracts many were broken; many had engaged to pay more than they were able; the whole ſtock of the adventurers was conſumed by the extravagance of the winners; new adventurers no more engaged in it; and many becoming ſenſible of the odious traffic in which they had been concerned, returned to their former occupations. By theſe means, as the value of tulips ſtill fell, and never roſe, the ſellers wiſhed to deliver the roots *in natura* to the purchaſers at the prices agreed on; but as the latter had no deſire for tulips at even ſuch a low rate, they refuſed to take them or to pay for them. To end this diſpute, the tulip-dealers of Alkmaar ſent, in the year 1637, deputies to Amſterdam; and a reſolution was paſſed on the 24th of February, that all contracts made prior to the laſt of November 1636 ſhould be null and void; and that, in thoſe made after that date, purchaſers ſhould be free on paying ten *per cent.* to the vender.

The more diſguſted people became with this trade, the more did complaints increaſe to the magiſtrates of the different towns; but as the courts there would take no cognizance of it, the complainants applied to the States of Holland and Weſt Frieſland. Theſe referred the buſineſs to the determination of the provincial council at the Hague; which, on the 27th of April 1637, declared that it would not deliver its opinion on this traffic until it had received more information on the ſubject; that in the mean time every vender ſhould offer his tulips to the purchaſer; and, in caſe he refuſed to receive them, the vender ſhould either keep them, or ſell them to another, and have recourſe on the purchaſer for any loſs he might ſuſtain. It was ordered alſo, that all contracts ſhould remain in force till farther enquiry was made. But as no one could foreſee what judgment would be given reſpecting the validity of each contract, the buyers were more obſtinate in refuſing payment than before; and venders, thinking it much ſafer to accommodate matters amicably, were at length ſatisfied with a ſmall profit inſtead of exorbitant gain: and thus ended this extraordinary traffic, or rather gambling. *Beckmann's Hiſtory of Inventions*, vol. i.

TUMAR, in Bengal, rent-roll or aſſeſſment.

TUMBREL, is a kind of carriage with two wheels, uſed either in huſbandry for dung, or in artillery to carry the tools of the pioneers, &c. and ſometimes likewiſe the money of an army.

TUNGSTEN (ſee CHEMISTRY, n° 178, &c. in this *Suppl.*) when well fuſed, is, according to Guyton *alias* Morveau, of no higher ſpecific gravity than 8.3406. This is very different from the ſpecific gravity which has hitherto been aſſigned to it. The ſame eminent chemiſt concludes, from its extreme brittleneſs and difficulty of fuſion, that it affords little promiſe of utility in the arts, except in metallic alloys, or by virtue of the property which its oxyd poſſeſſes, of affording fixed colours, or giving fixity to the colours of vegetables.

TURNSOL, a dye-ſtuff manufactured in Holland, the preparation of which was long kept a profound ſecret. In order to miſlead foreigners, the Dutch pretended that turnſol was made from rags dyed with the juice of the ſun-flower (*Helianthus*), from which it obtained its name. Since the late revolution, however, in Holland, the true method employed by the Dutch for preparing this colour has been diſcovered, and the proceſs is as follows:—That kind of lichen called orchil (LICHEN-*Rocella*. See that article in this *Suppl.*), or, when that cannot be procured, the large oak-moſs, after being dried and cleaned, is reduced to powder, and by means of a kind of oil-preſs the powder is forced thro' a braſs ſieve, the holes of which are ſmall. The ſifted powder is then thrown into a trough and mixed with an alkali called *vetas*, which is nothing elſe than the

aſhes

aſhes of wine lees, in the proportion of half a pound of aſhes to one pound of powder. This mixture is moiſtened with a little human urine, for that of other animals contains leſs ammonia, by which a fermentation is produced; and the moiſtneſs is ſtill kept up by the addition of more urine. As ſoon as the mixture aſſumes a red colour, it is poured into another trough; is again moiſtened with urine, and than ſtirred round in order that the fermentation may be renewed. In the courſe of a few days it acquires a bluiſh colour, and is then carefully mixed with a third part of very pure pulveriſed potaſh; after which the mixture is put into wooden pails, three feet in height, and about half a foot broad. When the third fermentation takes place, and the paſte has acquired a conſiderably dark blue colour, it is mixed with chalk or pulveriſed marble, and ſtirred well round that the whole may be completely united. This laſt ſubſtance gives the colour no higher quality, and is intended merely to add to the weight. The blue, prepared in this manner, is poured into oblong ſquare iron moulds; and the cakes, when formed, are placed upon fir boards on an airy floor in order to dry, after which they are packed up for ſale.

TURPENTINE, a well known ſubſtance extracted from the pine. Under the article PINUS (*Encycl.*), we have given an account of one proceſs by which this extract is made; but the following, which is taken from the 31ſt volume of the *Journal de Phyſique*, is very different, and probably better. The pine from which turpentine is extracted, is never fit for this operation till it be thirty years of age. The extraction is begun in February and continued to the end of October. Inciſions are made with an hatchet, beginning at the foot of the tree on one ſide, and riſing ſucceſſively: they are repeated once or twice a week, the ſize about one finger's breadth acroſs, and three or four inches long. During the four years in which it is continued, the inciſions have riſen to about eight or nine feet. Then the inciſions are begun on the other ſide; and during this time the old ones fill up, and may be again opened after ſome years, ſo that a tree on a good ſoil, and well managed, may yield turpentine for a century. At the bottom of the tree, under the inciſion, a hole is dug in the ground to receive the reſin which flows from the tree. This reſin is called *terebinthine brut*, is of a milky colour, and is that which flows during the three ſummer months; it requires further purification.

The winter crop is called *barras galipot*, or white reſin: it ſticks to the bark of the tree, when the heat has not been ſtrong enough to let it flow into the trough in the ground. It is ſcraped off with iron knives.

Two methods are practiſed for purifying theſe reſins. That which is followed at Bayonne is to have a copper cauldron which will hold 300lb. of materials fixed over a fire, and the flame circulating at the bottom of the copper. The turpentine is put in, melted with a gentle heat, and, when liquid, it is ſtrained through a ſtraw-baſket made for the purpoſe, and ſtretched over a barrel, which receives the ſtrained turpentine. This purification gives it a golden colour, and may be performed at all times of the year.

The ſecond manner, which is practiſed only in the mountain of De Buch, near Bourdeaux, conſiſts in having a large tub, ſeven or eight feet ſquare, and pierced with ſmall holes at the bottom, ſet upon another tub to catch the liquor. This is expoſed to the hotteſt ſun for the whole day, filled two-thirds with turpentine, which as it melts falls through the holes, and leaves the impurities behind. This pure turpentine is leſs golden-coloured, and is much more eſteemed than the other. This proceſs can only be done in the ſummer.

To make *oil* of turpentine, an alembic, with a worm like what is uſed by the diſtillers, is employed here. It generally contains 250lb. of turpentine, which is boiled gently, and kept at the boiling point till no more oil paſſes, when the fire is damped. This generally gives 60lb. of oil, and the operation laſts one day.

The boiling turpentine, when it will give no more oil, is tapped off from the ſtill and flows into a tub, and from thence into a mold of ſand, which it fills, and is ſuffered to cool for at leaſt two days without diſturbing it. This reſidue is known under the name of *colophony*. It is of a brown colour, and very dry. It may be made clearer and nearer in colour to that of the reſin, by adding hot water to it before it is tapped off the ſtill, and ſtill boiling and ſtirring the water well with it, which is done with a beſom of wet ſtraw; and it is then ſold for roſin, but is little eſteemed, as it contains no eſſential oil.

TUSCULANUM, a villa belonging to Cicero, near Tuſculum, where he wrote his *Quæſtiones Tuſculanæ*, ſo named from the place; thus become famous as well for the productions of genius as of nature. Formerly the villa of Sylla: now called *Grotta Ferrata*.—Another *Tuſculanum* (inſcription), a town of the Tranſpadana, ſituated on the weſt ſide of the Lacus Benatus. Now ſaid to be called *Toſcolano*, in the territory of Breſcia, ſubject to Venice. Here many monuments of antiquity are dug up.

TUSCULUM (anc. geog.), a town of Latium, to the north of Alba; ſituated on an eminence, and therefore called *Supernum* (Horace, Strabo). In ſight of Rome, at about the diſtance of 100 ſtadia, or 12 miles. Adorned with plantations and princely edifices: The ſpot remarkable for the goodneſs of the ſoil, and its plenty of water. Built by Telegonus, who ſlew his father Ulyſſes (Ovid, Horace); called the grandſon of Ulyſſes in Silius Italicus. A municipium (Cicero); the birth-place of the elder Cato (Nepos, Cicero). Now *Freſcati*, in the Campania of Rome.

TUTENAG, according to Sir George Staunton, is, properly ſpeaking, zinc extracted from a rich ore, or calamine. The ore is powdered and mixed with charcoal-duſt, and placed in earthen jars over a ſlow fire, by means of which the metal riſes in the form of vapour, in a common diſtilling apparatus, and afterwards is condenſed in water. The calamine from which tutenag is thus extracted, contains very little iron, and no lead or arſenic, ſo common in the calamine of Europe (See CALAMINE, *Encycl.*) Hence it is that tutenag is more beautiful than our zinc, and that the white copper of the Chineſe takes ſo fine a poliſh. See *White Copper*, in this *Supplement*.

TYERS (Thomas), an author both in poetry and proſe, the friend of Johnſon, and well known to moſt of the eminent characters of the preſent time, was a ſtudent of the Temple in 1753. His father intended him for the law, but the young man it ſeems penned a ſonnet when he ſhould engroſs. He was an accompliſhed, but not a profound man; and had taſte and elegance of mind, ſlightly tinged with gleams of genius. He wrote ſome paſtorals and political tracts, which probably will not ſurvive the partiality of his particular friends.

TYPOGRAPHY, as the word imports, is the art of printing by types; but it is likewiſe uſed to ſignify the multiplying of copies by any mechanical contrivance. Of the art of printing by types, and the many improvements from time to time either made or attempted in it, a pretty full account will be found in the *Encyclopædia*, under the titles Letter, Logography, and Printing; and in this *Supplement* under the word Printing. Of typography, in the other and larger ſenſe, ſome account may likewiſe be found in the *Encyclopædia* under the title *Method of Copying Writings*; but to almoſt all theſe articles there is ample room for ſome additions here.

The *ſtereotype* printing of *Didot* and *Herhan*, being conſidered in France as a great improvement, muſt not be paſſed over wholly without notice. The term *ſtereotype* is derived from the Greek words ϛερεος and τυπος, becauſe in this method the types are fixed and immoveable in the form, ſo that none of them can be pulled or diſplaced by the preſſman. We need hardly obſerve, to thoſe who are at all acquainted with the hiſtory of printing, that the project of ſoldering a whole form together, or of caſting a ſolid form from an impreſſion made by a general ſyſtem of types, or page ready compoſed, is not new. It was realiſed 70 years ago by William Ged, a goldſmith in Edinburgh; for an account of whoſe method we refer the reader to his life in the *Encyclopædia*. Didot now follows nearly the ſame proceſs as Ged. He does not indeed caſt his types in a maſs, but after the form is compoſed and carefully corrected, he cements or ſolders the types together ſo firmly that none of them is liable to be looſened by the action of the preſs or the adheſion of the balls. How far this method of printing is of value with regard to books which are altered and improved in every ſubſequent edition, may, perhaps, be queſtioned; but on a looſe conſideration of the ſubject, it ſeems as if it would, in every caſe, be advantageous to a bookſeller to print a few copies of a work, and keep the types ſtanding to print others as they may be wanted; —we ſay it would be advantageous, if it were not for the immenſe value in types, which would, by that means, be locked up. To form ſome judgment of this, it may be ſtated, that the works of Virgil, printed by Didot, in 18mo, form a beautiful volume of 418 pages, of 35 lines each. The character ranges line for line with that called burgeois, N° 2. in Caſlon's book of ſpecimens, the face of the letter being rather ſmaller; and we are told * that the price of the plates of this work is twelve hundred franks, or 50l. ſterling. From this fact ſome judgment may be formed of the commercial queſtion. We have caſually looked at different books printed by Didot, but can ſay nothing of their correctneſs: the page is very pretty.

For multiplying copies of any writing, or of a book of ordinary ſize, Rochon, of the French National Inſtitute, and now Director of the Marine Obſervatory at the port of Breſt, invented, about the year 1781, a machine for engraving, with great celerity and correctneſs, the pages of the book or manuſcript on ſo many plates of copper. It was ſubmitted to the examination of a committee of the Royal Academy of Sciences, whoſe report of its utility was given in the following words:

"This machine appears to us to unite ſeveral advantages. 1*ſt*, Engraved editions of books may be executed, by this means, ſuperior to thoſe which can be made by the hand of the engraver, however ſkilful; and theſe engraved originals will be made with much more ſpeed, and much leſs expence. 2*d*, As this machine is portable, and of no conſiderable bulk, it may become very uſeful in armies, fleets, and public-offices, for the impreſſion of orders, inſtructions, &c. 3*d*, It poſſeſſes the advantage which, in a variety of circumſtances, is highly valuable, of being capable of being uſed by any man of intelligence and ſkill, without requiring the aſſiſtance of any profeſſional workman. And, *laſtly*, It affords the facility of waiting for the entire compoſition and engravings of a work before any of the copies are pulled off; the expence of plates, even for a work of conſiderable magnitude, being an object of little charge; and this liberty it affords to authors, may prove highly beneficial in works of which the chief merit conſiſts in the order, method, and connection of ideas."

Rochon's machine conſiſts of two braſs wheels *, placed on the ſame axis above each other, and ſeparated by a number of pillars, each two inches in length. Theſe two wheels, with the interval which ſeparates them, are equivalent to a ſingle wheel about three inches thick. In order therefore to ſimplify the deſcription, they are conſidered as a ſingle wheel which moves freely on its axis.

This wheel is perforated near its circumference with a number of ſquare holes, which are the ſheaths or ſockets through which a like number of ſteel punches, of the ſame ſhape, are inſerted, and are capable of moving up and down. They are very well fitted; and from this circumſtance, as well as the thickneſs of the double wheel, they have no ſhake, or ſide motion, independent of the motion of the wheel itſelf. Every punch is urged upwards by a ſeparate ſpring, in ſuch a manner, that the wheel armed with its characters, or ſteel types (the lower faces of the punches being cut into the figures of the ſeveral letters), may turn freely on its axis; and if it be moved, the ſeveral punches will paſs in ſucceſſion beneath an upright ſcrew, for preſſure. The ſcrew is fixed in a very firm and ſolid frame, attached to the ſupports of the machine; and by this arrangement a copperplate, diſpoſed on the table, or bed of the apparatus, will receive the impreſſion of all the punches in ſucceſſion, as they may be brought beneath the vertical preſſing ſcrew, and ſubjected to its action.

But as the preſs is fixed, it would neceſſarily follow that each ſucceſſive impreſſion would, in part, deſtroy or mutilate the previous impreſſions, unleſs the plate itſelf were moveable. It therefore becomes neceſſary that the plate ſhould be moveable in two directions: the firſt, to determine the interval between the letters and words, and form the lines; and the other motion, which is more ſimple, becauſe its quantity may remain the ſame through the whole of a book, ſerves to give the interval between line and line, and to form the pages.

It will eaſily be conceived that it would be a tedious operation to ſeek, upon the circumference of the wheel, each ſeveral character, as it might be required to come

---

* *La Decade Philoſophique.*

* See Plate XLVI.

beneath the preſs, becauſe it is neceſſary to repeat this operation as many times as there are characters in a work. The author has conſiderably diminiſhed the time and trouble of this operation, by fixing upon the axis of the great wheel, which carries the punches, another ſmall wheel, about four inches in diameter, the teeth of which act upon a rack, which carries a rule moving between two ſliders. This rule, or ſtraight line, will therefore repreſent the developement, or unfolding of the circumference of the wheel which cauſes it to move, and will ſhew the poſition of the great wheel, which carries the punches. For theſe two wheels being concentric, the developement of the ſmall toothed wheel, of about two inches radius, will exhibit, in a ſmall ſpace (for example, that of a foot), an accurate regiſter of the relative poſitions of the punches with regard to the preſſing-ſcrew. To obtain this effect, nothing more is neceſſary than to place a fixed index oppoſite to the moveable rule, which laſt is divided in the following manner:

The punch on which the firſt letter of the alphabet is engraved, muſt be brought under the centre of the preſſing-ſcrew; and a line of diviſion then drawn upon the moveable rule, to which the letter itſelf muſt be added to diſtinguiſh it. The index, already mentioned, being placed oppoſite, and upon this firſt diviſion, will ſerve to place immediately beneath the preſſing-ſcrew the punch, or rather the character, correſponding with the diviſion upon the rule, without its being afterwards neceſſary to inſpect the place either of the punch or the ſcrew, with regard to each other. Conſequently, as ſoon as the diviſions which correſpond with all the punches inſerted in the wheel are engraved upon the ſtraight rule, the fixed index will immediately determine the poſition into which that wheel muſt be brought, in order to place the punches under the preſſing-ſcrew in the order which the work may require.

This regiſter, for this name diſtinguiſhes the rule and its index, has no other function in the machine than to guide the hand of the operator, and to ſhew when the punch is very near its proper poſition beneath the preſſing-ſcrew. When this is the caſe, the required poſition is accurately obtained by means of a detent or catch.

The detent which he uſes for this operation is a lever with two tails, one of which is urged toward the circumference of the wheel by a ſpring. To this extremity of the lever is fixed a piece of hardened ſteel, of the figure of a wedge, which, by means of a ſpring, is preſſed towards the axis of the great wheel, but may be relieved, or drawn back, by preſſure on the oppoſite tail of the lever, ſo as to permit the great wheel to revolve at liberty.

In the next place, it muſt be explained how this detent takes hold of the wheel, ſo as to retain it preciſely in the ſituation neceſſary to cauſe any one of the punches, at pleaſure, to give its impreſſion to the plate. For this purpoſe there are a number of notches cut in the circumference of the wheel, for the purpoſe of receiving the detent. Theſe notches may be about half an inch deep, wider towards the circumference than elſewhere, and it will be of advantage that this outer width ſhould be as great as the circumference of the wheel can conveniently allow. By this contrivance, the wedge will not fail to preſent itſelf oppoſite to one of the notches into which it will fall, and draw the wheel exactly to its due ſituation, even though the index of the regiſter ſhould not be brought preciſely to the line of diviſion appropriated to any particular letter. For if this laſt degree of preciſion were required in working the machine, it would be very prejudicial to the requiſite ſpeed which, above all things, is required in its uſe. When the wedge is therefore left at liberty, it not only enters immediately into its place, and moves the wheel till its two ſides apply fairly to the interior ſurfaces of the notch, but retains the wheel in this ſtate with the neceſſary degree of ſtability.

The method of giving the proper figure to theſe notches is very eaſy. For this purpoſe it is neceſſary, in the firſt place, to impreſs all the characters contained in the wheel on a plate of copper or pewter. The ſupport on which the plate is fixed muſt be moved in a right line, after each ſtroke of the punch, through ſuch a ſpace that the characters may be arranged one after the other without touching. Now, as the perfect linear arrangement (ſuppoſing every other part to be true) muſt depend on the notches, it might ſeem ſufficient to cut theſe according to the method uſed for the wheels of clock-work: but as it is very difficult to avoid ſome obliquity on the face of the punch, and perhaps in the hole through which it paſſes, it is in almoſt every caſe neceſſary to retouch the notch itſelf. The requiſite degree of preciſion may be eaſily obtained, when, upon examining with attention the print of the characters engraved upon the plate, the inequalities ſhall have been aſcertained by a very fine line paſſing exactly under the baſe of two ſimilar letters, aſſumed as objects of compariſon: for the irregularity of linear poſition may, by this means, be determined with great exactneſs, and remedied to the moſt extreme nicety. In this operation, the workman muſt file away part of that ſurface of the notch which is oppoſite to the direction of the motion the character requires. Great care muſt be taken to file only a ſmall portion at a time, in order that the inſtant may be ſeized at which the wedge, by entering into the notch, brings the character to its due ſituation.

Theſe details, reſpecting the right-lined arrangement on the characters, muſt not divert our attention from the very great celerity with which any letter is brought to its place under the preſs by means of the regiſter and detent. This celerity is an object of ſo much importance in the engraving of a great work, that every means ought to be purſued which may tend to increaſe it. For this reaſon it is, that inſtead of following the alphabetic order in the arrangement of punches on the ſurface of the wheel, we ought to prefer that in which the ſum of the different motions to be given to the wheel, for engraving an entire work, ſhall be the leaſt poſſible. This tedious enquiry may well be diſpenſed with, by obſerving the order in which printers diſpoſe their caſes of characters, that the letters of the moſt frequent recurrence may be moſt immediately under the hand of the workman.

If all the characters afforded an equal reſiſtance to impreſſion in a plate of metal, a conſtant force would never fail to drive the punches to the ſame depth. But the faces of the letters are very unequal, and conſequently it will be neceſſary to uſe a variable force. Moſt workmen uſe the hammer, and not a ſcrew, as in this

this machine, for ſtamping. If the hammer had been uſed in this machine, it is evident, that if we ſuppoſed it to have fallen from the ſame height upon every one of the punches, the force of the ſtroke could be rendered variable according to the nature of the characters, by placing a capital, or head, upon each, of an height properly adjuſted to receive the hammer after paſſing through a greater or leſs ſpace. But the heads of our punches are variable at pleaſure, becauſe they are ſcrewed on; and thus it is that, by experimentally adjuſting the heads of all the punches, a ſet of impreſſions are obtained of equal depths from every one of them. When, for example, the letter *i* is placed under the hammer, the upper part of its head is at a ſmall diſtance from the head of the hammer, in order that its fall, which begins always at the ſame place, may ſtrike this letter weakly; but when the letter M is brought under the hammer, the upper part of its head being much leſs elevated than that of the letter *i*, will receive a much ſtronger blow. The impreſſions of the letters M and *i* will therefore always be equally deep, if the heads of the punches be once properly fixed by experiment.

Inſtead of the ſtroke of a hammer, however, our author makes uſe of the preſſure of a ſcrew, of which the threads are ſo inclined that it runs through its female ſocket, and would fall out merely by its own weight. This conſtruction affords the double advantage of preſerving the impreſſions from the effects of the circular motion, and of affording a fall in the ſcrew of nearly nine lines for each revolution. The head of this ſcrew is ſolidly fixed in the centre of a braſs wheel, of which the poſition is horizontal. The diameter of this wheel muſt be ſufficiently large, that its motion may not be perceptibly affected by the irregularities of friction in the ſcrew. This conſiderable diameter is alſo requiſite, becauſe the preſſure of the ſcrew depends, not only upon the force which is applied, but the diſtance of the place of application from the centre of movement.

It is eſſential that this wheel ſhould have very little ſhake; for which reaſon it is adviſeable that the axis of the ſcrew ſhould be prolonged above the wheel itſelf, that it may ſlide in a ſocket firmly fixed to the frame of the machine. In this ſituation, the wheel, which is fixed on the prolongation of the ſcrew, will have its plane conſtantly preſerved in a ſituation parallel to itſelf, without any libration, notwithſtanding the riſe and fall of near nine lines, or three quarters of an inch, which it undergoes for each revolution on its axis.

It has been ſtated, as a requiſite condition, that the ſcrew ſhould conſtantly fall from the ſame fixed point, or elevation, upon the heads of every one of the punches. To accompliſh this eſſential purpoſe, a lever is firmly fixed to the ſupport of the ſcrew; which lever reſembles the beam of a balance, having one of its extremities armed with a claw, and the other ſerving to give it motion through a ſmall vertical ſpace. The claw falls into a notch in the upper ſurface of the wheel attached to the ſcrew, as ſoon as that wheel has riſen to the deſired elevation; and the lever itſelf is ſo far limited in its motion, that it cannot take hold of the wheel, excepting when it has reached that height. The wheel, therefore, remains confined and immoveable, by means of this detent, and cannot deſcend until it is delivered by preſſure upon the oppoſite tail of the lever. In this machine, the wheel which has the preſſing ſcrew for its axis does not perform an entire revolution. It was with a view that there might never be any fall capable of ſhaking and diſturbing the machine that the author determined to uſe only two-thirds of a revolution to ſtrike thoſe punches, which afford the ſtrongeſt reſiſtance. The ſcrew conſequently falls only through ſix lines upon thoſe heads which are leaſt elevated, and about two lines upon thoſe which ſtand higheſt. Whence the difference between the extreme heights does not exceed four lines.

It is obvious, that ſo ſmall a difference is not ſufficient to ſtrike all the characters from M to the letter *i*, when the wheel which governs the ſcrew is put in motion by a conſtant weight, of which the impulſe, like that of a hammer, is increaſed only by the acceleration of its fall. It is evident that this requiſite variation of force might be had by changing the weight; but it is equally clear, that the numberleſs and inceſſant changes which the engraving of an entire work would demand, would be incompatible with that degree of ſpeed which forms one of the firſt requiſites. He was therefore obliged to render the force of the weight, which turns the ſcrew, variable, by cauſing it to act upon levers of greater or leſs lengths, according to the different quantities of impulſe required by the ſeveral punches. For this purpoſe he adopted the following conſtruction: He connected by a ſteel chain to the wheel, which moves the ſcrew, another wheel, having its axis horizontal, ſo that the two wheels reſpectively command each other. They are of equal diameter, and the chain is no longer than to make an entire turn round each wheel. This ſecond wheel, or leading pulley, is intended to afford the requiſite variations of force, which it does by means of a ſnail fixed upon its axis. The ſnail is acted upon by a cord paſſing over its ſpiral circumference, or groove, and bearing a weight which is only to be changed when a new ſet of punches for characters of a different ſize are put into the great wheel. The ſpiral is ſo formed, that when the weight deſcends only through a ſmall ſpace, the part of the cord, which is unwound, acts at a very ſhort diſtance from the centre of the pulley; but when the fall is greater, the part of the ſnail upon which it acts is ſo far enlarged as to afford a much longer lever, and, conſequently, to give a proportionally greater effect to the ſtroke. This conſtruction, therefore, by giving the advantage of a longer lever to a greater fall of the ſcrew, affords all the power which the nature of the work, and the different ſpaces of the letters demand.

The ſupport on which the plate is fixed muſt, as has before been remarked, move ſo as to form ſtrait lines. This motion, which ſerves to ſpace the different characters with preciſion, is obtained by means of a ſcrew, the axis of which remains fixed, and carries a female ſcrew or nut. The nut itſelf is attached to the ſupport of the metallic plate, which receives the letters, and carries it in the right lined direction without any deviation; becauſe it is confined in a groove formed between two pieces of metal. The ſcrew is moved by a lever, which can turn it in one direction only, becauſe it acts by a click upon a ratchet-wheel, which is fixed to the head of the ſcrew. The action of this lever always begins from a fixed ſtop; but the ſpace through which it moves is variable, according to the reſpective breadths of the letters. This new conſideration induced M. Rochon to fix upon the rule or plate of the regiſter, a

number

ROCHON'S MACHINE FOR ENGRAVING METALLIC PLATES.

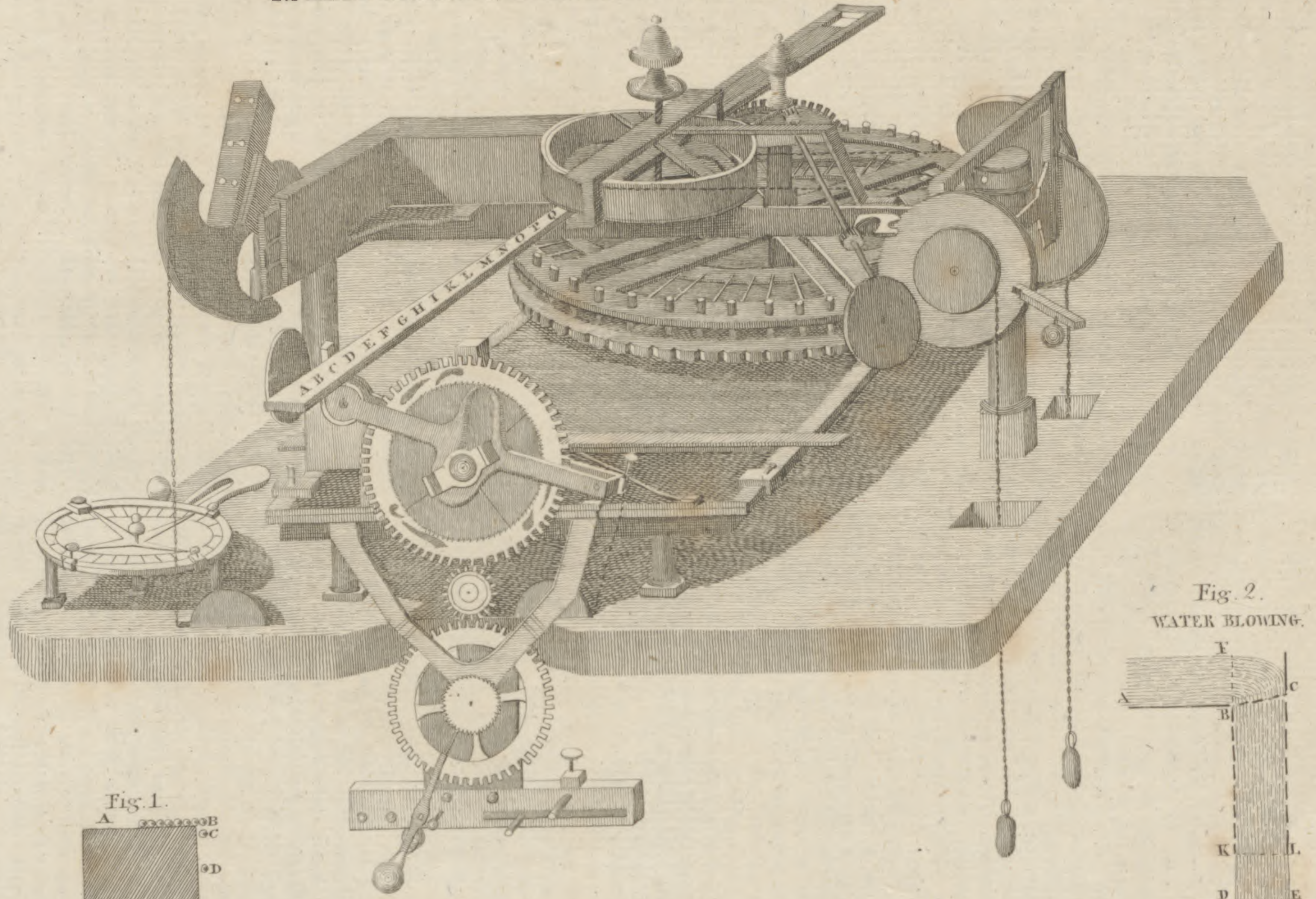


Fig. 1.

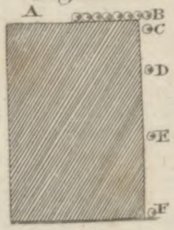
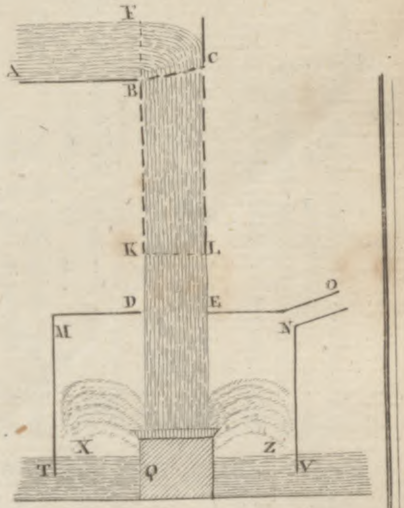


Fig. 2.

WATER BLOWING.



D Lizars Sculp^t

number of pins, correſponding with the different diviſions which anſwer to each punch: theſe pins determine the diſtance to which the lever can move. It therefore becomes a condition, that its poſition in the machine ſhould be oppoſite to the fixed index which determines the character at any time beneath the preſſing-ſcrew. The lever and its pin are therefore the ſole agents employed to ſpace the characters. If the plate were not moved by the lever, the impreſſions would fall upon each other; and thus, for example, the letter *i* would be totally obliterated by the impreſſion of the letter *l*.

Whenever, therefore, it is required to diſpoſe the letters *i* and *l* beſide each other, the plate muſt be moved after ſtriking the letter *i* through a ſpace equal to the quantity of the deſired operation. Suppoſe this to be one fourth of a line, and that the lever ſhould run through an arc of ten degrees to move the plate thro' this quantity; as ſoon as the pin of the letter *l* ſhall be adjuſted to the neceſſary length to enable the lever to deſcribe an arc of ten degrees, the operation of ſpacing the two letters *i* and *l* will be reduced to that of placing the laſt letter beneath the fixed index, and moving the plate till the lever ſhall be ſtopped by the pin belonging to the letter *l*. All the other letters will be equally ſpaced, if the diſpoſition of the punches in the wheel be ſuch, that the laſt ſtroke of any letter ſhall conſound itſelf with any letter of a ſingle ſtroke, ſuppoſing them to be impreſſed one after the other, without moving the lever between ſtroke and ſtroke. This arrangement deſerves to be very ſeriouſly attended to, becauſe the proceſs could not be performed without it.

Many well-informed perſons are of opinion, that the perfect equality which this machine for engraving affords in the formation of letters and ſigns the moſt difficult to be imitated, may afford a means of remedying the dangers of forgery. It is certain that the performance exhibits a ſimple and ſtriking character of preciſion, which is ſuch, that the leaſt experienced eyes might flatter themſelves, in certain caſes, to diſtinguiſh counterfeits from originals. Lavoiſier, whom the friends of ſcience and the arts will not ceaſe to regret, made ſome experiments of this kind for the *caiſſe de'ſcompte*, which were attended with perfect ſucceſs. Artiſts appointed for that purpoſe endeavoured in vain to imitate a vignette, formed by the ſucceſſive and equal motion of a character of ornament.

TYRTÆUS, an Athenian general and muſician, is celebrated by all antiquity for the compoſition of military ſongs and airs, as well as the performance of them. He was called to the aſſiſtance of the Lacedæmonians in the ſecond war with the Meſſenians, about 685 B. C.; and a memorable victory which they obtained over that people is attributed by the ancient ſcholiaſts upon Horace to the animating ſound of a new military flute or clarion, invented and played upon by Tyrtæus. Plutarch tells us that they gave him the freedom of their city; and that his military airs were conſtantly ſung and played in the Spartan army to the laſt hour of the republic. And Lycurgus the orator, in his oration againſt Leocrates, ſays, "The Spartans made a law, that whenever they were in arms, and going out upon any military expedition, they ſhould all be firſt ſummoned to the king's tent to hear the ſongs of Tyrtæus;" thinking it the beſt means of ſending them forth in a diſpoſition to die with pleaſure for their country. Fragments of his poetry, in elegiac verſe, are preſerved in Stobæus, Lycurgus Orat. in Fulvius Urſinus, at the end of Poems by illuſtrious Women: and in the Oxford edition of *Eleg. & Lyric. Frag. & Scholia.* printed 1759. Εκ Στοβαιου, &c.

TYTLER (William, Eſq;), ſo well known in the literary world as one of the ableſt, and certainly the moſt gentlemanly, of the defenders of the fame of Mary Queen of Scots, was born at Edinburgh, October 12. 1711. He was the ſon of Mr Alexander Tytler, writer (or attorney) in Edinburgh, by Jane, daughter of Mr William Leſlie, merchant in Aberdeen, and granddaughter of Sir Patrick Leſlie of Idan, provoſt of that city. He received his education at the grammar ſchool (or, as it is there called, the High School) and the univerſity of his native city, and diſtinguiſhed himſelf by an early proficiency in thoſe claſſical ſtudies, which, to the lateſt period of his life, were the occupation of his leiſure hours, and a principal ſource of his mental enjoyments.

In the year 1731, he attended the academical lectures of Mr Alexander Bayne, Profeſſor of municipal law in the univerſity of Edinburgh, a gentleman diſtinguiſhed alike for his profeſſional knowledge, his literary accompliſhments, and the elegance of his taſte. The Profeſſor found in his pupil a congenial ſpirit; and their connection, notwithſtanding the diſparity of their years, was ſoon ripened into all the intimacy of the ſtricteſt friendſhip. So ſtrong indeed became at length that tie of affection, that the worthy Profeſſor, in his latter years, not only made him the companion of his ſtudies, but when at length the victim of a lingering diſeaſe, choſe him as the comforter of thoſe many painful and melancholy hours which preceded his death.

At the age of 31, Mr Tytler was admitted into the Society of Writers to his Majeſty's Signet, and continued the practice of that profeſſion with very good ſucceſs, and with equal reſpect from his clients and the public, till his death, which happened on the 12th of September 1792. He married, in September 1745, Anne Craig, daughter of Mr James Craig of Dalnair, writer to the ſignet, by whom he has left two ſons, Alexander Fraſer Tytler, his Majeſty's Judge advocate for Scotland, and Profeſſor of civil hiſtory in the univerſity of Edinburgh; and Patrick Tytler, Lieutenant colonel of a regiment of fencible infantry, and Fort major of the caſtle of Stirling; together with one daughter, Miſs Chriſtina Tytler. His wife died about nine years before him; and, previouſly to that period, he had loſt a ſon and a daughter, both grown to maturity.

The moſt remarkable feature of Mr Tytler's character was an ardour and activity of mind, prompted always by a ſtrong ſenſe of rectitude and honour. He felt with equal warmth the love of virtue and the hatred of vice; he was not apt to diſguiſe either feeling, nor to compromiſe, as ſome men more complying with the world might have done, with the faſhion of the time, or the diſpoſition of thoſe around him. He ſeldom waved an argument on any topic of hiſtory, of politics, or literature; he never retreated from one on any ſubject that touched thoſe more important points on which he had formed a decided opinion. Decided opinions he always formed on ſubjects of importance; for on ſuch ſubjects he formed no opinions raſhly; and what he firmly believed he avowed with confidence, and ſometimes with warmth.

Nor was it in opinion or argument only that this warmth and ardour of mind were conſpicuous. They prompted him equally in action and conduct. His affection to his family, his attachment to his friends and companions, his compaſſion for the unfortunate, were alike warm and active. He was in ſentiment alſo what Johnſon (who felt it ſtrongly in himſelf, and mentions it as the encomium of one of his friends) calls a *good hater*; but his hatred or reſentment went no further than opinion or words, his better affections only roſe into action. In his opinions, or in his expreſſion of them, there was ſometimes a vehemence, an appearance of acrimony, which his friends might regret, and which ſtrangers might cenſure; but he had no aſperity in his mind to influence his actual conduct in life. He indulged oppoſition, not enmity; and the world was juſt to him in return. He had opponents; but two of his biographers, who knew him well, as well as the people with whom he moſt aſſociated, declare their belief that he had not a ſingle enemy. His conteſts were on opinions, not on things; his diſputes were hiſtorical and literary. In converſation, he carried on theſe with uncommon intereſt and vivacity; and the ſame kind of impulſe which prompted his converſation (as is juſtly obſerved by an author, who publiſhed ſome notices of his life and character in the periodical work intitled *The Bee*) induced him to become an author. He wrote not from vanity or vain-glory, which Rouſſeau holds to be the only inducement to writing; he wrote to open his mind upon paper; to ſpeak to the public thoſe opinions which he had often ſpoken in private; opinions on the truth of which he had firmly made up his own conviction, and was ſometimes ſurpriſed when he could not convince others: it was fair to try, if, by a fuller expoſition of his arguments, he could convince the world.

With this view, he publiſhed, in 1759, his “Inquiry, hiſtorical and critical, into the Evidence againſt *Mary Queen of Scots*, and an Examination of the Hiſtories of Dr Robertſon and Mr Hume with reſpect to that Evidence;” in which he warmly eſpouſed the cauſe of that unfortunate Princeſs, attacked with ſeverity the conduct of her enemies, and expoſed the fallacy, in many parts the fabrication, of thoſe proofs on which the charges againſt her had been founded.

This was a cauſe worthy of an advocate who loved truth better than popular applauſe; and Mr Tytler evinced himſelf to be ſuch an advocate. The problem of Mary's guilt or innocence, if conſidered merely as a detached hiſtorical fact, would appear an object which, at this diſtance of time, ſeems hardly to merit that laborious and earneſt inveſtigation to which it has given riſe; though, even in this point of view, the mind is naturally ſtimulated to ſearch out the truth of a dark myſterious event, diſgraceful to human nature; and our feelings of juſtice and moral rectitude are intereſted to fix the guilt upon its true authors. But when we conſider that this queſtion involves a diſcuſſion of the politics of both England and Scotland during one of the moſt intereſting periods of their hiſtory, and touches the characters, not only of the two ſovereigns, but of their miniſters and ſtateſmen, it muſt then be regarded in the light of a moſt important hiſtorical inquiry, without which our knowledge of the hiſtory of our own country muſt be obſcure, confuſed, and unſatisfactory. In addition to theſe motives of inquiry, this queſtion has exerciſed ſome of the ableſt heads both of earlier and of latter times; and it is no mean pleaſure to engage in a conteſt of genius and of talents, and to try our ſtrength in the deciſion of a controverſy which has been maintained on both ſides with conſummate ability.

As we have elſewhere (ſee Mary, *Encycl.*) given an abſtract of the arguments on both ſides of this diſputed queſtion, it would be altogether improper to repeat them here; but juſtice to the ſubject of this memoir requires us to ſay, that by his manner of diſcuſſing it he acquired high reputation in the republic of letters. Before the appearance of the Inquiry, ſays an ingenious writer, it was the faſhion for literary diſputants to attack each other like miſcreants and banditti. The *perſon* was never ſeparated from the *cauſe*; and whatever attached the *one*, was conſidered as equally affecting the *other*; ſo that ſcurrility and abuſe bloated the pages even of a Bentley and a Ruddiman. The Hiſtorical Inquiry was free from every thing of that ſort: and though the higheſt name produced not a mitigation of the force of any argument, the meaneſt never ſuffered the ſmalleſt abuſe. He conſidered it as being greatly beneath the dignity of a man contending for truth, to overſtretch even an argument in the ſmalleſt degree, far more to pervert a fact to anſwer his purpoſe on any occaſion. In the courſe of his argument, he had too often occaſion to ſhew that this had been done by others; but he diſdained to imitate them. His reaſoning was forcible and elegant; impartially ſevere, but always polite, and becoming the gentleman and the ſcholar.

When this book appeared, it was univerſally read in Britain, and very well tranſlated into French, under the title of “Recherches Hiſtoriques et Critiques ſur les Principales Preuves d l'Accuſation intentée contre Marie Reine d'Ecoſſe.” The intereſt it excited among literary men may be judged of from the character of thoſe by whom it was reviewed on its publication, in the periodical works of the time. Dr Douglas, now biſhop of Saliſbury, Dr Samuel Johnſon, Dr John Campbell, and Dr Smollet—all wrote reviews of Mr Tytler's book, containing very particular accounts of its merits, and elaborate analyſes of the chain of its arguments. As an argument on evidence, no ſuffrage could perhaps be more deciſive of its merit than that of one of the greateſt lawyers, and indeed one of the ableſt men that ever ſat on the woolſack of England, the late Lord Chancellor Hardwicke, who declared Mr Tytler's Inquiry to be the beſt concatenation of circumſtantiate proofs brought to bear upon one point that he had ever peruſed. What effect that body of evidence, or the arguments deduced from it, ought to have upon the minds of thoſe to whom the ſubject may become matter of inveſtigation, we do not preſume to determine. The opinion of the late Dr Henry, author of the Hiſtory of Great Britain on a New Plan, may perhaps be thought neither partial nor confident. He ſays, in a letter to Mr Tytler, publiſhed in the firſt volume of Tranſactions of the Antiquarian Society of Scotland, That he would be a bold man who ſhould now publiſh an hiſtory of Queen Mary in the ſame ſtrain with the two hiſtorians (Mr Hume and Dr Robertſon), whoſe opinions on the ſubject the Inquiry had examined and controverted.

The moſt exceptionable part of Mary's conduct, which, though it may admit of an apology, cannot be

Tytler.

vindicated, is her marriage to Bothwell; and for that marriage Mr Tytler made an apology, founded on facts, which he would be a daring or very bigotted man who would attempt to controvert. See the article already referred to.

Beſides the *Hiſtorical Inquiry*, and the *Diſſertation on the Marriage of Queen Mary with the Earl of Bothwell*, our author publiſhed ſeveral other works on hiſtorical and literary ſubjects; of which the firſt was, the *Poetical remains of James I. King of Scotland*, conſiſting of *the King's Queir*, in ſix cantos, and *Chriſt's Kirk on the Green*; to which is prefixed a diſſertation on the Life and Writings of King James, in one volume 8vo, printed at Edinburgh in 1783. This diſſertation forms a valuable morſel of the literary hiſtory of Europe; for James ranked ſtill higher in the literary world as a *poet*, than in the political world as a *prince* (A). Great juſtice is done to his memory in both reſpects in this diſſertation: and the two morſels of poetry here reſcued from oblivion will be eſteemed by men of taſte as long as the language in which they are written can be underſtood.

2. “A Diſſertation on Scottiſh Muſic,” firſt ſubjoined to Arnot's hiſtory of Edinburgh. The ſimple melodies of Scotland have been long the delight of the natives, many of which, to them, convey an idea of pathos that can be equalled by none other; and are much admired by every ſtranger of muſical talents who has viſited this country. They have a powerful effect, indeed, when properly introduced, as a relief, into a muſical compoſition of complicated harmony. Theſe are of two kinds, pathetic and humorous. Thoſe who wiſh to receive information concerning this curious ſubject, will derive much ſatisfaction from the peruſal of this diſſertation. There is yet another kind of muſic peculiar to the Highlands of Scotland, of a more wild, irregular, and animating ſtrain, which is but ſlightly treated here, and requires to be ſtill more fully elucidated.

3. “Obſervations on the Viſion, a poem,” firſt publiſhed in Ramſay's Evergreen, now alſo printed in the Tranſactions of the Society of Antiquaries of Scotland. This may be conſidered as a part of the literary hiſtory of Scotland.

4. “On the Faſhionable Amuſements in Edinburgh during the laſt century,” *ibid*. It is unneceſſary to dwell on the light that ſuch diſſertations as theſe, when judiciouſly executed, throw upon the hiſtory of civil ſociety and the progreſs of manners. Mr Tytler was likewiſe the author of N° 16. of the Lounger, a weekly paper, publiſhed at Edinburgh in the year 1786. His ſubject is the Defects of Modern Female Education in teaching the Duties of a Wife; and he treats that ſubject like a maſter.

On all Mr Tytler's compoſitions the character of the *man* is ſtrongly impreſſed, which never, as in ſome other inſtances, is in the ſmalleſt degree contradicted by, or at variance with, the character of the *author*. He wrote what he felt, on ſubjects which he felt, on ſubjects relating to his native country, to the arts which he loved, to the times which he revered. His heart, indeed, was in every thing which he wrote, or ſaid, or did. He had, as his family and friends could warmly atteſt, all the kindneſs of benevolence: he had its anger too; for benevolence is often the parent of anger. There was nothing neutral or indifferent about Mr Tytler. In philoſophy and in hiſtory, he could not bear the coldneſs, or what ſome might call the temperance of ſcepticiſm; and what he firmly believed, it was his diſpoſition keenly to urge.

His mind was ſtrongly impreſſed by ſentiments of religion. His piety was fervent and habitual. He believed in the doctrine of a particular Providence, ſuperintending all the actions of individuals as well as the great operations of Nature: he had a conſtant impreſſion of the power, the wiſdom, and the benevolence of the Supreme Being; and he embraced, with thorough conviction, the truths of Chriſtianity.

His reading was various and extenſive. There was ſcarcely a ſubject of literature or taſte, and few even of ſcience, that had not at times engaged his attention. In hiſtory he was deeply verſed; and what he had read his ſtrong retentive memory enabled him eaſily to recal. Ancient as well as modern ſtory was familiar to him; and, in particular, the Britiſh hiſtory, which he had read with the moſt minute and critical attention. Of this, beſides what he has given to the public, a great number of notes, which he left in MS. touching many controverted points in Engliſh and Scottiſh hiſtory, afford the moſt ample proof.

In muſic as a ſcience he was uncommonly ſkilled. It was his favourite amuſement; and with that natural partiality which all entertain for their favourite objects, he was apt to aſſign to it a degree of moral importance which ſome might deem a little whimſical. He has often been heard to ſay, that he never knew a good taſte in muſic aſſociated with a malevolent heart: And being aſked, What preſcription he would recommend for attaining an old age as healthful and happy as his own? “My preſcription (ſaid he) is ſimple—ſhort but cheerful meals, muſic, and a good conſcience.”

In domeſtic life, Mr Tytler's character was particularly amiable and praiſe worthy. He was one of the kindeſt huſbands and moſt affectionate fathers. At the beginning of this account, we mentioned his having loſt, at an advanced period of life, an excellent wife, and a ſon and a daughter both grown to maturity, who merited and poſſeſſed his warmeſt affections. The temper of mind with which he bore theſe loſſes, he has himſelf expreſſed in a MS. note, written not long before his death; with which, as it conveys a ſentiment equally important in the conſideration of this life, and in the contemplation of that which is to come, we ſhall conclude the preſent memoir: “The lenient hand of time (ſays he, after mentioning the death of his wife and children), the lenient hand of time, the affectionate care of my remaining children, and the duty which calls on my exertions for them, have by degrees reſtored me to myſelf. The memory of thoſe dear objects gone before me, and the ſoothing hope that we ſhall ſoon meet again, is now the ſource of extreme pleaſure to me. In my retired walks in the country I am never alone; thoſe dear ſhades are my conſtant companions! Thus what I looked upon as a bitter calamity, is now become to me the chief pleaſure in life.”

(A) There is a beautiful hiſtorical picture of this prince playing on the harp, with his queen and a circle of his courtiers liſtening to the muſic, by Graham, in London; one of the moſt eminent artiſts of the age.

U, V.

VACUUM Boyleanum, is the approach to a real vacuum, to which we can arrive by means of the air-pump.

Torricellian Vacuum, is the moſt complete vacuum which we can make by means of the torricellian tube. See Barometer, and Pneumatics, *Encycl.*

VADE mecum, the title given to ſuch books as men of particular profeſſions, having frequent occaſion to conſult, may eaſily carry about with them. Thus a ſmall volume, publiſhed in the beginning of the 18th century, giving an account of the ancient and preſent church of England, and of the duties, rights, privileges, and hardſhips of the clergy, is known by the title of *the Clergyman's Vade-mecum.*

VAKEEL, a miniſter, agent, or ambaſſador.

VALGUS, *Bow* or *Bandy Legged.* Some children are bow-legged from their birth; others become ſo from ſetting them on their feet too early. The tibia of ſome is crooked; the knees of others are diſtorted; from a fault in the ankle, the feet of ſome are turned inwards, theſe are called *vari;* and in others they turn outwards, theſe are called *valgi.* The beſt method of preventing theſe diſorders in weakly children, is to exerciſe them duly, but not violently; by dancing or toſſing them about in one's arms, and not ſetting them much on their feet, at leaſt not without properly ſupporting them: if the diſorder attends at the birth, or increaſes after it is begun, apply emollients, then apply boots of ſtrong leather, wood, &c. as required to diſpoſe the crooked legs gradually to a proper form: or other inſtruments may be uſed inſtead of boots, which, when not too coſtly, are uſually to be preferred. Slighter inſtances of theſe diſorders yield to careful nurſing without inſtruments.

VANDA', the Indian name of a plant of the genus Epidendrum; which ſee, *Encycl.* The *vandá* is thus deſcribed by Sir William Jones.

"Cal. *Spathes* minute, ſtraggling. Cor. *Petals* five, diverging, oval oblong, obtuſe, wavy; the two loweſt larger; the three higheſt equal, bent towards the nectary. *Nectary* central, rigid: *Mouth* gaping, oblique: *Upper lip* ſhorter, three parted, with a poliſhed honey-cup; *under lip* concave in the middle, keeled above, with two ſmaller cavities below, two proceſſes at the *baſe*, incurved, hollow, oval pointed, converging, honey-bearing. Stam. *Filaments* very ſhort. *Anthers* round, flattiſh, margined, covered with a lid, eaſily deciduous from the *upper lip* of the nectary. Pist. *Germ.* beneath long, ribbed, contorted with curves of oppoſite flexure. *Style* very ſhort, adhering to the *upper lip. Stigma* ſimple. Per. *Capſule* oblong-conic, wreathed, ſix-keeled, each with two ſmaller keels, three-celled, crowned with the dry corol. Seeds innumerable, like fine duſt affixed to the *receptacle* with extremely fine hairs, which become thick wool. *Scapes* incurved, ſolitary, from the cavity of the leaf, at moſt ſeven-flowered; pedicles alternate. *Petals* milk white externally, tranſparent; brown within, yellow-ſpotted. *Upper lip* of the nectary ſnow-white; *under lip* rich purple, or light crimſon, ſtriated at the baſe, with a bright yellow gland, as it ſeems, on each proceſs. The flowers gratefully fragrant, and exquiſitely beautiful, looking as if compoſed of ſhells, or made of enamel; criſp elaſtic, viſcid internally. *Leaves* ſheathing, oppoſite, equally curved, rather fleſhy, ſword-form, retuſe in two ways at the ſummit, with one acute point. *Roots* fibrous, ſmooth, flexible; ſhooting even from the top of the leaves."

This lovely plant attaches itſelf chiefly to the higheſt *Amras* and *Bilvas* (the *Mangifera* and *Cratæva* of Lin.); but it is an air-plant, and lives (ſays the Preſident) in a pot *without earth or water:* its leaves are excavated upwards, to catch and retain dew.

VANDALIA, a duchy of Farther Pomerania, ſubject to the king of Pruſſia. Stolpen is the capital.

Vandalia, a country in Germany, in the circle of Lower Saxony and duchy of Mecklenburg. It lies between the biſhopric and duchy of Schwerin, the lordſhips of Stocrock and Stargard, Pomerania, and the marquiſate of Brandenburg; and is 75 miles in length and 7 in breadth. It contains ſeveral ſmall lakes, and the principal town is Guſtrow.

VANDERMONDE, member of the National Inſtitute of Sciences and Arts, was born at Paris in the year 1735. He devoted his youth to ſelf-inſtruction; and even at the age of thirty was far enough from ſuſpecting that he was deſtined to inſtruct others in his turn. Chance brought him near to the celebrated Fontaine. That ſexagenary geometrician eaſily divined the progreſs which Vandermonde would one day make in the mathematics; in him he anticipated, as it were, a ſucceſſor to himſelf; he patroniſed and careſſed him, let him into the ſecret of his reſearches, calculations, inventions, of that lively enjoyment which profound ſpeculation gives to an elevated attentive mind; and which, blended with the ſweets of tranquillity, the charms of retreat, and the conſciouſneſs of ſucceſs, becomes often a ſort of paſſion, as felicitous as durable. All that time Fontaine, whoſe attention was again directed to the reſearches which he had added to thoſe of Jean Bernoulli, relative to the then famous queſtion *of the toutocrones*, had the glory to be vanquiſhed only by D'Alembert and La Grange. Vandermonde, a witneſs to this combat, neceſſarily illuſtrious, animated by the honour which he ſaw annexed to that glorious defeat, enchanted with the ſight of Fontaine, as happy, in ſpite of his age, from his love of geometry, as a youth of twenty could be with a ſentiment leſs tranquil, thought he ſhould inſure his happineſs for ever, by yielding to a paſſion which the ice of age could not extinguiſh; in a word, he devoted himſelf to geometry.

His labours, however, were for ſome time ſecret; and perhaps the public would never have enjoyed the benefit of any of his works, if another geometrician (whoſe name, ſays Lacepede, cannot be pronounced, in this place, without a mixture of intereſt and regret) had not inſpired him with a conſciouſneſs of his own ſtrength, and courage to diſplay it. Fontaine had already devoted him to geometry; Duſejour exhorted him to penetrate even into its ſanctuary. In brief, he preſented himſelf to the Academy of Sciences, into which he was admitted in 1771; and in that very year juſtified the ſuffrages of his aſſociates, by a paper which he publiſhed relative to the reſolution of equations.

From the 16th century the method of reſolving equations of the four firſt degrees has been known, and ſince that time the general theory of equations has received great improvements. In ſpite, however, of the recent labours of many great geometricians, the ſolutions of equations of the fifth degree had in vain been attempted. Vandermonde wiſhed to conſolidate his labours with thoſe of other illuſtrious analyſts; and he propoſed a new theory of equations, in which he ſeems to have made it particularly his buſineſs to ſimplify the methods of calculation, and to contract the length of the *formulæ*, which he conſidered as one of the greateſt difficulties of the ſubject.

This work was quickly followed by another on the problems called by geometricians *problems of ſituation*. It ſeems to have been the deſtiny of Vandermonde, as well as of Fontaine, who firſt initiated him into the myſteries of mathematical ſcience, to labour frequently upon ſubjects already handled by the greateſt maſter. In his firſt memoir he had ſtarted, ſo to ſpeak, in competition with La Grange and Euler; in his ſecond, with Euler and Leibnitz. This laſt was of opinion that the analyſis made uſe of in his time, by the geometricians, was not applicable to all queſtions in the phyſical ſciences; and that a new geometry ſhould be invented, to calculate the relations of poſitions of different bodies, in ſpace: this he called *geometry of ſituation**. Excepting, however, one application, made by Leibnitz himſelf, to the game of *ſolitaire*, and which, under the appearance of an object of curioſity, ſcarcely worthy the ſublimity and uſefulneſs of geometry, is an example for ſolving the moſt elevated and important queſtions, Euler was almoſt the only one who had practiſed this geometry of ſituation. He had reſorted to it for the ſolution of a problem called the *cavalier*, which alſo appeared very familiar at firſt ſight, and was alſo pregnant with uſeful and important applications. This problem, with the vulgar, conſiſted merely in running through all the caſes of the cheſs board, with the *knight* of the game of cheſs; to the profound geometrician, however, it was a precedent for tracing the route which every body muſt follow, whoſe courſe is ſubmitted to a known law, by conforming to certain required conditions, through all the points diſpoſed over a ſpace in a preſcribed order. Vandermonde was chiefly anxious to find in this ſpecies of analyſis a ſimple notation, likely to facilitate the making of calculations; and he gave an example of this, in a ſhort and eaſy ſolution of the ſame problem of the cavalier, which Euler had rendered famous.

His taſte for the high conceptions of the ſpeculative ſciences, as blended with that which the *amor patriæ* naturally inſpires for objects immediately uſeful to ſociety, had led him to turn his thoughts towards perfecting the arts converſant in weaving, by indicating a manner of noting the points through which are to paſs the threads intended to form the lines which terminate the ſurface of different regular bodies: accordingly a great part of the above memoir is taken up with this ſubject.

In the year following (1772) he printed a third memoir; in which he traced out a new path for geometers, diſcovering, by learned analytical reſearches, *irrational* quantities of a new ſpecies, ſhewing the ſequels of which theſe *irrationals* are the terms or the ſum, and pointing out a direct and general method of making in them all the poſſible reductions.

In the ſame year appeared his work on the Elimination of unknown Quantities in Algebra. This elimination is the art of bringing back thoſe equations which include many unknown quantities, to equations which only contain one. The perfection of reſearches in this art would conſiſt in obtaining a general and particular *formula* of elimination in a form the moſt conciſe and convenient, in which the number of equations and their degrees ſhould be deſigned by indeterminate letters. Vandermonde, while he conſidered the geometers as very diſtant from this point, had ſome glimpſe of a poſſibility of reaching it, and propoſed ſome new methods of approaching nearer it.

In 1778, he preſented, in one of the public ſittings of the Academy, a new ſyſtem of harmony, which he detailed more fully in another public ſitting of 1780. In this ſyſtem, Vandermonde reduces the modes of proceeding adopted until his time, to two principal rules, which thus become eſtabliſhed on effects admitted by all muſicians. Theſe two general rules, one on the ſucceſſion of according ſounds, the other on the arrangement of the parts, depend themſelves on a law more elevated, which, according to Vandermonde, ought to rule the whole ſcience of harmony.

By the publication of this work, he ſatisfactorily attained the end he had propoſed to himſelf, and obtained the ſuffrages of three great men, repreſentatives, ſo to ſpeak, of the three great ſchools of Germany, France, and Italy; Gluck, Philidor, and Piccini.

With theſe labours, intermingled with frequent reſearches on the mechanic arts, as well as on objects of political economy, the attention of Vandermonde was taken up; when, July 14. 1789, the voice of liberty reſounded over the whole ſurface of France, and ſuddenly all the thoughts, as well as all the affections, of Vandermonde, were engaged on the ſide of what he called liberty.

He became ſo furious a democrate, ſo outrageous an enemy to every thing eſtabliſhed, that he concurred in the abolition of the Royal Academy, of which he had been ſo ambitious of becoming a member, and aſſociated himſelf cloſely with Robeſpierre, Marat, and the reſt of that atrocious gang of villains, who covered France with ruins, with ſcaffolds, and with blood. This part of Vandermonde's hiſtory is ſuppreſſed by his eulogiſt Lacepede, becauſe, forſooth, diſcuſſions on *political opinions* ought not, in his opinion, to be admitted into the ſanctuary of the ſciences.

In that ſanctuary he did not long remain. Soon after his atrocities, he was attacked by a diſorder in his lungs, which almoſt taking away his breath, manifeſted itſelf by alarming ſymptoms, and conducted him by rapid ſteps to the tomb. He died in the end of the year 1795; a ſtriking inſtance of the wayward violence of the human mind, which even the love of ſcience could not keep at a diſtance from tumult and uproar.

VARENIUS (Bernard), a learned Dutch geographer and phyſician of the 17th century, who was author of the beſt mathematical treatiſe on geography, intitled, *Geographia Univerſalis, in qua affectiones generalis Tellu-*

* See Position, *Suppl.*

ris explicantur. This excellent work has been tranſlated into all languages, and was honoured by an edition, with improvements, by Sir Iſaac Newton, for the uſe of his academical ſtudents at Cambridge.

VARIABLE, in geometry and analytics, is a term applied by mathematicians to ſuch quantities as are conſidered in a variable or changeable ſtate, either increaſing or decreaſing. Thus the abſciſſes and ordinates of an ellipſis, or other curve line, are variable quantities; becauſe theſe vary or change their magnitude together, the one at the ſame time with the other. But ſome quantities may be variable by themſelves alone, or while thoſe connected with them are conſtant: as the abſciſſes of a parallelogram, whoſe ordinates may be conſidered as all equal, and therefore conſtant; alſo the diameter of a circle, and the parameter of a conic ſection, are *conſtant*, while their abſciſſes are *variable.* See Fluxions, *Encycl.*

VARIATION of Curvature, in geometry, is uſed for that inequality or change which takes place in the curvature of all curves except the circle, by which their curvature is more or leſs in different parts of them; and this variation conſtitutes the quality of the curvature of any line.

1 Variolæ vaccinæ long known in Glouceſterſhire,

VARIOLÆ Vaccinæ, or *Cow-pox*, is the name commonly, though, as ſome people think, improperly, given to a very ſingular diſeaſe, which, for two or three years paſt, has occupied a great ſhare of the attention of medical men. It has been many years prevalent in ſome of the great dairy counties in England, particularly Glouceſterſhire; and it has been long underſtood by the farmers and others in theſe counties, that it for ever exempts all perſons who have been infected with it from the contagion of ſmall pox.

It is very ſurpriſing that, though they knew this fact, and although no perſon had ever been known to die of the cow-pox, they never thought of having recourſe to a voluntary infection of this kind, in order to free themſelves and their families from the poſſibility of being infected with the variolous poiſon, which ſo often proves mortal. In one caſe, indeed, communicated to Dr Pearſon by Mr Downe of Bridport, the experiment was long ago tried by a farmer upon his own perſon, and with complete ſucceſs: But this only makes it the more wonderful that his example ſhould not have been followed.

2 And in the duchy of Holſtein.

In the town of Kiel, however, in the duchy of Holſtein, where the diſeaſe is ſaid to be well known, as frequently affecting cows, we are told that children are ſometimes inoculated with cow-pox *(Die Finnen)*, with a view to preſerve their beauty; but that the people in the country do not like this inoculation, becauſe they pretend that it leaves behind it ſeveral diſorders.

3 Vaccine inoculation introduced by Dr Jenner.

With theſe exceptions, Dr Jenner was the firſt perſon who introduced the vaccine inoculation; and to him the public are alſo indebted for the firſt careful and accurate inveſtigation of this intereſting ſubject. The following is his account of the origin and hiſtory of the diſeaſe, and of its characteriſtic ſymptoms.

4 Origin of the diſeaſe, according to him.

"There is a diſeaſe to which the horſe, from his ſtate of domeſtication, is frequently ſubject. The farriers have termed it *the greaſe.* It is an inflammation and ſwelling in the heel, from which iſſues matter poſſeſſing properties of a very peculiar kind, which ſeems capable of generating a diſeaſe in the human body (after it has undergone the modification which I ſhall preſently ſpeak of), which bears ſo ſtrong a reſemblance to the ſmall pox, that I think it highly probable that it may be the ſource of that diſeaſe.

"In this dairy county (Glouceſterſhire), a great number of cows are kept, and the office of milking is performed indiſcriminately by men and maid ſervants. One of the former having been appointed to apply dreſſings to the heels of a horſe affected with *the greaſe*, and not paying due attention to cleanlineſs, incautiouſly bears his part in milking the cows with ſome particles of the infectious matter adhering to his fingers. When this is the caſe, it commonly happens that a diſeaſe is communicated to the cows, and from the cows to the dairy maids, which ſpreads through the farm until moſt of the cattle and domeſtics feel its unpleaſant conſequences. This diſeaſe has obtained the name of the cow pox.

5 Its appearance on the cow and the perſon who milks her.

It appears on the nipples of the cows in the form of irregular puſtules. At their firſt appearance they are commonly of a paliſh blue, or rather of a colour ſomewhat approaching to livid, and are ſurrounded by an eryſipelatous inflammation. Theſe puſtules, unleſs a timely remedy be applied, frequently degenerate into phagedenic ulcers, which prove extremely troubleſome. The animals become indiſpoſed, and the ſecretion of milk is much leſſened. Inflamed ſpots now begin to appear on different parts of the hands of the domeſtics employed in milking, and ſometimes on the wriſts, which quickly run on to ſuppuration, firſt aſſuming the appearance of the ſmall veſications produced by a burn. Moſt commonly they appear about the joints of the fingers, and at their extremities; but whatever parts are affected, if the ſituation will admit, theſe ſuperficial ſuppurations put on a circular form, with their edges more elevated than their centre, and of a colour diſtantly approaching to blue. Abſorption takes place, and tumors appear in each axilla. The ſyſtem becomes affected, the pulſe is quickened, and ſhiverings, with general laſſitude, and pains about the loins and limbs, with vomiting, come on. The head is painful, and the patient is now and then even affected with delirium. Theſe ſymptoms, varying in their degrees of violence, generally continue from one day to three or four, leaving ulcerated ſores about the hands, which, from the ſenſibility of the parts, are very troubleſome, and commonly heal ſlowly, frequently becoming phagedenic, like thoſe from whence they ſprung. The lips, noſtrils, eyelids, and other parts of the body, are ſometimes affected with ſores; but theſe evidently ariſe from their being needleſsly rubbed or ſcratched with the patient's infected fingers. No eruptions of the ſkin have followed the decline of the feveriſh ſymptoms in any inſtance that has come under my inſpection, one only excepted; and in this caſe a very few appeared on the arms: they were very minute, of a vivid red colour, and ſoon died away without advancing to maturation: ſo that I cannot determine whether they had any connection with the preceding ſymptoms.

"Thus the diſeaſe makes its progreſs from the horſe to the nipple of the cow, and from the cow to the human ſubject.

6 Its ſingularity,

"Morbid matter of various kinds, when abſorbed into the ſyſtem, may produce effects in ſome degree ſimilar; but what renders the cow-pox virus ſo extremely ſingular is, that the perſon who has been thus affected

is

is for ever after ſecure from the infection of the ſmall-pox; neither expoſure to the variolous effluvia, nor the inſertion of the matter into the ſkin, producing this diſtemper.

"It is neceſſary to obſerve, that puſtulous ſores frequently appear ſpontaneouſly on the nipples of cows; and inſtances have occurred, though very rarely, of the hands of the ſervants employed in milking being affected with ſores in conſequence, and even of their feeling an indiſpoſition from abſorption. Theſe puſtules are of a much milder nature than thoſe which ariſe from that contagion which conſtitutes the true cow-pox. They are always free from the bluiſh or livid tint ſo conſpicuous in that diſeaſe. No eryſipelas attends them, nor do they ſhew any phagedenic diſpoſition, as in the other caſe, but quickly terminate in a ſcab, without creating any apparent diſorder in the cow. This complaint appears at various ſeaſons in the year, but moſt commonly in the ſpring, when the cows are firſt taken from their winter food and fed with graſs. It is very apt to appear alſo when they are ſuckling their young. But this diſeaſe is not to be conſidered as ſimilar in any reſpect to that of which I am treating, as it is incapable of producing any ſpecific effects on the human conſtitution. However, it is of the greateſt conſequence to point it out here, leſt the want of diſcrimination ſhould occaſion an idea of ſecurity from the infection of the ſmall-pox, which might prove deluſive."

Dr Jenner adds, that the active quality of the virus from the horſe's heels is greatly increaſed after it has acted on the nipples of the cow, as it rarely happens that the horſe affects his dreſſer with ſores, and as rarely that a milkmaid eſcapes the infection when ſhe milks infected cows. It is moſt active at the commencement of the diſeaſe, even before it has acquired a pus-like appearance. Indeed the Doctor is rather induced to think that the matter loſes this property entirely as ſoon as it is ſecreted in the form of pus, and that it is the thin darkiſh looking fluid only, oozing from the newly formed cracks in the heels, ſimilar to what ſometimes exudes from eryſipelatous bliſters, which gives the diſeaſe. He is led to this opinion, from having often inſerted pus taken from old ſores in the heels of horſes, into ſcratches made with a lancet, on the ſound nipples of cows, which has produced no other effect than ſimple inflammation.

He is uncertain if the nipples of the cow are at all times ſuſceptible of being acted upon by the virus from the horſe, but rather ſuſpects that they muſt be in a ſtate of prediſpoſition, in order to enſure the effect. But he thinks it is clear that when the cow pox virus is once generated, the cows, when milked with a hand really infected, cannot reſiſt the contagion, in whatever ſtate their nipples may chance to be. He is alſo doubtful whether the matter, either from the cow or the horſe, will affect the ſound ſkin of the human body; but thinks it probable that it will not, except on thoſe parts where the cuticle is very thin, as on the lips.

At what period the cow-pox was firſt noticed in Glouceſterſhire is not upon record. The oldeſt farmers were not unacquainted with it in their earlieſt days when it appeared upon their farms, without any deviation from the phenomena which it now exhibits. Its connection with the ſmall pox ſeems to have been unknown to them. Probably the general introduction of inoculation firſt occaſioned the diſcovery. Dr Jenner conjectures that its riſe in that neighbourhood may not have been of very remote date, as the practice of milking cows might formerly have been in the hands of women only; and conſequently the cows might not in former times have been expoſed to the contagious matter brought by the men ſervants from the heels of horſes. He adds, that a knowledge of the ſource of the infection is new in the minds of moſt of the farmers, but has at length produced good conſequences; and that it ſeems probable, from the precautions they are now diſpoſed to adopt, that the appearance of the cow-pox in that quarter may either be entirely extinguiſhed or become extremely rare.

"With reſpect to the opinion adduced (Dr Jenner obſerves), that the ſource of the infection is a peculiar morbid matter ariſing in the horſe; although I have not (ſays he) been able to prove it from actual experiments conducted immediately under my own eye, yet the evidence I have adduced appears to eſtabliſh it.

"They who are not in the habit of conducting experiments, may not be aware of the coincidence of circumſtances, neceſſary for their being managed ſo as to prove perfectly deciſive; nor how often men engaged in profeſſional purſuits are liable to interruptions, which diſappoint them almoſt at the inſtant of their being accompliſhed; however, I feel no room for heſitation reſpecting the common origin of the diſeaſe, being well convinced that it never appears among the cows, except it can be traced to a cow introduced among the general herd which has been previouſly infected, or to an infected ſervant, unleſs they have been milked by ſome one who, at the ſame time, has the care of a horſe affected with diſeaſed heels."

The following caſe, which we alſo quote from Dr Jenner, would ſeem to ſhew that not only the heels of the horſe, but other parts of the body of that animal, are capable of generating the virus which produces the cow pox.

"An extenſive inflammation of the eryſipelatous kind appeared, without any apparent cauſe, upon the upper part of the thigh of a ſucking colt, the property of Mr Millet, a farmer at Rockhampton, a village near Berkeley. The inflammation continued ſeveral weeks, and at length terminated in the formation of three or four ſmall abſceſſes. The inflamed parts were fomented, and dreſſings were applied by ſome of the ſame perſons who were employed in milking the cows. The number of cows milked was twenty-four, and the whole of them had the cow-pox. The milkers, conſiſting of the farmer's wife, a man, and a maid ſervant, were infected by the cows. The man-ſervant had previouſly gone through the ſmall pox, and felt but little of the cow-pox. The ſervant maid had ſome years before been infected with the cow-pox, and ſhe alſo felt it now in a ſlight degree: but the farmer's wife, who never had gone through either of theſe diſeaſes, felt its effects very ſeverely. That the diſeaſe produced upon the cows by the colt, and from them conveyed to thoſe who milked them, was the *true* and not the *ſpurious* cow-pox, there can be ſcarcely any room for ſuſpicion; yet it would have been more completely ſatisfactory had the effects of variolous matter been aſcertained on the farmer's wife; but there was a peculiarity in her ſituation which prevented my making the experiment."

8
Dr Jenner's opinion of the origin of the diſeaſe controverted.

Subſequent authors have not been all diſpoſed to adopt Dr Jenner's opinion that this diſeaſe derives its origin from the greaſe in horſes. We have ſeen the Doctor himſelf allow that he has not been able to prove it deciſively by actual experiments; and to eſtabliſh a fact ſo contrary to all analogy, perhaps no weaker evidence ought to be admitted. The only other beſtial diſorder with which we are acquainted, which is capable of being communicated by contagion to the human ſpecies, is hydrophobia: but here the diſorder is the ſame in man as in the animal from which he derives it; and the analogy holds good in the propagation of the vaccine diſeaſe from the cow to her milker. But that the diſcharge from a local diſeaſe in the heel of a horſe ſhould be capable of producing a general diſorder in the conſtitution of a cow, with ſymptoms totally different, and that this new diſeaſe once produced ſhould be capable of maintaining an uniform character in the cow and in man, ſeems a much greater departure from the ordinary proceeding of Nature. We are very far from ſaying that this is impoſſible; for little indeed do we know of what Nature can or cannot do. All we mean to ſay is, that a fact ſo very extraordinary ought not to be haſtily admitted.

In Holſtein, we are told that the farmers do not know of any relation exiſting between the greaſe and the cow pox, at leaſt a perſon who reſided three years in that country never heard of any. This, however, is certainly no proof. The ſame communication which contains this remark (a letter from Dr De Carro of Vienna to Dr G. Pearſon) adds, "that in great farms men do not milk cows, but that in the ſmaller ones that happens very often; that a diſeaſe of horſes, called *mauke* (true German name for *greaſe*), is known by all thoſe who take care of them; that old horſes particularly, attacked with the mauke, are always put in cow's ſtables, and there are attended by women; and that it is particularly in harveſt that men in ſmall farms milk cows." It muſt be allowed, then, that in this ſituation, ſuppoſing Doctor Jenner's opinion well founded, the cow-pox was naturally to be looked for, and here accordingly we find it. The queſtion is certainly of no real utility, and therefore it has very properly been leſs attended to than other points reſpecting this diſorder which lead to important practical concluſions

Of all the queſtions which have ariſen relative to the cow-pox, there is none ſo intereſting, and luckily there is none which has received ſo full a diſcuſſion, or ſo ſatisfactory an anſwer, as the one we are now about to conſider. Are thoſe perſons who have once had the cow-pox effectually and for ever ſecured againſt the variolous contagion?

9
A previous attack of this diſeaſe renders the body unſuſceptible of ſmall-pox.

Dr Jenner, in his firſt publication, was decidedly of opinion that a previous attack of this diſorder rendered the human body for ever unſuſceptible of the variolous virus; and beſides the univerſal popular belief in the countries where cow-pox is known, he brought forward a number of caſes in ſupport of his aſſertion. By ſome of theſe it appeared that perſons who had been affected with the cow pox above twenty or thirty years before, continued ſecure againſt infection, either by the effluvia from patients under ſmall pox, or by inoculation. But along with this opinion he entertained other two, which, to many people, appeared ſo ſurpriſing as to take away all credit from the former. The firſt was, that a previous attack of ſmall-pox did not prevent a ſubſequent attack of cow-pox; and the ſecond was perhaps ſtill more wonderful, that the cow-pox virus, although it rendered the conſtitution unſuſceptible of the ſmall-pox, ſhould nevertheleſs leave it unchanged with reſpect to its own action, for that the ſame perſon is ſuſceptible of repeated attacks of the cow-pox.

These opinions have been ſubmitted to the teſt of very extenſive experience by a variety of intelligent practitioners; and we think there can now be little doubt that the two laſt are erroneous, while the truth of the firſt has been eſtabliſhed by an immenſe body of incontrovertible evidence.

10
Difficulties explained.

The opinions that a perſon who has had the ſmall-pox may afterwards have the cow-pox, and that the ſame perſon may have the cow-pox more than once, probably aroſe from the diſtinction between the local effects of the vaccine virus, and the general diſorder of the conſtitution not having been ſufficiently attended to. It is generally admitted, that in the inoculated ſmall-pox the local affection may go ſo far as that a puſtule ſhall ariſe on the part, containing matter capable of communicating the true ſmall pox to others, and yet, if no general affection of the conſtitution takes place, the patient is not ſecure from the diſorder. In like manner, there are caſes upon record which prove that a perſon may, after having had the ſmall pox, have a local affection produced by inoculation, in which true variolous matter ſhall be formed capable of communicating both the local and conſtitutional ſymptoms of ſmall-pox to others; and nurſes, when much expoſed to variolous contagion, often have an eruption reſembling ſmall-pox upon ſuch parts of their ſkin as have been expoſed to the action of the virus, though they have formerly undergone the diſeaſe. Yet there is probably no perſon at this day who will go ſo far as to aſſert that the ſame perſon can have the ſpecific variolous fever more than once.

The caſe ſeems to be preciſely the ſame with reſpect to cow-pox. Doctor Pearſon and others have inoculated a number of perſons after they have had the ſmall pox with the vaccine virus, and have produced only the local affection; and by the ſame teſt it is aſcertained that the ſame perſon cannot more than once have the conſtitutional ſymptoms of the cow-pox. Dr Woodville indeed tells us that he has ſeen one caſe of genuine cow-pox puſtule and ſpecific fever in a conſtitution which had previouſly ſuffered the ſmall-pox. There can be no higher authority on this ſubject than that of Dr Woodville; and if he had actually ſeen his patient in the ſmall-pox as well as the cow pox, we ſhould have admitted this ſingle caſe as completely deciſive of the queſtion. But the only evidence of this perſon having had the ſmall pox, is the aſſertion of the patient that he had it *when a child*. This we can by no means ſuſtain as concluſive in oppoſition to the Doctor's own experience, as well as the experience of Dr Pearſon.

That the milkers are ſubject to repeated attacks of the local ſymptoms of cow pox, whether they have had the ſmall-pox or not, is certain. In the caſe of the farmer's ſervants at Rockhampton, which we have quoted above from Dr Jenner, one of whom had previouſly undergone the ſmall pox, and the other the cow-pox, and both of whom were afterwards infected

by

by the cow pox *in a ſlight degree*, it ſeems reaſonable to conclude that the local ſymptoms only were preſent in the laſt attack. We may at the ſame time obſerve, that in a caſe of this kind, where a very painful ulcer is produced in a very ſenſible part, this may probably be attended by an increaſed frequency of pulſe; yet if this has not the ſpecific marks of the cow-pox fever, we ſhould not ſay that ſuch a perſon has the diſorder conſtitutionally.

11 ſs of ine ula- t.

With reſpect to the principal propoſition, that the ſpecific fever of cow-pox renders the conſtitution unſuſceptible of the variolous fever, we think no doubt now remains. Above 1000 perſons who have undergone the vaccine inoculation have been afterwards inoculated with variolous matter, which has produced no other than local effects. Beſides theſe, there have been a vaſt number inoculated by private practitioners in different parts of the kingdom, the reſult of which has not been reported. But we may ſafely ſuppoſe, that if any one of them had afforded a concluſion oppoſite to the one now generally admitted, it would have been communicated to the public.

We muſt not, however, conceal one ſeemingly well authenticated caſe which has lately occurred, and which, ſo far as it goes, certainly militates againſt this concluſion, and which, we doubt not, will be eagerly caught at by the opponents of the new practice. We quote it from the Medical and Chirurgical Review for September 1800.

12 ſeeming- well au- nticated ception.

"Mr Malim, ſurgeon of Carey Street, London, inoculated a child, two years and an half old, with vaccine matter procured from Dr Jenner. On the third day there were ſufficient marks of the action of the virus, and from this time to the end of the diſeaſe the local affection proceeded regularly and without interruption. On the eighth day the child complained of headache and ſickneſs; had a quick pulſe, white tongue, and increaſed heat, with an enlargement and tenderneſs in the axilla. Theſe ſymptoms ſubſided in the courſe of the next day, and the child remained well till the twelfth, when it had a very ſevere attack of fever, ſucceeded, the following day, by an eruption; the appearance, progreſs, and termination of which, left no doubt in the minds of ſeveral eminent practitioners of its being the ſmall-pox. That it was really ſo, has been ſince clearly proved by inoculation. There was a child ill of ſmall-pox in the houſe at the time the above inoculation for cow-pox was performed."

The Reviewers juſtly remark, that the hiſtory is defective, in not deſcribing more minutely the appearances of the inoculated parts at the different ſtages, as well as in not mentioning the length of time that the matter had been taken previous to being uſed. Both theſe points are the more important, as a ſuſpicion naturally ariſes, that the local affection which ſucceeded the vaccine inoculation was not the genuine cow-pox puſtule, but one of the ſpurious kind, which had not the power of deſtroying variolous ſuſceptibility. The matter having been furniſhed by Dr Jenner, no doubt, renders this ſuppoſition the leſs probable; but if it was either long or improperly kept after it came out of his hands, it may have undergone a material change, by putrefaction or otherwiſe. Dr Jenner mentions an inſtance of a practitioner, who had been accuſtomed to preſerve variolous matter in a warm pocket; a ſituation favourable for producing putrefaction in it. This matter, when inſerted, was found to produce inflammation, ſwellings of the axillary glands, fever, and ſometimes eruptions; but not of the true variolous kind, as patients thus inoculated were found ſtill ſuſceptible of the ſmall-pox contagion. It is ſurely a poſſible ſuppoſition, tho' merely a conjecture, that the vaccine matter in Mr Malim's caſe had undergone ſome ſuch change.

The caſe however, is in ſeveral reſpects an intereſting one. As it has been ſuppoſed that variolous contagion, communicated in the form of exhalation, does not affect the conſtitution in leſs than fourteen or fifteen days, and as the vaccine matter, communicated by inoculation, produces its ſpecific effects ſome days earlier, it has been ſuggeſted, that wherever a perſon has been accidentally expoſed to variolous effluvia, we ſhould endeavour to anticipate the ſmall-pox by immediately inoculating with the vaccine virus. But if there be nothing falacious in the above caſe, it appears that this meaſure would not ſtop the progreſs of the ſmall-pox, but that our patient would incur the additional danger of having two diſeaſes inſtead of one.

13 Probably accounted for.

At all events, it muſt be allowed that this child had been infected by the ſmall-pox before the vaccine matter had begun to produce its ſpecific effects, and probably even before the inoculation. Thus the ſmall-pox may be conſidered as having begun before the cow-pox; and though we ſhould be forced to allow that, matters being thus ſituated, the latter diſorder could not prevent the farther progreſs of the former, it by no means follows, that when the cow pox has fairly run its courſe, the conſtitution is ſtill ſuſceptible of ſmall pox. The two diſeaſes muſt have exiſted in this patient at the ſame time, though the one was in a latent ſtate during the active ſtage of the other.

This ſolitary caſe, then, is by no means concluſive, and certainly is not ſufficient to outweigh the immenſe mals of concurring evidence which is oppoſed to it.

14 Advantages of the new practice.

We proceed now to another highly important branch of our ſubject—the compariſon of the advantages and diſadvantages of the two diſeaſes, with a view to the practice of inoculation.

Notwithſtanding the immenſe number of caſes in which the inoculation of the cow-pox has been tried, we are not yet fully qualified to appreciate the value of the new practice; becauſe the diſeaſe has varied very much in ſeverity, and even in its moſt remarkable ſymptoms, and that without any cauſe which has yet been diſcovered.

Dr Jenner's account of the diſeaſe gave us reaſon to think that the local affection in cow-pox was more ſevere than in the inoculated ſmall-pox: That the fever in this diſeaſe was never attended with dangerous ſymptoms: that thoſe ſymptoms which affect the patient with ſeverity are entirely ſecondary, excited by the irritating proceſſes of inflammation and ulceration: that the diſeaſe was not attended with any eruption reſembling ſmall-pox: and that the ſore produced by the inoculation was apt to degenerate into a very diſtreſſing phagedenic ulcer, which required to be treated with applications of a cauſtic nature, of which he found the unguentum hydrargyri nitrati the moſt uſeful.

Soon after Dr Jenner's publication, the attention of medical men was forcibly drawn to the ſubject; and ſeveral eminent practitioners in London, particularly Dr

George Pearſon, and Dr Woodville phyſician to the ſmall pox and inoculation hoſpitals, immediately began to practiſe the vaccine inoculation. The latter gentleman ſoon publiſhed an accurate and candid account of the effect of this virus upon 200 patients, with a table of the reſults of above 500 caſes in which the inoculation was performed.

15
Anomalies in the progreſs of the diſeaſe.

It is very remarkable, that in none of theſe caſes did the inoculated part ulcerate in the manner deſcribed by Dr Jenner, nor did the inflammation ever occaſion any inconvenience, excepting in one inſtance, in which it was ſoon ſubdued by the aqua lythargyri acetati. The general affection of the conſtitution, on the other hand, though in a great majority of caſes it was very ſlight, yet, in ſome inſtances, was ſevere. An eruption, exactly reſembling ſmall-pox, was, contrary to expectation, a very common occurrence, and in ſome the puſtules were not fewer than 1000; and although in theſe caſes the diſeaſe was ſtill unattended with ſecondary fever, yet the febrile ſymptoms which took place from the commencement were conſiderable, and even alarming, as ſometimes alſo happens with the inoculated ſmall pox.

Dr Woodville ſometimes inoculated with matter from the primary ſore in the arm, and ſometimes with matter taken from the puſtular eruption; and it appears from the table that a much larger proportion of thoſe who were inoculated in the latter way had puſtules, than of thoſe who were inoculated either with matter immediately from the cow, or from the primary ſore in the human body. There were 447 patients in all inoculated, either from the cow or from the primary ſore; and of theſe 241 had puſtules, and 206 had none. Sixty-two perſons, on the other hand, were inoculated with matter from the puſtules of ten different patients; and of theſe no fewer than 57 had puſtules, and only 5 eſcaped without. Nor can it be ſaid that this diſproportion aroſe from theſe 10 patients having the diſeaſe in a more virulent form than ordinary, for matter was alſo taken from the primary ſore in 4 of the 10, with which 48 were inoculated; of whom 27 had puſtules, and 21 had none: whereas, of 9 perſons who were inoculated with matter from the puſtules of theſe ſame 4, only 2 eſcaped without puſtules. This obſervation correſponds alſo with Dr Pearſon's experience.

Although theſe eruptions have been met with by other practitioners, yet they certainly appear very rarely in private practice. Dr Woodville, for this reaſon, conſiders them, in a more recent publication, as the effect of ſome adventitious cauſe, independent of the cow-pox: And this he ſuppoſes to be the variolated atmoſphere of the hoſpital, which thoſe patients were neceſſarily obliged to inſpire during the progreſs of the cow-pox infection. This opinion, however, does not ſeem to agree well with his former remark, which, as we have ſaid, is confirmed by Dr Pearſon, that eruptions rarely took place, if care was taken to avoid matter for inoculation from ſuch as had puſtules; a fact that cannot be explained on ſuch a ſuppoſition. Neither is this idea reconcileable with what he alſo tells us, that the proportion of caſes in the hoſpital attended with puſtules has been of late only three or four in a hundred.

This change in the appearances of the diſeaſe in the hands of different practitioners, and even of the ſame practitioner at different times, is one of the moſt unaccountable circumſtances reſpecting this ſingular diſorder. There is ſome curious information on this ſubject, contained in a letter from Mr Stromeyer of Hanover to Mr Hannehmaun.

"This year (ſays he) we have inoculated 40 perſons, as well with the vaccine matter received of Dr Pearſon as with that from Dr Jenner; all of whom underwent the diſeaſe properly.

"Betwixt the London and Glouceſter vaccine matter, it appears to me there ſubſiſts an eſſential difference. The London matter produces frequently an eruption of ſmall pimples; but they diſappear within a day or two at fartheſt. Dr Pearſon calls theſe eruptions *puſtules*.—The Glouceſter matter has never produced this effect here; but *frequently occaſioned ulcerations of the inoculated part, of a tedious and long duration; which the latter never did:* on account of which I now only make uſe of Dr Pearſon's vaccine matter. The nettle-fever-like eruptions I have obſerved ſeveral times, but never that ſort of eruption, repeatedly noticed in London, which ſo much reſembles the ſmall pox."

If theſe obſervations of Mr Stromeyer ſhould be confirmed by the experience of others, they would go far to explain the difference which the London practitioners have found in this diſeaſe from the account given of it by Dr Jenner, notwithſtanding the abſence of the eruption reſembling ſmall-pox at Hanover. We believe an interchange of vaccine matter has once or twice taken place between London and Glouceſterſhire. Is it ſince that period that the eruption has been leſs frequent at London? Dr Pearſon is inclined to ſuppoſe, that the comparative ſeverity of the diſeaſe at London, during the firſt winter, aroſe rather from the difference in the human conſtitution at the different ſeaſons of the year, than from any change in the ſtate of the vaccine matter.

16
Mortality for the old practice over-rated by the advocates for the new.

In comparing the degree of danger from the inoculation of cow-pox with that ariſing from the inoculated ſmall-pox, we are convinced that Dr Pearſon greatly over-rates the mortality in the latter diſorder. He ſuppoſes it to be no leſs than one in 200. Dr Moſeley, on the other hand, who is a violent opponent of the vaccine inoculation, aſſerts, that he has inoculated ſeveral thouſands with variolous matter, in Europe and the Weſt Indies, without ever loſing a patient, and that ſeveral other perſons, whom he knows, have done the ſame, with the ſame ſucceſs. We are afraid, however, that the experience of other inoculators does not afford ſo favourable a reſult. We believe that in this country the mortality is often occaſioned by improper treatment; and from comparing the accounts which we have received from practitioners of extenſive experience, and undoubted veracity, we believe that, where the treatment is proper from the beginning, the ſymptoms very rarely ariſe to an alarming height, and that the mortality is not ſo great as one in 600. And this eſtimate nearly correſponds with Dr Woodville's very great experience. It muſt be allowed, that patients in an hoſpital are ſubject to ſome diſadvantages, which may be avoided in private practice; yet, out of the laſt 5000 caſes of variolous inoculation at the inoculation hoſpital, prior to the publication of the Doctor's reports, the mortality did not exceed one in 600.

Notwithſtanding this ſtatement, however, we are happy to ſay, that the danger in the vaccine diſeaſe is ſtill much leſs. Dr Pearſon tells us, that in little more than ſix months after the new inoculation was introduced into London, which includes the period at which the cow-pox aſſumed the moſt unfavourable appearance, 2000 perſons at leaſt underwent the operation; of theſe, one only, an infant at the breaſt, under the care of Dr Woodville, died. In this ſolitary fatal caſe, the local tumor was but very inconſiderable; and the eruptive ſymptoms took place on the ſeventh day, when the child was attacked with fits of the ſpaſmodic kind, which recurred at ſhort intervals, with increaſed violence, and carried it off on the eleventh day after the cow-pox matter had been inſected into its arm, and after an eruption of about 80 puſtules had appeared.

17 Great ſucceſs of the new inoculation.

Since that time a much greater number, amounting certainly to ſeveral thouſands, have been inoculated with cow-pox in different parts of Great Britain and on the continent. Among theſe, not one fatal inſtance, that we have heard of, has occurred.

But even if the danger to the individual from the ſmall-pox and from the cow-pox were equal, there is an important advantage to the public attending the latter, which we think would alone be ſufficient to intitle it to a preference—It is not capable of being propagated by the effluvia ariſing from the bodies of perſons infected with it. There are many ſituations in which a prudent ſurgeon will be reſtrained from inoculating with ſmall pox, leſt the contagion ſhould ſpread to other people, who may be either prevented by prejudice from ſubmitting to the operation, or in whom it would be obviouſly improper, from the circumſtances of age, teething, or the preſence of ſome other diſeaſe. Here the cow pox virus may be ſubſtituted with great propriety. It is chiefly from this quality that the cow pox bids fair to extirpate the ſmall pox entirely.

This valuable property of the vaccine diſorder is not, however, to be admitted without ſome limitation. When it produces numerous puſtules on the body, Dr Woodville tells us, that the exhalations they ſend forth are capable of affecting others, in the ſame manner as the ſmall-pox. Two inſtances of caſual infection in this way have fallen under his obſervation. In one, the diſeaſe was ſevere, and the eruption confluent; in the other, the diſeaſe was mild, and the puſtules few. It has been remarked, that the inoculated cow pox is little, if at all, different from the diſeaſe when caſually caught. But, ſtrictly ſpeaking, the above are the only two caſes in which the diſeaſe has been communicated otherwiſe than by inoculation.

18 Whether the cow-pox and ſmall-pox ought to be conſidered as different diſeaſes.

The writers upon this ſubject are divided in opinion, whether the cow-pox and ſmall pox ought to be conſidered as different diſeaſes, or whether they are merely varieties of the ſame diſeaſe.

They certainly, notwithſtanding the ſtrong analogy which ſubſiſts between them, differ from each other in ſeveral ſtriking particulars. The cow pox comes to man from the cow, and is capable of being carried back from him to that animal. Similar attempts with variolous matter have failed: in this reſpect, then, theſe two morbid poiſons are altogether different.

The local tumor produced by the inoculation of the cow-pox is commonly of a different appearance from that which is the conſequence of inoculation with variolous matter: for if the inoculation of the cow pox be performed by a ſimple puncture, the conſequent tumor, in the proportion of three times out of four, according to Dr Woodville, aſſumes a form completely circular, and it continues circumſcribed, with its edges elevated and well defined, and its ſurface flat, through every ſtage of the diſeaſe; while that which is produced from the variolous matter, either preſerves a peculiar form, or ſpreads along the ſkin, and becomes angulated, or irregular, or disfigured by numerous veſiculæ. Another diſtinction ſtill more deciſive and general, is to be drawn from the contents of the cow-pox tumor; for the fluid here formed very rarely becomes puriform; and the ſcab which ſucceeds is of a harder texture, exhibits a ſmoother ſurface, and differs in its colour from that which is formed by the concretion of pus. The appearances, however, are ſometimes ſo changed, that they can in no reſpect be diſtinguiſhed from thoſe which ariſe from the inoculation of ſmall-pox. We may alſo mention that the tendency of the ſore in the inoculated part to degenerate into a phagedenic ulcer does not occur in ſmall pox.

On the other hand, the points in which theſe two diſeaſes reſemble each other are very remarkable. When introduced into the body by inoculation, they affect the conſtitution in nearly the ſame length of time, and ſeem to be governed by nearly the ſame laws. They mutually deſtroy the ſuſceptibility of the body for the action of each other.

Dr Pearſon, who thinks the diſeaſes ought to be conſidered as diſtinct ſpecies, nevertheleſs draws the following concluſions, as eſtabliſhed by experience.

"That in certain conſtitutions, or under the circumſtances of certain co-operating agents, *the vaccine poiſon produces a diſeaſe reſembling the ſmall pox*; and of courſe the puſtule in the inoculated part is *very different from that of the vaccine pox ordinarily occurring*, and the eruptions *reſemble very much, if not exactly, ſome varieties of the ſmall-pox*: That in ſome inſtances theſe eruptions have occurred, although the inoculated part exhibited the genuine vaccine puſtule: That the matter of ſuch eruptive caſes, whether taken from the inoculated part, or from other parts, produces univerſally (A), or at leaſt generally, ſimilar eruptive caſes; and has not (he believes) been ſeen to go back, by paſſing through different conſtitutions, to the ſtate in which it produces what is called the *genuine vaccine diſeaſe*: That eruptions, of a different appearance from variolous ones, ſometimes occur in the true cow pox."

19 They are probably only varieties of the ſame diſeaſe.

From theſe facts we are ſtrongly inclined to think that the vaccine diſeaſe and the ſmall pox ought merely to be conſidered as varieties of the ſame diſeaſe; and we have little doubt that they both derive their origin from the ſame ſource.

If Dr Jenner's opinion, that the vaccine diſeaſe is derived from *the greaſe*, were fully eſtabliſhed, we ſhould be diſpoſed to offer a conjecture, that the *ſmall-pox*, in coming from the horſe to man, may have paſſed thro'

(A) We have ſeen that Dr Woodville's table contains a few exceptions to this rule, though it ſtrongly confirms the general truth of the propoſition.

ſome animal different from the cow, and may thus have undergone a modification ſimilar to, but not exactly, the ſame with what takes place in the paſſage of the virus through the conſtitution of the cow.

But without having recourſe to this conjecture, which is perfectly gratuitous, we are of opinion that the variations which have taken place in the cow pox within the laſt three years are ſufficient to warrant a belief, that the ſmall-pox may have originally been exactly the ſame diſeaſe, even in the human conſtitution, as the cow-pox is now; but that in a ſucceſſion of ages, and from the operation of cauſes wholly unknown to us, it may have been changed to what we now ſee it.

We ſhall now conclude this article with a few practical remarks, which we hope may be of uſe to practitioners who mean to begin the vaccine inoculation.

20
Practical remarks.

It is of the utmoſt conſequence that the matter employed ſhould be the genuine vaccine virus. Dr Jenner points out the following particulars as ſources of a ſpurious cow-pox: 1. That ariſing from puſtules on the nipples or udder of the cow, which puſtules contain no ſpecific virus. 2. From matter, although originally poſſeſſing the ſpecific virus, which has ſuffered a decompoſition, either from putrefaction, or any other cauſe leſs obvious to the ſenſes. 3. From matter taken from an ulcer in an advanced ſtage, though the ulcer aroſe from a true cow-pox. 4. From matter produced on the human ſkin from the contact of ſome peculiar morbid matter generated by a horſe.

Many have remarked that inoculation with the vaccine matter is more apt to fail in communicating the infection than with variolous matter, eſpecially if it be ſuffered to dry upon the lancet before it is uſed. This does not ſeem to depend upon the virus of the former being more volatile, but upon its becoming more hard and indiſſoluble upon exſiccation. Care ſhould therefore be taken to moiſten it a conſiderable time before it is uſed.

We have already noticed the danger that may ariſe from miſtaking the local effects of the vaccine diſeaſe for its effects upon the conſtitution. To guard practitioners againſt this error, Dr Woodville makes the following remarks: "When a conſiderable tumor and an extenſive redneſs take place at the inoculated part, within two or three days after the infectious matter has been applied, the failure of inoculation may be conſidered as certain as where neither redneſs nor tumor is the conſequence. This rapid and premature advancement of the inflammation will always be ſufficient to prevent the inoculator from miſtaking ſuch caſes for thoſe of efficient inoculation. But there are other circumſtances under which I have found the inoculation to be equally ineffectual, and which, as being more likely to deceive the inoculator, require his utmoſt circumſpection and diſcrimination. I here allude to caſes in which it happens that though the local affection does not exhibit much more inflammation than is uſual, yet neither veſicle nor puſtule ſupervenes; and in which, about the ſixth or ſeventh day, it rapidly advances into an irregular ſuppuration, producing a feſtering or cruſtaceous ſore. Care, however, ſhould be taken to diſtinguiſh this caſe from that in which the inoculated part aſſumes a puſtular form, though it continues for one or two days only, when the ſame appearances follow as thoſe above deſcribed; for I have experienced the latter inoculation to be as effectual as where the tumor has proceeded in the moſt regular manner."

"The efflореſcence at the inoculated part, which ſeldom intervenes before the eighth, or later than the eleventh, day, is to be regarded as an indication that the whole ſyſtem is affected; and if the patient has not felt any indiſpoſition on or before its approach, he may be aſſured that there will not be any afterwards. When effloreſcence does not commence till the eleventh day, it is almoſt always attended with more indiſpoſition than when it occurs on the eighth or ninth day. The effloreſcence is more frequent in young infants than in children advanced to three or four years of age; and the former have the effloreſcence and the diſeaſe more favourably than the latter, inſomuch that by far the greater part of them have no perceptible illneſs, and require no medicines. On the other hand, in adults, the cow-pox frequently produces headache, pain of the limbs, and other febrile ſymptoms, for two or three days, which are greatly relieved by a briſk purgative."

We would, upon the whole, recommend the vaccine inoculation to our medical readers as being an effectual preventative againſt the ſmall-pox, and ſafer to the individual, while it is more advantageous to the public at large, in being leſs capable of propagation by contagion.

VECTOR, or RADIUS VECTOR, in aſtronomy, is a line ſuppoſed to be drawn from any planet, moving round a centre, or the focus of an ellipſe, to that centre or focus. It is ſo called, becauſe it is that line by which the planet ſeems to be carried round its centre; and with which it deſcribes areas proportional to the times.

VEGETABLES. } See *Vegetable SUBSTANCES* in
VEGETATION. } this *Suppl.*

VENTILATION OF SHIPS is a matter of ſo great importance, that we would rather hazard the ſtating of an idle project for this purpoſe, than omit any thing which may be uſeful. We hazard nothing, however, in ſtating the following plan by Mr Abernethy, who candidly acknowledges that it is built upon the principles which we, together with the learned editor of Chambers's Cyclopædia, have borrowed from Dr Hailes. This plan conſiſts merely in cauſing two tubes to deſcend from above the deck to the bottom of a veſſel, or as low as ventilation is required; and which ſhould communicate by ſmaller pipes (open at their extremities) with thoſe places deſigned to be ventilated. There ſhould be a contrivance for ſtopping theſe communicating pipes, ſo that ventilation may be occaſionally prevented from taking place, or confined to any particular part of the veſſel.

One of the principal air tubes ſhould deſcend as near to the ſtern of the veſſel as convenient, and the other as near to the ſtem.

Through that tube which is in the head, the foul air is to be extracted; and through that which is in the ſtern, the freſh air is to deſcend to the different decks and other apartments of the veſſel.

The extraction of the air is eaſily effected in the following manner: Let a tranſverſe tube be fitted to that which deſcends in the head of the veſſel; it may be ſunk within the level of the deck, ſo as to cauſe no inequality of ſurface. Let it be continued till it comes beneath

neath the fire-place, then aſcend in a perpendicular direction through the fire, and open a little above it; or it may be made to communicate with the chimney. It would be more convenient if the fire was near the place where the tube riſes through the deck; but the experiment muſt equally ſucceed, if the tube be made to deſcend again till it is beneath the common fire-place. The effect that will reſult from this contrivance is obvious; when the tube which paſſes through the fire is heated, the air will aſcend with a force proportionable to its levity, and the aſcending column can only be ſupplied from below, conſequently it muſt come from all thoſe parts of the ſhip with which the main tube communicates.

When the ports are open, the quantity of air thus exhauſted from the ſhip will be ſupplied from all quarters; but if they were all ſhut, and the hatchways and other openings completely cloſed, the renewal of freſh air is made certain by means of the tube which deſcends in the ſtern. The main air tube, where it riſes above the deck in the ſtern, ſhould have an horizontal one fitted to it, which might be made to traverſe, ſo that it could be turned to windward; it might alſo expand at its extremity like the mouth of a trumpet; and thus perfectly freſh air muſt enter, and the force of the gale would tend to impel it into the veſſel.

When that part of the tube which paſſes through the fire is red hot, the draught which would be thus occaſioned might perhaps be too great, and the open pipes which communicate with the decks might emit and imbibe the freſh air in ſo direct a ſtream, that it might be injurious to thoſe perſons within the current.

Mr Abernethy therefore thinks it would be better if thoſe ſmaller pipes which lead from the main tubes were made to run along the decks, and communicate with them by numerous orifices. Two pipes opening into the main exhauſting tube might be extended along the tops of the deck, in the angle formed between the ſides and the cieling: and thus the air would be extracted equally from all parts, and in a manner not likely to occaſion injurious currents. Some diviſion of the ſtream of air which enters from the ſtern might alſo be made, if it were thought neceſſary.

Thus a very complete, and in no way injurious, ventilation may be obtained: the air in the veſſel would be perfectly changed when the fire was ſtrong, without expence or trouble; and a gradual and ſalubrious alteration of it might at all times be made, by a very little additional quantity of fuel. The air tubes ſhould conſiſt of ſeparate joints, ſo that occaſionally they might be taken to pieces; and to prevent their being injured or put out of order by rough uſage, the copper pipes ſhould be made of conſiderable ſtrength, placed againſt the ſides of the veſſel, and even incaſed in wood.

In the Letters and Papers of the Bath Society, &c. we have the following deſcription of a ventilator for preſerving corn on ſhip board, by Thomas South, Eſq;

Plate XLVII. Fig. 1. is a cylindrical air-veſſel, or forcing pump, of lead, tin, or other cheap metal; its internal diameter being ten inches, and its length three feet; having a crutch-handled piſton to work with, and an iron noſle, *viz.* a hollow inverted cone, two feet long, to condenſe the air, and increaſe its power in its paſſage downwards. This cylinder ſhould be rivetted or ſcrewed, by means of an iron collar or ſtraps, to the deck it paſſes through, both above and below, as at *a a*; and ſhould be farther ſecured by ſome holdfaſt near *b*, to keep it ſteady in working.

Fig. 2. is a bottom of wood, four inches and a half thick, with a projecting rim at its baſe, for the metal cylinder to reſt on when cemented and ſcrewed to the wood. The centre of this bottom is excavated, for the reception of the crown of the noſle. In the ſame figure the noſle is repreſented with its crown like a bowl diſh, to condenſe the air gradually, without reſiſtance, in its advance to the more contracted baſe of the inverted cone, *i. e.* the top or entrance of the noſle. About two-thirds down this noſle may be fixed a male ſcrew, as *c c*, for the purpoſe hereafter mentioned.

N. B. The forcing-pump ſhould be caſed in wood, to protect it from outward bruiſes, which would prevent the working of the piſton, and ruin its effects. The leather round the embolus ſhould be greaſed when uſed.

Fig. 3. is a crutch-handle, faſtened to the embolus A by its iron legs B, B. A is a cylinder of wood, caſed with leather, ſo as to fit well, but glide ſmoothly, in the metal cylinder; having an opening as large as its ſtrength will permit, for the free acceſs of atmoſpheric air. C is a valve well leathered on its top, and yielding downwards to the preſſure of the air when the piſton is raiſed up. D is a croſs bar of iron, to confine the valve, ſo that it may cloſe inſtantly on the return of the piſton downwards.

Fig. 4. is a tin pipe or tube, of leſs than four inches diameter, and of ſuch length as, when fixed to the baſe of the cylinder, fig. 1. ſhall admit the noſle *d*, fig. 2. to within half an inch of the valve E, at the bottom of the wooden cylinder F, in fig. 4; which valve E will then yield to the preſſure of air condenſed in its paſſage through the noſle, and deliver it into the pipes below. This valve muſt be well leathered on its upper ſurface, and faſtened with an hinge of leather to the cylinder it is meant to cloſe: affixed to its bottom is the ſpindle G, paſſing through a ſpiral ſpring H, which, being compreſſed on the deſcent of the valve, will, by its elaſticity, cauſe it to riſe again, cloſe the aperture above, and retain the air delivered beneath it. On connecting this cylinder with the upper end of the noſle, at *e e*, fig. 2. we muſt carefully prevent any lapſe of air that way, by a bandage of oakum ſmeared with wax, on which to ſcrew the cylinder, like the joints of a flute, air-tight. I is a bar of iron, having a riſing in its centre, wide enough for the ſpindle to play through, but at the ſame time ſufficiently contracted to prevent the paſſage of the ſpiral ſpring

Fig. 5. is an aſſemblage of tin pipes, of any lengths, ſhaped ſuitably and conveniently to their ſituation in the ſhip, to the form of which, when ſhut into one another, they muſt be adapted; obſerving only, that the neck be ſtraight for a length ſufficient to admit the lower end of the cylinder, fig. 4. as high as the letter F, or higher.

Fig. 6. To the middle pipe, which runs along the bottom, ſhould be fixed a perpendicular one, fully perforated, to convey the air more readily into the centre of the heap; and this may have a conical top, as repreſented in the Plate, perforated with a ſmaller punch to prevent the air from eſcaping too haſtily. In large cargoes, two or three of theſe perpendiculars may be

neceſſary; and each ſhould be well ſecured by an iron bar *g*, ſcrewed down to prevent their being injured by the ſhifting of the cargo in ſtormy weather or a rolling ſea. The top of the conical cap of theſe pipes may reach two-thirds up the cargo.

Fig. 7. is a valve of the ſame conſtruction as that repreſented in fig. 4. but incloſed in a tube of braſs, having a female ſcrew at *ff*, adapted to the male ſcrew *cc*, on the noſle fig 2. and may then be inſerted into the head of the pipe fig. 5. This will add to the expence; but in a large apparatus is to be preferred, as a more certain ſecurity from lapſe of air, than the junction of the tube fig. 4. to the neck *ee* in fig. 2.

N. B *ee* is a neck of wood, making a part of the bottom fig. 2. whereon to ſecure the tube fig. 4. when applied to the noſle. The joints of the pipes, when put together for uſe, ſhould be made air-tight, by means of bees wax or ſome ſtronger cement, till they reach the bottom of the veſſel, when there is no farther need of this precaution. The horizontal pipes ſhould run by the ſide of the kelſon the whole length of the hold. The tin plates of which K is made, ſhould be punched in holes, like the roſe of a watering pot, in two or three lines only at moſt, and then formed into a tube, with the rough ſide outwards. L may have four or five lines of the like perforations. M, and the reſt, ſhould gradually increaſe in their number as they advance towards the middle of the hold, and continue fully perforated to the laſt pipe which ſhould be cloſed at its end to prevent the ingreſs of the corn. It is the centre of the cargo which moſt requires ventilating, yet air ſhould pervade the whole. Like the trade-winds, it will direct its courſe to the part moſt heated, and, having effected its ſalutary purpoſe there, will diſperſe itſelf to refreſh the maſs.

Where the hatches are cloſe-caulked, to prevent the influx of water, vent-holes may be bored in convenient parts of the deck, to be bunged up, and opened occaſionally, from whence the ſtate of the corn may be known by the effluvia which aſcend when the ventilator is working.

The power of the ventilator is determined by the ſquare of its diameter multiplied into the length of the ſtroke, and that again by the number of ſtrokes in any given time.

The air-veſſel or forcing pump, with the reſt of the apparatus here deſcribed, is adapted to a veſſel of 120 tons burden; but by lengthening the air veſſel, extending its diameter to 14 inches, and adding 10 inches more to the length of the ſtroke, a power may be obtained of ventilating a cargo of 400 tons within the hour. If this machine be properly wrought for one hour every day, or even every two days, beginning the operations immediately when the corn is put on board, the cargo may be preſerved from taint or injury of every kind during the longeſt voyage.

VERDEN, a duchy of Germany, in the circle of Lower Saxony. It is bounded on the eaſt and ſouth by that of Lunenburg; on the weſt, by the Weſer and the duchy of Bremen; and on the north, by the duchies of Bremen and Lunenburg; extending both in length and breadth about 28 miles. It conſiſts chiefly of heaths and high dry lands; but there are good marſhes on the rivers Weſer and Aller. In 1712, the Danes wreſted this duchy from Sweden, and, in 1715, ceded it to the king of Great Britain, as elector of Hanover; which ceſſion, in 1718, was confirmed by the Swedes. The inhabitants are Lutherans.

VERDIGRIS, or ACETITE OF COPPER. See that article, *Encycl* where an account is given of the proceſs by which verdigris was long manufactured. A different, and more economical proceſs, however, has for ſome years been practiſed in Montpellier, which is worthy of notice, becauſe it may be adopted in this country by ſubſtituting the huſks of gooſeberries or currants for thoſe of grapes.

In the manufacture of verdigris, the materials are copper and the huſks of grapes after the laſt preſſing. The copper is formed into round plates, half a line in thickneſs, and from twenty to twenty five inches in diameter. Each plate, at Montpellier, is divided into twenty-five laminæ, forming almoſt all oblong ſquares of from four to ſix inches in length, three in breadth, and weighing about four ounces. They are beat ſeparately with the hammer on an anvil to ſmooth their ſurfaces, and to give the copper the neceſſary conſiſtence. Without this precaution it would exfoliate, and it would be more difficult to ſcrape the ſurface in order to detach the oxydated cruſt. Beſides this, ſcales of pure metal would be taken off, which would haſten the conſumption of the copper.

The huſks, which ſhould not be too much preſſed, are firſt made to ferment by being put into cloſe vats, and the fermentation is generally completed in three or four days The time, however, muſt vary according to the temperature in which they are kept, and other circumſtances. Whilſt the huſks are fermenting, a preliminary preparation is given to the copper plates. This conſiſts in diſſolving verdigris in water in an earthen veſſel, and rubbing over each plate with a piece of coarſe linen dipped in this ſolution. The plates are then immediately placed cloſe to each other, and left in that manner to dry. Sometimes the plates are only laid on the top of the fermented huſks, or placed under thoſe which have been already uſed for cauſing the copper to oxydate. It has been obſerved, that when this operation has not been employed, the plates grow black at the firſt operation, inſtead of becoming green. It is not, however, neceſſary to thoſe which have been once uſed, and are to be uſed again.

When the plates are thus prepared, and the huſks have been brought to ferment, the workmen try whether the latter are proper for the proceſs, by placing under them a plate of copper, and leaving it buried there for twenty-four hours. If the plate, after this period, is found covered with a ſmooth green cruſt, in ſuch a manner that none of the metal appears, they are then thought fit for being diſpoſed in layers with the copper. On the other hand, if drops of water are obſerved on the ſurface of the plates, the plates are ſaid to *ſweat*, and it is concluded that the heat of the huſks has not ſufficiently ſubſided. They conſequently defer making another trial till the next day. When they are aſſured that the huſks are in a proper ſtate, they form them into layers in the following manner:

The plates are all put into a box, which, inſtead of having a bottom, is divided in the middle by a wooden grate. The plates diſpoſed on this grate are ſo ſtrongly heated by a chaffing diſh placed under them, that the woman employed in this labour is ſometimes obliged

rdigris,
erdun.

to take them up with a cloth, in order that ſhe may not burn her hands. As ſoon as they have acquired that heat, they are put into jars in layers with the huſks. Each jar is then cloſed with a covering of ſtraw, and left to oxydate. Thirty or forty pounds of copper, more or leſs according to the thickneſs of the plates, are put into each jar. At the end of ten, twelve, fifteen, or twenty days, the jar is opened; and if the huſks are white, it is time to take out the plates. The cryſtals are then ſeen detached, and of a ſilky appearance on their ſurface. The huſks are thrown back, and the plates are put in what is called *relai*. For that purpoſe they are immediately depoſited in a corner of the cellar on ſticks ranged on the floor. They are placed in an upright poſition, one leaning againſt the other; and at the end of two or three days they are moiſtened, by taking them up in handfuls and immerſing them in water in earthen pans. They are depoſited quite wet in their former poſition, and left there for ſeven or eight days; after which they are once or twice immerſed again. This immerſion and drying are renewed ſix or eight times every ſeven or eight days. As the plates were formerly put into wine, theſe immerſions were called *one wine*, *two wines*, *three wines*, according to the number of times. By this proceſs the plates ſwell up, the green is nouriſhed, and a coat of verdigris is formed on all their ſurfaces, which may be eaſily detached by ſcraping them with a knife.

This verdigris, which is called *freſh* verdigris, *moiſt* verdigris, is ſold by the manufacturers to people who dry it for foreign exportation. In this firſt ſtate it is only a paſte, which is carefully pounded in large wooden troughs, and then put into bags of white leather, a foot in height and ten inches in diameter. Theſe bags are expoſed to the air or the ſun, and are left in that ſtate till the verdigris has acquired the proper degree of dryneſs. By this operation it decreaſes about 50 *per cent.* more or leſs according to its primitive ſtate. It is ſaid to ſtand proof by the knife, when the point of that inſtrument puſhed againſt a cake of verdigris through the ſkin cannot penetrate it. White lead may be made by a ſimilar proceſs.

Cryſtallized VERDIGRIS is manufactured at Montpellier in the following manner: A vinegar, prepared by the diſtillation of ſour wine, is put into a kettle, and boiled on the common verdigris. After ſaturation the ſolution is left to clarify, and then poured into another kettle of copper, where it is evaporated till a pellicle forms on the ſurface. Sticks are then immerſed into it, and by means of ſome packthread are tied to ſome wooden bars that reſt on the edge of the kettle. Theſe ſticks are about a foot long, and are ſplit croſs-wiſe nearly two inches at the end, ſo that they open into four branches, kept at about the diſtance of an inch from each other by ſmall bags. The cryſtals adhere to theſe ſticks and cover them entirely, forming themſelves into groups or cluſters, of a dark blue colour, and a rhomboidal ſhape. Each cluſter weighs from five to ſix pounds. Three pounds of moiſt verdigris are required for one pound of the cryſtals; the undiſſolved reſiduum is thrown away.

VERDUN, an ancient, ſtrong, and conſiderable town of France, in the department of Meuſe, and late province of Lorrain, with a biſhop's ſee, and a ſtrong citadel. Its fortifications were conſtructed by the Chevalier de Ville and Marſhal de Vauban. The latter was a native of this place. In 1755, great part of the cathedral was deſtroyed by lightning. Verdun was taken by the Pruſſians in 1792, but retaken by the French ſoon after. The inhabitants are noted for the fine ſweetmeats they make. It is ſeated on the river Maeſe. which runs through the middle, 42 miles ſouth-weſt of Luxemburg, and 150 eaſt of Paris. E. Lon. 5° 28' N. lat. 43° 9'.

Vermifuge.

VERMIFUGE, a medicine which expels worms from the inteſtines. Of theſe medicines numbers are daily advertiſed in the newſpapers as infallible, though the ingredients of which they are compoſed are carefully kept ſecret. We think it our duty therefore to aſſure our readers, that the medicines vended by quacks are generally the very ſame that would be preſcribed by a regular phyſician for the diſeaſe in which they are pretended to be ſpecifics, with this only difference, that the unſeen and unprincipled quack generally preſcribes them in more powerful doſes than the regular phyſician deems ſafe for his patient. Thus Ching's famous worm medicine, which has been ſo ſtrenuouſly recommended, is nothing more than mercury given in the very ſame form in which it is given by every phyſician; but Ching gives it in doſes, which, though they have not injured the children of a biſhop and a judge, we have *known* to *ſalivate* other children to the great hazard of their lives. It is indeed wonderful that parents ſhould truſt the health and the lives of their children to men whom they never ſaw, and whom they know to be not oppreſſed with an over delicate ſenſe of honour, in preference to a man of ſcience who has a character to ſupport, and who is probably their friend, and almoſt always their acquaintance.

Of the different vermifuges, however, it muſt be confeſſed that the greater number are liable occaſionally to fail. One of the moſt powerful which we have mentioned in the article MEDICINE, *Encycl.* is compoſed of the ſpiculæ of the *cowhage* or *cow-itch*; and ſince that article was publiſhed, it has come more into uſe, chiefly through the recommendation of Mr Chamberlaine ſurgeon. He ſays that a tea-ſpoonful of the electuary (See MEDICINE, *Encycl.* p. 342.) may be ſafely given to a young child, and one or even two table ſpoonfuls to adults. The medicine is to be taken in the morning faſting; and the doſe to be repeated for two or three mornings, after which a gentle purge completes the cure. This medicine, however, Mr Chamberlaine prohibits in every caſe where there is a tendency to inflammation in any part of the inteſtinal canal, or where the mucus has been carried off or greatly diminiſhed by dyſentery or any other cauſe.

Dr Haemmerlin of Ulm has lately recommended as a very powerful and ſafe vermifuge the coraline of Corſica, and ſays that it has been ſo uſed in that iſland with complete ſucceſs from time immemorial. It is a fucus adhering to the rocks waſhed by the ſea, and ſometimes to the ſtones and ſhells thrown upon the ſhore. It is found in little tufts. It is generally of a yellow colour, with a reddiſh tincture. When dried, as it appears when offered for ſale, it contains a ſtrong ſmell of the ſea. It conſiſts of little cartilaginous ſtalks, with full threads, gradually cylindrical and tubulated. Its taſte is ſalt and unpleaſant. In the ſyſtem of plants of Linnæus, it belongs to the claſs *cryptogamia*. Its moſt com-

Vermont, Veſpa

mon names are, ſea rock moſs; the Grecian herb; lemithochorton; and the coraline of Corſica. It is the *conferva helminthortos* of Schwendimann, and the *fucus helminthocorton* of Latourette. There is reaſon to think that all thoſe ſpecies of fucus whoſe texture is ſoft and ſpungy, might be applied to the ſame medicinal uſes. There is a ſort of red coraline found in Sweden which, according to ſome writers, is a greater deſtroyer of worms than any other known ſubſtance; being not too ſtrong for the ſtomach either of infants or of adults. Schwendimann aſſerts that the *conferva dichotoma* of Linnæus, which is found in the ditches in England, bears a ſtrong analogy to the coraline of Corſica. Might not this conferva be tried as a vermifuge? The Corſican coraline is in great eſtimation in the pharmacopœias of the Continent, eſpecially in that of Geneva, in which is given a recipe for preparing a ſyrup of it.

VERMONT, one of the United States of North America, bounded on the north by Canada; on the eaſt, by the river Connecticut, which divides it from New Hampſhire; on the ſouth, by Maſſachuſſets; and on the weſt by New York. It is about 155 miles long, and 60 broad, and is divided into 7 counties. A chain of high mountains, running north and ſouth, divides this ſtate nearly in the centre, between the river Connecticut and lake Champlain. The height of land is generally from 20 to 30 miles from the river, and about the ſame diſtance from the New York line. The natural growth upon this mountain is hemlock, pine, ſpruce, and other evergreens: hence it has always a green appearance, and, on this account, has obtained the deſcriptive name of Vermont, from the French *Verd Mont*, Green Mountain. On ſome high parts of this mountain, ſnow lies till May, and ſometimes till July. The country is generally hilly, but not rocky. It is finely watered, the ſoil is very fertile, and there is not a better climate in the world. The inhabitants have very lately been eſtimated at 100,000. The bulk of them are emigrants from Connecticut and Maſſachuſets. The principal town is Bennington, but the aſſembly generally hold their ſeſſions at Windſor.

VESPA (See *Encycl.*). A new ſpecies of this genus of inſects has been lately deſcribed by *Cuvier*, in a note read before the Philomathic Society of Paris. It has ſome reſemblance to the *veſpa nidulans* of Fabricius, which, as is generally known, is a native of certain parts of America. The neſts of the veſpa nidulans are conſtructed of a very fine web, of a very ſolid and pretty white paſte. Their form is that of a bell cloſed upon all ſides, excepting a narrow hole at the bottom; and they are ſuſpended from the branches of trees.

The *veſpa* deſcribed by Cuvier, which is a native of Cayenne in America, has in general more volume than the preceding ſpecies, and its paſte is grey, coarſer, leſs homogeneous, and leſs ſolid. The bottom of its neſt alſo, in lieu of being ſhaped funnel-like, is flat, and the orifice appears at one of the ſides of the bottom part, and not in the middle. In the country where it is found, this ſpecies of waſp is called the *tatou fly* (*mouche tatou*). It differs greatly in form from that which Fabricius has deſcribed; it is all entirely of a ſhining black; the firſt articulation, or joint of its abdomen, is narrow, and in form of a pear; the ſecond, larger than the others, is in form of a bell: the wings are brown. The following is the character aſſigned to it by Cuvier:

Veſpatatua, Nigra, Nitida, Alis fuſcis, abdomine pedicellato.

Veſpertilio.

VESPERTILIO (ſee *Encycl.*) has been ſubjected to ſome cruel, but curious experiments, by the Abbé Spallanzani and M. de Jurine. The former of theſe philoſophers having let looſe ſeveral bats in a chamber perfectly dark, found that they flew about in it without any impediment, neither ruſhing againſt any thing in the apartment, nor touching the walls with their wings. This ſurpriſed him; but imagining that they were conducted by ſome glimpſe of light which he did not perceive, he blindfolded them with a ſmall and very cloſe hood. They then ceaſed to fly; but he obſerved, at the ſame time, that this did not proceed from any deprivation of light, but rather from the conſtraint thence occaſioned, eſpecially when a hood of a very light texture was attended with the ſame effect.

He then conceived the idea of paſting up the eyes of the bats with a few drops of ſize or gum; but they ſtill flew about in the ſame manner as if their eyes had been open. As this, however, was not ſufficient, he paſted up the eyes of theſe animals with round bits of leather; and this even did not impede them in their flight.

That he might at length be certain of his object, he blinded them entirely, either by burning the cornea with a red hot wire, or by pulling out the pupil with a pair of ſmall pincers, and ſcooping out the eye entirely. Not contented even with this precaution, he covered the wounds with pieces of leather, that the light might have no influence whatever on the remains of the organs which had been deſtroyed. The animals ſeemed to ſuffer very much by this cruel operation; but when they were compelled to uſe their wings, either by day or by night, and even in an apartment totally dark, they flew perfectly well, and with great caution, towards the walls, in order to ſuſpend themſelves when they wiſhed to reſt. They avoided every impediment, great or ſmall, and flew from one apartment to another, backwards and forwards, through the door by which they were connected, without touching the frame with their wings. In a word, they ſhewed themſelves as bold and lively in their flight as any other animals of the ſame ſpecies which enjoy the uſe of their eye-ſight.

Theſe experiments were repeated by M. Jurine, and with the ſame reſults. Spallanzani had ſuppoſed that the bat poſſeſſed ſome organ or ſenſe which is wanting in the human ſpecies, and which ſupplies to theſe animals the place of viſion; and Jurine determined to aſcertain the truth or falſehood of this hypotheſis by anatomical reſearches. During the courſe of theſe, he found the organ of hearing very great in proportion to that of other animals, and a conſiderable nervous apparatus aſſigned to that part. The upper jaw alſo is furniſhed with very large nerves, which are expanded in a tiſſue on the muzzle.

M. Jurine then extended his experiments to the organ of hearing and that of ſmell. Having put a ſmall hood on a long-eared bat, it immediately pulled it off, and flew. He ſtopped up its ears with cotton; but it freed itſelf in the like manner from that inconvenience. He then put into its ears a maſtic of turpentine and wax. During the operation the animal ſhewed a great deal of impatience, and flew afterwards very imperfectly.

A long-eared bat, the ears of which had been bound up, flew very badly: but this did not ariſe from any pain

ertilio
bration
gures.

pain occaſioned by the ligature; for when its ears were ſewed up, it flew exceedingly well. In all probability the animal would have preferred having its ears bound up to having them ſewed. Sometimes it flew towards the cieling, extending its muzzle before it ſettled.

M. Jurine poured liquid pomatum into the ears of a bat which enjoyed the uſe of its ſight. It appeared to be much affected by this operation; but when the ſubſtance was removed it took flight. Its ears were again filled, and its eyes were taken out; but it flew then only in an irregular manner, without any certain or fixed direction.

The ears of a horſe ſhoe bat, which had the uſe of its ſight, were filled with tinder mixed with water. It was uneaſy under the operation, and appeared afterwards reſtleſs and ſtunned; but it conducted itſelf tolerably well. On being blinded, it ruſhed with its head againſt the cieling, and made the air reſound with ſtrokes which it gave itſelf on the muzzle. This experiment was repeated on other bats with the like effect.

The tympanum of a large horſe-ſhoe bat was pierced with a pin (*trois quart*). The animal appeared to ſuffer much from the operation, and fell down in a perpendicular direction when thrown into the air. It died next morning. The ſame effect was produced on piercing the tympanum of a long-eared bat with a needle.

The author then made very accurate reſearches on the difference between the organiſation of the brain of theſe two kinds of bats; and, after a careful diſſection, found that the eye of the long eared bat is much larger than that of the horſe ſhoe bat, but that the optic nerve is proportioned to it. The outer part of the ear of the former is much larger than that of the latter, but the interior part is ſmaller.

The horſe ſhoe bat is indemnified for this difference by a greater extenſion of the organ of ſmell, as evidently appears when the external elevations and irregularities of its muzzle are examined. When it is about to take flight, it agitates its noſe much more than the long-eared bat.

From theſe experiments, the author concludes: *Firſt*, That the eyes of the bat are not indiſpenſably neceſſary to it for finding its way; *ſecondly*, That the organ of hearing appears to ſupply that of ſight in the diſcovery of bodies, and to furniſh theſe animals with different ſenſations to direct their flight, and enable them to avoid thoſe obſtacles which may preſent themſelves.

VIBRATION Figures, are certain figures, formed by ſand or very dry ſaw duſt, on a vibrating ſurface, which is connected with the ſenſation of ſound in our organs of hearing. If the ſurface, on which the figures are to be formed, be ſtrewed over with bodies eaſily put in motion, theſe, during the vibration, remain on the parts at reſt, and are thrown from the parts in motion. The form of the parts at reſt, which will be ſhewn by the ſand that remains unmoved, and which, in general, is ſymmetric, is called a *vibration figure*. To produce ſuch a figure, nothing is neceſſary but to know the method of bringing that part of the ſurface which you wiſh not to vibrate into a ſtate of reſt, and of putting in motion that which you wiſh to vibrate. On this depends the whole expertneſs of producing vibration figures

Vibration
Figures,
Vieta

Thus take a ſquare piece of glaſs, pretty thin, and very ſmooth, ſuch as that uſed for windows, about four or five inches over, or even more. Smooth it at the edges on a grinding-ſtone; ſtrew a little ſaw-duſt over its ſurface, and lay hold of it gently with the thumb and fore-finger of the left hand. Holding it thus by the middle, with the right hand rub a violin bow ſoftly againſt one of its edges, drawing the bow either up or down in a direction almoſt perpendicular to the ſurface of the glaſs, and you will ſee a tremulous movement, and the whole duſt leap about. If the bow be exactly in the middle of one of the ſides, the duſt will arrange itſelf almoſt in the direction of the two diagonals, dividing the ſquare into four iſoſceles triangles. If the bow be applied at a quarter only of the diſtance of the one corner from the other, the duſt will arrange itſelf in ſuch a manner as to be found in the two diameters of the ſquare, dividing it into four equal ſquares. At other times, when the bow deviates a little, the duſt forms a figure like a double C, when the two letters are joined back to back. If the ſquare be held by the two extremities of the diameter, oppoſite to that againſt which the bow is applied, the duſt will form a kind of oval, one of the axes of which will be the ſame diameter. If the glaſs be of a circular figure, and be held by the middle, the duſt will arrange itſelf in ſuch a manner as to form the ſix radii of a regular hexagon. Theſe diſcoveries were made by Dr Chladni, about the time that he invented the muſical inſtrument, to which he gave the name of Euphon (ſee that article, *Suppl.*); and as he found the vibration figures to vary in form with the various tones produced by the vibrating ſubſtances, a proſecution of his experiments may probably contribute to throw new light on the philoſophy of muſical ſounds. We ſhall therefore give, from the 3d volume of *Neues Journal der Phyſik*, by Profeſſor Gren, a few directions for making ſuch experiments.

Any ſort of glaſs may be employed, provided its ſurface be ſmooth; and when the plate has acquired the proper vibration, it ſhould be kept in that ſtate for ſome ſeconds, by continuing to rub it with the bow. The figures will thus be accurately formed.

Such plates ſhould be procured as are pretty equal in thickneſs. It may be ſaid, in general, that a plate the thinner it is will be ſo much the fitter for theſe experiments, though in this reſpect there is a certain minimum. In ſmall plates, ſuch as thoſe that are circular, and not above ſix inches in diameter, the obſervation is general; but in larger plates too great thinneſs is prejudicial. Beſides, it will be found that very thin glaſs is commonly very uneven, and muſt therefore be unfit for the experiments.

In practiſing the experiments, it will be proper to have plates of different ſizes; and the ſand employed ſhould not be too fine. In other words, it muſt be of ſuch a nature that when you incline the glaſs-plate it may readily roll off; becauſe, in that caſe, it will be eaſily thrown from the vibrating parts. It will be of advantage that it be mixed with fine duſt, which ſhews peculiar phenomena during the experiments, as it collects itſelf at one place of the vibrating part.

The plate muſt be equally beſtrewed with ſand, and not too thick, as the lines will then be exceedingly fine, and the figures will acquire a better defined appearance.

VIETA (Francis), a very celebrated French mathematician, was born in 1540 at Fontenai, or Fontenai le-Comté, in Lower Poitou, a province of France. He

Hutton's Mathematical Dictionary.

He was Maſter of requeſts at Paris, where he died in 1603, being the 63d year of his age. Among other branches of learning in which he excelled, he was one of the moſt reſpectable mathematicians of the 16th century, or indeed of any age. His writings abound with marks of great originality, and the fineſt genius, as well as intenſe application. His application was ſuch, that he has ſometimes remained in his ſtudy for three days together without eating or ſleeping. His inventions and improvements in all parts of the mathematics were very conſiderable. He was in a manner the inventor and introducer of Specious Algebra, in which letters are uſed inſtead of numbers, as well as of many beautiful theorems in that ſcience. He made alſo conſiderable improvements in geometry and trigonometry. His angular ſections are a very ingenious and maſterly performance: by theſe he was enabled to reſolve the probem of Adrian Romanus, propoſed to all mathematicians, amounting to an equation of the 45th degree. Romanus was ſo ſtruck with his ſagacity, that he immediately quitted his reſidence of Wirtzbourg in Franconia, and came to France to viſit him, and ſolicit his friendſhip. His Apollonius Gallus, being a reſtoration of Apollonius's tract on Tangencies, and many other geometrical pieces to be found in his works, ſhew the fineſt taſte and genius for true geometrical ſpeculations.—He gave ſome maſterly tracts on Trigonometry, both plane and ſpherical, which may be found in the collection of his works, publiſhed at Leyden in 1646, by Schooten, beſides another large and ſeparate volume in folio, publiſhed in the author's life-time, at Paris, in 1579, containing extenſive trigonometrical tables, with the conſtruction and uſe of the ſame, which are particularly deſcribed in the introduction to Dr Hutton's Logarithms, p. 4. &c. To this complete treatiſe on trigonometry, plane and ſpherical, are ſubjoined ſeveral miſcellaneous problems and obſervations; ſuch as, the quadrature of the circle, the duplication of the cube, &c. Computations are here given of the ratio of the diameter of a circle to the circumference, and of the length of the ſine of 1 minute, both to a great many places of figures; by which he found that the ſine of 1 minute is

between 2908881959
and 2908882056;

alſo the diameter of a circle being 1000, &c. that the perimeter of the inſcribed and circumſcribed polygon of 393216 ſides will be as follows, viz. the

perim. of the inſcribed polygon - 31415926535
perim. of the circumſcribed polygon 31415926537

and that therefore the circumference of the circle lies between thoſe two numbers.

Vieta having obſerved that there were many faults in the Gregorian Kalendar, as it then exiſted, compoſed a new form of it, to which he added perpetual canons, and an explication of it, with remarks and objections againſt Clavius, whom he accuſed of having deformed the true Lelian reformation, by not rightly underſtanding it.

Beſides theſe, it ſeems a work, greatly eſteemed, and the loſs of which cannot be ſufficiently deplored, was his *Harmonicon Cœleſte*, which, being communicated to father Merſenne, was, by ſome perfidious acquaintance of that honeſt minded perſon, ſurreptitiouſly taken from him and irrecoverably loſt, or ſuppreſſed, to the great detriment of the learned world. There were alſo, it is ſaid, other works of an aſtronomical kind, that have been buried in the ruins of time.

Vieta was alſo a profound decipherer, an accompliſhment that proved very uſeful to his country. As the different parts of the Spaniſh monarchy lay very diſtant from one another, when they had occaſion to communicate any ſecret deſigns, they wrote them in ciphers and unknown characters during the diſorders of the league. The cipher was compoſed of more than 500 different characters, which yielded their hidden contents to the penetrating genius of Vieta alone. His ſkill ſo diſconcerted the Spaniſh councils for two years, that they publiſhed it at Rome, and other parts of Europe, that the French king had only diſcovered their ciphers by means of magic.

VINTAIN, a town, ſituated about two miles up a creek on the ſouthern ſide of the river Gambia. It is much reſorted to by Europeans, on account of the great quantities of bees-wax which are brought hither for ſale. The wax is collected in the woods by the Feloops, a wild and unſociable race of people. Their country, which is of conſiderable extent, abounds in rice; and the natives ſupply the traders, both on the Gambia and Caſſamanſa rivers, with that article, and alſo with goats and poultry, on very reaſonable terms. The honey which they collect is chiefly uſed by themſelves in making a ſtrong intoxicating liquor, much the ſame as the mead which is produced from honey in Great Britain.

In their traffic with Europeans, the Feloops generally employ a factor, or agent, of the Mandingo nation, who ſpeaks a little Engliſh, and is acquainted with the trade of the river. This broker makes the bargain; and, with the connivance of the European, receives a certain part only of the payment; which he gives to his employer as the whole; the remainder (which is very truly called the *cheating money*) he receives when the Feloop is gone, and appropriates to himſelf as a reward for his trouble. Vintain, according to Mr Park, from whoſe valuable travels this account of the Feloops is taken, is ſituated in 13° 9′ North Lat. and 15° 56′ Long. Weſt from Greenwich.

VIRGINITY, the teſt or criterion of a virgin; or that which intitles her to the denomination. See HYMEN, *Encycl.*

VISION. In the article OPTICS, n° 154. (*Encycl.*), it is ſaid, that as we have a power of contracting or relaxing the *ligamenta ciliaria*, and thereby altering the form of the cryſtalline humour of the eye, we hence ſee objects diſtinctly at different diſtances. It appears, however, from ſome experiments made by Mr Everard Home and Mr Ramſden, in the year 1794, that this power of contracting and relaxing the ligamenta ciliaria is not alone ſufficient to account for the phenomenon. Converſing with Mr Home on the different uſes of the chryſtalline humour, Mr Ramſden ſaid, that as that humour "conſiſts of a ſubſtance of different denſities, the central parts being the moſt compact, and from thence diminiſhing in denſity gradually in every direction, approaching the vitreous humour on one ſide, and the aqueous humour on the other, its refractive power becomes nearly the ſame with that of the two contiguous ſubſtances That ſome philoſophers have ſtated the uſe of the cryſtalline humour to be, for accommodating

commodating the eye to ſee objects at different diſtances; but the firmneſs of the central part, and the very ſmall difference between its refractive power near the circumference and that of the vitreous or the aqueous humour, ſeemed to render it unfit for that purpoſe; its principal uſe rather appearing to be for correcting the aberration ariſing from the ſpherical figure of the cornea, where the principal part of the refraction takes place, producing the ſame effect that, in an achromatic object-glaſs, we obtain in a leſs perfect manner by proportioning the radii of curvature of the different lenſes. In the eye the correction ſeems perfect, which in the object-glaſs can only be an approximation; the contrary aberrations of the lenſes not having the ſame ratio: ſo that, if this aberration be perfectly corrected, at any given diſtance from the centre, in every other it muſt be in ſome degree imperfect.

"Purſuing the ſame compariſon: In the achromatic object glaſs we may conceive how much an object muſt appear fainter from the great quantity of light loſt by reflection at the ſurfaces of the different lenſes, there being as many primary reflections as there are ſurfaces; and it would be fortunate if this reflected light was totally loſt. Part of it is again reflected towards the eye by the interior ſurfaces of the lenſes: which, by diluting the image formed in the focus of the object-glaſs, makes that image appear far leſs bright than it would otherwiſe have done, producing that milky appearance ſo often complained of in viewing lucid objects through this ſort of teleſcope.

"In the eye, the ſame properties that obviate this defect, ſerve alſo to correct the errors from the ſpherical figure, by a regular diminution of denſity, from the centre of the cryſtalline outward. Every appearance ſhews the cryſtalline to conſiſt of laminæ of different denſities; and if we examine the junction of different media, having a very ſmall difference of refraction, we ſhall find that we may have a ſenſible refraction without reflection. Now, if the difference between the contiguous media in the eye, or the laminæ in the cryſtalline, be very ſmall, we ſhall have refraction without having reflection: and this appears to be the ſtate of the eye; for although we have two ſurfaces of the aqueous, two of the cryſtalline, and two of the vitreous humour, yet we have only one reflected image; and that being from the anterior ſurface of the cornea, there can be no ſurface to reflect it back, and dilute an image on the retina.

"This hypotheſis may be put to the teſt whenever accident ſhall furniſh us with a ſubject having the cryſtalline extracted from one eye, the other remaining perfect in its natural ſtate; at the ſame time we may aſcertain whether or no the cryſtalline is that part of the organ which ſerves for viewing objects at different diſtances diſtinctly. Seeing no reflection at the ſurface of the cryſtalline, might lead ſome perſons to infer that its refractive power is very inconſiderable; but many circumſtances ſhew the contrary: yet what it really is may be readily aſcertained by having the focal length and diſtance of a lens from the operated eye, that enables it to ſee objects the moſt diſtinctly; alſo the focal length of a lens, and its diſtance from the perfect eye, that enables it to ſee objects at the ſame diſtance as the imperfect eye: theſe data will be ſufficient whereby to calculate the refractive power of the cryſtalline with conſiderable preciſion.

"Again, having the ſpherical aberration of the different humours of the eye, and having aſcertained the refractive power of the cryſtalline, we have data from whence to determine the proportional increaſe of its denſity as it approaches the central part, on a ſuppoſition that this property corrects the aberration.

"An opportunity preſented itſelf for bringing the obſervations of Mr Ramſden, reſpecting the uſe of the cryſtalline lens, to the proof. A young man came into St George's Hoſpital with a cataract in the right eye. The cryſtalline lens was readily extracted, and the union of the wound in the cornea took place unattended by inflammation; ſo that the eye ſuffered the ſmalleſt degree of injury that can attend ſo ſevere an operation. The man himſelf was in health, 21 years of age, intelligent, and his left eye perfect: the other had been an uncommonly ſhort time in a diſeaſed ſtate, and 27 days after the operation appeared to be free from every other defect but the loſs of the cryſtalline lens.

"A number of experiments were made on the imperfect eye, aſſiſted by a lens, and compared with the perfect eye. The aim of theſe trials, which were judiciouſly varied, was to aſcertain whether the eye which had been deprived of the cryſtalline lens was capable of adjuſting itſelf to diſtinct viſion at different diſtances. Among other reſults, the perfect eye, with a glaſs of $6\frac{1}{2}$ inches focus, had diſtinct viſion at 3 inches; the near limit was $1\frac{7}{8}$ inch, the diſtant limit leſs than 7 inches. The imperfect eye, with a glaſs $2\frac{2}{10}$ inches focus, with an aperture $\frac{3}{15}$ths of an inch, had diſtinct viſion at $2\frac{7}{8}$ inches, the near limit $1\frac{7}{8}$ inch, and the diſtant limit 7 inches. The accuracy with which the eye was brought to the ſame point, on repeating the experiment, proved it to be uncommonly correct; and as he did not himſelf ſee the ſcale uſed for admeaſurement, there could be no ſource of fallacy. From the reſult of this experiment, it appears that the range of adjuſtment of the imperfect eye, when the two eyes were made to ſee at nearly the ſame focal diſtance, exceeded that of the perfect eye. Mr Ramſden ſuggeſted a reaſon why the point of diſtinct viſion of the imperfect eye might appear to the man himſelf nearer than it was in reality; namely, that from the imperfection of this organ he might find it eaſier to read the letters when they ſubtended a greater angle than at his real point of diſtinct viſion. The experiments, however, appear to ſhew that the internal power of the eye, by which it is adjuſted to ſee at different diſtances, does not reſide in the cryſtalline lens, at leaſt not altogether; and that if any agency in this reſpect can be proved to reſide in the cryſtalline, the other powers, whatever they may be, are capable of exertion beyond their uſual limits, ſo as to perform its office in this reſpect.

"From theſe conſiderations, and in conſequence of other reflections tending to ſhew that an elongation of the optical axis is not probably the means of adjuſtment, theſe philoſophers directed their enquiries to aſcertain how far the curvature of the cornea might be ſubject to change. They found by trial that this part of the organ poſſeſſes a degree of elaſticity which is very conſiderable, both for its perfection and its range; and by anatomical diſſection it was found that the four ſtraight muſcles of the eye do in effect terminate in the cornea at their tendinous extremities: that the whole external lamina of the cornea could by gentle force be ſeparated, by means of theſe muſcles, from the eye; ſo that the tendons ſeem loſt in the cornea, and this laſt has the appearance of a central tendon. It was alſo ſeen that the central part of the cornea is the thickeſt and the moſt elaſtic.

"Theſe were conſiderable advances towards eſtabliſhing the hypotheſis of adjuſtment by the external curve of the eye. It remained to be ſhewn, by experiments on the living ſubject, that this curve does really vary in the due direction, when the mind perceives the diſtinct viſible ſenſation of objects at different diſtances. For this purpoſe Mr Ramſden provided an apparatus, conſiſting of a thick board ſteadily fixed, in which was a ſquare hole large enough to admit a perſon's face; the forehead and chin reſting againſt the upper and lower bars, and the cheek againſt either of the ſides; ſo that when the face was protruded, the head was ſteadily fixed by reſting on three ſides; and in this poſition the left eye projected beyond the outer ſurface of the board. A microſcope, properly mounted, ſo as with eaſe to be ſet in every requiſite poſition, was applied to view the cornea with a magnifying power of thirty times. In this ſituation, the perſon whoſe eye was the object of experiment was deſired to look at the corner of a chimney, at the diſtance of 235 yards, through a ſmall hole in a braſs plate, fixed for that purpoſe, and afterwards to look at the edge of the hole itſelf, which was only ſix inches diſtant. After ſome management and caution, which the delicate nature of theſe experiments requires, the motion of the cornea, which was immediately perceptible, became very diſtinct and certain. The circular ſection of its ſurface remained in a line with the wire in the field of the microſcope, when the eye was adjuſted to the diſtant object, but projected conſiderably beyond it when adapted to the near one. When the diſtant object was only 90 feet from the obſerver, and the near object ſix inches, the difference in the prominence of the cornea was eſtimated at 1 800th of an inch. Theſe experiments were repeated and varied at different times and on different ſubjects. The obſerver at the microſcope found no difficulty in determining, from the appearance of the cornea, whether the eye was fixed on the remote or the near object.

"From theſe different experiments Mr Home conſiders the following facts to have been aſcertained:

"1 That the eye has a power of adjuſting itſelf to different diſtances when deprived of the cryſtalline lens; and therefore the fibrous and laminated ſtructure of that lens is not intended to alter its form, but to prevent reflections in the paſſage of the rays through the ſurfaces of media of different denſities, and to correct ſpherical aberration.

"2 That the cornea is made up of laminæ; that it is elaſtic, and when ſtretched is capable of being elongated 1 11th part of its diameter, contracting to its former length immediately upon being left to itſelf

"3. That the tendons of the four ſtraight muſcles of the eye are continued on to the edge of the cornea, and terminate, or are inſerted, in its external laminæ: their action will therefore extend to the edge of the cornea.

"4. That in changing the focus of the eye from ſeeing with parallel rays to a near diſtance, there is a viſible alteration produced in the figure of the cornea, rendering it more convex; and when the eye is again adapted to parallel rays, the alteration by which the cornea is brought back to its former ſtate is equally viſible."

Mr Home made many other experiments with a view to throw light upon this curious ſubject; and the reſult of the whole appears to be, that the adjuſtment of the eye is produced by three different changes in that organ; an increaſe of curvature in the cornea, an elongation of the axis of viſion, and a motion of the cryſtalline lens. Theſe changes, in a great meaſure, depend upon the contraction of the four ſtraight muſcles of the eye. Mr Ramſden, from computations grounded on the principles of optics and general ſtate of the facts, eſtimates that the increaſe of curvature of the cornea may be capable of producing one-third of the effect, and that the change of place of the lens, and elongation of the axis of viſion, ſufficiently account for the other two thirds of the quantity of adjuſtment neceſſary to make up the whole.

VITALITY, the power of ſubſiſting in life, which the faſhionable philoſophers of the French and German ſchools attribute to *chemiſtry*. For a confutation of their abſurd and impious jargon on this ſubject, we refer our readers, with ſome degree of confidence, to the articles PHYSIOLOGY (*Encycl.*), and *Animal* SUBSTANCES (*Suppl.*)

VIVERRA (ſee *Encycl.*) A new ſpecies of this genus of animals was diſcovered by Vaillant during his laſt travels in Africa; at leaſt he ranks under the generic name *Viverra*, the animal of which he gives the following deſcription Its body was of the ſize of that of a kitten ſix months old: it had a very large noſe, the upper jaw exceeding the lower near two-thirds of an inch in length, and forming a ſort of moveable ſnout reſembling that of the *coati* of Guiana. The fore feet were armed with four large claws, very ſharp and curved; the hind ones have each five, but they are ſhort and blunt. All the fur on the upper part of the body is marked with croſs bands of a deep brown colour, on a ground of light brown with which many white hairs are intermixed. The lower part of the body and inſides of the legs are of a reddiſh white. The tail, which is very fleſhy, and more than two thirds longer than the body, is black at the tip, and the reſt brown, intermixed with white hairs

This animal employs its fore paws to dig very deep holes in the earth, in which it remains concealed during the day, not going out till ſun-ſet in queſt of food.

The Hottentots who accompanied our traveller called it *muys-hond* (a mouſe dog); a general name among the inhabitants of the Cape for all the ſmaller carnivorous quadrupeds

VIVES (Ludovicus), the contemporary and friend of Eraſmus, was a native of Valentia in Spain. Though well trained in all the ſubtleties of the ſcholaſtic philoſophy at Paris, he had the good ſenſe to diſcover its futility, and diligently applied himſelf to more uſeful ſtudies. At Louvain he undertook the office of a preceptor, and exerted himſelf with great ability and ſucceſs in correcting barbariſm, chaſtiſing the corrupters of learning, and reviving a taſte for true ſcience and elegant letters. Eraſmus, with whom he lived upon the footing

Vives, Ultramarine.

footing of intimate friendſhip, ſpeaking of Vives when he was only 26 years of age, ſays, that there was no part of philoſophy in which he did not excel; and that he had made ſuch proficiency in learning, and in the arts of ſpeaking and writing, that he ſcarcely knew his equal. He wrote a commentary upon Auguſtine's treatiſe *De Civitate Dei*, which diſcovers an extenſive acquaintance with ancient philoſophy. Henry VIII. of England, to whom he dedicated this work, was ſo pleaſed with it, that he invited the author to his court, and made him preceptor to his daughter Mary. Though he diſcharged his office with great fidelity, yet in conſequence of his oppoſition to the king's divorce, he fell under his diſpleaſure; and it was not without difficulty that he eſcaped to Bruges, where he devoted the remainder of his days to ſtudy. He died in the year 1537, or, according to Thuanus, in 1541. With Eraſmus and Buddæus he formed a triumvirate of literature which did honour to the age. He wrote *De Prima Philoſophia*, "On the Firſt Philoſophy;" *De Explanatione Eſſentiarum*, "On the Explanation of Eſſences;" *De Cenſura Veri*, "On the Teſt of Truth;" *De Initiis, Sectis, et Laudibus Philoſophiæ*, "On the Origin, Sects, and Praiſes of Philoſophy;" and *De Corruptis Artibus et Tradendis Diſciplinis*, "On the Corruption of Science, and on Education." Theſe writings, of which the two laſt are the moſt valuable, diſcover great ſtrength of judgment, an extenſive knowledge of philoſophy, much enlargement of conception, uncommon ſagacity in detecting the errors of ancient and modern philoſophers, particularly of Ariſtotle and his followers, and, in fine, a mind capable of attempting things beyond the ſtandard of the age in which he lived. To all this he added great perſpicuity and elegance of ſtyle, not unworthy of the friend of Eraſmus.

ULTRAMARINE is a very fine blue powder, almoſt of the colour of the corn-flower or blue-bottle, which has this uncommon property, that, when expoſed to the air or a moderate heat, it neither fades nor becomes tarniſhed. On this account it is uſed in painting; but it was employed formerly for that purpoſe much more than at preſent, as ſmalt, a far cheaper article, was not then known. (See COBALT, in this *Suppl.*) Ultramarine is made of the blue parts of the lapis lazuli, by ſeparating them as much as poſſible from the other coloured particles with which they are mixed, and reducing them to a fine powder. The real lapis lazuli is found in the mountains of that part of Tartary called Bucharia, which extends eaſtwards from the Caſpian ſea, and particularly at Kalab and Budukſchu. It is ſent thence to the Eaſt Indies, and from the Eaſt Indies to Europe. Good ultramarine muſt be of a beautiful dark colour, and free from ſand as well as every other mixture. It muſt unite readily with oil; it muſt not become tarniſhed on a red-hot tile or plate of iron, and it ought to diſſolve in ſtrong acids, almoſt like the zeolite, without cauſing an efferveſcence. In the year 1763, an ounce of it at Paris coſt four pounds ſterling, and an ounce of *cendre d'outremer*, which is the refuſe, two pounds. The baſis of this colour was long ſuſpected to be copper, but the experiments of Margraff ſhewed that it was iron, in ſome unknown ſtate of combination. New light has been thrown on this ſubject by Morveau, who has diſcovered that ſelenite loaded with iron, when decompoſed by carbonaceous matter, yields a blue ſulphuret of iron of equal permanency with the true ultramarine.

Vortices.

At preſent, ſmalt of a good colour is often purchaſed at a dear rate and ſubſtituted for ultramarine; and it is found that the colour of this preparation of cobalt is more durable in the fire than even that of the lapis lazuli. For the analyſis of lapis lazuli, ſee MINERALOGY, n° 69. *Suppl.*

VORTICES of Des Cartes are now juſtly exploded; but being the fiction of a very ſuperior mind, they are ſtill an object of curioſity, as being the foundation of a great philoſophical romance. According to the author of that romance, the whole of infinite ſpace was full of matter; for with him matter and extenſion were the ſame, and conſequently there could be no void. This immenſity of matter he ſuppoſed to be divided into an infinite number of very ſmall cubes; all of which, being whirled about upon their own centres, neceſſarily gave occaſion to the production of two different elements. The firſt conſiſted of thoſe angular parts which, having been neceſſarily rubbed off, and grinded yet ſmaller by their mutual friction, conſtituted the moſt ſubtle and moveable part of matter. The ſecond conſiſted of thoſe little globules that were formed by the rubbing off of the firſt. The interſtices betwixt theſe globules of the ſecond element were filled up by the particles of the firſt. But in the infinite colliſions, which muſt occur in an infinite ſpace filled with matter, and all in motion, it muſt neceſſarily happen that many of the globules of the ſecond element ſhould be broken and grinded down into the firſt. The quantity of the firſt element having thus been increaſed beyond what was ſufficient to fill up the interſtices of the ſecond, it muſt, in many places, have been heaped up together, without any mixture of the ſecond along with it. Such, according to Des Cartes, was the original diviſion of matter. Upon this infinitude of matter thus divided, a certain quantity of motion was originally impreſſed by the Creator of all things, and the laws of motion were ſo adjuſted as always to preſerve the ſame quantity in it, without increaſe, and without diminution. Whatever motion was loſt by one part of matter, was communicated to ſome other; and whatever was acquired by one part of matter, was derived from ſome other: and thus, through an eternal revolution from reſt to motion, and from motion to reſt, in every part of the univerſe, the quantity of motion in the whole was always the ſame.

But as there was no void, no one part of matter could be moved without thruſting ſome other out of its place, nor that without thruſting ſome other, and ſo on. To avoid, therefore, an infinite progreſs, he ſuppoſed that the matter which any body puſhed before it rolled immediately backwards to ſupply the place of that matter which flowed in behind it; as we may obſerve in the ſwimming of a fiſh, that the water which it puſhes before it immediately rolls backwards to ſupply the place of what flows in behind it, and thus forms a ſmall circle or vortex round the body of the fiſh. It was in the ſame manner that the motion originally impreſſed by the Creator upon the infinitude of matter neceſſarily produced in it an infinity of greater and ſmaller vortices, or circular ſtreams: and the law of motion being ſo adjuſted as always to preſerve the ſame quantity of motion in the univerſe, thoſe vortices either continued for ever, or by their diſſolution gave birth to others of the ſame kind. There was thus at all times an infinite number of greater and ſmaller vortices, or circular ſtreams, revolving in the univerſe.

But whatever moves in a circle is conſtantly endeavouring to fly off from the centre of its revolution. For the natural motion of all bodies is in a ſtraight line. All the particles of matter therefore, in each of thoſe greater vortices, were continually preſſing from the centre to the circumference, with more or leſs force, according to the different degrees of their bulk and ſolidity. The larger and more ſolid globules of the ſecond element forced themſelves upwards to the circumference, while the ſmaller, more yielding, and more active particles of the firſt, which could flow even through the interſtices of the ſecond, were forced downwards to the centre. They were forced downwards to the centre notwithſtanding their natural tendency was upwards to the circumference; for the ſame reaſon that a piece of wood, when plunged in water, is forced upwards to the ſurface, notwithſtanding its natural tendency is downwards to the bottom; becauſe its tendency downwards is leſs ſtrong than that of the particles of water, which, therefore, if one may ſay ſo, preſs in before it, and thus force it upwards. But there being a greater quantity of the firſt element than what was neceſſary to fill up the interſtices of the ſecond, it was neceſſarily accumulated in the centre of each of theſe great circular ſtreams, and formed there the fiery and active ſubſtance of the ſun. For, according to that philoſopher, the ſolar ſyſtems were infinite in number, each fixed ſtar being the centre of one; and he is among the firſt of the moderns who thus took away the boundaries of the univerſe: even Copernicus and Kepler, themſelves, have confined it within what they ſuppoſed the vault of the firmament.

The centre of each vortex being thus occupied by the moſt active and moveable parts of matter, there was neceſſarily among them a more violent agitation than in any other part of the vortex, and this violent agitation of the centre cheriſhed and ſupported the movement of the whole. But among the particles of the firſt element, which fill up the interſtices of the ſecond, there are many, which, from the preſſure of the globules on all ſides of them, neceſſarily receive an angular form, and thus conſtitute a third element of particles leſs fit for motion than thoſe of the other two. As the particles, however, of this third element were formed in the interſtices of the ſecond, they are neceſſarily ſmaller than thoſe of the ſecond, and are therefore, along with thoſe of the firſt, urged down towards the centre, where, when a number of them happen to take hold of one another, they form ſuch ſpots upon the ſurface of the accumulated particles of the firſt element, as are often diſcovered by teleſcopes upon the face of that ſun which enlightens and animates our particular ſyſtem. Thoſe ſpots are often broken and diſpelled by the violent agitation of the particles of the firſt element, as has hitherto happily been the caſe with thoſe which have ſucceſſively been formed upon the face of our ſun. Sometimes, however, they encruſt the whole ſurface of that fire which is accumulated in the centre; and the communication betwixt the moſt active and the moſt inert parts of the vortex being thus interrupted, the rapidity of its motion immediately begins to languiſh, and can no longer defend it from being ſwallowed up and carried away by the ſuperior violence of ſome other like circular ſtream; and, in this manner, what was once a ſun becomes a planet. Thus the time was, according to the ſyſtem, when the Moon was a body of the ſame kind with the ſun, the fiery centre of a circular ſtream of ether, which flowed continually round her; but her face having been cruſted over by a congeries of angular particles, the motion of this circular ſtream began to languiſh, and could no longer defend itſelf from being abſorbed by the more violent vortex of the earth, which was then, too, a ſun, and which chanced to be placed in its neighbourhood. The moon therefore became a planet, and revolved round the earth. In proceſs of time, the ſame fortune, which had thus befallen the moon, befel alſo the earth; its face was encruſted by a groſs and inactive ſubſtance; the motion of its vortex began to languiſh, and it was abſorbed by the greater vortex of the ſun: but though the vortex of the earth had thus become languid, it ſtill had force enough to occaſion both the diurnal revolution of the earth, and the monthly motion of the moon. For a ſmall circular ſtream may eaſily be conceived as flowing round the body of the earth, at the ſame time that it is carried along by that great ocean of ether which is continually revolving round the ſun; in the ſame manner, as in a great whirlpool of water, one may often ſee ſeveral ſmall whirlpools, which revolve round centres of their own, and at the ſame time are carried round the centre of the great one. Such was the cauſe of the original formation and conſequent motions of the planetary ſyſtem. When a ſolid body is turned round its centre, thoſe parts of it which are neareſt, and thoſe which are remoteſt from the centre, complete their revolutions in one and the ſame time. But it is otherwiſe with the revolutions of a fluid: the parts of it which are neareſt the centre complete their revolutions in a ſhorter time than thoſe which are remoter. The planets, therefore, all floating in that immenſe tide of æther which is continually ſetting in from weſt to eaſt round the body of the ſun, complete their revolutions in a longer or a ſhorter time, according to their nearneſs or diſtance from him.

This bold ſyſtem was eminently fitted to captivate the imagination; and though fraught with contradictions and impoſſibilities, attempts have been made to revive it, even in this country, under different names. All thoſe ſyſtems which repreſent the motions of the heavenly bodies as being the effect of the phyſical agency of æthers, of air, of fire, and of light, of which the univerſe is conceived to be full, labour under the ſame difficulties with the Carteſian hypotheſis; and very few of them, if any, are ſo neatly put together. It is ſurely ſufficient, however, to demoliſh this goodly fabric, barely to aſk how an abſolute infinity of matter can be divided into cubes, or any thing elſe? how there can poſſibly be interſtices in a perfect plenum? or how in ſuch a plenum any portion of matter can be thruſt from its place?

URALIAN Coſſacs, a people that inhabit the Ruſſian province of Orenburg in Aſia, on the ſouth ſide of the river Ural. Theſe Coſſacs are deſcended from thoſe of the Don: they are a very valiant race. They profeſs the Greek religion; but there is a kind of diſſenters from the eſtabliſhed religion, whom the Ruſſians called *Roſkolniki*, or Separatiſts, and who ſtyle themſelves *Staroverſki*, or Old Believers. They conſider the ſervice of the eſtabliſhed church as profane and ſacrilegious, and have their own prieſts and ceremonies. The Uralian Coſſacs are all enthuſiaſts for the ancient ritual, and prize their beards almoſt equal to their lives. A Ruſſian officer having ordered a number of Coſſac recruits to be publicly ſhaved in the town of Yaitſk, in 1771, this wanton inſult excited an inſurrection, which was ſuppreſſed for a time; but, in 1773, that daring impoſtor, Pugatchef, having aſſumed the name and perſon of Peter III. appeared among them, and taking advantage of this circumſtance, and of their religious prejudices, rouſed them once more into open rebellion. This being at laſt effectually ſuppreſſed by the defeat and execution of the impoſtor (See Suworow, *Suppl.*), in order to extinguiſh all remembrance of this rebellion, the river Yaik was called *Ural;* the Yaik Coſſacs were denominated *Uralian Coſſacs;* and the town of Yaitſk, *Uralſk.* The Uralian Coſſacs enjoy the right of fiſhing on the coaſt of the Caſpian Sea, for 47 miles on each ſide of the river Ural. Their principal fiſhery is for ſturgeons and beluga, whoſe roe ſupplies large quantities of caviare; and the fiſh, which are chiefly ſalted and dried, afford a conſiderable article of conſumption in the Ruſſian empire. In conſequence of theſe fiſheries, theſe Coſſacs are very rich.

URBINO, a town of Italy, in the territory of the Pope, and capital of the duchy of Urbino, with an old citadel, an archbiſhop's ſee, and a handſome palace, where the dukes formerly reſided. The houſes are well built, and great quantities of fine earthen ware are made here. It is ſeated on a mountain, between the rivers Metro and Foglia, 18 miles ſouth of Rimini, 58 eaſt of Florence, and 120 north-eaſt of Rome. E. Lon. 12. 40. N. lat. 43. 46.

Urbino, a duchy of Italy, in the territory of the church, bounded on the north by the gulph of Venice; on the ſouth, by Perugino and Umbria; on the eaſt, by the marquiſate of Ancona; and on the weſt, by Tuſcany and Romagna. It is about 55 miles in length, and 45 in breadth. Here is great plenty of game and fiſh; but the air is not very wholeſome, nor is the ſoil fertile. Urbino is the capital.

URCEOLA, a lately diſcovered genus of the *pentandria* claſs, and *monogynia* order of plants, ranking immediately after Tabernæ montana (ſee *Encycl.*), and conſequently belonging to the 30th natural order or claſs called *Contortæ* by Linnæus in his natural method of arrangement. One of the qualities of the plants of this order is their yielding, on being cut, a juice which is generally milky, and for the moſt part deemed of a poiſonous nature. The genus is thus characteriſed by Dr Roxburgh: *Calyx* beneath five-toothed; corol one petaled, pitcher ſhaped, with its contracted mouth five toothed: nectary entire, ſurrounding the germs; follicles two, round, drupacious; ſeeds numerous, immerſed in pulp. There is but one known ſpecies, which is thus deſcribed by the ſame eminent botaniſt;

Urceola elastica: Shrubby, twining, leaves oppoſite, oblong, panicles terminal, is a native of Sumatra, Prince of Wales's Iſland, &c. Malay countries. *Stem* woody, climbing over trees, &c. to a very great extent, young ſhoots twining, and a little hairy, bark of the old woody parts thick, dark coloured, conſiderably uneven, a little ſcabrous, on which are found ſeveral ſpecies of moſs, particularly large patches of lichen; the wood is white, light, and porous. *Leaves* oppoſite, ſhort-petioled, horizontal, ovate, oblong, pointed, entire, a little ſcabrous, with a few ſcattered white hairs on the under ſide. *Stipules* none. *Panicles* terminal, brachiate, very ramus. *Flowers* numerous, minute, of a dull greeniſh colour, and hairy on the outſide. *Bracts* lanceolate, one at each diviſion and ſubdiviſion of the panicle. *Calyx* perianth, one-leaved, five toothed, permanent. *Corol* one petaled, pitcher-ſhaped, hairy, mouth much contracted, five-toothed, diviſions erect, acute, nectary entire, cylindric, embracing the lower two-thirds of the germs. *Stamens*, filaments five, very ſhort from the baſe of the corol. Anthers arrow-ſhaped, converging, bearing their pollen in two grooves on the inſide, near the apex; between theſe grooves and the inſertions of the filaments they are covered with white ſoft hairs. *Piſtil*, germs two; above the nectary they are very hairy round the margins of their truncated tops. Style ſingle, ſhorter than the ſtamens. Stigma ovate, with a circular band, dividing it into two portions of different colours. *Per.* Follicles two, round, laterally compreſſed into the ſhape of a turnip, wrinkled, leathery, about three inches in their greateſt diameters—one celled, two valved. *Seeds* very numerous, reniform, immerſed in firm fleſhy pulp.

See Plate XLVII. where fig. 1. is a branchlet in flower of the natural ſize. 2. A flower magnified. 3. The ſame laid open, which expoſes to view the ſituation of the ſtamens inſerted into the bottom of the corol, the nectarium ſurrounding the lower half of the two germs, their upper half with hairy margins, the ſtyle and ovate party coloured; ſtigma appearing above the nectary. 4. Outſide of one of the ſtamens; and, 5. Inſide of the ſame, both much magnified. 6. The nectarium laid open, expoſing to view the whole of the piſtil 7. The two ſeed veſſels (called by Linnæus *follicles*), natural ſize; half of one of them is removed, to ſhew the ſeed immerſed in pulp. A portion thereof is alſo cut away, which more clearly ſhews the ſituation and ſhape of the ſeed.

From wounds made in the bark of this plant there oozes a milky fluid, which on expoſure to the open air ſeparates into an elaſtic coagulum, and watery liquid, apparently of no uſe, after the ſeparation takes place. This coagulum is not only like the American caoutchouc or Indian rubber, but poſſeſſes the ſame properties; for which, ſee Caoutchouc, both in the *Encycl.* and *Suppl.*

The chemical properties of this vegetable milk, while freſh, were found by Mr Howiſon, late ſurgeon on Prince of Wales's Iſland, ſurpriſingly to reſemble thoſe of animal milk. From its decompoſition, in conſequence of ſpontaneous fermentation, or by the addition of acids, a ſeparation takes place between its caſeous and ſerous parts, both of which are very ſimilar to thoſe produced by the ſame proceſſes from animal milk. An oily or butyrous matter is alſo one of its component parts, which appears upon the ſurface of the gum ſo ſoon as the latter has attained its ſolid form. He endeavoured to form an extract of this milk ſo as to approach to the conſiſtence of new butter, by which he hoped to retard its fermentative ſtage, without depriving it of its uſeful qualities; but as he had no apparatus for diſtilling, the ſurface of the milk, that was expoſed to the air, inſtantly formed into a ſolid coat, by which

which the evaporation was in a great degree prevented. He, however, learned, by collecting the thickened milk from the inſide of the coats, and depoſiting it in a jelly pot, that, if excluded from the air, it might be preſerved in this ſtate for a conſiderable length of time ; and even without any preparation he kept it in bottles, tolerably good, upwards of twelve months.

URINARY concretions. See *Animal Substances*, Suppl.

URTICA. See *Encycl.* where it is obſerved that the common nettle, though it has a place in the *materia medica*, is now very little uſed. It has lately been recommended, however, by *Zannetini*, a phyſician who attended the French army in Italy, as a good ſubſtitute in fevers for cinchona. The ſucceſs of ſome experiments, which he made with it in tertian and quartan malignant fevers, ſurpaſſed, he ſays, his moſt ſanguine expectation. The nettle often produces a ſpeedier effect than bark ; for it heats in a great degree, and when the doſe is pretty ſtrong, occaſions a lethargic ſleep. The doſe muſt never exceed a dram, and is given in wine two or three times in the courſe of 24 hours. Zannetini found this medicine of great ſervice to guard againſt that total exhauſtion which forms the principal character of malignant fevers ; and he recommends a ſlight infuſion of it in wine as an excellent preſervative for thoſe who reſide in marſhy and inſalubrious diſtricts. In employing the nettle in fever, Zannetini gives the ſame caution as ought to be obſerved in regard to cinchona, that is, that it muſt not be employed where there is an inclination to inflammation, or where a continued fever, ariſing from obſtructions, exiſts. This diſcovery is not unworthy the attention of phyſicians, and deſerves at leaſt to be farther inveſtigated, as a great deal would be ſaved if cinchona could be entirely diſpenſed with.

W.

WALES, New South, is a country which muſt be intereſting on account of the ſingular colony which was ſettled there in the year 1788. Under the title *New Holland* (*Encycl.*) ſome account has been given of that ſettlement, as well as of the climate and the ſoil about Port Jackſon ; but it will probably gratify the curioſity of our readers, if we give a ſhort hiſtory of thoſe European ſettlers, of whom it is to be hoped that they carried not with them, to that diſtant ſhore,

> “ Minds not to be changed by time or place.”

This hiſtory we ſhall take from the accurate *Account of the Engliſh Colony in New South Wales*, by David Collins, Eſq; who went out with Governor Phillip, and continued to execute the offices of Judge-advocate and Secretary till the cloſe of the year 1796 ; and we ſhall begin our narrative from the diſembarkation of the firſt coloniſts, when his Majeſty's commiſſion to the governor, and the letters patent eſtabliſhing courts of criminal and civil judicature in the territory were read.

The criminal court was conſtituted a court of record, and was to conſiſt of the judge-advocate and ſuch ſix officers of the ſea and land ſervice as the governor ſhall, by precept iſſued under his hand and ſeal, require to aſſemble for that purpoſe. This court has power to inquire of, hear, determine, and puniſh all treaſons, miſpriſions of treaſons, murders, felonies, forgeries, perjuries, treſpaſſes, and other crimes whatſoever that may be committed in the colony ; the puniſhment for ſuch offences to be inflicted according to the laws of England as nearly as may be, conſidering and allowing for the circumſtances and ſituation of the ſettlement and its inhabitants. The charge againſt any offender is to be reduced into writing, and exhibited by the judge-advocate : witneſſes are to be examined upon oath, as well for as againſt the priſoner ; and the court is to adjudge whether he is guilty or not guilty by the opinion of the major part of the court. If guilty, and the offence is capital, they are to pronounce judgment of death, in like manner as if the priſoner had been convicted by the verdict of a jury in England, or of ſuch corporal puniſhment as the court, or the major part of it, ſhall deem meet. And in caſes not capital, they are to adjudge ſuch corporal puniſhment as the majority of the court ſhall determine. But no offender is to ſuffer death unleſs five members of the court ſhall concur in adjudging him to be guilty, until the proceedings ſhall have been tranſmitted to England, and the king's pleaſure ſignified thereupon. The provoſt-marſhall is to cauſe the judgement of the court to be executed according to the governor's warrant under his hand and ſeal.

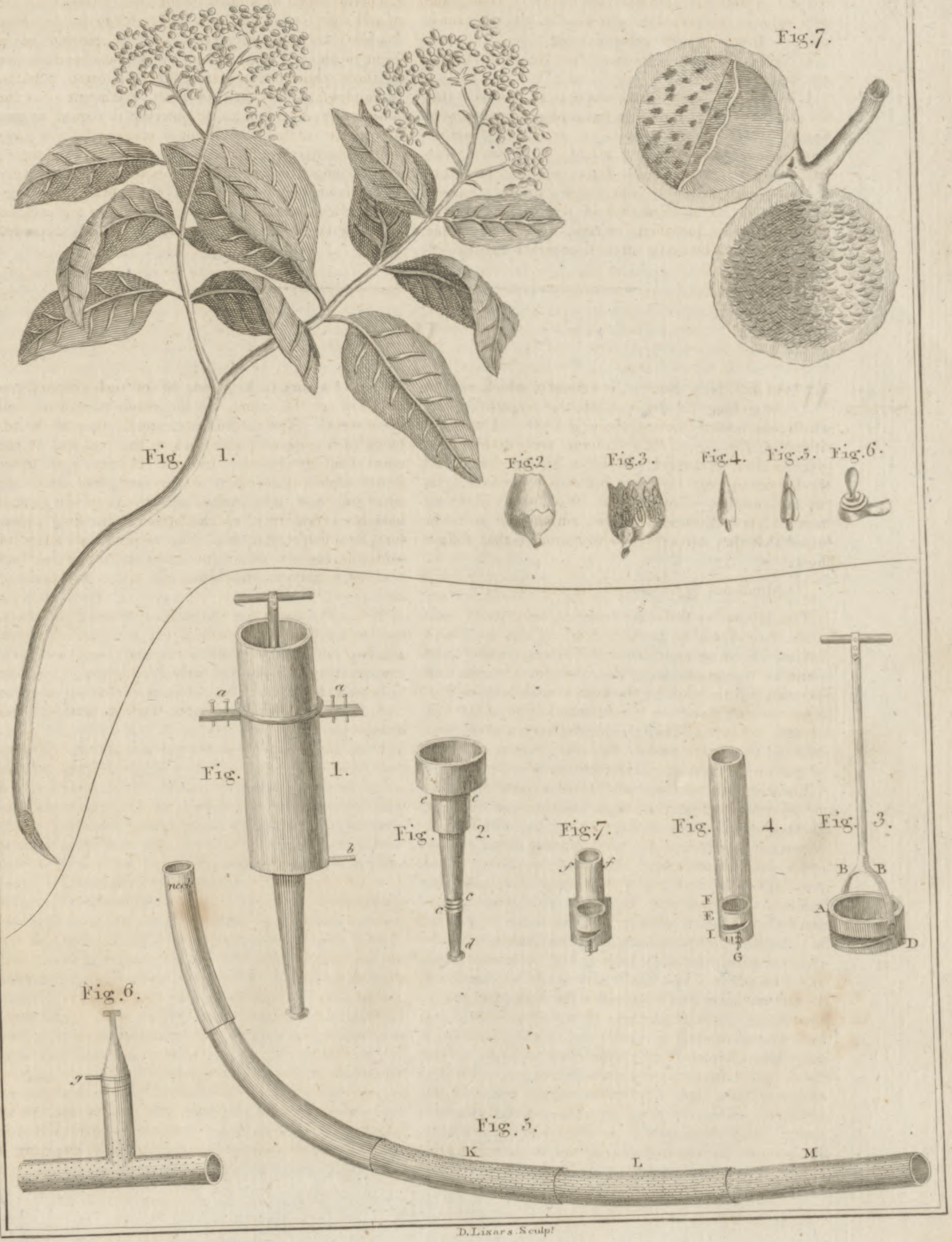
Beſide this court for the trial of criminal offenders, there is a civil court, conſiſting of the judge-advocate and two inhabitants of the ſettlement, who are to be appointed by the governor ; which court has full power to hear and determine in a ſummary way all pleas of lands, houſes, debts, contracts, and all perſonal pleas whatſoever.

From this court, on either party, plaintiff or defendant, finding himſelf or themſelves aggrieved by the judgment or decree, an appeal lies to the governor, and from him, where the debt or thing in demand ſhall exceed the value of L. 300, to the king in council.

A vice-admiralty court was alſo appointed, for the trial of offences on the high ſeas ; and the governor, lieutenant-governor, and judge-advocate, were by patent made juſtices of the peace, with a power in the governor to appoint other juſtices.

The ſituation which Governor Phillip had ſelected for his reſidence, and for the principal ſettlement, was the eaſt ſide of a cove in Port Jackſon, which he called *Sydney Cove*. Its latitude was found to be 33° 52′ 30″ ſouth, and its longitude 152° 19′ 30″ eaſt. This ſituation was choſen without due examination ; for it ſoon appeared that the head or upper part of the cove wore a much more favourable appearance than the ground immediately about the ſettlement. From the natives, the new ſettlers met no oppoſition : during the firſt ſix weeks they received only one viſit from them, two men ſtrolling one evening into the camp, and remaining in

URCEOLA ELASTICA. PLATE XLVII.



D. Lizars Sculp^t

it for about half an hour. They appeared to admire whatever they ſaw; and after receiving a hatchet (of the uſe of which the eldeſt inſtantly and curiouſly ſhewed his knowledge, by turning up his foot and ſharpening a piece of wood on the ſole with the hatchet) took their leave, apparently well pleaſed with their reception. The fiſhing boats alſo frequently reported their having been viſited by many of theſe people when hauling the ſeine; at which labour they often aſſiſted with cheerfulneſs, and in return were generally rewarded with a part of the fiſh taken.

The firſt labour in which the convicts were employed was that of building huts; and for this purpoſe it was found neceſſary to divide them into gangs, and to appoint an overſeer to each, who ſhould ſee that the proper quantity of work was performed. The proviſions were diſtributed by a weekly ration, and to each man were allowed 7 lb. of biſcuit, 1 lb. of flour, 7 lb. of beef or 4 lb. of pork, 3 pints of peaſe, and 6 ounces of butter. To the female convicts two thirds of this ration were allowed. This was the full ration, which, in many inſtances, it became neceſſary to reduce; and once, in conſequence of the delay of tranſports with a ſupply, the convicts were put on an allowance of which fleſh meat conſtituted no part.

The temporary huts in which the coloniſts lived, for ſome time after their arrival, were formed principally of the cabbage tree. With this the ſides and ends were filled; the poſts and plates being made of the pine; and the whole was plaſtered with clay. The roofs were generally thatched with the graſs of the gumruſh; though ſome were covered with clay, but ſeveral of theſe failed; the weight of the clay and rain ſoon deſtroying them. In a ſhort time they applied themſelves to the burning of bricks; by which their habitations ſoon became much more laſting and comfortable. The progreſs of the colony, however, towards that degree of convenience which was within its reach, was greatly impeded by the incorrigible vices of thoſe who principally compoſed it. Drunkenneſs, theft, robbery, and unconquerable lazineſs, continued to mark the character of the great body of the convicts. Though to fly from the colony, and venture into the interior of the country, was inevitable death in the form of famine or of murder, yet ſuch was the invincible antipathy to labour manifeſted by ſome of thoſe people, that they often fled to the woods, from which they ſeldom returned; ſome dying of hunger, and ſome being ſacrificed by the natives. Diſinclination to labour produced here, as elſewhere, its natural effect—robbery.

In the month of May 1788, a lad of 17 years of age was tried, convicted, and executed, for breaking open a tent belonging to one of the tranſport ſhips; ſeveral others were taken into cuſtody in that month for various thefts and burglaries, and two were afterward tried and executed. One of theſe had abſconded, and lived in the woods for 19 days, ſubſiſting by what he was able to procure by nocturnal depredations among the huts and ſtock of individuals. His viſits for this purpoſe were ſo frequent and daring, that it became abſolutely neceſſary to proclaim him an outlaw. By the negligence of one of thoſe fellows who had been entruſted with the care of the cattle, the bull and four cows were loſt: he left them in the fields, and returned to his hut to dine; and in the mean time they either ſtrayed away or were driven off by the natives. Five years elapſed before theſe cattle were diſcovered wild, at a conſiderable diſtance up the country, and greatly multiplied.

The perpetration of crimes, chiefly theft and robbery, had become ſo prevalent before twenty months had paſſed ſince the colony was eſtabliſhed, that it was neceſſary to think of a ſyſtem of police. A plan was preſented to the governor by a *convict*, which with ſome improvements was adopted on the 8th of Auguſt 1789. The following are the heads of the arrangement.

The ſettlement was divided into four diſtricts, over each of which was placed a watch conſiſting of three perſons, one principal and two ſubordinate watchmen. Theſe being ſelected from among thoſe convicts whoſe conduct and character had been unexceptionable ſince their landing, were veſted with authority to patrole at all hours in the night, to viſit ſuch places as might be deemed requiſite for the diſcovery of any felony, treſpaſs, or miſdemeanor, and to ſecure for examination all perſons that might appear to be concerned therein; for which purpoſe they were directed to enter any ſuſpected hut or dwelling, or to uſe any other means that might appear expedient. They were required to detain and give information to the neareſt guardhouſe of any ſoldier or ſeaman who ſhould be found ſtraggling after the tattoo had been beat. They were to uſe their utmoſt endeavours to trace out offenders on receiving accounts of any depredation; and in addition to their night-duty, they were directed to take cognizance of ſuch convicts as gamed, or ſold or bartered their ſlops or proviſions, and report them for puniſhment. A return of all occurrences during the night was to be made to the judge-advocate; and the military were required to furniſh the watch with any aſſiſtance they might be in need of, beyond what the civil power could give them. They were provided each with a ſhort ſtaff, to diſtinguiſh them during the night, and to denote their office in the colony; and were inſtructed not to receive any ſtipulated encouragement or reward from any individual for the conviction of offenders, but to expect that negligence or miſconduct in the execution of their truſt would be puniſhed with the utmoſt rigour. It was to have been wiſhed, ſays Mr Collins, that a watch eſtabliſhed for the preſervation of public and private property had been formed of free people, and that neceſſity had not compelled us, in ſelecting the firſt members of our little police, to appoint them from a body of men, in whoſe eyes, it could not be denied, the property of individuals had never before been ſacred. But there was not any choice: The military had their line of duty marked out for them, and between them and the convict there was no deſcription of people from whom overſeers or watchmen could be provided. It might, however, be ſuppoſed, that among the convicts there muſt be many who would feel a pride in being diſtinguiſhed from their fellows, and a pride that might give birth to a returning principle of honeſty. It was hoped that the convicts whom we had choſen were of this deſcription; ſome effort had become neceſſary to detect the various offenders who were prowling about with ſecurity under cover of the night; and the convicts who had any property were themſelves intereſted in defeating ſuch practices. They promiſed fidelity and diligence, from which the ſcorn of their fellow-priſoners ſhould not induce them to ſwerve, and began with a confidence of ſucceſs the duty which they had themſelves offered to undertake.

A ſpecies of diſturber now infeſted the colony, againſt which the vigilance of a police could not guard. Rats, in immenſe numbers, had attacked the proviſion-ſtores, and could be counteracted only by removing the proviſions from one ſtore to another. When their ravages were firſt diſcovered, it was found that eight caſks of flour were already deſtroyed by theſe vermin. Such of theſe animals as eſcaped the dogs, which were ſet upon them, flew to the gardens of individuals, where they rioted on the Indian corn that was growing, and did conſiderable miſchief.

Our author gives the moſt melancholy account of the extreme ſufferings of the early coloniſts from want of proviſions, and of the diſeaſes imported into the country by newcomers, who had either caught them on the voyage or brought them from England. The ſettlers on *Norfolk-Iſland* (ſee *Encycl.*), to which New South Wales was a mother country, muſt have been much more liable than that colony to ſuffer from famine, had they not ſometimes obtained a temporary ſupply from a ſource which was unknown at Sydney Cove. On a mountain in the iſland, to which had been given the name of *Mount Pitt*, they were fortunate enough to obtain, in an abundance almoſt incredible, a ſpecies of aquatic birds, anſwering the deſcription of that known by the name of the *puffin*. Theſe birds came in from the ſea every evening, in clouds literally darkening the air, and deſcending on Mount Pitt, depoſited their eggs in deep holes made by themſelves in the ground, generally quitting them in the morning, and returning to ſeek their ſubſiſtence in the ſea. From two to three thouſand of theſe birds were often taken in a night. Their ſeeking their food in the ocean left no doubt of their own fleſh partaking of the quality of that upon which they fed; but to people circumſtanced as were the inhabitants on Norfolk Iſland, this leſſened not their importance; and while any Mount Pitt birds (ſuch being the name given them) were to be had, they were eagerly ſought.

The firſt ſettler in New South Wales, who declared himſelf able to live on the produce of his farm, without any aſſiſtance from the ſtores, was James Ruſe; who in April 1792 relinquiſhed his claim to any farther ſhare of the public proviſion. As a reward, the governor immediately put him in poſſeſſion of an allotment of 30 acres.

In the July of the ſame year, the convicts whoſe terms of tranſportation had expired were now collected, and by the authority of the governor informed, that ſuch of them as wiſhed to become ſettlers in this country ſhould receive every encouragement; that thoſe who did not, were to labour for their proviſions, ſtipulating to work for 12 or 18 months certain; and that in the way of ſuch as preferred returning to England no obſtacles would be thrown, provided they could procure paſſages from the maſters of ſuch ſhips as might arrive; but that they were not to expect any aſſiſtance on the part of government to that end. The wiſh to return to their friends appeared to be the prevailing idea, a few only giving in their names as ſettlers, and none engaging to work for a certain time.

That the wiſh to return home was ſtrong indeed, and paramount to all other feelings, was evinced in a very melancholy inſtance ſome time before. A convict, an elderly man, was found dead in the woods, near the ſettlement; who, on being opened, it appeared, had died from want of nouriſhment; and it was found that he was accuſtomed to deny himſelf even what was abſolutely neceſſary to his exiſtence, abſtaining from his proviſions, and ſelling them for money, which he was reſerving, and had ſomewhere concealed, in order to purchaſe his paſſage to England when his time ſhould terminate!

Of ſome convicts whoſe terms of tranſportation had expired, the governor eſtabliſhed a new ſettlement in Auguſt 1791, at a place which he called *Proſpect Hill*, about twenty miles diſtant from Sydney Cove; and another reſidence was formed at the Ponds within three or four miles of the former. This made the fourth ſettlement in the colony, excluſively of that at Norfolk Iſland.

About this time the governor received from England a public ſeal for the colony: on the obverſe of which were the king's arms and royal titles; and on the reverſe, emblematic figures ſuited to the ſituation of the people for whoſe uſe it was deſigned. The motto was "*Sic fortis Etruria crevit*;" and in the margin were the words "*Sigillum Nov. Camb. Auſt.*" A commiſſion alſo arrived, empowering him to remit abſolutely, or conditionally, the whole or any part of the term for which the felons ſent to the colony might be tranſported. By this power he was enabled to beſtow on ſuperior honeſty and induſtry the moſt valuable reward which, in ſuch circumſtances, they could receive.

In addition to the calamities under which the ſettlement had ſo often laboured from being reduced to very ſhort allowance of proviſions, and the frequency of the ordinary diſeaſes which were to be expected among a people ſo ſituated, a new malady of a very alarming nature was perceived about April 1792. Several convicts were ſeized with inſanity; and as the major part of thoſe who were viſited by this calamity were females, who, on account of their ſex, were not haraſſed with hard labour, and who in general ſhared largely of ſuch little comforts as were to be procured in the ſettlement, it was difficult to aſſign a cauſe for this diſorder. It ſeems, however, to have been of ſhort duration; for we hear not of it again during the period that Mr Collins's narrative comprehends.

About this time (1792) the colony had aſſumed ſomething of an eſtabliſhed form. Brick huts were in hand for the convicts in room of the miſerable hovels occupied by many, which had been put up at their firſt landing, and in room of others which, from having been erected on ſuch ground as was then cleared, were now found to interfere with the direction of the ſtreets which the governor was laying out. People were alſo employed in cutting paling for fencing in their gardens. At a place called Paramatta, about 16 miles from Sydney Cove, ſituated on a ſmall river which runs into Port Jackſon, the people were employed, during the greateſt part of the month of May, in getting in the maize and ſowing wheat. A foundation for an hoſpital was laid, a houſe built for the maſter carpenter, and roofs prepared for the different huts either building or to be built in future.

In December 1792, when Captain Phillip reſigned the government, nearly five years from the foundation of of the colony, there were in cultivation at the different ſettlements 1429 acres, of which 417 belonged to ſettlers; that is, 67 ſettlers, for there were no more, cultivated nearly half as much ground as was cultivated by the public labour of all the convicts; a ſtriking proof of the ſuperior zeal and diligence with which men exert themſelves when they have an intereſt in their labour. Of free ſettlers, whoſe exertions promiſed ſo fairly to promote the intereſts of the colony, ſeveral arrived from England in January 1793, and fixed themſelves in a ſituation which they called *Liberty Plains*. To one of theſe, Thomas Roſe, a farmer from Dorſetſhire, and his family of a wife and four children, 120 acres were allotted. The conditions under which theſe people agreed to ſettle were, "to have their paſſage provided by government (A); an aſſortment of tools and implements to be given to them out of the ſtores; that they ſhould be ſupplied with two years proviſions; that their lands ſhould be granted free of expence; the ſervice of convicts alſo to be aſſigned to them free of expence; and that thoſe convicts ſhould be ſupplied with two years rations and one year's clothing."

Among the great difficulties with which this infant eſtabliſhment had to ſtruggle, not the leaſt was that of procuring cattle. Of thoſe which were embarked in England and other places for the colony, a very ſmall proportion only arrived; for of 15 bulls and 119 cows, which had been embarked for Botany Bay, only 3 bulls and 28 cows were landed at the ſettlement. It was not until the arrival of the Endeavour, Captain Bampton, in 1795, that the mode of conveying cattle to the colony without material loſs was diſcovered. In that veſſel, out of 130 head which he embarked at Bombay, one cow only died on the paſſage, and that too on the day before his arrival.

The ſcarcity of cattle naturally raiſed their price. Even after this laſt importation, an Engliſh cow in calf ſold for L. 80.

Notwithſtanding the various obſtacles which induſtry had met in the cultivation of this ſettlement, it yet made conſiderable advances; for in October 1793, the value of land had ſo riſen, that one ſettler ſold his allotment of 30 acres for as many pounds; and one farm, with the houſe, &c. ſold for L. 100. The value of ground, indeed, was conſiderably enhanced by government agreeing to purchaſe the redundance of the produce of the ſettlers at fixed prices. Wheat properly dried and cleanſed was received from the ſettlers at Sydney, by the commiſſary, at 10s. per buſhel. Some cultivators, however, had deviſed another mode of diſpoſing of their corn. One of them, whoſe ſituation was near Parramatta, having obtained a ſmall ſtill from England, found it more advantageous to draw an ardent diabolical ſpirit from his wheat, than to ſend it to the ſtores. From one buſhel of wheat he obtained nearly five quarts of ſpirit, which he ſold or paid in exchange for labour, at the rate of five or ſix ſhillings per quart. A better uſe was made of grain by another ſettler; who, having a mill, ground it, and procured 44lb. of good flour, from a buſhel of wheat taken at 59lb. This flour he ſold at 4d. per lb.

By a return of the number of perſons in New South Wales and Norfolk Iſland in April 1794, it appeared that there were in all 4414, including women and children; the annual expence of whom, to the mother-country, Mr Collins eſtimates at L. 161,101. Rapid ſtrides, however, were at that time making towards independence, if not towards an ability of repaying to England a part of what the ſettlement had coſt her. Already the colony lived on grain of its own growth, and an increaſe of live ſtock was become almoſt certain. There were now 4665 acres of ground cleared for cultivation; more than half of which had been effected by thoſe who had become ſettlers in the courſe of fifteen months.

To this ſpirit of improvement ſuch a check was given in September 1794, that not more than a third of government ground, and a fifth of ground belonging to individuals, was in cultivation 1795. As this event has been miſrepreſented, we ſuſpect purpoſely, by ſome of our journaliſts, we ſhall give the true account of it in the words of Mr Collins himſelf.

"The Francis ſchooner (ſays he) returned from Norfolk, having been abſent about eight weeks and three days. From Mr King, who commanded in that iſland, we learned that his harveſt had been prodigiouſly productive. He had purchaſed from the firſt crops, which the ſettlers had brought to market, upwards of 11,000 buſhels of maize: and bills for the amount were drawn by him in favour of the reſpective ſettlers; but requiring the ſanction of the Lieutenant governor, they were now ſent to Port Jackſon. Mr King had been partly induced to make this proviſional kind of purchaſe, under an idea, that the corn would be acceptable at Port-Jackſon, and alſo in compliance with the conditions on which the ſettlers had received their reſpective allotments under the regulations of Governor Phillip; that is to ſay, that their overplus grain ſhould be purchaſed at a fair market-price. Being, however, well ſtocked with that article already, the Lieutenant governor did not think himſelf juſtifiable in putting the crown to ſo great an expence (nearly L. 3000 Sterling), and declined accepting the bills." This naturally excited ſome diſcontents in Norfolk Iſland, and one or two ſettlers gave up their farms; but immediately on the arrival of Governor Hunter, he paid for the corn, and tranquillity was reſtored to the iſland.

Though ſeveral quarrels had occurred between the natives and individuals among the coloniſts, yet it was ſuppoſed that our people were in general the aggreſſors. The governor had taken much pains to inſpire the natives with confidence, and had in a great meaſure ſucceeded. To theft they were naturally and irreſiſtibly inclined: but, like other ſavages, they ſeemed unconſcious of the crime, and were ſeldom deterred by detection from mixing with the coloniſts. At a ſettlement which had early been formed at a river called the *Hawkeſbury* (and at which, cultivation having gone on well, there was, in courſe, much grain to ſtimulate to depredation), the natives aſſumed a more formidable appearance.

"At that ſettlement (ſays Mr Collins) an open war

(A) Government paid for the paſſage of each perſon above ten years of age L. 8, 8 s. and one ſhilling per day for victualling them.

ſeemed about this time to have commenced between the natives and the ſettlers; and word was received overland, that two people were killed by them; one a ſettler of the name of Wilſon, and the other a freeman, one William Thorp, who had hired himſelf to this Wilſon as a labourer. The natives appeared in large bodies, men, women, and children, provided with blankets and nets to carry off the corn, of which they appeared as fond as the natives who lived among us, and ſeemed determined to take it whenever and wherever they could meet with opportunities. In their attacks they conducted themſelves with much art; but where that failed they had recourſe to force; and on the leaſt appearance of reſiſtance made uſe of their ſpears or clubs. To check at once, if poſſible, theſe dangerous depredators, Captain Paterſon directed a party of the corps to be ſent from Paramatta, with inſtructions to deſtroy as many as they could meet with of the wood tribe (Bè-diagal); and, in the hope of ſtriking terror, to erect gibbets in different places, whereon the bodies of all they might kill were to be hung. It was reported that ſeveral of theſe people were killed in conſequence of this order; but none of their bodies being found (perhaps if any were killed they were carried off by their companions), the number could not be aſcertained. Some priſoners, however, were taken, and ſent to Sydney; one man (apparently a cripple), five women, and ſome children. One of the women, with a child at her breaſt, had been ſhot through the ſhoulder, and the ſame ſhot had wounded the babe. They were immediately placed in a hut near our hoſpital, and every care taken of them that humanity ſuggeſted. The man was ſaid, inſtead of being a cripple, to have been very active about the farms, and inſtrumental in ſome of the murders which had been committed. In a ſhort time he found means to eſcape, and by ſwimming reached the north ſhore in ſafety; whence, no doubt, he got back to his friends. Captain Paterſon hoped, by detaining the priſoners and treating them well, that ſome good effect might reſult; but finding, after ſome time, that coercion, not attention, was more likely to anſwer his ends, he ſent the women back. While they were with us, the wounded child died, and one of the women was delivered of a boy, which died immediately. On our withdrawing the party, the natives attacked a farm nearly oppoſite Richmond Hill, belonging to one William Rowe, and put him and a very fine child to death; the wife, after receiving ſeveral wounds, crawled down the bank, and concealed herſelf among ſome reeds half immerſed in the river, where ſhe remained a conſiderable time without aſſiſtance: being at length found, this poor creature, after having ſeen her huſband and her child ſlaughtered before her eyes, was brought into the hoſpital at Paramatta, where ſhe recovered, though ſlowly, of her wounds."

By the vigorous meaſures which were adopted, the colony, towards the cloſe of 1796, had acquired a degree of ſtrength which ſeemed to enſure its future proſperity. Not only the neceſſary edifices were raiſed for the habitations of its people, but ſome for the purpoſes of religion, amuſement, &c. A playhouſe had been erected at the expence of ſome perſons who performed in it for their own emolument, and who admitted auditors at one ſhilling each. A convenient church had been built, a printing-preſs had been ſet up, the civil court was open for the recovery of debts by action and for proving wills, licences had been iſſued to regulate the ſale of ſpirits, and paſſage-boats were eſtabliſhed for the convenience of communication between the different ſettlements. In the houſes of individuals were to be found moſt of the comforts, and not a few of the luxuries, of life; and, in a word, the former years of famine, toil, and difficulty, were now exchanged for thoſe of plenty, eaſe, and pleaſure.

The quantity of ground at this time in cultivation was 5419 acres; of which 2547 were occupied by ſettlers. The number of perſons in New South Wales and its dependencies amounted to 4848. The price of labour, however, compared with the prices of proviſions (as given in Mr Collins's Tables), does not appear ſo high as to enable the workman to live very comfortably. He who receives but three ſhillings for his day's work, and gives two ſhillings for a pound of mutton, fifteen pence for a pound of pork, and half of that ſum for a pound of flour, will ſcarcely derive from his mere labour the ſupport neceſſary for a family.

That many things are yet wanted to give full effect to the advantages which the colony now enjoys, Mr Collins declares in the following paragraph, with which he concludes his account:

"The want at this time of ſeveral public buildings in the ſettlement has already been mentioned. To this want muſt be added, as abſolutely neceſſary to the well-being and comfort of the ſettlers, and the proſperity of the colony in general, that of a public ſtore, to be opened on a plan, though not exactly the ſame, yet as liberal as that of the Iſland of St Helena, where the Eaſt India Company iſſue to their own ſervants European and Indian goods at 10 *per cent.* advance on the prime coſt. Conſidering our immenſe diſtance from England, a greater advance would be neceſſary; and the ſettlers and others would be well ſatisfied, and think it equally liberal, to pay 50 *per cent.* on the prime coſt of all goods brought from England; for at preſent they pay never leſs than 100, and frequently 1000, *per cent.* on what they have occaſion to purchaſe. It may be ſuppoſed that government would not chooſe to open an account, and be concerned in the retail of goods; but any individual would find it to his intereſt to do this, particularly if aſſiſted by government in the freight; and the inhabitants would gladly prefer the manufactures of their own country to the ſweepings of the Indian bazars.

"The great want of men in the colony muſt be ſupplied as ſoon as a peace ſhall take place; but the want of reſpectable ſettlers may, perhaps, be longer felt; by theſe are meant men of property, with whom the gentlemen of the colony could aſſociate, and who ſhould be thoroughly experienced in the buſineſs of agriculture. Should ſuch men ever arrive, the adminiſtration of juſtice might aſſume a leſs military appearance, and the trial by jury, ever dear and moſt congenial to Engliſhmen, be ſeen in New South Wales."

There is, however, one ſerious difficulty which the colony has not yet overcome, and which, until it be overcome, will certainly prevent ſuch men from ſettling in New South Wales. Till ſome ſtaple commodity can be raiſed for exportation, induſtrious free ſettlers will never be tempted to emigrate from Europe to a country where their induſtry cannot procure the comforts as

Wales, Walpole.

well as the neceſſaries of life. The American colonies, in their infancy, did not labour under this diſadvantage. Tobacco ſoon became, and ſtill continues to be, an article of ſuch importance, that its cultivation afforded the trans-atlantic farmer a ready exchange for European commodities; whilſt in New South Wales there ſeems to be no vegetable production of much value, except New Zealand hemp, which is produced indeed in great abundance in Norfolk Iſland, and which Captain Cook long ago pointed out as an article of great importance to the Britiſh navy. This is indeed a valuable plant, and grows in all the cliffs of the iſland, where nothing elſe will grow, in ſufficient abundance to give conſtant employment to 500 people; yet when Mr Collins left the ſettlement, there was no more than one loom on the iſland, and the ſlay or reed was deſigned for coarſe canvas; nor did they poſſeſs a ſingle tool required by flax-dreſſers or weavers beyond the poor ſubſtitutes which they were obliged to fabricate for themſelves. In this defect of neceſſaries for the manufacture, only 18 people could be employed in it; and of theſe the united labour in a week produced 16 yards of canvas, of the ſize called N° 7.

Beſides a uſeful manufactory of this plant, which certainly might be eſtabliſhed, the colony appears to poſſeſs ſeveral important advantages. From Mr Collins's narrative, it appears probable that a ſeal and perhaps a whale fiſhery might be eſtabliſhed with a fair proſpect of ſucceſs; good rich earth is found near Sydney Cove; there are immenſe ſtrata of coal in the ſouthern part of New Holland; Norfolk Iſland abounds with lime; and vaſt quantities of ſhells, which anſwer the ſame purpoſe, have been found on the main-land. Though the wood in general be not of a durable kind, it appears that there is ſome good timber near the Hawkeſbury river; and at Norfolk Iſland and New Zealand it is remarkably fine.

WALPOLE (Horace, Earl of Orford), was the youngeſt ſon of the celebrated Sir Robert Walpole, afterwards Earl of Orford, by his firſt wife, Catharine, daughter of Robert Shorter, Eſq; of Bybrook in Kent. He was born 1716; and was educated, firſt at Eton ſchool, and afterwards at Cambridge. At Eton he formed an intimate acquaintance with the celebrated poet Gray; and they went together on the tour of Europe, in the years 1739, 1740, and 1741. Unhappily they had a diſpute in the courſe of their travels, which produced a ſeparation.

Mr Walpole was able to make a ſplendid figure during the remainder of his deſtined courſe; but poor Gray, after the ſeparation, was obliged to obſerve a very ſevere economy. "This difference aroſe from the difference of their tempers: the latter being, from his earlieſt years, curious, penſive, and philoſophical; the former, gay, lively, and inconſiderate. This, therefore, occaſioned their ſeparation at Reggio. Mr Gray went before him to Venice; and ſtaying there till he could find means of returning to England, he made the beſt of his way home, repaſſing the Alps, and following almoſt the ſame rout, through France, which he had before gone to Italy. In juſtice to the memory of ſo reſpectable a friend, Mr Walpole (ſays Mr Maſon, Life of Gray, 4to, p. 41.) enjoins me to charge him with the chief blame in their quarrel, confeſſing that more attention, complaiſance, and deference, to a warm friendſhip, and ſuperior judgment and prudence, might have prevented a rupture that gave much uneaſineſs to them both, and a laſting concern to the ſurvivor; though in the year 1744 a reconciliation was effected between them, by a lady who wiſhed well to both parties."—This event took place after their return to England; but the *wound* in their friendſhip left a *ſcar* that never was totally effaced.

Walpole.

We do not, indeed, think that Horace Walpole and Mr Gray were formed, either by nature or by habits, to continue long in a ſtate of intimate friendſhip. Gray appears to have been a man of the pureſt moral principles, a friend to religion, penſive, and at leaſt ſufficiently conſcious of his intellectual powers and intellectual attainments. Walpole's morality was certainly of a looſer kind; he ſeems to have had no religion; he was often unſeaſonably gay; and to an equal ſhare of intellectual pride, though without equal reaſon, he added the pride of birth. It can therefore excite no ſurpriſe that a man of Gray's independent ſpirit could not bear the ſupercilious freaks of ſuch a character.

Mr Walpole was nominated to repreſent the city of Norwich, when his father viſited it July 3d, 1733, having acquired conſequence, not only as the ſon of the miniſter, but as having attended the Prince of Orange to England in that year. He was choſen member for Collington, in Cornwall, in the parliament which met June 25th, 1741; was a ſecond time in parliament as repreſentative for Caſtle-Riſing, in Norfolk, in 1747; and for King's Lynn in 1754 and 1761; and, at the expiration of that parliament, he finally retired from the ſtage of politics, and confined himſelf wholly to literary purſuits. He held to his death the office of uſher of his Majeſty's exchequer, comptroller of the pipe, and clerk of the eſtreats. Upon the death of his nephew, George, third Earl of Orford, 1791, he ſucceeded to the title and eſtates; but that event made ſo little alteration in his mode of living, that we know not whether he ever took his ſeat in the houſe of peers. During almoſt the whole courſe of his life he was the victim of the gout, which at laſt reduced him to a cripple: but it never impaired his faculties; and, to the very moment of death, his underſtanding ſeemed to bid defiance to the ſhock of Nature. He died at his houſe in Berkeſley Square, in 1796, having juſt entered his 80th year; and was interred in the family vault at Houghton, in a private manner, agreeably to his particular directions.

Horace, Lord Orford, was never married, and, by one of his biographers, his chief miſtreſs through life is ſaid to have been the muſe. It is certain that he devoted the greater part of his life to belles lettres and virtú, though he ridiculouſly affected, in his letters to his friends, to deſpiſe learning and learned men, for which he was very properly reprimanded both by Gray and Hume. It was an affectation peculiarly abſurd in him, who was conſtantly publiſhing ſomething, and who wrote with uncommon acrimony againſt all who preſumed to call in queſtion the fidelity of the picture which he had drawn of Richard III. or indeed to controvert any of his opinions. Hence his antipathy to Johnſon, becauſe he was a tory, a Chriſtian, and a rigid moraliſt; whilſt he himſelf was a whig, an infidel, and ſuch a moraliſt as could retail, without bluſhing, all the ſcandalous anecdotes, whether true or falſe, of that auguſt family, from whom he acknowledged his whole fortune to be derived He had, indeed, another reaſon for diſliking Johnſon. Lord Orford ſhone in converſation, and ſurpaſſed all his contemporaries in that kind of talk, which, without dazzling by its wit, always delighted; while Johnſon, when rouſed, knocked down, as by a flaſh of lightning, his Lordſhip, and every one elſe who had the confidence before him to talk profanely. Johnſon's wit was original: Lord Orford's conſiſted of ludicrous ſtories and of literary and political anecdotes. His works, of which by far the moſt valuable part has long been in the hands of the public, were collected in 1798, and publiſhed in five volumes, 4to. They reſemble his converſation, being rather amuſing than profound or inſtructive.

WARING (Edward, M. D.), Lucaſian Profeſſor of Mathematics in the univerſity of Cambridge, was the ſon of a wealthy farmer, of the Old Heath, near Shrewſbury. The early part of his education he received at the free ſchool in Shrewſbury; whence he removed to Cambridge, and was admitted on the 24th of March 1753 a member of Magdalen college. Here his talents for abſtruſe calculation ſoon developed themſelves, and, at the time of taking his degree, he was conſidered as a prodigy in thoſe ſciences which make the ſubject of the bachelor's examination. The name of Senior Wrangler, or the firſt of the year, was thought ſcarcely a ſufficient honour to diſtinguiſh one who ſo far outſhone his contemporaries; and the merits of John Jebb were ſufficiently acknowledged, by being the ſecond in the liſt. Waring took his firſt, or bachelor's degree, in 1757, and the Lucaſian Profeſſorſhip became vacant before he was of ſufficient ſtanding for the next, or maſter's degree, which is a neceſſary qualification for that office. This defect was ſupplied by a royal mandate, through which he became maſter of arts in 1760; and ſhortly after his admiſſion to this degree, the Lucaſian Profeſſor.

The royal mandate is too frequently a ſcreen for indolence; and it is now become almoſt a cuſtom, that heads of colleges, who ought to ſet the example in diſcipline to others, are the chief violaters of it, by making their office a pretext for taking their doctor's degree in divinity, without performing thoſe exerciſes which were deſigned as proofs of their qualifications. Such indolence cannot be imputed to Waring; yet ſeveral circumſtances, previous to his election into the profeſſorial chair, diſcovered that there was, at leaſt, one perſon in the univerſity who diſapproved of the anticipation of degrees by external influence.—Waring, before his election, gave a ſmall ſpecimen of his abilities, as proof of his qualification for the office which he was then ſoliciting; and a controverſy on his merits enſued: Dr Powell, the maſter of St John's college, attacking, in two pamphlets, the Profeſſor; and his friend, afterwards Judge Wilſon, defending. The attack was ſcarcely warranted by the errors in the ſpecimen; and the abundant proofs of talents in the exerciſe of the profeſſorial office are the beſt anſwers to the ſarcaſms which the learned divine amuſed himſelf in caſting on riſing merit. An office held by a Barrow, a Newton, a Whiſton, a Cotes, and a Sanderſon, muſt excite an ingenuous mind to the greateſt exertions; and the new Profeſſor, whatever may have been his ſucceſs, did not fall behind any of his predeceſſors, in either zeal for the ſcience, or application of the powers of his mind, to extend its boundaries. In 1762. he publiſhed his Miſcellanea Analytica; one of the moſt abſtruſe books written on the abſtruſeſt parts of algebra. This work extended his fame over all Europe. He was elected, without ſolicitation on his part, member of the ſocieties of Bononia and Gottingen; and received flattering marks of eſteem from the moſt eminent mathematicians at home and abroad. The difficulty of this work may be preſumed from the writer's own words, "I cannot ſay that I know any one who thought it worth while to read through the whole, and perhaps not the half of it."

Mathematics did not, however, engroſs the whole of his attention. He could dedicate ſome time to the ſtudy of his future profeſſion; and in 1767, he was admitted to the degree of doctor of phyſic; but, whether from the incapacity of uniting together the employments of active life with abſtruſe ſpeculation, or from the natural diffidence of his temper, for which he was moſt peculiarly remarkable; the degree which gave him the right of exerciſing his talents in medicine was to him merely a barren title. Indeed he was ſo embarraſſed in his manners before ſtrangers, that he could not have made his way in a profeſſion in which ſo much is done by addreſs; and it was fortunate that the caſe of his circumſtances permitted him to devote the whole of his time to his favourite purſuit. His life paſſed on, marked out by diſcoveries, chiefly in abſtract ſcience; and by the publication of them in the Philoſophical Tranſactions, or in ſeparate volumes, under his own inſpection. He lived ſome years after taking his doctor's degree, at St Ives, in Huntingdonſhire. While at Cambridge he married—quitted Cambridge with a view of living at Shrewſbury; but the air or ſmoke of the town being injurious to Mrs Waring's health, he removed to his own eſtate at Plaiſley, about 8 miles from Shrewſbury, where he died in 1797, univerſally eſteemed for inflexible integrity, modeſty, plainneſs, and ſimplicity of manners. They who knew the greatneſs of his mind from his writings looked up to him with reverence everywhere; but he enjoyed himſelf in domeſtic circles with thoſe chiefly among whom his purſuits could not be the object either of admiration or envy. The outward pomp which is affected frequently in the higher departments in academic life, was no gratification to one whoſe habits were of a very oppoſite nature; and he was too much occupied in ſcience to attend to the intrigues of the univerſity. There, in all queſtions of ſcience, his word was the law; and at the annual examination of the candidates for the prize inſtituted by Dr Smith, he appeared to the greateſt advantage. The candidates were generally three or four of the beſt proficients in the mathematics at the previous annual examination for the bachelor's degree, who were employed from nine o'clock in the morning to ten at night, with the exception of two hours for dinner, and twenty minutes for tea, in anſwering, *viva voce*, or writing down anſwers to the profeſſor's queſtions, from the firſt rudiments of philoſophy to the deepeſt parts of his own and Sir Iſaac Newton's works. Perhaps no part of Europe affords an inſtance of ſo ſevere a proceſs; and there was never any ground for ſuſpecting the Profeſſor of partiality,

lity. The zeal and judgment with which he performed this part of his office cannot be obliterated from the memory of thoſe who paſſed through his fiery ordeal.

Wiſhing to do ample juſtice to the talents and virtue of the Profeſſor, we feel ourſelves ſomewhat at a loſs in ſpeaking of the writings by which alone he will be known to poſterity. He is the diſcoverer, according to his own account, of nearly 400 propoſitions in the analytics. This may appear a vain glorious boaſt, eſpecially as the greater part of thoſe diſcoveries are likely to ſink into oblivion; but he was, in a manner, compelled to make it by the inſolence of Lalande, who, in his life of Condorcet, aſſerts that, in 1764, there was no firſt-rate analyſt in England. In reply to this aſſertion, the Profeſſor, in a letter to Dr Maſkelyne, firſt mentions, with proper reſpect, the inventions and writings of Harriot, Briggs, Napier, Wallis, Halley, Bruncker, Wren, Pell, Barrow, Mercator, Newton, De Moivre, Maclaurin, Cotes, Stirling, Taylor, Simpſon, Emerſon, Landen, and others; of whom Emerſon and Landen were living in 1764. He then gives a fair and full detail of his own inventions, of which many were publiſhed anterior to 1764; and concludes his letter in theſe words.

" I know that Mr Lalande is a firſt-rate aſtronomer, and writer of aſtronomy; but I never heard that he was much converſant in the deeper parts of mathematics; for which reaſon I take the liberty to aſk him the following queſtions:

" Has he ever read or underſtood the writings of the Engliſh mathematicians: and, as the queſtion comes from me, I ſubjoin, particularly of mine? If the anſwer be in the negative, as it is my opinion, if his anſwer be the truth, that it will, then there is an end of all further controverſy;—but if he aſſerts that he has, which is more than Condorcet did by his own acknowledgment, then he may know, from the enumeration of inventions made in the prefaces, with ſome ſubſequent ones added, that they are ſaid to amount to more than 400 of one kind or other. Let him try to reduce thoſe to as low a number as he can, with the leaſt appearance of candour and truth; and then let him compare the number with the number of inventions of any French mathematician or mathematicians, either in the preſent or paſt times, and there will reſult a compariſon (if I miſtake not) not much to his liking; and, further, let him compare ſome of the firſt inventions of the French mathematicians with ſome of the firſt contained in my works, both as to utility, generality, novelty, difficulty, and elegance, but wiſely as to utility, there is little contained in the deep parts of any ſcience; he will find their difficulty and novelty from his difficulty of underſtanding them, and his never having read any thing ſimilar before; their generality, by the application of them; principles of elegance will differ in different perſons.—I muſt ſay, that he will probably not find the difference expected. After or before this inquiry is inſtituted for mine, let him perform the ſame for the other Engliſh mathematicians; and when he has completed ſuch inquiries, and not before, he will become a judge of the juſtice of his aſſertion; but I am afraid that he is not a ſufficient adept in theſe ſtudies to inſtitute ſuch inquiries; and if he was, ſuch inquiries are invidious, troubleſome, and of ſmall utility."

By mathematical readers this account, which was not publiſhed by the Profeſſor himſelf, is allowed to be very little, if at all, exaggerated. Yet if, according to his own confeſſion, " few thought it worth their while to read even half of his works," there muſt be ſome grounds for this neglect, either from the difficulty of the ſubject, the unimportance of the diſcoveries, or a defect in the communication of them to the public. The ſubjects are certainly of a difficult nature, the calculations are abſtruſe; yet Europe contained many perſons not to be deterred by the moſt intricate theorems. Shall we ſay then, that the diſcoveries were unimportant? If this were really the caſe, the want of utility would be a very ſmall diſparagement among thoſe who cultivate ſcience with a view chiefly to entertainment and the exerciſe of their rational powers. We are compelled, then, to attribute much of this neglect to a perplexity in ſtyle, manner, and language; the reader is ſtopped at every inſtant, firſt to make out the writer's meaning, then to fill up the chaſm in the demonſtration. He muſt invent anew every invention; for, after the enunciation of the theorem or problem, and the mention of a few ſteps, little aſſiſtance is derived from the Profeſſor's powers of explanation. Indeed, an anonymous writer, certainly of very conſiderable abilities, has aptly compared the works of Waring to the heavy appendages of a Gothic building, which add little of either beauty or ſtability to the ſtructure.

A great part of the diſcoveries relate to an aſſumption in algebra, that equations may be generated by multiplying together others of inferior dimenſions. The roots of theſe latter equations are frequently terms called *negative* or *impoſſible*; and the relation of theſe terms to the coefficients of the principal equation is a great object of inquiry. In this art the profeſſor was very ſucceſsful, though little aſſiſtance is to be derived from his writings in looking for the real roots. We ſhall not, perhaps, be deemed to depreciate his merits, if we place the ſeries for the ſum of the powers of the roots of any equation among the moſt ingenious of his diſcoveries; yet we cannot add, that it has very uſefully enlarged the bounds of ſcience, or that the algebraiſt will ever find occaſion to introduce it into practice. We may ſay the ſame on many ingenious transformations of equations, on the diſcovery of impoſſible roots, and ſimilar exertions of undoubtedly great talents. They have carried the aſſumption to its utmoſt limits; and the difficulty attending the ſpeculation has rendered perſons more anxious to aſcertain its real utility; yet they who reject it may occaſionally receive uſeful hints from the Miſcellanea Analytica.

The firſt time of Waring's appearing in public as an author was, we believe, in the latter end of the year 1759, when he publiſhed the firſt chapter of the Miſcellanea Analytica, as a ſpecimen of his qualifications for the profeſſorſhip; and this chapter he defended, in a reply to a pamphlet, intitled, " Obſervations on the Firſt Chapter of a book called Miſcellanea Analytica." Here the Profeſſor was ſtrangely puzzled with the common paradox, that nothing divided by nothing may be equal to various finite quantities, and has recourſe to unqueſtionable authorities in proof of this poſition. The names of Maclaurin, Sanderſon, De Moivre, Bernoulli, Monmort, are ranged in favour of his opinion: But Dr Powell was not ſo eaſily convinced, and returns to the charge in defence of the Obſervations; to which the

Profeſſor replied in a letter to the Rev. Dr Powell, Fellow of St John's college, Cambridge, in anſwer to his Obſervations, &c. In this controverſy, it is certain that the Profeſſor gave evident proofs of his abilities; though it is equally certain that he followed too implicitly the deciſions of his predeceſſors. No apparent advantage, no authority whatever, ſhould induce mathematicians to ſwerve from the principles of right reaſoning, on which their ſcience is ſuppoſed to be peculiarly founded. According to Maclaurin, Dr Waring, and others, If $P = \frac{a - x}{a^2 - x^2}$, then, when $x = a$, P is equal to $\frac{1}{2a}$; for, ſay they, $\frac{a - x}{a^2 - x^2}$ is equal to $\frac{a - x}{a - x} \times \frac{1}{a + x}$; that is, when x is equal to a, $P = \frac{1}{a + x}$, or $\frac{1}{2a}$. But when x is equal to a, the numerator and denominator of the fraction $\frac{a - x}{a^2 - x^2}$ are both, in their language, equal to nothing. Therefore, nothing divided by nothing is equal to $\frac{1}{2a}$. In the ſame manner, $\frac{a - x}{a^3 - x^3} = \frac{1}{a^2 + ax + x^2} \times \frac{a - x}{a - x}$, which, when x is equal to a, becomes $\frac{1}{3a^2}$. Therefore, nothing divided by nothing is equal to $\frac{1}{3a^2}$, or $\frac{1}{3a^2} = \frac{1}{2a}$; that is, $\frac{1}{3a} = \frac{1}{2}$; which is abſurd. But we need only trace back our ſteps to ſee the fallacy in this mode of reaſoning. For P is equal to ſome number multiplied into $\frac{a - x}{a - x}$; that is, when x is equal to a, P is equal to ſome number multiplied into nothing, and divided by nothing; that is, P is, in that caſe, no number at all. For $a - a$ cannot be divided by $a - x$ when x is equal to a, ſince, in that caſe, $a - x$ is no number at all.

If, in the beginning of his career, the Profeſſor could admit ſuch paralogiſms into his ſpeculations, and the writings of the mathematicians, for nearly a century before him, may plead in his excuſe, we are not to be ſurpriſed that his diſcoveries ſhould be built rather on the aſſumptions of others than on any new principles of his own. Acquieſcing in the ſtrange notion, that nothing could be divided by nothing, and produce a variety of numbers, he as eaſily adopted the poſition, that an equation has as many roots as it has dimenſions.—Thus 2 and — 4 are ſaid to be roots of the equation $x^2 - 2x = 8$, though 4 can be the root only of the equation; $x^2 - 2x = 8$, which differs ſo materially from the preceding, that in one caſe $2x$ is added, in the other caſe it is ſubtracted from x^2.

Allowances being made for this error in the principles, the deductions are, in general, legitimately made; and any one, who can give himſelf the trouble of demonſtrating the propoſitions, may find ſufficient employment in the Profeſſor's analytics. Perhaps it will be ſufficient for a ſtudent to devote his time to the ſimpleſt caſe $x^n \pm 1 = 0$; and when he has found a few thouſand roots of + 1 and — 1, the publication of them may afford to poſterity a ſtrong proof of the ingenuity of their predeceſſors, and the application of the powers of their mind to uſeful and important truths. In this exerciſe may be conſulted the method given by the Profeſſor, of finding a quantity, which, multiplied into a given irrational quantity, will produce a rational product, or conſequently exterminate irrational quantities out of a given equation; but if an irrational quantity cannot come into an equation, the utility of this invention will not be admitted without heſitation.

The "Proprietates Algebraicarum Curvarum," publiſhed in 1772, neceſſarily labour under the ſame defects with the Miſcellanea Analytica, the Meditationes Algebraicæ, publiſhed in 1770, and the Meditationes Analyticæ, which were in the preſs during the years 1773, 1774, 1775, 1776. Theſe were the chief and the moſt laborious works edited by the Profeſſor; and in the Philoſophical Tranſactions is to be found a variety of papers, which alone would be ſufficient to place him in the firſt rank in the mathematical world. The nature of them may be ſeen from the following catalogue.

Vol. LIII. p. 294, Mathematical Problems.—LIV. 193. New Properties in Conics.—LV. 143. Two Theorems in Mathematics.—LXIX. Problems concerning Interpolations.—86. A General Reſolution of Algebraical Equations.—LXXVI. 81. On Infinite Series. LXXVII. 71. On Finding the Values of Algebraical Quantities by Converging Serieſes, and Demonſtrating and Extending Propoſitions given by Pappus and others.—LXXVIII. 67. On Centripetal Forces.—*Ib.* 588. On ſome Properties of the Sum of the Diviſion of Numbers.—LXXIX. 166. On the Method of Correſpondent Values, &c.—*Ib.* 185. On the Reſolution of Attractive Powers.—LXXXI. 146. On Infinite Serieſes.—LXXXIV. 385—415. On the Summation of thoſe Series whoſe general term is a determinate function of z, the diſtance of the term of the Series.

For theſe papers, the Profeſſor was, in 1784, deſervedly honoured by the Royal Society with Sir Godfrey Copley's medal; and moſt of them afford very ſtrong proofs of the powers of his mind, both in abſtract ſcience, and the application of it to philoſophy; though they labour, in common with his other works, under the diſadvantage of being clothed in a very unattractive form. The mathematician, who has reſolution to go through them, will not only add much to his own knowledge, but be uſefully employed in dilating on thoſe articles for the benefit of the more general reader. We might add in this place, a work written on morals and metaphyſics in the Engliſh language; but as a few copies only were preſented to his friends, and it was the Profeſſor's wiſh that they ſhould not have a more extenſive circulation, we ſhall not here enlarge upon its contents.

In the mathematical world, the life of Waring may be conſidered as a diſtinguiſhed æra. The ſtrictneſs of demonſtration required by the ancients had gradually fallen into diſuſe, and a more commodious, though almoſt mechanical mode by algebra and fluxions took its place, and was carried to the utmoſt limit by the Profeſſor. Hence many new demonſtrations may be attributed to him, but 100 diſcoveries can ſcarcely fall to the lot of a human being. If we examine thoroughly thoſe which our Profeſſor would diſtinguiſh by ſuch names, we ſhall find many to be mere deductions, others, there, as in the ſolution of biquadratics, anticipated by former writers. But if we cannot allow to him the merit of ſo inventive a genius, we muſt applaud his aſſiduity; and, diſtinguiſhed as he was in the ſcientific world, the purity of his life, the ſimplicity of his manners, and the zeal which he always manifeſted for the truths of the Goſpel, will intitle him to the reſpect of all who do not eſteem the good qualities of the heart inferior to thoſe of the head.

WARTON (Joſeph, D. D.) was born either towards the end of the year 1721, or in the beginning of the year 1722. He was the eldeſt ſon of Thomas Warton, B. D. who had been fellow of Magdalen College, Oxford; poetry profeſſor from the year 1718 to 1728, and vicar of Baſingſtoke in Hampſhire, and of Cobham in Surrey. Where the ſubject of this memoir was born we have not learned, though, were we to hazard a conjecture, we would ſay that it was in Oxford, as his father probably reſided in that city during his profeſſorſhip.

Our knowledge of the private hiſtory of Dr Warton is indeed extremely limited. We do not even know at what ſchool, or in what college, he was educated; tho' it was probably at Wincheſter ſchool, and certainly in ſome of the colleges in the univerſity of Oxford. For many years, he was ſucceſſively under and upper maſter of Wincheſter college; but reſigned the laſt of theſe offices when he found the infirmities of age coming upon him; and was ſucceeded by Dr Goddard the preſent excellent maſter. He was likewiſe prebendary of the cathedral church of Wincheſter, and rector of Wickham in Hampſhire, where he died, aged 78.

His publications are few, but valuable. A ſmall collection of poems, without a name, was the firſt of them, and contained the Ode to Fancy, which has been ſo much and ſo deſervedly admired. They were all of them afterwards printed in Dodſley's collection. He was alſo a conſiderable contributor to the Adventurer, publiſhed by Dr Hawkeſworth; and all the papers which contain criticiſms on Shakeſpeare were written by him and his brother Thomas Warton, the ſubject of the next article.

The firſt volume of his Eſſay on the Life and Writings of Pope was publiſhed, had paſſed through ſeveral editions, and an interval of between 20 and 30 years had elapſed, before he gave a ſecond volume of that elegant and inſtructive work to the world. He had not only meditated, but had collected materials for a literary hiſtory of the age of Leo X.; and propoſals were actually in circulation for a work of that kind; but it is probable that the duties of his ſtation did not leave him the neceſſary leiſure for an undertaking which required years of ſecluſion and independence. His laſt and late work, which he undertook for the bookſellers at a very advanced age, was an edition of Pope's Works, that has not altogether ſatisfied the public expectation. He retained, with great propriety indeed, many of the notes of Warburton; but is ſeverely reprehended by the author of the Purſuits of Literature for ſuppreſſing the name of that prelate on his title-page, or including it only, as ſubordinate to his own, in the general expreſſion *others*.

Dr Warton was cheerful in his temper, convivial in his diſpoſition, of an elegant taſte and lively imagination, with a large portion of ſcholarſhip, and a very general knowledge of the Belles Lettres of Europe; it may be preſumed that Dr Warton poſſeſſed, beyond moſt men, the power of enlivening Claſſical Society. He was the intimate friend of Dr Johnſon; was ſeen at the parties of Mrs Montague, as well as at the table of Sir Joſhua Reynolds, and was an original member of the Literary Club. He poſſeſſed a liberal mind, a generous diſpoſition, and a benevolent heart. He was not only admired for his talents and his knowledge, but was beloved for thoſe qualities which are the beſt gifts of this imperfect ſtate.

WARTON (Thomas), the brother of the preceding, was born in the year 1728. He received, as we have reaſon to believe, the firſt part of his education at Wincheſter; and at the age of 16 was entered a commoner of Trinity College, Oxford, under the tuition of Mr Geering.

Biog. Dict.

He began his poetical career at an early age. In 1745, he publiſhed five paſtoral eclogues, in which are beautifully deſcribed the miſeries of war to which the ſhepherds of Germany were expoſed. Not long after, in the year 1748, he had full ſcope afforded for the exertion of his genius. It is well known that Jacobite principles were ſuſpected to prevail in the univerſity of Oxford about the time of the rebellion in the year 1745. Soon after its ſuppreſſion, the drunkenneſs and folly of ſome young men gave offence to the court, in conſequence of which a proſecution was inſtituted in the court of King's Bench, and a ſtigma was fixed on the vice chancellor and ſome other heads of colleges in Oxford. Whilſt this affair was the general ſubject of converſation, Mr Maſon publiſhed his "Iſis," an elegy, in which he adverts to the above mentioned circumſtances. In anſwer to this poem, Mr Warton, encouraged by Dr Huddesford, the preſident of his college, publiſhed, in 1749, "The Triumph of Iſis," which excelled more in manly expoſtulation and dignity than the poem that produced it did in neatneſs and elegance. With great poetical warmth, and a judicious ſelection of circumſtances, he characteriſes the eminent men who had been educated in Oxford, and draws a ſtriking and animated portrait of Dr King, the celebrated public orator of that time. The whole poem ſhews the early maturity of his genius, and is finiſhed with happy diligence.

In the year 1751, he ſucceeded to a fellowſhip of his college, and was thus placed in a ſituation eaſy and independent, and particularly congenial with his habits of retirement and ſtudy. In 1753, appeared his obſervations on "The Faery Queen of Spencer," in 8vo, a work which he corrected, enlarged, and republiſhed, in two volumes crown octavo, in the year 1762. He ſent a copy of the firſt edition to Dr Johnſon, who, in a letter to him upon the ſubject, expreſſed this handſome compliment: "I now pay you a very honeſt acknowledgement for the advancement of the literature of our native country: you have ſhewn to all, who ſhall hereafter attempt the ſtudy of ancient authors, the way to ſucceſs, by directing them to the peruſal of the books which theſe authors had read."

In 1754, Dr Johnſon viſited Oxford for the firſt time after he had quitted reſidence there. Much of his time was ſpent with Mr Warton; and there appeared to have been a conſiderable degree of confidential intercourſe between them upon literary ſubjects, and particularly on their own works. A pleaſing account of this viſit was communicated by Mr Warton to Mr Boſwell, who has inſerted it in his life of Johnſon.

In 1755, Mr Warton exerted himſelf to procure for his friend the degree of maſter of arts by diploma from the univerſity of Oxford; an honour which Johnſon eſteemed of great importance to grace the title page of his dictionary which he was about to publiſh. In 1756, Mr Warton was elected profeſſor of poetry, which office he held for the uſual term of ten years. His lectures were remarkable for elegance of diction and juſtneſs of obſervation. One of them, on the ſubject of paſtoral poetry, was afterwards prefixed to his edition of Theocritus. In 1758, he contributed to aſſiſt Dr Johnſon in the ſubſcription to his edition of Shakeſpeare, and furniſhed him with ſome valuable notes. The Doctor remarks, in a letter to him, when ſoliciting his farther aid, "It will be reputable to my work, and ſuitable to your profeſſorſhip, to have ſomething of yours in my notes."

From the Clarendon preſs, in the year 1766, he publiſhed "Anthologiæ Græcæ, a Conſtantino Cephalâ conditæ, Libri tres," in 2 vols, 12mo. He concludes the learned and claſſical preface to this work, which is replete with accurate remarks on the Greek epigram, in the following words, which mark this publication for his own: "Vereor ut hactenus in plexendis florum corollis otium nimis longum pertraxerim. Proximè ſequetur, cui nunc omnes operas et vires intendo, Theocritus. Interea quaſi promulſidem convivii Lectoribus meis elegantias haſce vetuſtatis eruditæ propino."

In the year 1770, he conferred a ſimilar honour upon the academical preſs by his edition of Theocritus, in 2 vols, 8vo. He undertook this work by the advice of Judge Blackſtone, then fellow of All-Souls College, and an ardent promoter of every publication that was likely to do credit to the Clarendon preſs. This elaborate publication reflects no ſmall credit on the learning, diligence, and taſte of the editor.

In 1771, he was elected a fellow of the Antiquarian Society, and was preſented by the Earl of Lichfield to the ſmall living of Kiddington in Oxfordſhire, which he held till his death. He likewiſe in this year publiſhed an improved account of "The Life of Sir Thomas Pope, founder of Trinity College, Oxford. In compoſing theſe memoirs, he beſtowed much labour and reſearch, and ſhewed great judgment in the arrangement of his materials. But poſſibly, in his ardour to pay a debt of gratitude, he has not ſufficiently conſidered what was due to his own fame. The ſame ſtrength of deſcription and vigour of remark would have better ſuited the life of ſome eminently diſtinguiſhed character, and extended the reputation of the author as a biographer beyond the circle of thoſe academical readers who are influenced by the ſame feelings of veneration, reſpect, and gratitude which prompted Mr Warton to compoſe this work. The preface contains ſome excellent remarks on biographical writing.

The plan for a hiſtory of Engliſh poetry was laid by Pope, enlarged by Gray: but to bring an original plan nearly to a completion was reſerved for the perſeverance of Warton. In 1774 appeared his firſt volume; in 1778, the ſecond and third; which brings the narrative down to the commencement of the reign of Elizabeth in 1581. This work diſplays the moſt ſingular combination of extraordinary talents and attainments. It unites the deep and minute reſearches of the antiquary with the elegance of the claſſical ſcholar and the ſkill of the practiſed writer. The ſtyle is vigorous and manly; the obſervations acute and juſt; and the views of the ſubject are extenſive and accurate.

In 1777, he collected his poems into an octavo volume, containing miſcellaneous pieces, odes, and ſonnets. This publication may be conſidered in ſome meaſure original; there being only ſeven pieces that had before appeared, and near three times that number which were then printed for the firſt time.

In vindication of the opinion he had given in his ſecond volume of "The Hiſtory of Poetry," relative to the ingenious attempt of Chatterton to impoſe upon the public, he produced, in 1782, "An Inquiry into the Authenticity of the Poems attributed to Rowley." In this excellent pamphlet the principles of true criticiſm are laid down, an appeal is properly made to the internal evidence of the poems; and upon theſe grounds it is proved, in the moſt ſatisfactory manner, that they could not have been written by a monk of the fourteenth century.

The year 1785 brought him thoſe diſtinctions which were no leſs honourable to thoſe who conferred than to him who received them. He was appointed poet laureat on the death of Whitehead, and elected Camden profeſſor of ancient hiſtory on the reſignation of Dr Scott. His inauguration lecture was delivered in a clear and impreſſive manner from the profeſſorial chair. It contained excellent obſervations on the Latin hiſtorians, and was written in a ſtrong, perſpicuous, and claſſical ſtyle. In his odes, the vigour and brilliancy of his fancy were not proſtituted to an inſipid train of courtly compliments: each preſents an elegant ſpecimen of deſcriptive poetry, and as all of them have only a ſlight relation to the particular occaſion on which they were written, and have always a view to ſome particular and intereſting ſubject, they will be peruſed with pleaſure as long as this ſpecies of compoſition is admired.

He made occaſional journeys to London to attend the literary club, of which he was ſome years a member; and to viſit his friends, particularly Sir Joſhua Reynolds. At his houſe he was ſure to meet perſons remarkable for faſhion, elegance, and taſte.

His laſt publication, except his official odes, conſiſted of Milton's ſmaller poems. A quarto edition appeared in 1790, with corrections and additions. The great object of theſe notes is to explain the alluſions of Milton, to trace his imitations, and to illuſtrate his beauties.

Until he reached his ſixty ſecond year, he continued to enjoy vigorous and uninterrupted health. On being ſeized with the gout, he went to Bath, and flattered himſelf, on his return to college, that he was in a fair way of recovery. But the change that had taken place in his conſtitution was viſible to his friends On Thurſday, May 20, 1790, he paſſed the evening in the common room, and was for ſome time more cheerful than uſual. Between ten and eleven o'clock he was ſtruck with the palſy, and continued inſenſible till his death, which happened the next day at two o'clock. On the 27th, his remains were interred in the college chapel with the moſt diſtinguiſhed academical honours.

The inſcription upon the flat ſtone which is placed over his grave contains only an enumeration of his preferments.

Such was the general conduct and behaviour of Mr Warton as to render him truly amiable and reſpectable. By his friends he was beloved for his open and eaſy manners; and by the members of the univerſity at large he was reſpected for his conſtant reſidence, ſtrong attachment to Alma Mater, his ſtudious purſuits, and high literary character In all parties where the company accorded with his inclination, his converſation was eaſy and gay, enlivened with humour, enriched with anecdote, and pointed with wit. Among his peculiarities it may be mentioned that he was fond of all military ſights. He was averſe to ſtrangers, particularly to thoſe of a literary turn; and yet he took a great pleaſure in encouraging the efforts of riſing genius, and aſſiſting the ſtudious with his advice; as many of the young men of his college, who ſhared his affability and honoured his talents, could teſtify. He was bred in the ſchool of punſters; and made as many good ones as Barton and Leigh, the celebrated word-hunters of his day. Under the maſk of indolence, no man was more buſy; his mind was ever on the wing in ſearch of ſome literary prey. Although, at the accuſtomed hours of Oxford ſtudy, he was often ſeen ſauntering about, and converſing with any friend he chanced to meet; yet, when others were waſting their mornings in ſleep, he was indulging his meditations in his favourite walks, and courting the Muſes. His ſituation in Oxford was perfectly congenial with his diſpoſition, whether he indulged his ſallies of pleaſantry in the common room, retired to his own ſtudy, or to the Bodleian library; ſauntered on the banks of his favourite Cherwell, or ſurveyed, with the enthuſiaſtic eye of taſte, the ancient gateway of Magdalen College, and other ſpecimens of Gothic architecture.

The following is a liſt of Mr Warton's works: 1. "Five Paſtoral Eclogues," 4to, 1745. Reprinted in Pearch's Collection of Poems. 2. "The Pleaſures of Melancholy," written in 1745; firſt printed in Dodſley's Collection, and afterwards in the Collection of Mr Warton's Poems. 3. "Progreſs of Diſcontent," written in 1746. Firſt printed in the "Student," a periodical paper. 4. "The Triumph of Iſis, a Poem," 4to, 1750. 5. "Newmarket, a Satire," folio, 1751. 6. "Ode for Muſic," performed at the theatre in Oxford 1751. 7. "Obſervations on the Faerie Queen of Spenſer," 8vo, 1754. 8. "Inſcriptionum Metricarum Delectus," 4to, 1758. 9. "A Deſcription of the City, College, and Cathedral, of Wincheſter," 8vo, no date. 10. "The Life of Sir Thomas Pope," in the 5th volume of the Biographia Britannica," republiſhed in 1772. 11. "The Life and literary Remains of Ralph Bathurſt, M. D. Dean of Wells, and Preſident of Trinity College in Oxford," 1761. 12. "A Companion to the Guide, and a Guide to the Companion," 12mo, 1762. 13. "The Oxford Sauſage," in which are ſeveral Poems by Warton. 14. "Anthologiæ Græcæ a Conſtantino Cephalâ conditæ Libri tres," 2 tom. 1766. 15. "Theocritis Syracuſii quæ ſuperſunt, cum Scholiis Græcis," &c. 2 tom. 4to, 1770. 16. "Hiſtory of Engliſh Poetry, from the Cloſe of the 11th to the Commencement of the 18th Century," 4to, Vol. I. 1774. Vol. II. 1778. Vol. III. 1781 17. "Poems," 8vo, 1777 18. "Specimen of a Hiſtory of Oxfordſhire," 1783. 19. "An Enquiry into the Authenticity of the Poems attributed to Thomas Rowley," 8vo, 1782. 20. Verſes on Sir J. Reynolds's painted Window in New College Chapel, 4to." 1782. 21. "Poems on ſeveral Occaſions, by John Milton, with Notes critical and explanatory," 8vo, 1785.

WASHINGTON (George), whoſe name is likely to live as long as that of any modern, was born on the 11th of February 1732, in the pariſh of Waſhington, Virginia. He was deſcended from an ancient family in Cheſhire, of which a branch had been eſtabliſhed in Virginia about the middle of the 17th century. We are not acquainted with any remarkable circumſtances of his education or his early youth; and we ſhould not indeed expect any marks of that diſorderly prematureneſs of talent, which is ſo often fallacious, in a character whoſe diſtinguiſhing praiſe was to be regular and natural. His claſſical inſtruction was probably ſmall, ſuch as the private tutor of a Virginian country gentleman could at that period have imparted; and if his opportunities of information had been more favourable, the time was too ſhort to profit by them (A). Before he was twenty he was appointed a major in the colonial militia, and he had very early occaſion to diſplay thoſe political and military talents, of which the exertions on a greater theatre have ſince made his name ſo famous throughout the world.

The plenipotentiaries who framed the treaty of Aix la Chapelle, by leaving the boundaries of the Britiſh and French territories in North America unfixed, had ſown the ſeeds of a new war, at the moment when they concluded a peace. – The limits of Canada and Louiſiana, negligently deſcribed in vague language by the treaties of Utrecht and Aix la Chapelle, becauſe the greater part of theſe vaſt countries was then an impenetrable wilderneſs, furniſhed a motive, or a pretext, for one of the moſt ſucceſsful, but one of the moſt bloody and waſteful wars in which Great Britain had ever been engaged. See BRITAIN, *Encycl.*

In the diſputes which aroſe between the French and Engliſh officers on this ſubject, Major Waſhington was employed by the governor of Virginia, in a negociation with the French governor of Fort du Queſne (now Pitſburgh); who threatened the Engliſh frontiers with a body of French and their Indian allies He ſucceeded in averting the invaſion; but hoſtilities becoming inevitable, he was in the next year appointed lieutenant colonel of a regiment raiſed by the colony for its own defence; to the command of which he ſoon after ſucceeded. The expedition of Braddock followed in the

---

(A) Several accounts of the life of Waſhington have ſtated that he ſerved as a midſhipman on board a Britiſh frigate. This is a miſtake. His elder brother, who died young, ſerved in that capacity in Vernon's expedition againſt Carthagena; whence the family ſeat was called Mount Vernon. Waſhington himſelf never left the United States, except in one ſhort voyage to a Weſt India iſland, when he was very young.

year 1755; of which the fatal iſſue is too well known to require being deſcribed by us. Colonel Waſhington ſerved in that expedition only as a volunteer; but ſuch was the general confidence in his talents, that he may be ſaid to have conducted the retreat. Several Britiſh officers are ſtill alive who remember the calmneſs and intrepidity which he ſhewed in that difficult ſituation, and the voluntary obedience which was ſo cheerfully paid by the whole army to his ſuperior mind. After having acted a diſtinguiſhed part in a ſubſequent and more ſucceſsful expedition to the Ohio, he was obliged by ill health, in the year 1758, to reſign his military ſituation. The ſixteen years which followed of the life of Waſhington ſupply few materials for the biographer. Having married Mrs Cuſtis, a Virginian lady of amiable character and reſpectable connections, he ſettled at his beautiful ſeat of Mount Vernon, of which we have had ſo many deſcriptions; where, with the exception of ſuch attendance as was required by his duties as a magiſtrate and a member of the aſſembly, his time was occupied by his domeſtic enjoyments, and the cultivation of his eſtate, in a manner well ſuited to the tranquillity of his pure and unambitious mind. At the end of this period he was called by the voice of his country from this ſtate of calm and ſecure though unoſtentatious happineſs.

For almoſt half a century ſymptoms of diſaffection to the mother-country had been ſo viſible in the New England provinces, that ſo early as 1734 the celebrated Biſhop Berkeley had predicted a total ſeparation of North America from Great Britain. That prelate, when a private clergyman, had lived three years in Rhode Iſland, and was an attentive and ſagacious obſerver of the manners and principles of the people, among whom he perceived the old leaven of their forefathers fermenting even then with great violence. The middle and ſouthern provinces, however, were more loyal, and their influence, together with perpetual dread of the French before the peace of 1763, put off the ſeparation to a more diſtant day than that at which, we have reaſon to believe, the Biſhop expected it to take place. Virginia, the moſt loyal of all the colonies, had long been in the habit of calling itſelf, with a kind of proud pre-eminence, *his Majeſty's ancient dominion;* and it was with ſome difficulty that the demagogues of New England could gain over that province when the time arrived for effecting their long meditated revolt. At laſt, however, they ſucceeded; and we find Mr Waſhington as a delegate from Virginia in the Congreſs which met at Philadelphia on the 26th of October 1774. (See AMERICA, nº 174. *Encycl.*) As no American united in ſo high a degree as he did, military experience with reſpectability of character, he was appointed to the command of the army which had aſſembled in the New England provinces, to hold in check the Britiſh army which was then encamped under General Gage at Boſton.

At this period there is ſome reaſon to believe that neither Mr Waſhington nor his conſtituents entered heartily into the views of the New Englanders; but afraid leſt the army of thoſe rebellious fanatics, after ſhaking off the yoke of Great Britain, might give law to the continent, he took upon himſelf the command of that army in the month of July 1775 (B). To detail his conduct in the years which followed, would be to relate the hiſtory of the American war, which we have already related in the article AMERICA (*Encycl.*). Within a very ſhort period after the declaration of independence, the affairs of America were in a condition ſo deſperate, that perhaps nothing but the *peculiar* character of Waſhington's genius could have retrieved them. Activity was the policy of invaders. In the field of battle the ſuperiority of a diſciplined army is diſplayed. But delay was the wiſdom of a country defended by undiſciplined ſoldiers againſt an enemy who muſt be more exhauſted by time than he could be weakened by defeat. It required the conſummate prudence, the calm wiſdom, the inflexible firmneſs, the moderate and well-balanced temper of Waſhington to embrace ſuch a plan of policy, and to perſevere in it: to reſiſt the temptations of enterprize; to fix the confidence of his ſoldiers without the attraction of victory; to ſupport the ſpirit of the army and the people amidſt thoſe ſlow and cautious plans of defenſive warfare which are more diſpiriting than defeat itſelf; to contain his own ambition and the impetuoſity of his troops; to endure temporary obſcurity for the ſalvation of his country, and for the attainment of ſolid and immortal glory; and to ſuffer even temporary reproach and obloquy, ſupported by the approbation of his own conſcience and the applauſe of that ſmall number of wiſe men, whoſe praiſe is an earneſt of the admiration and gratitude of poſterity. Victorious generals eaſily acquire the confidence of their army. Theirs, however, is a confidence in the *fortune* of their general. That of Waſhington's army was a confidence in his *wiſdom.* Victory gives ſpirit to cowards, and even the agitations of defeat ſometimes impart a courage of deſpair. Courage is inſpired by ſucceſs, and it may be ſtimulated to deſperate exertion even by calamity; but it is generally palſied by inactivity.—A ſyſtem of cautious defence is the ſevereſt trial of human fortitude; and by this teſt the firmneſs of Waſhington was tried. It muſt not, however, be concealed, that ſome of the Britiſh commanders gave him advantages, which he ſurely did not expect; for more than once, as it appears to us, they had it in their power to annihilate his army, merely by following up their victories. The iſſue of the conteſt is known.

Much has been ſaid by the Britiſh and American democrates of the magnanimity of Waſhington during the ravages of a civil war, in which he acted ſo conſpicuous a part; and we feel not ourſelves inclined to refuſe him the praiſe which he may have merited on this or on any other account. But granting that duty required him to execute as a ſpy the accompliſhed *André,* true magnanimity would have prevented him from inſultingly erecting, in the view of that unfortunate officer, the gallows on which he was to be hung, ſeveral days

---

(B) That ſuch were the motives of his conduct on this occaſion, is rendered in the higheſt degree probable in the preface to *A View of the Cauſes and Conſequences of the American Revolution, in thirteen Diſcourſes, Preached in North America, between the years* 1763 and 1775; by Jonathan Boucher, A. M. and F. A. S. Vicar of Epſom in the County of Surrey.

days before his execution! When Earl Cornwallis was overpowered by numbers, and obliged at York town to ſurrender to the united armies of America and France, a magnanimous conqueror would not have maliciouſly claimed, contrary to the uſage of civilized war, the ſword from the hands of that gallant nobleman. On theſe two occaſions, and on ſome others, the conduct of Waſhington agreed ſo ill with his general character, that we are inclined to believe that he muſt have been influenced by the leaders of the French army Rochembeau and Fayette. One thing is certain, that he was ſo little pleaſed either with his own conduct on particular occaſions, or with the general principle of the American revolution, that he never could be forced to talk on the ſubject. An Italian nobleman, who viſited him after the peace, had often attempted, in vain, to turn the converſation to the events of the war. At length he thought he had found a favourable opportunity of effecting his purpoſe; they were riding together over the ſcene of an action where Waſhington's conduct had been the ſubject of no ſmall animadverſion. Count —— ſaid to him, "Your conduct, Sir, in this action has been criticiſed." Waſhington made no anſwer, but clapped ſpurs to his horſe; after they had paſſed the field, he turned to the Italian and ſaid, "Count ——, I obſerve that you wiſh me to ſpeak of the war; it is a converſation which I always avoid. I rejoice at the eſtabliſhment of the liberties of America. But the time of the ſtruggle was a horrible period, in which the beſt men were compelled to do many things repugnant to their nature." This, we think, is the language of a good man not altogether ſatisfied with the part which he had been compelled to act, and who though he rejoiced at the eſtabliſhment of the *liberties* of America, probably foreſaw that ſhe would reap no benefit from her favourite *independence*.

The concluſion of the American war permitted Waſhington to return to thoſe domeſtic ſcenes, from which no views of ambition ſeem to have had the power to draw him. But he was not allowed long to enjoy this privacy. The ſupreme government of the United States, haſtily thrown up, in a moment of turbulence and danger, as a temporary fortification againſt anarchy, proved utterly inadequate to the preſervation of general tranquillity and permanent ſecurity. The confuſions of civil war had given a taint to the morality of the people, which rendered the reſtraints of a juſt and vigorous government more indiſpenſably neceſſary. Confiſcation and paper money, the two greateſt ſchools of rapacity and diſhoneſty in the world, had widely ſpread their poiſon among the Americans. One of their own writers tells us, that the whole ſyſtem of paper money was a ſyſtem of public and private frauds. In this ſtate of things, which threatened the diſſolution of morality and government, good men ſaw the neceſſity of concentrating and invigorating the ſupreme authority. Under the influence of this conviction, a convention of delegates was aſſembled at Philadelphia, which ſtrengthened the bands of the Federal Union, and beſtowed on Congreſs thoſe powers which were neceſſary for the purpoſes of good government. Waſhington was the preſident of this convention, as he, in three years after, was elected preſident of the United States of America, under what was called "The New Conſtitution," tho' it ought to have been called a *reform* of the republican government, as that republican government itſelf was only a *reform* of the ancient colonial conſtitution under the Britiſh crown. None of theſe changes extended ſo far as an attempt to new-model the whole ſocial and political ſyſtem.

Events occurred during his chief magiſtracy which convulſed the whole political world, and which tried moſt ſeverely his moderation and prudence. The French revolution took place; Waſhington, who had experienced the evils of one revolution, augured, from the beginning, no good from the daring ſpeculations of inexperienced viſionaries; and the progreſs of the revolution was not calculated to cure his diſtruſt. When, in the year 1793, France, then groaning under the moſt intolerable and hideous tyranny, became engaged in war with almoſt all the governments of the civilized world, it is ſaid to have been a matter of deliberation with the Preſident of the United States, whether the republican envoy, or the agent of the French princes ſhould be received in America as the diplomatic repreſentative of France. But whatever might be his private feelings of repugnance and horror, his public conduct was influenced only by his public duties. As a virtuous man he muſt have abhorred the ſyſtem of crimes which was eſtabliſhed in France. But as the firſt magiſtrate of the American commonwealth, he was bound only to conſider how far the intereſt and ſafety of the people whom he governed were affected by the conduct of France. He ſaw that it was wiſe and neceſſary for America to preſerve a good underſtanding and a beneficial inrercourſe with that great country, in whatever manner ſhe was governed, as long as ſhe abſtained from committing injury againſt the United States. Guided by this juſt and ſimple principle, uninfluenced by the abhorrence of crimes which he felt, and which others affected, he received Mr Genet, the miniſter of the French Republic. The hiſtory of the outrages which that miniſter committed, or inſtigated, or countenanced, againſt the American government, muſt be freſh in the memory of all our readers. The conduct of Waſhington was a model of firm and dignified moderation. Inſults were offered to his authority in official papers, in anonymous libels, by incendiary declaimers, and by tumultuous meetings. The law of nations was trampled under foot. His confidential miniſters were ſeduced to betray him, and the deluded populace were ſo inflamed by the arts of their enemies, that they broke out into inſurrection. No vexation, however galling, could diſturb the tranquillity of his mind, or make him deviate from the policy which his ſituation preſcribed. With a more confirmed authority, and at the head of a longer eſtabliſhed government, he might perhaps have thought greater vigour juſtifiable. But in his circumſtances, he was ſenſible that the nerves of authority were not ſtrong enough to bear being ſtrained. Perſuaſion, always the moſt deſirable inſtrument of government, was in his caſe the ſafeſt. Yet he never overpaſſed the line which ſeparates conceſſion from meanneſs. He reached the utmoſt limits of moderation, without being betrayed into puſillanimity. He preſerved external and internal peace by a ſyſtem of mildneſs, without any of thoſe virtual confeſſions of weakneſs, which ſo much diſhonour and enfeeble ſupreme authority. During the whole of that arduous ſtruggle, his perſonal character gave that ſtrength to a *new magiſtracy* which in other countries ariſes from ancient habits of obedience and reſpect. The authority of his virtue was more efficacious for the preſervation of America than the legal powers of his office.

During this turbulent period, he was re-elected to the office of the Preſidency of the United States, which he held from April 1789 till September 1796. Probably no magiſtrate of any commonwealth, ancient or modern, ever occupied a place ſo painful and perilous. Certainly no man was ever called upon ſo often to ſacrifice his virtuous feelings (he had no other ſacrifices to make) to his public duty. Two circumſtances of this ſort deſerve to be particularly noticed. In the ſpring of 1794, he ſent an ambaſſador to Paris with credentials, addreſſed to his "Dear friends the citizens compoſing the Committee of Public Safety of the French Republic," whom he prays God "to take under his holy protection." Fortunately the American ambaſſador was ſpared the humiliation of preſenting his credentials to theſe bloody tyrants. Their power was ſubverted, and a few of them had ſuffered the puniſhment of their crimes, which no puniſhment could expiate, before his arrival at Paris. Readily as we admit the purity of the motives which induced him to ſend this embaſſy to Paris, we cannot poſſibly approve of his conduct in deviating ſo far from the uſual diplomatic ſtyle, as to call Robeſpierre his friend: but he was beſet by an abſurd, though formidable, faction at home.

He had another ſtruggle of feeling and duty to encounter, when he was compelled to ſuppreſs the inſurrection in the weſtern counties of Pennſylvania by force of arms. But here he had a conſolation. The exerciſe of mercy conſoled his mind for the neceſſity of having recourſe to arms. Never was there a revolt quelled with ſo little blood. Scarcely ever was the baſeſt daſtard ſo tender of his own life, as this virtuous man was of the lives of his fellow-citizens. The value of his clemency is enhanced by recollecting that he was neither without provocations to ſeverity, nor without pretexts for it. His character and his office had been reviled in a manner almoſt unexampled among civilized nations. His authority had been inſulted.—His ſafety had been threatened. Of his perſonal and political enemies ſome might, perhaps, have been ſuſpected of having inſtigated the inſurrection; a greater number were thought to wiſh well to it; and very few ſhewed much zeal to ſuppreſs it. *Is habitus animorum fuit, ut peſſimum faſcinus auderent pauci, plures vellent, omnes paterentur.* But neither reſentment, nor fear, nor even policy itſelf, could extinguiſh the humanity of Waſhington. This ſeems to have been the only ſacrifice which he was incapable of making to the intereſt of his country.

Throughout the whole courſe of his ſecond Preſidency, the danger of America was great and imminent almoſt beyond example. The ſpirit of change, indeed, at that period, ſhook all nations. But in other countries it had to encounter ancient and ſolidly eſtabliſhed power; it had to tear up by the roots long habits of attachment in ſome nations for their government; of awe in others; of acquieſcence and ſubmiſſion in all.—But in America the government was new and weak. The people had ſcarce time to recover from the ideas and feelings of a recent civil war. In other countries the volcanic force muſt be of power to blow up the mountains, and to convulſe the continents that held it down, before it could eſcape from the deep caverns in which it was impriſoned: in America it was covered only by the aſhes of a late convulſion, or at moſt by a little thin ſoil, the produce of a few years quiet.

The government of America had none of thoſe ſalutary prejudices to employ, which in every other country were uſed with ſucceſs to open the eyes of the people to the enormities of the French revolution. They had, on the contrary, to contend with the prejudices of their people in the moſt moderate precautions againſt internal confuſion, in the moſt meaſured and guarded reſiſtance to the unparalleled inſults and enormous encroachments of France. Without zealous ſupport from the people, the American government was impotent. It required a conſiderable time, and it coſt an arduous and dubious ſtruggle, to direct the popular ſpirit againſt a ſiſter republic, eſtabliſhed among a people to whoſe aid the Americans aſcribed the eſtabliſhment of their independence. It is probable, indeed, that no policy could have produced this effect, unleſs it had been powerfully aided by the crimes of the French government, which have proved the ſtrongeſt allies of all eſtabliſhed governments; which have produced ſuch a general diſpoſition to ſubmit to any *known* tyranny, rather than ruſh into all the unknown and undefinable evils of civil confuſion, with the horrible train of new and monſtrous *tyrannies* of which it is uſually the forerunner. But of theſe circumſtances Waſhington availed himſelf with uncommon addreſs. He employed the horror excited by the atrocities of the French revolution for the moſt honeſt and praiſe-worthy purpoſes; to preſerve the internal quiet of his country; to aſſert the dignity, and to maintain the rights, of the commonwealth which he governed, againſt foreign enemies. He avoided war without incurring the imputation of puſillanimity. He cheriſhed the deteſtation of Americans for anarchy, without weakening the ſpirit of liberty; and he maintained, and even conſolidated, the authority of government, without abridging the privileges of the people.

The reſignation of Waſhington in 1796 was certainly a meaſure of prudence, and we doubt not of patriotiſm; but the conduct of his ſucceſſor has been ſuch as to give the Americans reaſon to regret that the reins of government were thrown up by the only hand, perhaps, that was fit to guide them during ſo unſettled a ſtate of public affairs. When he retired, he publiſhed a valedictory addreſs to his countrymen, as he had before done when he quitted the command of the army in 1783. In theſe compoſitions, the whole heart and ſoul of Waſhington are laid open. Other ſtate papers have, doubtleſs, ſhewn more ſpirit and dignity, more eloquence, greater force of genius, and a more enlarged comprehenſion of mind; but none ever diſplayed more ſimplicity and ingenuouſneſs, more moderation and ſobriety, more good ſenſe, more prudence, more honeſty, more earneſt affection for his country and for mankind, more profound reverence for virtue and religion; more ardent wiſhes for the happineſs of his fellow-creatures, and more juſt and rational views of the means which alone can effectually promote that happineſs.

From his reſignation till the month of July 1798, he lived in retirement at Mount Vernon. At this latter period, it became neceſſary for the United States to arm. They had endured with a patience, of which there is no example in the hiſtory of ſtates, all the contumely and wrong which ſucceſſive adminiſtrations in France had heaped upon them. Their ſhips were everywhere captured, their miniſters were detained in a ſort of impriſonment at Paris; while incendiaries, clothed in the ſacred character of ambaſſadors, ſcattered over their peaceful provinces the fire-brands of ſedition and civil war. An offer was made to terminate this long courſe of injuſtice, for a bribe to the French miniſters. This offer was made by perſons who *appeared* to be in the confidence of M. Talleyrand, who *profeſſed* to act by his authority; who have been ſince, indeed, diſavowed by him; but who never will be believed not to have been his agents, till he convict them of impoſture by legal evidence, and procure them to be puniſhed for ſo abominable a fraud.

The United States reſolved to arm by land and ſea. The command of the army was beſtowed on General Waſhington; which he accepted, becauſe he was convinced that "every thing we hold dear and ſacred was ſeriouſly threatened*;" though he had flattered himſelf "that he had quitted for ever the boundleſs field of public action, inceſſant trouble and high reſponſibility, in which he had long acted ſo conſpicuous a part." In this office he continued during the ſhort period of his life which ſtill remained.—On Thurſday the 12th December 1799, he was ſeized with an inflammation in his throat, which became conſiderably worſe the next day; and of which, notwithſtanding the efforts of his phyſicians, he died on Saturday the 14th of December 1799, in the 68th year of his age, and in the 23d year of the independence of the United States, of which he may be conſidered as the founder. The ſame calmneſs, ſimplicity, and regularity, which had uniformly marked his demeanor, did not forſake him in his dying moments. He ſaw the approaches of death without fear:—he met them without parade.—Even the perfectly well ordered ſtate of the moſt minute particulars of his private buſineſs, bore the ſtamp of that conſtant authority of prudence and practical reaſon over his actions, which was a diſtinguiſhing feature of his character. He died with theſe ſentiments of piety which had given vigour and conſiſtency to his virtue, and adorned every part of his illuſtrious life.

WATCHWORK. Our intention in this article does not extend to the manual practice of this art, nor even to all the parts of the machine. We mean to conſider the moſt important and difficult part of the conſtruction, namely, the method of applying the maintaining power of the wheels to the regulator of the motion, ſo as not to hurt its power of regulation. Our obſervations would have come with more propriety under the title SCAPEMENT, that being the name given by our artiſts to this part of the conſtruction. Indeed they were intended for that article, which had been unaccountably omitted in the body of the Dictionary under the words CLOCK and WATCH. But the bad health and occupations of the perſon who had engaged to write the article, have obliged us to defer it to the laſt opportunity which the alphabetical arrangement affords us; and, even now, the ſame cauſes unfortunately prevent the author from treating the ſubject in the manner he intended, and which it well deſerves. But we truſt that, from the account which is here given, the reader, who is converſant in mathematical philoſophy, will perceive the juſtneſs of the concluſions, and that an intelligent artiſt will have no heſitation in acceding to the propriety of the maxims of conſtruction deduced from them.

The regulator of a clock or watch is a pendulum or a balance. Without this check to the motion of the wheels, impelled by a weight or a ſpring, the machine would run down with a motion rapidly accelerating, till friction and the reſiſtance of the air induced a ſort of uniformity, as they do in a kitchen jack. But if a pendulum be ſo put in the way of this motion, that only one tooth of a wheel can paſs it at each vibration, the revolution of the wheels will depend on the vibration of the pendulum. This has long been obſerved to have a certain conſtancy, inſomuch that the aſtronomers of the Eaſt employed pendulums in meaſuring the times of their obſervations, patiently counting their vibrations during the phaſes of an eclipſe or the tranſits of the ſtars, and renewing them by a little puſh with the finger when they became too ſmall. Gaſſendi, Riccioli, and others, in more recent times, followed this example. The celebrated phyſician Sanctorius is the firſt perſon who is mentioned as having applied them as regulators of clock movements. Machines, however, called *clocks*, with a train of toothed wheels leading round an index of hours, had been contrived long before. The earlieſt of which we have any account is that of Richard of Wallingford, Abbot of St Alban's, in 1326 (A). It appears to have been regulated by a fly like a kitchen jack*. Not long after this Giacomo Dondi made one at Padua, which had a *motus ſuccuſſorius*, a hobbling or trotting motion; from which expreſſion it ſeems probable that it was regulated by ſome alternate movement. We cannot think that this was a pendulum, becauſe, once it was introduced, it never could have been ſupplanted by a balance. The alternate motion of a pendulum, and its ſeeming uniformity, are among the moſt familiar obſervations of common life; and it is ſurpriſing that they were not more early thought of for regulating time meaſurers. The alternate motions of the old balance is one of the moſt far-fetched means that can be imagined, and might paſs for the invention of a very reflecting mind, while a pendulum only requires to be drawn aſide from the plumb-line, to make it vibrate with regularity. The balance muſt be put in motion by the clock, and that motion muſt be ſtopped, and the contrary motion induced; and we muſt know that the ſame force and the ſame checks will produce uniform oſcillations. All this muſt be previouſly known before we can think of it as a regulator; yet ſo it is that clocks, regulated by a balance, were long uſed, and very common through Europe, before Galileo propoſed the pendulum, about the year 1600. Pendulum clocks then came into general uſe, and were found to be greatly preferable to balance clocks as accurate meaſurers of time. Mathematicians ſaw that their vibrations had ſome regular

* See his *Letter of Acceptance*.

* *Conradi Geſneri Epitome*, p. 604.

(A) Profeſſor Beckmann, in the firſt volume of his *Hiſtory of Inventions*, expreſſes a belief that clocks of this kind were uſed in ſome monaſteries ſo early as the 11th century, and that they were derived to the monks from the Saracens. His authorities, however, are diſcordant, and ſeem not completely ſatisfactory even to himſelf.

gular dependance on uniform gravity, and in their writings we meet with many attempts to determine the time and demonſtrate the iſochroniſm of the vibrations. It is amuſing to read theſe attempts. We wonder at the awkwardneſs and inſufficiency of the explanation given of the motions of pendulums, even by men of acknowledged eminence. Merſennus carried on a moſt uſeful correſpondence with all the mathematicians of Europe, and was the means of making them acquainted with each other; nay, he was himſelf well converſant in the ſcience; yet one cannot but ſmile at his reaſonings on this ſubject. Standing on the ſhoulders of our predeceſſors, we look around us, in great ſatisfaction with our own powers of obſervation, not thinking how we are raiſed up, or that we are trading with the ſtock left us by the diligent and ſagacious philoſophers of the 17th century (B). Riccioli, Gaſſendus, and Galileo, made ſimilar attempts to explain the motion of pendulums; but without ſucceſs. This honour was reſerved for Mr Huyghens, the moſt elegant of modern geometers. He had ſucceeded in 1656 or 1657 in adapting the machinery of a clock to the maintaining of the vibrations of a pendulum. Charmed with the accuracy of its performance, he began to inveſtigate with ſcrupulous attention the theory of its motion. By the moſt ingenious and elegant application of geometry to mechanical problems, he demonſtrated that the wider vibrations of a pendulum employed more time than the narrower, and that the time of a ſemicircular vibration is to that of a very ſmall one nearly as 34 to 29; and, aided by a new department of geometrical ſcience invented by himſelf, namely, the evolution of curves, he ſhewed how to make a pendulum ſwing in a cycloid, and that its vibrations in this curve are all performed in equal times, whatever be their extent.

But before this time, Dr Hooke, the moſt ingenious and inventive mechanician of his age, had diſcovered the great accuracy of pendulum clocks, having found that the manner in which they had been employed had obſcured their real merit. They had been made to vibrate in very large arches, the only motion that could be given them by the contrivances then known; and in 1656 he invented another method, and made a clock which moved with aſtoniſhing regularity. Uſing a heavy pendulum, and making it ſwing in very ſmall arches, the clocks ſo conſtructed were found to excel Mr Huyghens's cycloidal pendulums; and thoſe who were unfriendly to Huyghens had a ſort of triumph on the occaſion. But this was the reſult of ignorance. Mr Huyghens had ſhewn, that the error of $\frac{1}{100}$ of an inch, in the formation of the parts which produced the cycloidal motion, cauſed a greater irregularity of vibration than a circular vibration could do, although it ſhould extend five or ſix degrees on each ſide of the perpendicular. It has been found that the unavoidable inaccuracies, even of the beſt artiſts, in the cycloidal conſtruction, make the performance much inferior to that of a common pendulum vibrating in arches which do not exceed three or four degrees from the perpendicular. Such clocks alone are now made, and they exceed all expectation.

We have ſaid that a pendulum needed only to be removed from the perpendicular, and then let go, in order to vibrate and meaſure time. Hence it might ſeem, that nothing is wanted but a machinery ſo connected with the pendulum as to keep a regiſter, as it were, of the vibration. It could not be difficult to contrive a method of doing this; but more is wanted. The air muſt be diſplaced by the pendulum This requires ſome force, and muſt therefore employ ſome part of the momentum of the pendulum. The pivot on which it ſwings occaſions friction— the thread, or thin piece of metal by which it is hung, in order to avoid this friction, occaſions ſome expenditure of force by its want of perfect flexibility or elaſticity. Theſe, and other cauſes, make the vibrations grow more and more narrow by degrees, till at laſt the pendulum is brought to reſt. We muſt therefore have a contrivance in the wheelwork which will reſtore to the pendulum the ſmall portion of force which it loſes in every vibration. The action of the wheels therefore may be called a *maintaining power*, becauſe it keeps up the vibrations

But we now ſee that this may affect the regularity of vibration. If it be ſuppoſed that the action of gravity renders all the vibrations iſochronous, we muſt grant that the additional impulſion by the wheels will deſtroy that iſochroniſm, unleſs it be ſo applied that the ſum total of this impulſion and the force of gravity may vary ſo with the ſituation of the pendulum, as ſtill to give a ſeries of forces, or a law of variation, perfectly ſimilar to that of gravity. This cannot be effected, unleſs we know both the law which regulates the action of gravity. producing iſochroniſm of vibration, and the intenſity of the force to be derived from the wheels in every ſituation of the pendulum.

The neceſſary requiſite for the iſochronous motion of the pendulum is, that the force which urges it toward the perpendicular, be proportional to its diſtance from it (ſee DYNAMICS, n° 103. Cor. 7. *Suppl.*); and therefore, ſince pendulums ſwinging in ſmall circular arches are ſenſibly iſochronous, we muſt infer that ſuch is the law by which the accelerating action of gravity on them is really accommodated to every ſituation in thoſe arches.

Plate XLVIII.

It will greatly conduce to the better underſtanding of the effect of the maintaining power, if the reader keep in continual view the chief circumſtances of a motion of this kind. Therefore let AC*a* (fig. 1.) repreſent the arch paſſed over by the pendulum, ſtretched out into a ſtraight line. Let C be its middle point, when the pendulum hangs perpendicular, and A and *a* be the extremities of the oſcillation. Let AD be drawn perpendicular to AC, to repreſent the accelerating action of gravity on the pendulum when it is at A. Draw the ſtraight line DC*d*, and *ad*, perpendicular to A*a*. About C, as a centre, deſcribe the ſemicircle AFH*a*. Through

---

(B) We are provoked to make this obſervation, by obſerving at this moment, in a literary journal, a pert and petulant upſtart ſpeaking of Newton's optical diſcoveries in terms of ridicule and abuſe, employing theſe very diſcoveries to diminiſh his authority. Is it not thus that Chriſtianity is now ſlighted by thoſe who enjoy the fruits of the pure morality which it introduced?

Through any points B, K, *k*, *b*, &c. of A *a*, draw the perpendiculars BFE, KLM, &c. cutting both the ſtraight line and the ſemicircle. Then,

1. The actions of gravity on the pendulum, when in the ſituations B, K, &c. by which it is urged toward C, are proportional to, and may be repreſented by, the ordinates BE, KL, *b e*, *k l*, &c. to the ſtraight line DC *d*.

2. The velocities acquired at B, K, &c. by the acceleration along AB, AK, &c. are proportional to the ordinates BF, KM, &c. to the ſemicircle AH *a*; and, therefore, the velocity with which the pendulum paſſes through the middle point C, is to its velocity in any other point B, as CH to BF.

3. The times of deſcribing the parts AB, BK, KC, &c. of the whole arch of oſcillation, are proportional to, and may be repreſented by, the arches AF, FM, MH, &c. of the ſemicircle.

4. If one pendulum deſcribe the arch repreſented by AC *a*, and another deſcribe the arch KC *k*, they will deſcribe them in equal times, and their maximum velocities (viz. their velocities in the middle point), are proportional to AC and KC; that is, the velocities in the middle point are proportional to the width of the oſcillations.

The ſame proportions are true with reſpect to the motions outwards from C. That is, when the pendulum deſcribes CA, with the initial velocity CH, its velocity at K is reduced to KM by the retarding action of gravity. It is reduced to BF at B, and to nothing at A; and the times of deſcribing CK, KB, BA, CA, are as HM, HF, HA. Another pendulum ſetting out from C, with the initial velocity CO, reaches only to K, CK being = CO. Alſo the times are equal.—If we conſider the whole oſcillation as performed in the direction A *a*, the forces AD, BE, KL accelerate the pendulum, and the ſimilar forces *a d*, *b e*, *k l*, on the other ſide, retard it. The contrary happens in the next oſcillation *a*CA.

5. The areas DABE, DAKL, &c. are proportional to the ſquares of the velocities acquired by moving along AB, AK, &c. or to the diminution of the ſquares of the velocities ſuſtained by moving outwards along BA or KA, &c.

The conſideration of this figure will enable the reader (even though not a mathematician) to form ſome notion of the effect of any propoſed application of a maintaining power by means of wheelwork: For, knowing the weight of the pendulum, we know the accelerating action of that weight in any particular ſituation A of the pendulum. We alſo know what addition or ſubtraction we produce on the pendulum in that ſituation by the wheel-work. Suppoſe it is an addition of preſſure equal to a certain number of grains. We can make AD to D δ as the firſt to the laſt; and then A δ will be the whole force urging the pendulum toward C. Doing the ſame for every point of AC, we obtain a line $\delta\,\varepsilon\,\lambda\,c$, which is a new ſcale of forces, and the ſpace DC δ, comprehended between the two ſcales CD and C δ, will expreſs the addition made to the ſquare of the velocity in paſſing along AC by the joint action of gravity and the maintaining power. Alſo, by drawing a line $\kappa\,\pi$ perpendicular to AC, making the ſpace C $\tau\,\kappa$ equal to CAD, the point π will be the limit of the oſcillation outward from C, where the initial velocity HC is extinguiſhed. If the line $\kappa\,\pi$ cut the ſame circle in θ, one-half the arch θ A will nearly expreſs the contraction made in the time of the outward oſcillation by the maintaining power. An accurate determination of this laſt circumſtance is operoſe, and even difficult; but this ſolution is not far from the truth, and will greatly aſſiſt our judgment of the effect of any propoſal, even though $\kappa\,\pi$ be drawn only by the judgement of the eye, making the area left out as nearly equal to the area taken in as we can eſtimate by inſpection. This is ſaid from experience.

Since the motion of a pendulum or balance is alternate, while the preſſure of the wheels is conſtantly in one direction, it is plain that ſome art muſt be uſed to accommodate the one to the other. When a tooth of the wheel has given the balance a motion in one direction, it muſt quit it, that it may get an impulſion in the oppoſite direction. The balance or pendulum thus eſcaping from the tooth of the wheel, or the tooth eſcaping from the balance, has given to the general contrivance the name of SCAPEMENT among our artiſts, from the French word *echappement*. We proceed, therefore, to conſider this ſubject more particularly, firſt conſidering the ſcapements which are peculiarly ſuited to the ſmall vibrations of pendulums, and then thoſe which muſt produce much wider vibrations in balances. This, with ſome other circumſtances, render the ſcapements for pendulums and balances very different.

I. *Of the Action of a Wheel and Pallet.*

THE ſcapement which has been in uſe for clocks and watches ever ſince their firſt appearance in Europe, is extremely ſimple, and its mode of operation is too obvious to need much explanation. In fig. 2. XY repreſents a horizontal axis, to which the pendulum P is attached by a ſlender rod, or otherwiſe. This axis has two leaves C and D attached to it, one near each end, and not in the ſame plane, but ſo that when the pendulum hangs perpendicularly, and at reſt, the piece C ſpreads a few degrees to the right hand, and D as much to the left. They commonly make an angle of 70, 80, or 90 degrees. Theſe two pieces are called PALLETS. AFB repreſents a wheel, turning round on a perpendicular axis EO, in the order of the letters AFEB. The teeth of this wheel are cut into the form of the teeth of a ſaw, leaning forward, in the direction of the motion of the rim. As they ſomewhat reſemble the points of an old-faſhioned royal diadem, this wheel has got the name of the CROWN WHEEL. In watches it is often called the *balance wheel*. The number of teeth is generally odd; ſo that when one of them B is preſſing on a pallet D, the oppoſite pallet C is in the ſpace between two teeth A and I. The figure repreſents the pendulum at the extremity of its excurſion to the right hand, the tooth A having juſt eſcaped from the pallet C, and the tooth B having juſt dropped on the pallet D. It is plain, that as the pendulum now moves over to the left, in the arch PG, the tooth B *continues* to preſs on the pallet D, and thus accelerates the pendulum, both during its deſcent along the arch PH, and its aſcent along the arch HG. It is no leſs evident, that when the pallet D, by turning round the axis XY, raiſes its point above the plane of the wheel, the tooth B eſcapes from it, and I drops on the pallet C, which is now nearly perpendicular. I preſſes C to the right, and

and accelerates the motion of the pendulum along the arch GP. Nothing can be more obvious than this action of the wheel in maintaining the vibrations of the pendulum. We can eaſily perceive, alſo, that when the pendulum is hanging perpendicularly in the line XH, the tooth B, by preſſing on the pallet D, will force the pendulum a little way to the left of the perpendicular, and will force it ſo much the farther as the pendulum is lighter; and, if it be ſufficiently light, it will be forced ſo far from the perpendicular that the tooth B will eſcape, and then I will catch on C, and force the pendulum back to P, where the whole operation will be repeated. The ſame effect will be produced in a more remarkable degree, if the rod of the pendulum be continued through the axis XY, and a ball Q put on the other end to balance P. And, indeed, this is the contrivance which was firſt applied to clocks all over Europe, before the application of the pendulum. They were balance clocks. The force of the wheel was of a certain magnitude, and therefore able, during its action on a pallet, to communicate a certain quantity of motion and velocity to the balls of the balance. When the tooth B eſcapes from the pallet D, the balls are then moving with a certain velocity and momentum. In this condition, the balance is checked by the tooth I catching on the pallet C. But it is not inſtantly ſtopped. It continues its motion a little to the left, and the pallet C forces the tooth I a little backward. But it *cannot* force it ſo far as to eſcape over the top of the tooth I; becauſe all the momentum of the balance was generated by the force of the tooth B; and the tooth I is equally powerful. Beſides, when I catches on C, and C continues its motion to the left, its lower point applies to the face of the tooth I, which now acts on the balance by a long and powerful lever, and ſoon ſtops its farther motion in that direction, and now, continuing to preſs on C, it urges the balance in the oppoſite direction.

Thus we ſee that in a ſcapement of this kind, the motion of the wheel muſt be very hobbling and unequal, making a great ſtep forward, and a ſhort ſtep backward, at every beat. This has occaſioned the contrivance to get the name of the RECOILING SCAPEMENT, the recoiling pallets. This hobbling motion is very obſervable in the wheel of an alarm.

Thus have we obtained two principles of regulation. The firſt and moſt obvious, as well as the moſt perfect, is the natural iſochronous vibration of a pendulum. The only uſe of the wheelwork here, beſides regiſtering the vibrations, is to give a gentle impulſion to the pendulum, by means of the pallet, in order to compenſate friction, &c. and thus maintain the vibrations in their primitive magnitude. But there is no ſuch native motion in a balance, to which the motion of the wheels muſt accommodate itſelf. The wheels, urged by a determined preſſure, and acting through a determined ſpace (the face of the pallet), muſt generate a certain determined velocity in the balance; and therefore the time of the oſcillation is alſo determined, both during the progreſſive and the retrograde motion of the wheel. The actions being ſimilar, and through equal ſpaces, in every oſcillation, they muſt employ the ſame time. Therefore a balance, moved in this manner, muſt be iſochronous, and a regulator for a time-keeper.

By thus employing a balance, the horizontal poſition of the axis XY is unneceſſary. Accordingly, the old clocks had this axis perpendicular, by which means the whole weight of the balance reſted on the point of the pivot Y or X, according as the balance PQ was placed above or below. By making the ſupporting pivot of hard ſteel, and very ſharp, friction was greatly diminiſhed. Nay, it was entirely removed from this part of the machine by ſuſpending the balance by a thread at the end X, inſtead of allowing it to reſt on the point of the pivot Y.

As the balance regulator of the motion admits of every poſition of the machine, thoſe clocks were made in an infinite variety of fanciful forms, eſpecially in Germany, a country famous for mechanical contrivances. They were made of all ſizes, from that of a great ſteeple clock, to that of an ornament for a lady's toilet. The ſubſtitution of a ſpring in place of a weight, as a firſt mover of the wheel-work, was a moſt ingenious thought. It was very gradual. We have ſeen, in the Emperor's muſeum at Bruſſels, an old (perhaps the firſt) ſpring clock, the ſpring of which was an old ſword blade, from the point of which a catgut was wound round the barrel of the firſt wheel. Some ingenious German ſubſtituted the ſpiral ſpring, which both took leſs room, and produced more revolutions of the firſt wheel.

When clocks had been reduced to ſuch ſmall ſizes, the wiſh to make them portable was very natural; and the means of accompliſhing this were obvious, namely, a farther reduction of their ſize. This was accompliſhed very early; and thus we obtained pocket watches, moved by a ſpiral ſpring, and regulated by a balance with the recoiling ſcapement, which is ſtill in uſe for common watches. The hobbling motion of the crown wheel is very eaſily ſeen in all of them.

It is very uncertain who firſt ſubſtituted a pendulum in place of the balance (CLOCK, *Encycl.*) Huyghens, as we have already obſerved, was the firſt who inveſtigated the motions of pendulums with ſucceſs, and his book *De Horologio Oſcillatorio* may be conſidered as the elements of refined mechanics, and the ſource of all the improvements that have been made in the conſtruction of ſcapements. But it is certain that Dr Hooke had employed a pendulum for the regulation of a clock many years before the publication of the abovementioned treatiſe, and he claims the merit of the invention of the *only proper* method of employing it. We imagine therefore that Dr Hooke's invention was nothing more than a ſcapement for a pendulum making ſmall vibrations, without making uſe of the oppoſite motions of the two ſides of the crown wheel. Dr Hooke had contrived ſome ſcapement more proper for pendulums than the recoiling pallets, becauſe certainly thoſe might be employed, and are actually employed as a ſcapement for pendulum clocks to this day, although they are indeed very ill adapted to the purpoſe. He had not only remarked the great ſuperiority of ſuch pendulum clocks as were made before Huyghens's publication of the cycloidal pendulum over the balance clocks, but had alſo ſeen their defects, ariſing from the light pendulums and wide arches of vibration, and invented a ſcapement of the nature of thoſe now employed. The pendulum clock which he made in 1658 for Dr Wilkins, afterwards Biſhop of Cheſter, is mentioned by the inventor as peculiarly ſuited to the moderate ſwing of a pendulum; and he oppoſes this circumſtance to a general practice of wide vibrations and trifling pendulums. The French are not in the practice of aſcribing to us any thing that they can claim as their own; yet Lepaute ſays that the *Echappement à l'Ancre* came from England about the year 1665. It is alſo admitted by him that clock-making flouriſhed in England at that time, and that the French artiſts went to London to improve in it. Putting theſe and other circumſtances together, we think it highly probable that we are indebted to Dr Hooke for the ſcapement now in uſe. The principle of this is altogether different from the ſimple pallets and direct impulſe already deſcribed; and is ſo far from being obvious, that the manner of action has been miſunderſtood, even by men of ſcience, and writers of ſyſtems of mechanics.

In this ſcapement we employ thoſe teeth of the wheel which are moving in one direction; whereas in the former ſcapement, oppoſite teeth were employed moving in contrary directions. Yet even here we muſt communicate an alternate motion to the axis of the pallets. The contrivance, in general, was as follows: On the axis A (See fig. 3) of the pendulum or balance is fixed a piece of metal BAC, called the CRUTCH by our artiſts, and the ANCHOR by the French. It terminates in two faces B b C c of tempered ſteel, or of ſome hard ſtone. Theſe are called the PALLETS, and it is on them that the teeth of the wheel act. The faces B b C c are ſet in ſuch poſitions that the teeth puſh them out of the way. Thus B puſhes the pallet to the left, and C puſhes its pallet to the right. Both puſh their pallets ſidewiſe outward from the centre of the wheel. The pallet B is uſually called the *leading*, and C the *driving* pallet by the artiſts, although it appears to us that theſe names ſhould be reverſed, becauſe B *drives* the pallet out of the way, and C *pulls* or leads it out of the way. They might be called the *firſt* and *ſecond* pallet, in the order in which they are acted on by the wheel. We ſhall uſe either denomination. The figure is accommodated to the inactive or reſting poſition of the pendulum. Suppoſe the pendulum drawn aſide to the right at Q, and then let go. It is plain that the tooth B, preſſing on the face of the pallet β B b all the way from β to b, thruſts it aſide outwards, and thus, by the connection of the crutch with the pendulum rod, aids the pendulum's motion along the arch QPR. When the pendulum reaches R, the point of the tooth B has reached the angle b of the pallet, and eſcapes from it. The wheel preſſing forward, another tooth C drops on the pallet face C c, and, by preſſing this pallet outward, evidently aids the pendulum in its motion from R to P. The tooth C eſcapes from this pallet at the angle c, and now a tooth B′ drops on the firſt pallet, and again aids the pendulum; and this operation is repeated continually.

The mechaniſm of this communication of motion is thus explained by ſeveral writers of elements. The tooth B (fig. 2.) is urged forward in the direction BD, perpendicular to the radius MB of the SWING WHEEL. It therefore preſſes on the pallet, which is moveable only in the direction BE, perpendicular to BA the radius of the pallet. Therefore the force BD muſt be reſolved into two, *viz.* BE, in the direction in which alone the pallet can move, and ED, or BF, perpendicular to that direction. The laſt of theſe only preſſes the pallet and crutch againſt the pivot hole A. BE is the only uſeful force, or the force communicated to the pallet, enabling it to maintain the pendulum's motion, by reſtoring the momentum loſt by friction and other cauſes.

But this is a very erroneous account of the *modus operandi*, as may be ſeen at once, by ſuppoſing the radius of the pallets to be a tangent to the wheel. This is a poſition moſt frequently given to them, and is the very poſition in fig. 3. In this caſe MB is perpendicular to BA, and therefore BD will coincide with BA, and there will be no ſuch force as BE to move the pendulum. It is a truth, deducible from what we know of the mechanical conſtitution of ſolid bodies, and confirmed by numberleſs obſervations, that when two ſolid bodies preſs on each other, either in impulſion or in dead preſſure, the direction in which the mutual preſſure is exerted is always perpendicular to the touching ſurfaces, whatever has been the direction of the impelling body (See IMPULSION, *Suppl.* n° 66. MACHINERY, *Suppl.* n° 35. and ſeveral other parts of this Work) Moreover this preſſure is mutual, equal, and oppoſite. Whatever be the ſhapes of the faces of the tooth and pallet, we can draw a plane BN, which is the common tangent to both ſurfaces, and a line HBI through the point of contact perpendicular to BN. It is farther demonſtrated in the article MACHINERY, *Suppl.* n° 35, &c. that the action of the wheel on the pendulum is the ſame as if the whole crutch were annihilated, and in its ſtead there were two rigid lines AH, MI, from the centres of the crutch and wheel, perpendicular to HI, and connected by a third rigid line or rod HI, touching the two in H and I.

For if a weight V be hung at v, the extremity of the horizontal radius M v of the wheel, it will act on the lever v MI, preſſing its point I upwards in the direction IH perpendicular to MI; the upper end of this rod IH will, in like manner, preſs the extremity H of the rod HA, and this will urge the pendulum from P toward R. To withſtand this, the pendulum rod AP may be withheld by a weight z, hanging by a thread on the extremity of the horizontal lever A z, equal to M v, and connected with the crutch and pendulum. The weights V and z may be ſo proportioned to each other that, by acting perpendicularly on the crooked levers v MI, and z AH, the preſſures at H and I ſhall be equal, and juſt balance each other by the intervention of the rod HI. When this is the caſe, we have put things into the ſame mechanical ſtate, in reſpect of mutual action, as is effected by the crutch, pallets, and wheel, which, in like manner, produce equal preſſures at B the point of contact, in the direction BH and BI. The weight V may be ſuch as produces the very ſame effect at B that is produced by the previous train of wheel-work. The weight z therefore muſt be juſt equal to the force produced by the wheel-work on the point z of the pendulum rod, becauſe by acting in the oppoſite direction it juſt balances it. Let us ſee therefore what force is communicated to the pendulum by the wheels.

Let x be the upward preſſure excited at I, and y the equal oppoſite preſſure excited at H. Then, by the property of the lever, we have $\mathrm{MI} : \mathrm{M}v = \mathrm{V} : x$, and $x \times \mathrm{MI} = \mathrm{V} \times \mathrm{M}v$. In like manner $y \times \mathrm{AH} = \mathrm{Z} \times \mathrm{A}z$. Therefore, becauſe $x = y$, and $\mathrm{A}z = \mathrm{M}v$, we have $\mathrm{V} : \mathrm{Z} = \mathrm{MI} : \mathrm{AH}$. That is, the force exerted by the tooth of the wheel in the direction of its motion is to the force impreſſed on the pendulum rod at a diſtance equal to the radius of the wheel as MI to AH. The force impreſſed on the ball of the pendulum is leſs than this in the proportion of AP to A z, or M v.

Cor. 1. If the perpendiculars MN. AV, be drawn on the tangent plane, the forces at B and z will be as BN to BO. For theſe lines are reſpectively equal to MI and AH.

Cor. 2. If HI meet the line of the centres AC in S, the forces will be as SM to SA ; that is, $V : Z = SM : SA$.

Cor. 3. If the face β B b of the pallet be the evolutrix of a circle deſcribed with the radius AH, and the face of the tooth be the evolutrix of a circle deſcribed with the radius MI, the force impreſſed on the pendulum by the wheels will be conſtant during the whole vibration (Machinery, nº 36) But theſe are not the only forms which produce this conſtancy. The forms of teeth deſcribed by different authors, ſuch as De la Hire, Camus, &c. for producing a conſtant force in trains of wheel-work, will have the ſame effect here. It is alſo eaſy to ſee that the force impreſſed on the pendulum may be varied according to any law, by making theſe faces of a proper form. Therefore the face, from B outwards, may be ſo formed that the force communicated to the pendulum by the wheels, during its deſcent from Q to P, may be in one conſtant proportion to the acceleration of gravity, and then the ſum of the forces will be ſuch as produce iſochronous vibrations. If the inner part B b of the face be formed on the ſame principle, the difference of the forces will have the ſame law of variation. If the face βb be the evolutrix of a circle, and the tooth B terminate in a point gently rounded, or quite angular, the force on the pendulum will continually increaſe as the tooth ſlides from β to b For the line AH continues of the ſame magnitude, and MI diminiſhes. The contrary will happen, if the pallet be a point, either ſharp or rounded, and if the face of the tooth be the evolutrix now mentioned ; for MI will remain the ſame, while AH diminiſhes. If the tooth be pointed, and βb be a ſtraight line, the force communicated to the pendulum will diminiſh, while the tooth ſlides from β to b. For in this caſe AH diminiſhes and MI increaſes.

Cor. 4. In general, the force on the pendulum is greater as the angle MB b increaſes, and as AB b diminiſhes.

Cor. 5. The angular velocity of the wheel is to that of the pendulum, in any part of its vibration, as AH to MI. This is evident, becauſe the rod IH moving (in the moment under conſideration) in its own direction, the points H and I move through equal ſpaces, and therefore the angles at A and M muſt be inverſely as the radii.

All that has now been ſaid of the firſt pallet AB may be applied to the ſecond pallet AC.

If the perpendiculars C s be drawn to the touching plane o C n, cutting AM in s, we ſhall have $V : z = sM : sA$, as in Cor. 2. And if the perpendiculars Mi, Ah, be drawn on Cs, we have $V : Z = Mi : Ah$, as in the general theorem. The only difference between the action on the two pallets is, that if the faces of both are plain, the force on the pendulum increaſes during the whole of the action on the pallet C, whereas it diminiſhes during the progreſs of the tooth along the other pallet.

The reader will doubtleſs remark that each tooth of the wheel acts on both pallets in ſucceſſion ; and that, during its action on either of them, the pendulum makes one vibration. Therefore the number of vibrations during one turn of the wheel is double the number of the teeth : conſequently, while the tooth ſlides along one of the pallets, it advances half the ſpace between two ſucceſſive teeth ; and when it eſcapes from the pallet, the other tooth *may* be juſt in contact with the other pallet. We ſay it *may* be ſo ; in which caſe there will be no dropping of the teeth from pallet to pallet. This, however, requires very nice workmanſhip, and that every tooth be at preciſely the ſame diſtance from its neighbour. Should the tooth which is juſt going to apply to a pallet chance to be a little too far advanced on the wheel, it would touch the pallet before the other had eſcaped. Thus, ſuppoſe that before B eſcapes from the point b of the pallet, the tooth C is in contact with the pallet CG, B cannot eſcape. Therefore when the pendulum returns from R towards Q, the pallet βb, returning along with it, will puſh back the tooth B of the wheel. It does this in oppoſition to the force of the wheel. Therefore, whatever motion the wheel had communicated to the pendulum, during its ſwing from P to Q, will now be taken from it again. The pendulum will not reach Q, becauſe it had been aided in its motion from Q, and had proceeded further than it would have done without this help. Its motion toward Q is further diminiſhed by the friction of the pallet. Therefore it will now return again from ſome nearer point q, and will not go ſo far as in the laſt vibration, but will return through a ſtill ſhorter arch : And this will be ſtill more contracted in the next vibration, &c. &c. Thus it appears that if a tooth chances to touch the pallet before the eſcape of the other, the wheel will advance no farther, and ſoon after the pendulum will be brought to reſt.

For ſuch reaſons it is neceſſary to allow one tooth to eſcape *a little before* the other reaches the pallet on which it is to act, and to allow a ſmall drop of the teeth from pallet to pallet. But it is accounted bad workmanſhip to let the drop be conſiderable, and *cloſe ſcapement* is accounted a mark of care and of good workmanſhip It is evidently an advantage, becauſe it gives a longer time of action on each pallet. This freeing the ſcapement cannot be accompliſhed by filing ſomething from the face of the tooth ; becauſe this being done to all, the diſtance between them is diminiſhed rather than augmented. The pallets muſt be firſt ſcaped as cloſe as poſſible. This obliges the workman to be careful in making the teeth equidiſtant. Then a ſmall matter is taken from the point of each pallet, by filing off the back $b\,r$ of the pallet. The tooth will now eſcape before it has moved through half a ſpace.

From all that has been ſaid on this particular, it appears that the interval between the pallets muſt comprehend a certain number of teeth, and half a ſpace more.

The firſt circumſtance to be conſidered in contriving a ſcapement is the angular motion that is intended to be given to the pendulum during the action of the wheel. This is uſually called the *angle of ſcapement*, or the *angle of action*. Having fixed on an angle a that we think proper, we muſt ſecure it by the poſition and form of the face of the pallets. Knowing the number of teeth in the ſwing-wheel, divide 180° by this number, and the quotient is the angle b of the wheel's motion during one vibration of the pendulum. In the line AM, joining the centres of the crutch and wheel, make SM to SA, and sM to sA, as the angle a to the angle b; and then, having determined how many teeth ſhall be comprehended between the pallets, call this number n. Multiply the angle b by $n + 1$. and take the half of the product. Set off this half in the circumference of the wheel (at the points of the teeth) on each ſide of the line joining the centres of the crutch and wheel, as at TB and TC. Through S and s draw SB and sC, and through B draw β B b perpendicular to SB, for the medium poſition of the face of the firſt pallet; that is, for its poſition when the pendulum hangs perpendicular. In like manner, drawing o C n perpendicular to sC, we have the medium poſition of the ſecond pallet. The demonſtration of this conſtruction is very evident from what has been ſaid.

We have hitherto ſuppoſed that the pendulum finiſhes its vibration at the inſtant that a tooth of the wheel eſcapes from a pallet, and another tooth drops on the other pallet. But this is never, or ſhould never be, the caſe. The pendulum is made to ſwing ſomewhat beyond the angle of ſcapement: for if it do not when the clock is clean and in good order, but ſtop preciſely at the drop of a tooth, then, when it grows foul, and the vibration diminiſhes, the teeth will not eſcape at all, and the clock will immediately ſtop. Therefore the force communicated by the wheels during the vibration within the limits of ſcapement, muſt be increaſed ſo as to make the pendulum *throw* (as the artiſts term it) farther out; and a clock is more valued when it throws out conſiderably beyond the angle of ſcapement. There are good reaſons for this The momentum of the pendulum, and its power to regulate the clock (which Mr Harriſon ſignificantly called its *dominion*), is proportional to the width of its vibrations very nearly.

This circumſtance of exceeding the angle of ſcapement has a very great influence on the performance of the clock, or greatly affects the dominion of the pendulum. It is eaſy to ſee that, when the face βb of the leading pallet is a plane, if the pendulum continue its motion to the right, from P toward Q, after the tooth B has dropped on it, the pallet will puſh the wheel back again, while the tooth ſlides outward on the pallet toward β. Such pallets therefore will make a *recoiling ſcapement*, reſembling, in this circumſtance, the old pallet employed with the crown wheel, and will have the properties attached to this circumſtance. One conſequence of this is, that it is much affected by any inequalities of the maintaining power. It is a matter of the moſt familiar obſervation, that a common watch goes ſlower when within a quarter of an hour of being down, when the action of the ſpring is very weak, in conſequence of its not pulling by a radius of the fuſee. We obſerve the ſame thing in the beating of an alarum clock. Alſo if we at any time preſs forward the wheelwork of a common watch with the key, we obſerve its beats accelerate immediately. The reaſon of this is pretty plain. The balance, in conſequence of the acceleration in the angle of ſcapement, would have gone much farther, employing a conſiderable time in the excurſion. This is checked abruptly, which both ſhortens the vibration and the time employed in it. In the return of the pendulum, the motion is accelerated the whole way, along an arch which is ſhorter than what correſponds to its velocity in the middle point; for it is again checked on the other ſide, and does not make its full excurſion. Moreover, all this irregularity of force, or the great deviation from a reſiſtance to the excurſion proportional to the diſtance from the middle point, is exerted on the pendulum when it is near the end of the excurſion, where the velocity being ſmall, this irregular force acts long upon it, at the very time that it has little force wherewith to reſiſt it. All temporary inequalities of force, therefore, will be more felt in this ſituation of the balance than if they had been exerted in the middle of its motion. And although the regulating power of a pendulum greatly exceeds that of the light balances uſed in pocket watches, ſomething of the ſame kind may be expected even in pendulum clocks. Accordingly this appears by a ſeries of experiments made by Mr Berthoud, a celebrated watchmaker of Paris. A clock, with a half ſecond pendulum weighing five drams, was furniſhed with a recoiling ſcapement, whoſe pallets were planes. The angle of ſcapement was $5\frac{1}{2}$ degrees. When actuated with a weight of two pounds, it ſwung 8°, and loſt 15″ per hour; with four pounds, it ſwung 10°, and loſt 6″. Thus it appears that by doubling the maintaining power, although the vibration was increaſed in conſequence of the greater impulſe, the time was leſſened 9″ per hour, viz about $\frac{1}{400}$. It is plain, from what was ſaid when we deſcribed the firſt ſcapement, that an increaſe of maintaining power muſt render the vibration more frequent. We ſaw, on that occaſion, that, even when the gravity of the pendulum is balanced by a weight on the other end of the rod, the force of the wheels will produce a vibratory motion, and that an augmentation of this force will increaſe it, or make the vibrations more rapid. The preciſe effect of any particular form of teeth can be learned only by computing the force on the pendulum in every poſition, and then conſtructing the curve $\delta \epsilon \lambda$ C of fig. 1. The rapid increaſe of the ordinates beyond thoſe of the triangle ADC, forms a conſiderable area DA πo, to compenſate the area πo C, and thus makes a conſiderable contraction A π of the vibration, and a ſenſible contraction $\frac{A\theta}{2}$ of the time.

Mr George Graham, the celebrated watchmaker in London, was alſo a good mathematician, and well qualified to conſider this ſubject ſcientifically. He contrived a ſcapement, which he hoped would leave the pendulum almoſt in its natural ſtate. The acting face of the pallet $a\,b\,c$ (fig. 4.) is a plane. The tooth drops on a, and eſcapes from c, and is on the middle point b when the pendulum is perpendicular. Beyond a, the face of the pallet is an arch $a\,d$, whoſe centre is A, the centre of the crutch. The maintaining power is made ſo great as to produce a much greater vibration than the angle of active ſcapement a A c. The conſequence of this is that, when the tooth drops on the angle a, the pendulum, continuing its motion, carries the crutch along with it, and the tooth paſſes on the arch $a\,d$, in a direction paſſing through the centre of the crutch. This preſſure can neither accelerate nor retard the motion

tion of the crutch and pendulum. As the pendulum was accelerated after it paſſed the perpendicular, by the other pallet, it will (if quite unobſtructed) throw out farther than what correſponds to the velocity which it had in the middle point of its vibration; perhaps till the tooth paſſes from *a* to *e* on the circular arch of the pallet. But although it ſuſtains no contrary action from the wheels during this excurſion beyond the angle of ſcapement, it will not proceed ſo far, but will ſtop when the tooth reaches *d*; becauſe there muſt be ſome reſiſtance ariſing from the friction of the tooth along the arch *a d*, and from the clammineſs of the oil employed to lubricate it: but this reſiſtance is exceedingly minute, not amounting to $\frac{1}{8}$th of the preſſure on the arch. Nay, we think that it appears from the experiments of Mr Coulomb that, in the caſe of ſuch minute preſſures on a ſurface covered with oil, there is no ſenſible retardation analogous to that produced by friction, and that what retardation we obſerve ariſes entirely from the clammineſs of the oil. We are ſo imperfectly acquainted with the manner in which friction and viſcidity obſtruct the motions of bodies, that we cannot pronounce deciſively what will be their effect in the preſent caſe. Friction does not increaſe much, if at all, by an increaſe of velocity, and appears like a fixed quantity when the preſſure is given. This makes all motions which are obſtructed by friction terminate abruptly. This will ſhorten both the length and the time of the outward excurſion of the pendulum. The viſcidity of the oil reſiſts differently, and more nearly in the proportion of the velocities. The diminution of motion will not be in this proportion, becauſe in the greater velocities it acts for a ſhorter time. Were this accurately the caſe, the reſiſtance of viſcidity would alſo be nearly conſtant, and it would operate as friction does. But it does not ſtop a motion abruptly, and the motions are extinguiſhed gradually. Therefore, although viſcidity muſt always diminiſh the extent of the excurſion, it may ſo vary as not to diminiſh the time. We apprehend, however, that it generally does. But whatever happens in the excurſion, the return will certainly be ſlower, and employ more time than if it had not been obſtructed, becauſe the velocity in every point is leſs than if perfectly free. The whole arch, conſiſting of a returning arch and an excurſion on the other ſide, may be either ſlower or quicker, according as the compenſation is complete or not, or is even overdone.

All theſe reflections occurred to Mr Graham; and he was perſuaded that the time of the tooth's remaining on the arch *a d*, both aſcending and deſcending, would differ very little from that of the deſcription of the ſame arch by a free pendulum. The great cauſes of irregularity ſeemed to be removed, viz. the inequalities in the action of the wheels in the vicinity of the extremity of the vibration, where the pendulum having little momentum is, long in the ſame little ſpace, expoſed to their action. The derangement produced by any force depends on the time of its action, and therefore muſt be greateſt when the motion is ſloweſt. The pendulum gets its impulſe in the very middle of its vibration, where its velocity is the greateſt; and therefore the inequalities of the maintaining power act on it only for a ſhort time, and make a very trifling alteration in the time of its deſcribing the arch of ſcapement. Beyond this, it is nearly in the ſtate of a free pendulum; nay, even though it be affected by an inequality of the maintaining power, and it be accelerated beyond its uſual rate in that arch, the chief effect of this will be to cauſe it to deſcribe a larger arch of excurſion. The ſhortening of the time of this deſcription by the friction will be the ſame as before, happening at the very end of the excurſion; but the return will be more retarded by the friction on a longer arch. And, by this, a compenſation may be made for the trifling contraction of the time of deſcribing the arch of ſcapement.

This circumſtance of giving the impulſe in the middle of the vibration, where its time of action is the ſmalleſt poſſible, and whereby the pendulum is ſo long left free from the action of the wheels, is of the very firſt importance in all ſcapements, and ſhould ever be in the mind of the mechanician. When this is adhered to, the form of the face *a b c* is ſcarcely of any moment. Much has been written ou this form, and many attempts have been made to make it ſuch that the action of the wheels ſhall be proportional to the action of gravity. To do this is abſolutely impoſſible. Mr Graham made them planes, not only becauſe of eaſieſt execution, but becauſe a plane really conſpires pretty well with the change of gravity. While the pendulum moves from Q to P (fig. 3.), the force of gravity, acting in the direction QP, is continually diminiſhing. So is the accelerating power of the pallet from *a* to *b*. When the pendulum riſes from P to R, a force in the oppoſite direction RP continually increaſes. This is analogous to the continual diminution of a force in the direction PR. Now we have ſuch a diminution of ſuch a force, in the action of the pallet from *b* to *c*, and ſuch an augmentation in the action of the other pallet.

For all theſe reaſons, this conſtruction of a ſcapement appeared very promiſing. Mr Graham put it in practice, and it anſwered his moſt ſanguine expectation, and is now univerſally adopted in all nice clocks. Mr Graham, however, did not think it prudent to cauſe a tooth to drop on the very angle *a* of the pallet. He made it drop on a point *f* of the arch of excurſion. This has alſo the advantage of diminiſhing the angle of action, which we have proved to be of ſervice. It requires, indeed, a greater maintaining power; but this can eaſily be procured, and is leſs affected by the changes to which it is liable by the effect of heat and cold on the oil. Our obſervations on the effects of friction and viſcidity in the arch *a d* ſeem to be confirmed by the obſervations of ſeveral artiſts, who agree in ſaying that a great increaſe of maintaining power increaſes the vibrations, but makes them perceptibly ſlower. When they wrote, much oil was applied to diminiſh the friction on the arch of repoſe; but, ſince that time, the rubbing parts were made ſuch as required no oil, and this retardation diſappeared. In the clock of the tranſit room of the Royal Obſervatory, the angle of action ſeldom exceeds one-third of the ſwing of the pendulum. The pallets are of oriental ruby, and the wheel is of ſteel tempered to the utmoſt degree of hardneſs. This clock never varies a whole ſecond from equable motion in the courſe of five days.

This contrivance is known by the name of the DEAD BEAT, the DEAD SCAPEMENT; becauſe the ſeconds index ſtands ſtill after each drop, whereas the index of a clock with a recoiling ſcapement is always in motion, hobbling backward and forward.

Theſe ſcapements, both recoiling and dead beat, have been made in a thouſand forms; but any perſon tolerably acquainted with mechanics, will ſee that they are all on the ſame principles, and differ only in ſhape or ſome equally unimportant circumſtance. Perhaps the moſt convenient of any is that repreſented in fig. 5. where the ſhaded part is the crutch, made of braſs or iron, and A and B are two pieces of agate, flint, or other hard ſtone, cut into the proper ſhape for a pallet of either kind, and firmly fixed in proper ſockets. They project half an inch, or thereabouts, in front of the crutch, ſo that the ſwing wheel is alſo before the crutch, diſtant about $\frac{1}{10}$th of an inch or ſo. Pallets of ruby, driven by a hard ſteel ſwing wheel, need no oil, but merely to be once rubbed clean with an oily cloth.

Sometimes the wheel has pins inſtead of teeth. They are ranged round the rim of the wheel, perpendicular to its plane, and both pallets are on one ſide of the wheel, ſtanding perpendicular to its plane. One of theſe pins drops from the firſt to the ſecond pallet at once. The pallets are placed on two arms, as in fig. 6. in which caſe the pins are alternately on different ſides of the wheel; or on one, as in fig. 7. By the motion of the pendulum to the right, the pin (in fig. 7.), after reſting on the concave arch *d a*, acts on the face *a c*, and drops from *c* on the other concave arch *i g*, which continues to move a little way to the right. It then returns, and the pin ſlides and acts on the pallet *i h*, and eſcapes at *h*; and the next pin is then on the arch of repoſe *d a*.

It being evident that the recoiling ſcapement accelerates the vibrations beyond the rate of a free pendulum, and it alſo appearing to many of the firſt artiſts that the dead ſcapement retards them, they have attempted to form a ſcapement which ſhall avoid both of theſe defects, by forming the arches *a d*, *i g*, ſo as to produce a very ſmall recoil. Mr Berthoud does this in a very ſimple manner, by placing the centre of *a d* at a ſmall diſtance from that of the crutch, ſo as to make the riſe of the pallet above the concentric arch about one-third of the arch itſelf. Applying ſuch a crutch to the light pendulum mentioned in a former paragraph, he found that doubling, and even trebling the maintaining power, produced no change in the time of vibration, though it increaſed the width from 8° to 12° and 14°. We have no doubt of the efficacy of this contrivance, and think it very proper for all clocks which require much oil, ſuch as turret clocks. &c. But we apprehend that no rule can be given for the angle that the recoiling arch ſhould make with the concentric one. We imagine that this depends entirely on the ſhare which friction and oil have in producing the retardation of the dead beat.

Other artiſts have endeavoured to avoid the inconveniences of friction and oil on the arch of repoſe in another way. Inſtead of allowing the tooth of the wheel to drop on the back of the pallet, which we called the *arch of excurſion*, and others call the *arch of repoſe*, it drops on a detent *o t a* (fig. 8.), of which the part *t a* is part of an arch whoſe centre is A, the centre of the crutch, and the part *t o* is in the direction of the radius. This piece does not adhere to the pallet, but is on the end of an arm *o* A, which turns round the axis A of the crutch on fine pivots: it is made to apply itſelf to the back of the pallet by means of a ſlender ſpring A*p*, attached to the pallet, and preſſing inward on a pin *p*, fixed in the arm of the detent. When ſo applied, its arch *t a* makes the repoſe, and its point *a* makes a ſmall portion of the face *a c* of the pallet.

The action of this apparatus is very eaſily underſtood. When a tooth eſcapes from the ſecond pallet, by the motion of the pendulum from the left to the right, another tooth drops on this pallet (which the figure ſhews to be the firſt or leading pallet) at the angle *t*, and reſts on the ſmall portion *t a* of an arch of repoſe. But the crutch, continuing its motion to the right, immediately quits the arm *o* A, carrying the pallet *a c r* along with it, and leaving the wheel locked on the detent *o t a*. By and bye the pendulum finiſhes its excurſion to the right, and returns. When it enters the arch of action, the pallet has applied itſelf to the detent *o t a*, and withdraws it from the tooth. The tooth immediately acts on the face *a c* of the pallet, and reſtores the motion loſt during the laſt vibration. The uſe of the ſpring is merely to keep the detent applied to the pallet without ſhaking. It is a little bent during their ſeparation, and adds ſomething of an oppoſing force to the aſcent of the pendulum on the other ſide of the wheel, and accelerates its return. A ſimilar detent on the back of the ſecond pallet performs a ſimilar office, ſupporting the wheel while the pendulum is beyond the arch of ſcapement, and quitting it when the pendulum enters that arch.

We do not know who firſt practiſed this very ingenious and promiſing invention. Mr Mudge certainly did ſo early as 1753 or 1754. Mr Berthoud ſpeaks obſcurely of contrivances of the ſame nature. So does Le Roy, and (we think) Le Paute. We ſay that it is very promiſing. Friction is almoſt annihilated by transferring it to the pivots at A; ſo that, in the excurſion beyond the angle of ſcapement, the pendulum ſeems almoſt free. Indeed ſome artiſts of our acquaintance have even avoided the friction of the pivots at A, by making the arm of the detent a ſpring of conſiderable thickneſs, except very near to A, where it is made very thin and broad. But we do not find that this conſtruction, though eaſily executed, and ſuſceptible of great preciſion and ſteadineſs of action, is much practiſed. We preſume that the performance has not anſwered expectations. It has not been ſuperior to the incomparably more ſimple dead ſcapement of Graham. Indeed we think that it cannot A part of the friction ſtill remains, which cannot be removed; namely, while the arch *t a* is drawn from between the tooth and pallet. Nay we apprehend that ſomething more than friction muſt be overcome here. The tooth is apt to force the detent outward, unleſs the part *t a* be a little elevated at its point *a* like a claw, above the concentric arch, and the face of the tooth be made to incline forward, ſo as to fit this ſhape of the detent. This will conſume ſome force, when the momentum of the pendulum is by no means at its maximum. Should the clock be foul, and the excurſions beyond ſcapement be very ſmall, this diſturbance muſt be exceedingly pernicious. But we have a much greater objection. During the whole excurſion beyond ſcapement, there is a new force of a ſpring acting on the pendulum, which deviates conſiderably from the proportions of the accelerating power of gravity. It does not commence its action till the detent ſeparates from the arm of the crutch. Then the ſpring of the detent acts as a retarding force againſt

againſt the excurſion of the pendulum, now on the other ſide, bringing it ſooner to reſt, and then accelerating it in its way back to the beginning of the arch of ſcapement. In ſhort, this conſtruction ſhould have the properties of a recoiling ſcapement. We got a clockmaker to make ſome experiments on one which he had made for an amateur, which fully confirmed our conjecture. When the detent ſpring was ſtrong, an increaſe of maintaining power made the vibrations both wider and more rapid. The artiſt reduced the ſtrength of the ſpring till this effect was rendered very ſmall. It might perhaps be quite removed by means of a ſtill weaker ſpring: But the ſpring was already ſo weak that a hard ſtep on the floor of the room did ſometimes diſengage the detent from the wheel. It appears, therefore, that nothing can be reaſonably expected from this conſtruction that is not as well performed by the dead ſcapement of Mr Graham, of much eaſier execution, and more certain performance.

Very ſimilar to this conſtruction (at leaſt in the excurſion beyond the angle of ſcapement) is the conſtruction of Mr Cumming, and it has the ſame defects. His pallets are carried, as in the one deſcribed, by the crutch. The detents preſs on them behind by their weight only: therefore, when the tooth is locked on the detent of one pallet, its weight is taken off from the pendulum on that ſide, and the weight of the detent on the other ſide oppoſes the aſcent, and accelerates the deſcent of the pendulum.

Mr Cumming executed another ſcapement, conſiſting, like thoſe, of a pallet and detent. But the manner of applying the maintaining power is extremely different in principle from any yet deſcribed. It is exceedingly ingenious, and ſeems to do all that is poſſible for removing every ſource of irregularity in the maintaining power, and every obſtruction to free motion ariſing from friction and oil in the ſcapement. For this reaſon we ſhall give ſuch an account of its eſſential circumſtances as may ſuffice to give a clear conception of its manner of acting, and its good properties and defects; but referring the inquiſitive reader to Mr Cumming's Elements of Clock and Watch Work, publiſhed in 1766, for a more full account.

In the ſcapements laſt deſcribed, the pallets were fixed to the crutch and pendulum, and the maintaining power, during its action, was applied to the pendulum by means of the pallets, in the ſame way as in ordinary ſcapements. The detents were unconnected with the pendulum, and it was free during the whole excurſion. In the preſent ſcapement both the pallets and detents are detached from the pendulum, except in the moment of unlocking the wheel; ſo that the pendulum may be ſaid to be free during its whole vibration, except during this ſhort moment.

ABC (fig. 9.) repreſents a portion of the ſwing wheel, of which O is the centre, and A one of the teeth; Z is the centre of the crutch, pallets, and pendulum. The crutch or detents is repreſented of a form reſembling the letter A, having in the circular croſs piece a ſlit *i k*, alſo circular, Z being the centre. This form is very different from Mr Cumming's, and inferior to his, but was adopted here in order to avoid a long deſcription. The arm ZF forms the firſt detent, and the tooth A is repreſented as locked on it at F. D is the firſt pallet on the end of the arm Z *d* moveable round the ſame centre with the detents, but moveable independently of them. The arm *d e*, to which the pallet D is attached, lies altogether behind the arm ZF of the detent, being fixed to a round piece of braſs *e f g*, which has pivots turning concentric with the verge or axis of the pendulum. To the ſame round piece of braſs is fixed the horizontal arm *e* H, carrying at its extremity the ball H, of ſuch ſize, that the action of the tooth A on the pallet D is juſt able (but without any riſk of failing) to raiſe it up to the poſition here drawn. ZP*p* repreſents the fork, or the pendulum rod, behind both detent and pallet. A pin *p* projects forward, coming through the ſlit *i k*, without touching the upper or under margin of it. There is alſo attached to the fork the arm *m n* (and a ſimilar one on the other ſide), of ſuch length that, when the pendulum rod is perpendicular, as is repreſented here, the angular diſtance of *n q* from the rod *e q* H is preciſely equal to the angular diſtance of the left ſide of the pin *p* from the left end *i* of the ſlit *i k*.

The mode of action on this apparatus is abundantly ſimple. The natural poſition of the pallet D is at δ, repreſented by the dotted lines, reſting on the back of the detent F. It is naturally brought into this poſition by its own weight, and ſtill more by the weight of the ball H. The pallet D, being ſet on the fore ſide of the arm at Z, comes into the ſame plane with the detent F and the ſwing-wheel. It is drawn, however, in the figure in another poſition. The tooth C of the wheel is ſuppoſed to have eſcaped from the ſecond pallet, on which the tooth A immediately engages with the pallet D, ſituated at δ, forces it out, and then reſts on the detent F, the pallet D leaning on the tip of the tooth. F is brought into this ſituation in a way that will appear preſently. After the eſcape of C, the pendulum, moving down the arch of ſemivibration, is repreſented as having attained the vertical poſition. Proceeding ſtill to the left, the pin *p* reaches the extremity *i* of the ſlit *i k*; and, at the ſame inſtant, the arm *n* touches the rod *e* H in *q*. The pendulum proceeding a hair's breadth further, withdraws the detent F from the tooth, which now even puſhes off the detent, by acting on the ſlant face of it. The wheel being now unlocked, the tooth following C on the other ſide acts on its pallet, puſhes it off, and reſts on its detent, which has been rapidly brought into a proper poſition by the action of A on the ſlant face of F. It was a ſimilar action of C on its detent, in the moment of eſcape, which brought F into a fit poſition for locking the wheel by the tooth A. The pendulum ſtill going on, the arm *m n* carries the weight of the ball H, and the pallet connected with it, and it comes to reſt before the pin *p* again reaches the end of the ſlit, which had been ſuddenly withdrawn from it by the action of A on the ſlant face of F. The pendulum now returns towards the right, loaded on the left with the ball H, which reſtores the motion which it had loſt during the laſt vibration. When, by its motion to the right, the pin *p* reaches the end *k* of the ſlit *i k*, it unlocks the wheel on the right ſide. At the ſame inſtant the weight H ceaſes to act on the pendulum, being now raiſed up from it by the action of a tooth like B on the pallet D.

Let us now conſider the mechaniſm of theſe motions. The prominent feature of the contrivance is the almoſt complete diſengagement of the regulator from the wheels.

The wheels, indeed, act on the pallets; but the pallets are then detached from the pendulum. The ſole uſe of the wheel is to raiſe the little weights while the pendulum is on the other ſide, in order to have them in readineſs at the arrival of the pendulum. They are then laid on the pendulum, and ſupply an accelerating force, which reſtores to the pendulum the momentum loſt during the preceding vibration. Therefore no inequalities in the action of the wheel on the pallets, whether ariſing from friction or oil, has any effect on the maintaining power. It remains always the ſame, namely, the rotative momentum of the two weights. The only circumſtance, in which the irregularity of the action of the wheels can affect the pendulum is at the moment of unlocking. Here indeed the regulator may be affected; but this moment is ſo ſhort, in compariſon with other ſcapements, that it muſt be conſidered as a real improvement.

It is very uncandid to refuſe the author a claim to the character of an ingenious artiſt on account of this contrivance, as has been done by a very ingenious univerſity Profeſſor, who taxes Mr Cumming with ignorance of the *firſt elements of mechanics*, and ſays that the beſt thing in his book is his advice to ſuſpend the pendulum from a great block of marble, firmly fixed in the wall *. This is certainly a good advice, and we doubt not but that the Profeſſor's clock would have performed ſtill better if he had condeſcended to follow it. It is ſtill leſs candid to queſtion the originality of the invention. We know for certain that it was invented at a time and place where the author *could* not know what had been done by others. It would have been more like the urbanity of a well educated man to have acknowledged the genius, which, without ſimilar advantages, had done ſo much.

But, while we thus pay the tribute of juſtice to Mr Cumming, we do not adopt all his opinions. The clock has the ſame defects of the former in reſpect of the laws of the force which accelerates the pendulum. The ſudden addition of the ſmall weight, and this almoſt at the extremity of the vibration, would derange it very much, if the addition were ſuſceptible of any ſenſible variation. The irregularity of the action of the wheels *may* ſenſibly affect the motion during the unlocking, when the clock is foul, and the pendulum *juſt* able to unlock; for any diſturbance at the extremity of the vibration greatly affects the time. We acknowledge that the parts which we here ſuppoſe to be foul may not be ſo in the courſe of twenty years, theſe parts being only the pivots of the ſcapement. The great defect of the ſcapement is its liableneſs to unlock by any jolt. It is more ſubject to this than the others already mentioned. This riſk is much increaſed by the ſlender make of the parts, in Mr Cumming's drawings, and in the only clock of the kind we have ſeen; but this is not neceſſary: and it ſhould be avoided for another reaſon; the interpoſing ſo many ſlender and crooked parts between the moving power and the pendulum weakens the communication of power, and requires a much more powerful wheelwork.

All theſe, however, are ſlight defects, and only the laſt can be called a fault. The clocks made on this principle have gone remarkably well, as may be ſeen by the regiſters of his majeſty's private obſervatory. But the greateſt objection is, that they do not perform better than a well-made dead ſcapement; and they are vaſtly more troubleſome to make and to manage. This is ſtrictly true, and is a ſerious objection. The fact is, that the dominion of a heavy pendulum is ſo great, that if *any one* of the ſcapements now deſcribed be well executed with pallets of agate, and a wheel of hard ſteel, and if the pendulum be ſuſpended agreeably to Mr Cumming's advice, there is hardly any difference to be obſerved in their performance. We ſhall content ourſelves with a ſingle proof of this from fact. The clock invented by the celebrated Harriſon is *at leaſt equal* in its performance to any other. Friction is almoſt annihilated, and no oil is required. It went fourteen years without being touched, and during that time did not vary one complete ſecond from one day to another, nor ever deviated half a minute by accumulation from equable motion: Yet the ſcapement, in ſo far as it reſpects the law of the accelerating force, deviates more from the proportion of the ſpaces than the moſt recoiling ſcapement that ever was put to a good clock. It is ſo different from all hitherto deſcribed, both in form and principle, that we muſt not omit ſome account of it, and with it we ſhall conclude our ſcapements for clocks.

Let GDO repreſent the ſwing wheel, of which M is the centre. A is the verge or axis of the pendulum. It has two very ſhort arms AB, AE. A ſlender rod BC turns on fine pivots in the joint B, and has at its extremity C a hook or claw, which takes hold of a tooth D of the ſwing-wheel when the pendulum moves from the right ſide to the left. This claw, when at liberty, ſtands at right angles, or, at leaſt, in a certain determinate angle, with regard to the arm AB; and when drawn a little from that poſition, it is brought back to it again by a very ſlender ſpring. The arm AE is furniſhed with a detent EF, which alſo, when at liberty, maintains its poſition on the arm by means of a very ſlender ſpring.

Let us now ſuppoſe that the tooth D is preſſing on the claw C, while the pendulum is moving to the right. The joint B yields, by its motion round A, to the preſſure of the tooth on the claw. By this yielding, the angle ABC opens a little. In the mean time, the ſame motion round A cauſes the point F of the detent on the other ſide to approach the circumference of the wheel in the arch of a circle, and the tooth G at the ſame time advances. They meet, and the point of G is lodged in the notch under the projecting heel *f*. When this takes place, it is evident that any farther motion of the point E round A muſt puſh the tooth G a little backward, by means of the detent EF. It cannot come any nearer to the wheel, becauſe the point of the tooth ſtops the heel *f*. The inſtant that F puſhes G back, the tooth D is withdrawn from the claw C, and C flies out, by the action of its ſpring, and reſumes its poſition at right angles to BA; and the wheel is now free from the claw, but is puſhing at the detent F (c). The pendulum, having

* See Ludlam's Eſſay.

(c) The reader may here remark the manner in which the preſſure of the tooth G on the detent is transferred to the joint E by the intervention of the ſhank FE, and from the joint E to the pendulum rod, by the intervention

Watch-work.

ving finiſhed its excurſion to the right (in which it cauſes the wheel to recoil by means of the detent F), returns toward the left. The wheel now advances again, and, by preſſing on F, aids the pendulum through the whole angle of ſcapement. By this motion the claw C deſcribes an arch of a circle round A, and approaches the wheel, till it take hold of another tooth, namely, the one following D, and pulls it back a little. This immediately frees the detent F from the preſſure of the tooth G, and it flies out a little from the wheel, reſuming its natural poſition by means of its ſpring. Soon after, the motion of the pendulum to the left ceaſes, and the pendulum returns; D pulling forward the hook C to aid the pendulum, and the former operation is repeated, &c. &c.

Such is the operation of the pallets of Harriſon and Hindley. Friction is almoſt totally avoided, and oil entirely (D). The motion is given to the pendulum by a fair pull or puſh, and the teeth of the wheel only apply themſelves to the detents without rubbing. There is no drop, and the ſcapement makes no noiſe, and is what the artiſts call *a ſilent ſcapement.* The mechanician will readily perceive, that by properly diſpoſing the arms AB, AE, and diſpoſing the pallets on the circumference of the wheel, the law, by which the action of the wheel on the pendulum is regulated, may be greatly varied, ſo as to harmonize, as far as the nature of ſcapement, alternately puſhing and pulling, will admit, with the action of gravity.

But this is evidently a recoiling ſcapement, and one of the worſt kind; for the recoil is made at the very confines of the vibration, where every diſturbance of the regular cycloidal vibration occaſions the greateſt diſturbance to the motion. Yet this clock kept time with moſt unexampled preciſion, far excelling all that had been made before, and equal to any that have been made ſince. This is entirely owing to the immenſe ſuperiority of the momentum of the pendulum over the maintaining power.

II. *Of Scapements for a Watch.*

The execution of a proper ſcapement for watches is a far more delicate and difficult problem than the foregoing, on account of the ſmall ſize, which requires much more accurate workmanſhip, becauſe the error of the hundredth part of an inch has as great a proportion to the dimenſions of the regulator as an inch in a common houſe clock. It is much more difficult on another account. We have no ſuch means of accumulating ſuch a dominion (to uſe Mr Harriſon's expreſſive term) over the wheel-work in the regulator of a watch as in that of a clock. The heavieſt balance that we can employ, without the certainty of ſnapping its pivots by every ſlight jolt, is a mere trifle, in compariſon with the pendulum of the moſt ordinary clock. A dozen or twenty grains is the utmoſt weight of the balance, even of a very large pocket watch. The only way that we can accumulate any notable quantity of regulating power in ſuch a ſmall pittance of matter is by giving it a very great velocity. This we do by accumulating all its weight in the rim, by giving it very wide vibrations, and by making them extremely frequent. The balance-rim of a middling good watch ſhould paſs through at leaſt ten inches in every ſecond. Now, when we reflect on the ſmall momentum of this regulator, the inevitable inequalities of the maintaining power, and the great arch of vibration on which theſe inequalities will operate, and the comparative magnitude even of an almoſt inſenſible friction or clammineſs, it appears almoſt chimerical to expect any thing near to equability in the vibrations, and incredible that a watch can be made which will not vary more than one beat in 86400. Yet ſuch have been made. They muſt be conſidered as the moſt maſterly exertions of human art. The performance of a reflecting teleſcope is a great wonder: the worſt that can find a market muſt have its mirrors executed without an error of the ten thouſandth part of an inch; but we now know that this accuracy is attained almoſt in ſpite of us, and that we ſcarcely *can* make them of a worſe figure. But the caſe is far otherwiſe in watch-work. Here all thoſe wonderful approaches to perfection are the reſults of rational diſcuſſion, by means of ſound principles of ſcience; and, unleſs the artiſt who puts theſe principles into practice be more than a mere copyiſt, unleſs the principles themſelves are perceived by him, and actually direct his hand, the watch may ſtill be good for nothing. Surely, then, this is a liberal art, and far above a manual knack. The ſtudy of the means by which ſuch wonders are ſteadily effected, is therefore the ſtudy of a gentleman.

In the account given above of the ſcapements for pendulums, we aſſumed as one leading principle that *the natural vibrations of a pendulum are performed in equal times, whether wide or narrow.* This is ſo nearly true, when the arches on each ſide of the perpendicular do not exceed four degrees, that the retardation of the wider arches within that limit will not become ſenſible, though accumulated for a long time. The common ſcapement with a plane face of the pallet, helps to correct even this ſmall inequality much better than the niceſt form of the cycloidal checks propoſed by Huyghens.

In watch-work we aſſume a ſimilar principle, namely, that *the oſcillations of a balance, urged by its ſpring, and undiſturbed*

---

tion of the arm EA. This communication of preſſure is preciſely the ſame that we made uſe of in explaining the common ſcapement. MG, FE, and EA, in this fig. 10. are performing the offices which we then gave to the lines MB, BH, and HA, in fig. 3. Harriſon's pallet realiſes the abſtract theory.

(D) Mr Harriſon was at firſt by profeſſion a carpenter in a country place. Being extremely ingenious and inventive, he had made a variety of curious wooden clocks. He made one, in particular, for a turret in a gentleman's houſe. Its expoſure made it waſte oil very faſt, and the maker was often obliged to walk two or three miles to renew it, and got nothing for his trouble. In trudging home, not in very good humour, he pondered with himſelf how to make a clock go without oil. He changed all his pinion leaves into rollers; which anſwered very well. But the pallets required it more than any other part. After various other projects, he contrived thoſe now repreſented, where there was no friction, and no oil is wanted. The turret clock continued to go without being touched till Mr Harriſon left the country.

undiſturbed by all foreign forces, are performed in equal times, whether they be wide or narrow. This principle was aſſumed by the celebrated mechanician Dr Robert Hooke, on the authority of many experiments which he had made on the bending and unbending of ſprings. He found that the force neceſſary for retaining a ſpring in any conſtrained poſition was proportional to its tenſion, or deflection from its natural form. He expreſſed this in an anagram, which he publiſhed about the year 1660, in order to eſtabliſh his claim to the diſcovery, and yet conceal it. till he had made ſome important application of it. When the anagram was explained ſome years afterwards, it was, "*Ut tenſio, ſic vis.*" Dr Hooke thought of applying this diſcovery to the regulation of watch movements. For, if a ſlender ſpring be *properly* applied to the axis of a watch balance, it will put that balance in a certain determinate poſition. If the balance be turned aſide from this poſition, it ſeems to follow that it will be urged back toward it by a force proportional to its diſtance from it. He immediately made the application to an old watch, which he afterward gave to Dr Wilkins, Biſhop of Cheſter. This was in 1658. Its motion was ſo amazingly improved, that Hooke was perſuaded of the perfection of his principle, and thought that nothing was now wanting for making a watch of this kind a perfect chronometer but the hand of a good workman. For his watch ſeemed almoſt perfect, though made in a ſmall country town, in a very coarſe manner. Mr Huyghens alſo claims this diſcovery. He publiſhed his claim about the year 1675, and propoſed to make watches for diſcovering the longitude of a ſhip at ſea. But there is the moſt unqueſtionable evidence of Dr Hooke's priority by fifteen years, and of his having made ſeveral watches of this kind. One of them was in the poſſeſſion of his majeſty king Charles II. Dr Hooke's firſt balance ſpring was ſtraight, and acted on the balance in a very imperfect manner. But he ſoon ſaw the imperfections, and made ſeveral ſucceſſive alterations; and, among others, he employed the cylindrical ſpiral now employed by Mr Arnold; but he gave it up for the flat ſpiral: and the king's watch had one of this kind before Mr Huyghens publiſhed his invention. His project of longitude watches had been carried on along with Lord Brouncker and Sir Robert Moray, and they had quarrelled ſome years before that publication. See WATCH, *Encycl.*

But both Dr Hooke and Mr Huyghens were too ſanguine in their expectations. We, by no means, have the evidence for the truth of this principle that we have for the accelerating action of gravity on a pendulum. It reſts on the nicety and the propriety of the experiments; and long experience has ſhewn that it is ſenſibly true only within certain limits. The demonſtrations by which Bernoulli ſupports the unqualified principle of Mr Huyghens, proceed on hypothetical doctrines concerning the nature of elaſticity. And even theſe ſhew that the law of elaſticity which he aſſumed was ſelected, not becauſe founded on ſimpler principles than any other, but becauſe it was conſiſtent with the experiments of Hooke and Huyghens. Beſides, although this ſhould be the true law of a ſpring, it does not follow that this ſpring, applied in *any way* to the axis of a balance, will urge that balance agreeably to the ſame law: and if it did, it ſtill does not follow that the oſcillations of the balance will be iſochronous; for the force has to move not only the balance but alſo the ſpring. Part of the reſtoring force of the ſpring is employed in reſtoring it rapidly to its quieſcent ſhape, and thus enabling it to *follow and ſtill impel* the yielding balance. It is therefore only the ſurplus which is employed in actually moving the balance, and it is uncertain whether this ſurplus varies according to the ſame law, being always the ſame proportion of the whole force of the ſpring. We find it an extremely difficult problem to determine the law of variation of this ſurplus, even in the ſimpleſt form of the ſpring; nay, it is by no means an eaſy problem to determine the law of oſcillation of a ſpring, unloaded with any balance; and we can eaſily ſhew that there are ſuch forms of a ſpring, that although the velocity with which the different parts approach to their quieſcent poſition be exactly as their excurſion from it, this is by no means the law of velocity which this ſpring will produce in a balance. The matter of fact is, that when the ſpring is a ſimple ſtraight ſteel wire, ſuſpending the balance in the direction of its axis, the motions of it, if not immoderate, are preciſely agreeable to Huyghens's and Hooke's rule; and that the motion of a balance urged by a ſpring wound up into a flat, or a cylindrical ſpiral, as in common watches, and thoſe of Arnold, deviates ſenſibly from it, unleſs a certain analogy be preſerved between the length and the elaſticity of the ſpring. If the ſpring be immoderately long, the wide vibrations are ſlower than the narrow ones; and the contrary is obſerved when the ſpring is immoderately ſhort. A certain taper, or gradual diminution of the ſpring, is alſo found to have an effect in equalizing the wide and narrow vibrations. There is alſo a great difference between the force with which a part of the ſpring unbends itſelf, and the action of that force in urging the balance round its axis; and the performance of many watches, good in other reſpects, is often faulty from the manner in which this unbending force is employed.

But, ſince theſe corrections are in our power in a conſiderable degree, we may ſuppoſe them applied, and the true motion (which we ſhall call the cycloidal) attained; and we may then adapt the conſtruction of the ſcapement to the preſerving this motion undiſturbed. And here we muſt ſee at once that the problem is incomparably more delicate than in the caſe of pendulums. The vibrations muſt be very wide, and the angular motion rapid, that it may be little affected by external motions. The ſmalleſt inequalities of maintaining power acting through ſo great a ſpace, muſt bear a conſiderable proportion to the very minute momentum of a watch balance. Oil is as clammy on the pallets of a watch as on thoſe of a clock; a viſcidity which would never be felt by a pendulum of 20 pounds weight will ſtop a balance of 20 grains altogether. For the ſame reaſon, it is evident that any impropriety in the form of the pallet muſt be incomparably more pernicious than in the caſe of a pendulum; the deviation which this may occaſion from a force proportional to the angular diſtance from the middle point, muſt bear a great proportion to the whole force.

The common recoiling ſcapement of the old clocks ſtill holds its place in the ordinary pocket watches, and anſwers all the common purpoſes of a watch very well. A well finiſhed watch, with a recoiling ſcapement, will keep time within a minute in the day. This is enough for the ordinary affairs of life. But ſuch watches are ſubject to great variation in their rate of going, by any change in the power of the wheels. This is evident; for if the watch be held back, or preſſed forward, by the key applied to the fuſee ſquare, we hear the beating greatly retarded or accelerated. The maintaining power, in the beſt of ſuch watches, is never leſs than one fifth of the regulating power of the ſpring. For, if we take off the balance ſpring, and allow the balance to vibrate by the impulſe of the wheels alone, we ſhall find the minute hand to go forward from 25 to 30 minutes per hour. Suppoſe it 30. Then, ſince the wheels act through equal ſpaces with or without a ſpring, the forces are as the ſquares of the acquired velocities. (Dynamics, *Suppl.* n° 95.) The velocity in this caſe is double; therefore the accelerating force is quadruple, and the force of the ſpring is three times that of the wheels. If the hand goes forward 25 minutes, the force of the wheels is about one-fifth of that of the ſpring. This great proportion is neceſſary, as already obſerved, that the watch may go as ſoon as unſtopped.

We have but little to ſay on this ſcapement; its principle and manner of action, and its good and bad qualities, being the ſame with thoſe of the ſimilar ſcapement for pendulums. It is evident that the maintaining power being applied in the moſt direct manner, and during the whole of the vibration, it will have the greateſt poſſible influence to move the balance. A given mainſpring and train will keep in motion a heavier balance by means of this ſcapement than by any other. But, on the other hand, and for the ſame reaſon, the balance has leſs dominion over the wheel-work, and its vibrations are more affected by any irregularities of the wheel-work. Moreover, the chief action of the wheel being at the very extremities of the vibrations, and being very abrupt, the variations in its force are moſt hurtful to the iſochroniſm of the vibrations.

Although this ſcapement is extremely ſimple, it is ſuſceptible of more degrees of goodneſs or imperfection than almoſt any other, by the variation of the few particulars of its conſtruction. We ſhall therefore briefly deſcribe that conſtruction which long experience has ſanctioned as approaching near to the beſt performance that can be obtained from the common ſcapement. Fig. 11. repreſents it in what are thought its beſt proportions, as it appears when looking ſtraight down on the end of the balance arbor. C is the centre of the balance and verge. CA and CB are the two pallets; CA being the upper pallet, or the one next to the balance, and CB being the lower one. F and D are two teeth of the crown wheel, moving from left to right; and E, G, are two teeth on the lower part of the circumference, moving from right to left. The tooth D is repreſented as juſt eſcaped from the point of CA, and the lower tooth E as juſt come in contact with the lower pallet. The ſcapement ſhould not, however, be quite ſo cloſe, becauſe an inequality on the teeth might prevent D from eſcaping at all. For if E touch the pallet CB before D has quitted CA, all will ſtand ſtill. This fault will be corrected by withdrawing the wheel a little from the verge, or by ſhortening the pallets.

The proportions are as follow The diſtance between the front of the teeth (that is, of G, F, E, D) and the axis C of the balance is one-fifth of FA, the diſtance between the points of the teeth. The length CA, CB of the pallets is three-fifths of the ſame diſtance. The pallets make an angle ACB of 95 degrees, and the front DH or FK of the teeth make an angle of 25° with the axis of the crown-wheel The ſloping ſide of the tooth muſt be of an epicycloidal form, ſuited to the relative motion of the tooth and pallet.

From theſe proportions it appears that the pallet A can *throw out*, by the action of the tooth D, till it reaches *a*, 120 degrees from CL, the line of the crown-wheel axis. For it can throw out till the pallet B ſtrike againſt the front of E, which is inclined 25° to CL. To this add BCA, = 95°, and we have LC*a* = 120. In like manner B will throw out as far on the other ſide. From 240°, the ſum of theſe angles, take the angle of the pallets 95°, and there remains 145° for the greateſt vibration which the balance can make without ſtriking the front of the teeth. This extent of vibration ſuppoſe the teeth to terminate in points, and the acting ſurfaces of the pallets to be planes directed to the very axis of the verge. But the points of the teeth muſt be rounded off a little for ſtrength, and to diminiſh friction on the face of the pallets. This diminiſhes the angle of ſcapement very conſiderably, by ſhortening the teeth. Moreover, we muſt by no means allow the point of the pallet to bank or ſtrike on the foreſide of a tooth. This would greatly derange the vibration by the violence and abruptneſs of the check which the wheel would give to the pallet. This circumſtance makes it improper to continue the vibrations much beyond the angle of ſcapement. One-third of a circle, or 120°, is therefore reckoned a very proper vibration for a ſcapement made in theſe proportions. The impulſe of the wheels, or the angle of ſcapement, may be increaſed by making the face of the pallets a little concave (preſerving the ſame angle at the centre). The vibration may alſo be widened by puſhing the wheel nearer to the verge. This would alſo diminiſh the recoil. Indeed this may be entirely removed by bringing the front of the wheel up to C, and making the face of the pallet not a radius, but parallel to a radius and behind it, *i. e.* by placing the pallet CA ſo that its acting face may be where its back is juſt now. In this caſe, the tooth D would drop on it at the centre, and lie there at reſt, while the balance completes its vibration But this would make the banking (as the ſtroke is called) on the teeth almoſt unavoidable. In ſhort, after varying every circumſtance in every poſſible manner, the beſt makers have ſettled on a ſcapement very nearly ſuch as we have deſcribed. Preciſe rules can ſcarcely be given; becauſe the law by which the force acting on the pallets varies in its intenſity, deviates ſo widely from the action of the balance ſpring, eſpecially near the limits of the excurſions.

The diſcoveries of Huyghens and Newton in rational mechanics engaged all the mathematical philoſophers of Europe in the ſolution of mechanical problems, about the end of the laſt century. The vibrations of elaſtic plates or wires, and their influence on watch balances, became familiar to every body. The great requiſites for producing iſochronous vibrations were well underſtood, and the artiſts were prompted by the ſpeculatiſts to attempt conſtructions of ſcapements proper for this purpoſe. It appeared clearly, that the moſt effectual means for

for this purpoſe was to leave the balance unconnected with the wheels, eſpecially near the extremities of the vibration, where the motion is languid, and where every inequality of maintaining power muſt act for a longer time, and therefore have a great effect on the whole duration of the vibrations The maxim of conſtruction that naturally ariſes from theſe reflections is to *confine*, if poſſible, *the action of the wheels to the middle of the vibration*, where the motion is rapid, and where the chief effect of an increaſe or diminution of the maintaining power will be to enlarge or contract the angular motions, but will make little change on their duration; becauſe the greateſt part of the motion will be effected by the balance ſpring alone. This maxim was inculcated in expreſs terms by John Bernoulli, in his *Recherches Mechaniques et Phyſiques*; but it had been ſuggeſted by common ſenſe to ſeveral unlettered artiſts before that time About the beginning of this century watches were made in London, where the verge had a portion *e d b* (fig. 12.) of a ſmall cylinder, having its centre *c* in the axis, and a radial pallet *b a* proceeding from it. Suppoſe a tooth juſt eſcaped from the point of the pallet, moving in the direction *b d e*, the cylindrical part was ſo ſituated that the next tooth dropped on it at a ſmall diſtance from its termination. While the verge continues turning in the direction *b d e*, the tooth continues reſting on the cylinder, and the balance ſuſtains no *action* from the wheels, and has only to overcome the minute frictions on the poliſhed ſurface of a hard ſteel cylinder. This motion may perhaps continue till the pallet acquires the poſition *f*, almoſt touching the tooth. It then ſtops, its motion being extinguiſhed by the increaſing force of the ſpring It now returns, moving in the direction *e d b*; and when the pallet has acquired the poſition *c i*, the tooth *g* quits the circumference of the cylinder, and drops in on the pallet at the very centre. The crooked form of the tooth allows the pallet to proceed ſtill farther, before there is any danger of banking on the tooth. This vibration being alſo ended, the balance reſumes its firſt direction, and the tooth now acts on the face of the pallet, and reſtores to the balance all the motion which it had loſt by friction, &c. during the two preceding vibrations.

It is evident that this conſtruction obviates all the objections to the former recoiling ſcapement, and that, by ſufficiently diminiſhing the diameter of the cylindrical part, the friction may be reduced to a very ſmall quantity, and the balance be made to move by the action of the ſpring during the whole of the excurſion, and of the returning vibration. Yet this conſtruction does not ſeem to have come much into uſe, owing, in all probability, to the great difficulty of making the drop ſo accurate in all the teeth. The ſmalleſt inequality in the length of a tooth would occaſion it to drop ſooner or later; and if the cylinder was made very ſmall, to diminiſh friction, the formation of the notch was almoſt a microſcopical operation, and the ſmalleſt ſhake in the axis of the verge or the balance-wheel would make the tooth ſlip paſt the cylinder, and the watch run down amain.

About the ſame time, a French artiſt in London (then the ſchool of this art) formed another ſcapement, with the ſame views. We have not any diſtinct account of it, but are only informed (in the 7th volume of the *Machines approuvées par l'Acad. des Sciences*) that the tooth reſted on the ſurface of a hollow cylinder, and then eſcaped by acting on the inclined edge of it. But we may preſume that it had merit, being there told that Sir Iſaac Newton wore a watch of this kind.

A much ſuperior ſcapement, on the ſame principle, was invented by Mr Geo. Graham, at the ſame time that he changed the recoiling ſcapement for pendulums into the dead beat. Indeed it is the ſame ſcapement, accommodated to the large vibrations of a balance In fig 13. DE repreſents part of the rim of the balance-wheel. A and C are two of its teeth, having their faces *b e* formed into planes, inclined to the circumference of the wheel, in an angle of about 15 degrees; ſo that the length *b e* of the face is nearly quadruple of its height *e m*. Suppoſe a circular arch ABC deſcribed round the centre of the wheel, and through the middle of the faces of the teeth. The axis of the balance paſſes thro' ſome point B of this arch, and we may ſay that the mean circumference of the teeth paſſes through the centre of the verge. On this axis is fixed a portion of a thin hollow cylinder *b c d*, made of hard tempered ſteel, or of ſome hard and tough ſtone, ſuch as ruby or ſapphire. Agates, though very hard, are brittle Chalcedony and cornelian are tough, but inferior in hardneſs. This cylinder is ſo placed on the verge, that when the balance is in its quieſcent poſition, the two edges *b* and *d* are in the circumference which paſſes through the points of the teeth. By this conſtruction the portion of the cylinder will occupy 210° of the circumference, or 30° more than a ſemicircle. The edge *b*, to which the tooth approaches from without, is rounded off on both angles. The other edge *d* is formed into a plane, inclined to the radius about 30°

Now, ſuppoſe the wheel preſſed forward in the direction AC The point *b* of the tooth, touching the rounded edge, will puſh it outwards, turning the balance round in the direction *b c d*. The heel *e* of the tooth will eſcape from this edge when it is in the poſition *h*, and *e* is in the poſition *f*. The point *b* of the tooth is now at *d*, but the edge of the cylinder has now got to *i*. The tooth, therefore, reſts on the inſide of the cylinder, while the balance continues its vibration a little way, in conſequence of the ſhove which it has received from the action of the inclined plane puſhing it out of the way, as the mould board of a plough ſhoves a ſtone aſide. When this vibration is ended, by the oppoſition of the balance-ſpring, the balance returns, the tooth (now in the poſition B) rubbing all the while on the inſide of the cylinder The balance comes back into its natural poſtion *b c d*, with an accelerated motion, by the action of its ſpring, and would, of itſelf, vibrate as far, at leaſt, on the other ſide. But it is aided again by the tooth, which, preſſing on the edge *d*, puſhes it aſide, till it come into the poſition *k*, when the tooth eſcapes from the cylinder altogether.. At this moment the other edge of the cylinder is in the poſition *l*, and therefore is in the way of the next tooth, now in the poſition A. The balance continues its vibration the tooth all the while reſting, and rubbing on the outſide of the cylinder. When this vibration, in the direction *d c b*, is finiſhed, the balance reſumes its firſt motion *b c d*, by the action of the ſpring, and the tooth begins to act on the firſt edge *b*, as ſoon as the balance gets into its natural poſition, ſhoves it aſide, eſcapes from it, and drops on the inſide of the cylinder. In this manner are the vibrations produced, gradually increaſed to their maximum, and maintained in that ſtate. Every ſucceeding tooth of the wheel acts firſt on the edge *b*, and then on the edge *d*; reſting firſt on the outſide, and then on the inſide of the cylinder. The balance is under the influence of the wheels while the edge *b* paſſes to *h*, and while *d* paſſes to *k*; and the reſt of the vibration is performed without any *action* on the part of the wheels, but is a little obſtructed by friction, and by the clammineſs of the oil. In the conſtruction now deſcribed, the arch of action or ſcapement is evidently 30°, being twice the angle which the face of a tooth makes with the circumference.

The reader will perceive, that when this ſcapement is executed in ſuch a manner that the ſucceeding tooth is in contact with the cylinder at the inſtant that the preceding one eſcapes from it, the face of the tooth muſt be equal to the inſide diameter of the cylinder, and that the diſtance between the heel of one tooth and the point of the following one muſt be equal to the outſide diameter. When the ſcapement is ſo cloſe there is no drop. A good artiſt approaches as near to this adjuſtment as poſſible; becauſe, while a tooth is dropping, but not yet in contact, it is not acting on the balance, and ſome force is loſt. The execution is accounted very good, if the diſtance between the centres of two teeth is twice the external diameter of the cylinder. This allows a drop equal to the thickneſs of the cylinder, which is about $\frac{1}{2}$ th of its diameter.

We muſt alſo explain how this cylinder is ſo connected with the verge as to make ſuch a great revolution round the tooth of the wheel. The triangular tooth *e b m* is placed on the top of a little pillar or pin fixed into the extremity of the piece of braſs *m* D formed on the rim of the wheel. Thus the wedge-tooth has its plane parallel to the plane of the wheel, but at a ſmall diſtance above it. Fig. B repreſents the verge, a long hollow cylinder of hard ſteel. A great portion of the metal is cut out. If it were ſpread out flat, it would have the ſhape of fig. C. Suppoſe this rolled up till the edges GH and G′H′ are joined, and we have the exact form. The part acted on by the point of the tooth is the dotted line *b d*. The part DIFE′ ſerves to connect the two ends. Thus it appears to be a very ſlender and delicate piece; but being of tempered ſteel, it is ſtrong enough to reſiſt moderate jolts. The ruby cylinders are much more delicate.

Such is the cylinder ſcapement of Mr Graham, called alſo the HORIZONTAL SCAPEMENT, becauſe the balance wheel is parallel to the others. Let us ſee how far it may be expected to anſwer the intended purpoſes. If the excurſions of the balance beyond the angle of impulſion were made altogether unconnected with the wheels, the *whole vibration* would be quicker than one of the ſame extent, made by the action of the balance-ſpring alone, becauſe the middle part of it is accelerated by the wheels. But the excurſions are obſtructed by friction and the clammineſs of oil. The effect of this in *obſtructing* the motion is very conſiderable. Mr Le Roy placed the balance ſo, that it reſted when the point of the tooth was on the middle of the cylindric ſurface. When the wheel was allowed to preſs on it, and it was drawn 80° from this poſition, it vibrated only during 4½ ſeconds. When the wheel was not allowed to touch the cylinder, it vibrated 90 ſeconds, or 20 times as long; ſo much did the friction on the cylinder exceed that of the pivots. We are not ſufficiently acquainted with the laws of either of theſe obſtructions to pronounce decidedly whether they will increaſe or diminiſh the *time* of the whole vibrations. We obſerve diſtinctly, in motions with conſiderable friction, that it does not increaſe nearly ſo faſt as the velocity of the motion; nay, it is often leſs when the velocity is very great. In all caſes it is obſerved to terminate motions abruptly. The friction requires a certain force to overcome it, and if the body has any leſs it will ſtop. Now this will not only contract the excurſion of the balance, but will ſhorten the time. But the return to the angle of impulſion will undoubtedly be of longer duration than the excurſion; for the arch of return, from the extremity of the excurſion to its beginning, where the angle of impulſion ends, is the ſame with the arch of excurſion. The velocity which the balance has in any point of the return is leſs than what it had in the ſame point of the excurſion; becauſe, in the excurſion, it had velocity enough to carry it to the extremity, and alſo to overcome the friction. In the return, it could, even without friction, only have the velocity which would have carried it to the extremity; and this ſmaller velocity is diminiſhed by friction during the return. The velocity being leſs through the whole return than during the excurſion, the time muſt be greater. It may therefore happen that this retardation of the return may compenſate the contraction of the excurſion and the diminution of its duration. In this caſe the vibration will occupy the ſame time as if the balance had been free from the wheels. But it may more than compenſate, and the vibrations will then be ſlower; or it may not fully compenſate, and they will be quicker. We cannot therefore ſay, *à priori*, which of the two will happen: but we may venture to ſay that an increaſe of the force of the wheels will make the watch go ſlower: for this will exert a greater preſſure, give a greater impulſion, produce a wider excurſion, and increaſe the friction during that greater excurſion, making the wide vibrations ſlower than the narrow ones; becauſe the angle of impulſion remaining the ſame, the preſſures exerted muſt be quadrupled, in order to double the excurſion (ſee DYNAMICS, n° 95. *Suppl.*), and therefore the friction will be increaſed in a greater proportion than the momentum which is to overcome it. But, with reſpect to the obſtruction ariſing from the viſcidity of the oil, we know that it follows a very different law. It bears a manifeſt relation to the velocity, and is nearly proportional to it. But ſtill it is difficult to ſay how this will affect the whole vibration. The duration of the excurſion will not be ſo much contracted as by an equal obſtruction from friction, becauſe it will not terminate the motion abruptly. There are therefore more chances of the increaſed duration of the return exceeding the diminution of it in the excurſion. All that we can ſay, therefore, is, that there will be a compenſation in both caſes. The time of excurſion will be contracted, and that of return augmented.

Now, as the friction may be greatly diminiſhed by fine poliſh, fine oil, and a ſmall diameter of the cylinder, we may reaſonably expect that the vibrations of ſuch a balance will not vary nearly ſo much from iſochroniſm as with a recoiling ſcapement, and will be little affected by changes in the force of the wheels.

Accord-

Watch-work.

Accordingly, Graham's cylindrical ſcapement ſupplanted all others as ſoon as it was generally known. We cannot compare the vibrations with thoſe of a free balance, becauſe we have no way of making a free balance vibrate for ſome hours. But we find that doubling or trebling the force of the wheels makes very little alteration in the rate of the watch, though it greatly enlarges the angular motion. Any one may perceive the immenſe ſuperiority of this ſcapement over the common recoiling ſcapement, by preſſing forward the movement of a horizontal watch with the key, or by keeping it back. No great change can be obſerved in the frequency of the beats, however hard we preſs. But a more careful examination ſhews that an increaſe of the power of the wheels generally cauſes the watch to go ſlower; and that this is more remarkable as the watch has been long going without being cleaned. This ſhews that the cauſe is to be aſcribed to the friction and oil operating on the wide arches of excurſion. But when this ſcapement is well executed, in the beſt proportions of the parts, the performance is extremely good. We know ſuch watches, which have continued for ſeveral weeks without ever varying more than 7′ in one day from equable motion. We have ſeen one whoſe cylinder was not concentric with the balance, but ſo placed on the verge that the axis of the verge was at o (fig. 13.), between the centre B of the cylinder and the entering edge b, and Be was equal to the thickneſs of the cylinder. The watch was made by Emery of London, and was ſaid to go with aſtoniſhing regularity, ſo as to equal any time piece while the temperature of the air did not vary; and when clean, was ſaid to be leſs affected by the temperature than a watch with a free ſcapement, but unprovided with a compenſation piece. It is evident that this watch muſt have a minute recoil. This was ſaid to be the aim of the artiſt, in order to compenſate for the obſtruction cauſed by friction during the return of the balance from its excurſions. It indeed promiſes to have this effect; but we ſhould fear that it ſubjects the excurſions to the influence of the wheels. We ſuſpect that the indifferent performance of cylinder watches may often ariſe from the cylinder being off the centre in ſome diſadvantageous manner.

The watch from which the proportions here ſtated were taken, is a very fine one made by Graham for Archibald Duke of Argyle, which has kept time with the regularity now mentioned. We believe that there are but few watches which have ſo large a portion of the cylinder: few indeed have more than one half, or 180° of the circumference. But this is too little. The tooth of the wheel does not begin to act on the reſting cylinder till its middle point A or B touch one of the edges. To obtain the ſame angle of ſcapement, the inclination of the face of the tooth muſt be increaſed (it muſt be doubled); and this requires the maintaining power to be increaſed in the ſame proportion. Beſides, in ſuch a ſcapement it may happen that the tooth will never reſt on the cylinder; becauſe the inſtant that it quits one edge it falls on the other, and puſhes it aſide, ſo that the balance acquires no wider vibration than the angle of ſcapement, and is continually under the influence of the wheels. The ſcapement is in its beſt ſtate when the portion of the cylinder exceeds 180° by twice the inclination of the teeth to the circumference of the wheel.

Watch-work.

It would employ volumes to deſcribe all the ſcapements which have been contrived by different artiſts, aiming at the ſame points which Graham had in view. We ſhall only take notice of ſuch as have ſome eſſential difference in principle.

Fig. 14. repreſents a ſcapement invented in France, and called the *Echappement à VIRGULE*, becauſe the pallet reſembles a comma. The teeth A, B, C, of the balance wheel are ſet very oblique to the radius, and there is formed on the point of each a pin, ſtanding up perpendicular to the plane of the wheel. This greatly reſembles the wheel of Graham's ſcapement, when the triangular wedge is cut off from the top of the pin on which it ſtands. The axis c of the verge is placed in the circumference paſſing through the pins. The pallet is a plate of hard ſteel $a e f d b$, having its plane parallel to the plane of the wheel. The inner edge of this plate is formed into a concave cylindrical ſurface between o and b, whoſe axis c coincides with the axis of the verge. Adjoining to this is the acting face $b d$ of the pallet. This is either a ſtraight line $b d$, making an angle of nearly 30° with a line $c b g$ drawn from the centre, or it is more generally curved, according to the noſtrum of the artiſt. The back of the pallet $a e f$ is alſo a cylindrical ſurface (convex) concentric with the other. This extends about 100° from a to f. The part between f and d may have any ſhape. The interval $a o$ is formed into a convex ſurface, in ſuch a manner as to be everywhere interſected by the radius in an angle of 30° nearly; *i. e.* it is a portion of an equiangular ſpiral. The whole of this is connected with the verge by a crank, which paſſes perpendicularly through it between f and e; and the plate is ſet at ſuch height on the crank or verge, that it can turn round clear of the wheel, but not clear of the pins. The teeth of the wheel are ſet ſo obliquely, and made ſo ſlender, that the verge may turn almoſt quite round without the crank's banking on the teeth. The part $f d b$, called the horn, is of ſuch a length, that when one pin B reſts on the outſide cylinder at a, the point d is juſt clear of the next pin A.

When the wheel is not acting, and the balance ſpring is in equilibrio, the poſition of the balance is ſuch that the point d of the horn is near i, about 30° from d. The figure repreſents it in the poſition which it has when the tooth A has juſt eſcaped from the point d of the horn. In this poſition the next tooth B is applied to the convex cylinder, a very little way (about 5°) from its extremity a. This deſcription will enable the reader to underſtand the operation of the virgule ſcapement.

Now ſuppoſe the pin A juſt eſcaped from the horn. The ſucceeding pin B is now in contact with the back of the cylinder; and the balance, having got an impulſe by the action of A along the concave pallet $b d$, continues its motion in the direction $d g h$, till its force is ſpent, the point of the horn arriving perhaps at h, more than 90° from d. All this while the following tooth B is reſting on the back $e f$ of the cylinder. The balance now returns, by the action of its ſpring; and when the horn is at i, the pin gets over the edge $a o$, and drops on the oppoſite ſide of the concave cylinder, where it reſts, while the horn moves from i to k, where it ſtops, the force of the balance being again ſpent. The balance then returns; and when the horn comes within

30° of *d*, the pin gets out of the hollow cylinder, ſhoves the horn out of its way, and eſcapes at *d*. Beſides the impulſe which the balance receives by the action of the wheel on the horn *b d*, there is another, though ſmaller, action in the contrary direction, while the point of B paſſes over the ſurface *a o*; for this ſurface being inclined to the radius, the preſſure on it urges the balance round in the direction *b d i*.

The chief difference of this ſcapement from the former is that the inclined plane is taken from the teeth of the wheel, and placed on the verge. This alone is a conſiderable improvement; for it is difficult to ſhape all the teeth alike; whereas the horn *b d* is invariable. Moreover, the reſting parts, although they be drawn large in this figure for the ſake of diſtinctneſs, may be made vaſtly ſmaller than Graham's cylinder, which muſt be big enough to hold a tooth within it. By this change, the friction, during the repoſe of the wheel, that is, during the excurſions of the balance, may be vaſtly diminiſhed. The inſide cylinder need be no bigger than to receive the pin. But although the performance of theſe ſcapements is excellent, they have not come into general uſe in this country. The cauſe ſeems to be the great nicety requiſite in making the pins of the wheel paſs exactly through the axis of the verge. The leaſt ſhake in the pivots of the balance and balance-wheel muſt greatly change the action. A very minute increaſe of diſtance between the pivots will cauſe the pin B to ſlide from the edge *a* to the horn, without reſting at all on the inſide cylinder; and when it does ſo, it will ſtop the balance at once, and, immediately after, the watch will run down. The ſame irregularities will happen if all the pins be not at preciſely the ſame diſtance from the axis of the wheel.

This ſcapement was greatly improved, and, in appearance, totally changed, by Mr Lepaute of Paris in 1753. By placing the pins alternately on the two ſides of the rim of the balance-wheel, he avoided the uſe of the outſide cylinder altogether. The ſcapement is of ſuch a ſingular form, that it is not eaſy to repreſent it by any drawing. We ſhall endeavour, however, to deſcribe it in ſuch a manner as that our readers, who are not artiſts, will underſtand its manner of acting. Artiſts by profeſſion will eaſily comprehend how the parts may be united which we repreſent as ſeparate.

Let ABC (fig. 15.) repreſent part of the rim of the balance-wheel, having the pins 1, 2, 3, 4, 5, &c. projecting from its faces; the pins 1, 3, 5, being on the ſide next the eye, but the pins 2 and 4 on the farther ſide. D is the centre of the balance and verge, and the ſmall circle round D repreſents its thickneſs. But the verge in this place is crooked, like a crank, that the rim of the wheel may not be interrupted by it. This will be more particularly deſcribed by and bye. There is attached to it a piece of hard tempered ſteel *a b c d*, of which the part *a b c* is a concave arch of a circle, having D for its centre. It wants about 30° of a ſemicircle. The reſt of it *c d* is alſo an arch of a circle, having the ſame radius with the balance-wheel. The natural poſition of the balance is ſuch, that a line drawn from D, through the middle of the face *c d*, is a tangent to the circumference of the wheel. But, ſuppoſe the balance turned round till the point *d* of the horn comes to *d*, and the point *c* comes to 2, in the circumference in which the pins are placed. Then the pin, preſſing on the beginning of the horn or pallet, puſhes it aſide, ſlides along it, and eſcapes at *d*, after having generated a certain velocity in the balance. So far this ſcapement is like the virgule ſcapement deſcribed already. But now let another pallet, ſimilar to the one now deſcribed, be placed on the other ſide of the wheel, but in a contrary poſition, with the acting face of the pallet turned away from the centre of the wheel. Let it be ſo placed at E, that the moment that the pin 1, on the upper ſide of the wheel, eſcapes from the pallet *c d*, the pin 4, on the under ſide of the wheel, falls on the end of the circular arch *e f g* of the other pallet. Let the two pallets be connected by means of equal pulleys G and F on the axis of each, and a thread round both, ſo that they ſhall turn one way. The balance on the axis D, having gotten an impulſe from the action of the pin 1, will continue its motion from A towards *i*, and will carry the other pallet with a ſimilar motion round the centre E from *b* towards *k*. The pin 4 will therefore reſt on the concave arch *g f e* as the pallet turns round. When the force of the balance is ſpent, the pallet *c d* returns towards its firſt poſition. The pallet *g b* turns along with it; and when the point of the firſt has arrived at *d*, the beginning *g* of the other arrives at the pin 4; and, proceeding a little farther, this pin eſcapes from the concave arch *e f g*, and ſlides along the pallet *g b*, puſhing it aſide, and therefore urging the pallet round the centre E, and conſequently (by means of the connection of the pulleys) urging the balance on the axis D round at the ſame time, and in the ſame direction. The pin 4 eſcapes from the pallet *g b*, when *b* arrives at 3; but in the time that the pin 4 was ſliding along the yielding pallet *g b*, the pin 3 is moving in the circumference BDA; and the inſtant that the pin 4 eſcapes from *b* at 3, the pin 3 arrives at 2, and finds the beginning *c* of the concave arch *c b a* ready to receive it. It therefore reſts on this arch, while the balance continues its motion. This perhaps continues till the point *b* of the arch comes to 2. The balance now ſtops, its force being ſpent, and then returns; and the pin 3 eſcapes from the circle at *c*, ſlides along the yielding pallet *c d*, and when it eſcapes at 1, another pin on the under ſide of the wheel arrives at 4, and finds the arch *g f e* ready to receive it. And in this manner will the vibration of the balance be continued.

This deſcription of the mode of action at the ſame time points out the dimenſions which muſt be given to the parts of the pallet. The length of the pallet *c d* or *g b* muſt be equal to the interval between two ſucceeding pins, and the diſtance of the centres D and E muſt be double of this. The radius D *e* or E *g* may be as ſmall as we pleaſe. The concave arches *c b a* and *g f e* muſt be continued far enough to keep a pin reſting on them during the whole excurſion of the balance. The angle of ſcapement, in which the balance is under the influence of the wheels, is had by drawing D *c* and D *d*. This angle *c* D *d* is about 30°, but may be made greater or leſs.

Fig. B will give ſome notion how the two pallets may be combined on one verge. KL repreſents the verge with a pivot at each end. It is bent into a crank MNO, to admit the balance wheel between its branches. BC repreſents this wheel, ſeen edgewiſe, with its pins, alternately on different ſides. The pallets are alſo repreſented

preſented edgewiſe by *b c d* and *h g f*, fixed to the inſide of the branches of the crank, fronting each other. The poſition of their acting faces may be ſeen in the preceding figure, on the verge D, where the pallet *g h* is repreſented by the dotted line 2 *i*, as being ſituated behind the pallet *c d*. The remote pallet 2 *i* is placed ſo, that when the point *d* of the near pallet is juſt quitted by a pin 1 on the upper ſide of the wheel, the angle formed by the face and the arch of reſt of the other pallet is juſt ready to receive the next pin 2, which lies on the under ſide of the rim. A little attention will make it plain, that the action will be preciſely the ſame as when the pallets were on ſeparate axes. The pin 1 eſcapes from *d*, and the pin 2 is received on the arch of reſt, and locks the wheel while the balance is continuing its motion. When it returns, 2 gets off the arch of reſt, puſhes aſide the pallet 2 *i*, eſcapes from it when *i* gets to 1, and then the pin 3 finds the point *c* ready to receive it, &c. The vibrations may be increaſed by giving a ſufficient impulſe through the angle of ſcapement. But they cannot be more than a certain quantity, otherwiſe the top N of the crank will ſtrike the rim of the wheel. By placing the pins at the very edge of the wheel, the vibrations may eaſily be increaſed to a ſemicircle. By placing them at the points of long teeth, the crank may get in between them, and the vibrations extended ſtill farther, perhaps to 240°.

This ſcapement is unqueſtionably a very good one; and when equally well executed, ſhould excel Graham's, both by having but two acting faces to form (and theſe of hard ſteel or of ſtone), and by allowing us to make the circle of reſt exceedingly ſmall without diminiſhing the acting face of the pallet. This will greatly diminiſh the friction and the influence of oil. But, on the other hand, we apprehend that it is of very difficult execution. The figure of the pallets, in a manner that ſhall be ſuſceptible of adjuſtment and removal for repair, and yet ſufficiently accurate and ſteady, ſeems to us a very delicate job.

Mr Cumming, in his Elements of Clock and Watch-work, deſcribes (ſlightly) pallets of the very ſame conſtruction, making what he conceives to be conſiderable improvements in the form of the acting faces and the curves of reſt. He has alſo made ſome watches with this ſcapement; but they were ſo difficult, that few workmen can be found fit for the taſk; and they are exceedingly delicate, and apt to be put out of order. The connection of the pallets with each other, and with the verge, makes the whole ſuch a contorted figure, that it is eaſily bent and twiſted by any jolt or unſkilful handling.

There remains another ſcapement of this kind, having the tooth of the balance-wheel reſting on a cylindrical ſurface on the axis of the verge during the excurſions of the balance beyond the angle of ſcapement, and which differs ſomewhat in the application of the maintaining power from all thoſe already deſcribed.

This is known by the name of *Dupleix's ſcapement*, and is as follows: Fig. 16. repreſents the eſſential parts greatly magnified. AD is a portion of the balance-wheel, having teeth *f*, *b*, *g*, at the circumference. Theſe teeth are entirely for producing the *reſt* of the wheel, while the balance is making excurſions beyond the ſcapement. This is effected by means of an agate cylinder *o p q*, on the verge. This cylinder has a notch *o*. When the cylinder turns round in the direction *o p q*, the notch eaſily paſſes the tooth B which is reſting on the cylindric ſurface; but when it returns in the direction *q p o*, the tooth B gets into the notch, and follows it, preſſing on one ſide of it till the notch comes into the poſition *o*. The tooth, being then in the poſition *b*, eſcapes from the notch, and another tooth drops on the convex ſurface of the cylinder at B.

The balance wheel is alſo furniſhed with a ſet of ſtout flat ſided pins, ſtanding upright on its rim, as repreſented by *a*, D. There is alſo fixed on the verge a larger cylinder GFC above the ſmaller one *o p q*, with its under ſurface clear of the wheel, and having a pallet C, of ruby or ſapphire, firmly indented into it, and projecting ſo far as juſt to keep clear of the pins on the wheel. The poſition of this cylinder, with reſpect to the ſmaller one below it, is ſuch that, when the tooth *b* is eſcaped from the notch, the pallet C has juſt paſſed the pin *a*, which was at A while B reſted on the ſmall cylinder; but it moved from A to *a*, while B moved to *b*. The wheel being now at liberty, the pin *a* exerts its preſſure on the pallet C in the moſt direct and advantageous manner, and gives it a ſtrong impulſion, following and accelerating it till another tooth ſtops on the little cylinder. The angle of ſcapement depends partly on the projection of the pallet, and partly on the diameter of the ſmall cylinder and the advance of the tooth B into the notch. Independent of the action on the ſmall cylinder, the angle of ſcapement would be the whole arch of the large cylinder between C and *x*. But *a* ſtops before it is clear of the pallet, and the arch of impulſion is ſhortened by all the ſpace that is deſcribed by the pin while a tooth moves from B to *b*. It ſtops at *a*.

We are informed by the beſt artiſts, that this ſcapement gives great ſatisfaction, and equals, if it do not excel, Graham's cylindrical ſcapement. It is eaſier made, and requires very little oil on the ſmall cylinder, and none at all on the pallet. They ſay that it is the beſt for pocket watches, and is coming every day more into repute. Theory ſeems to accord with this character. The reſting cylinder may be made very ſmall, and the direct impulſe on the pallet gives it a great ſuperiority over all thoſe already deſcribed, where the action on the pallet is oblique, and therefore much force is loſt by the influence of oil. But we fear that much force is loſt by the tooth B ſhifting its place, and thus ſhortening the arch of impulſion; for we cannot reckon much on the action of B on the ſide of the notch, becauſe the lever is ſo extremely ſhort. Accordingly, all the watches which we have ſeen of this kind have a very ſtrong main ſpring in proportion to the ſize and vibration of the balance. If we leſſen this diminution of the angle of impulſion, by leſſening the cylinder *o p q*, and by not allowing B to penetrate far into the notch, the ſmalleſt inequality of the teeth, or ſhake in the pivots of the balance or wheel, will cauſe irregularity, and even uncertainties in the locking and unlocking the wheel by this cylinder.

A ſcapement exceedingly like this was applied long ago by Detertre, a French artiſt, to a pendulum. The only difference is, that in the pendulum ſcapement the ſmall cylinder is cut through to the centre, half of it only being left; but the pendulum ſcapement gives a more effective employment of the maintaining power, becauſe the wheel acts on the pallet during the *whole* of the aſſiſted vibration. In a balance ſcapement, if we attempt to diminiſh the inefficient motion of the pin from A to *a*, by leſſening the diameter of the ſmall cylinder, the hold given to the tooth in the notch will be ſo trifling, that the tooth will be thrown out by the ſmalleſt play in the pivot holes, or inequality in the length of the teeth.

With this we conclude our account of ſcapements, where the action of the maintaining power on the balance is ſuſpended during the excurſion beyond the angle of impulſion, by making a tooth reſt on the ſurface of a ſmall concentric cylinder. In ſuch ſcapements, the balance, during its excurſions, is almoſt free from any connection with the wheels, and its iſochroniſm is diſturbed by nothing but the friction on this ſurface.—We come now to ſcapements of more artful conſtruction, in which the balance is really and completely free during the whole of its excurſion, being altogether diſengaged from the wheelwork These are called DETACHED SCAPEMENTS. They are of more recent date. We believe that Mr Le Roi was the firſt inventor of them, about the year 1748. In the Memoirs of the Academy of Paris for that year, and in the Collection of approved Machines and Inventions, we have deſcriptions of the contrivance. The balance-wheel reſts on a detent, while the balance is vibrating in perfect freedom. It has a pallet ſtanding out from the centre, which, in the courſe of vibration, paſſes cloſe by the point of a tooth of the wheel. At that inſtant a pin, connected with this pallet, withdraws the detent from the wheel, and the tooth juſt now mentioned follows the pallet with rapidity, and gives it a ſmart puſh forward. Immediately after, another tooth of the wheel meets the other claw of the detent, and the wheel is again locked. When the balance returns, the pin puſhes the detent back into its former place, where it again locks the wheel. Then the balance, reſuming its firſt direction, unlocks the wheel, and receives another impulſion from it. Thus the balance is unconnected with the wheels, except while it gets the impulſion, and at the moments of unlocking the wheels.

This contrivance has been reduced to the greateſt poſſible ſimplicity by the Britiſh artiſts, and ſeems ſcarcely capable of farther improvement. The following is one of the moſt approved conſtructions. In fig. 17. *a b c* repreſents the pallet, which is a cylinder of hard ſteel or ſtone, having a notch *a b*. A portion of the balance-wheel is repreſented by AB. It is placed ſo near to the cylinder that the cylinder is no more than clear of *two adjoining* teeth. DE is a long ſpring, ſo fixed to the watch plate at E, as to preſs very gently on the ſtop pin G. A ſmall ſtud F is fixed to that ſide of the ſpring that is next to the wheel. The tooth of the wheel reſts on this ſtud, in ſuch a manner that the tooth *a* is juſt about to touch the cylinder, and the tooth *f* is juſt clear of it. Another ſpring, extremely ſlender, is attached to the ſpring DE, on the ſide next the balance-wheel, and claps cloſe to it, but keeping clear of the ſtud F, and having its point *o* projecting about $\frac{1}{30}$th of an inch beyond its extremity. When the point *o* is preſſed towards the wheel, it yields moſt readily; but, when preſſed in the oppoſite direction, it carries the ſpring DE along with it. The cylinder being ſo placed on the verge that the edge *a* of the notch is cloſe by the tooth *a*, a hole is drilled at *i*, cloſe by the projecting point of the ſlender ſpring, and a ſmall pin is driven into this hole. This is the whole apparatus; and this ſituation of the parts correſponds to the quieſcent poſition of the balance.

Now, let the balance be turned out of this poſition 80 or 90 degrees, in the direction *a b c*. When it is let go, it returns to this poſition with an accelerated motion. The pin *i* ſtrikes on the projecting point of the ſlender ſpring, and, preſſing the ſtrong ſpring DE outward from the wheel, withdraws the ſtud F from the tooth; and thus unlocks the wheel. The tooth *a* engages in the notch, and urges round the balance. The pin *i* quits the ſlender ſpring before the tooth quits the notch; ſo that when it is clear of the pallet, the wheel is locked again on the ſtud F, and another tooth *g* is now in the place of *a*, ready to act in the ſame manner. When the force of the balance is ſpent, it ſtops, and then returns toward its quieſcent poſition with a motion continually accelerated. The pin *i* arrives at the point *o* of the ſlender ſpring, raiſes it from the ſtrong ſpring without diſturbing the latter, and almoſt without *being* diſturbed by this trifling obſtacle; and it goes on, turning in the direction *a b c*, till its force is again ſpent; it ſtops, returns, again unlocks the wheel, and gets a new impulſion. And in this manner the vibrations are continued. Thus we ſee a vibration, almoſt free, maintained in a manner even more ſimple than the common crutch ſcapement. The impulſe is given direct, without any decompoſition by oblique action, and it is continued through the *whole* motion of the wheel. No part of this motion is loſt, as in Dupleix's ſcapement, by the *gradual* approach of the tooth to its active poſition. Very little force is required for unlocking the wheel, becauſe the ſpring DFE is made ſlender at the remote end E, ſo that it turns round E almoſt like a lever turning on pivots. A ſudden twitch of the watch, in the direction *b a*, might chance to unlock the wheel. But this will only derange one vibration, and even that not conſiderably, becauſe the teeth are ſo cloſe to the cylinder that the wheel cannot advance till the notch comes round to the place of ſcapement. A tooth will continue preſſing on the cylinder, and by its friction will change a little the extent and duration of a ſingle vibration. The greateſt derangement will happen if the wheel ſhould thus unlock by a jolt, while the notch paſſes through the arch of ſcapement in the returning vibration. Even this will not greatly derange it, when the watch is clean and vibrating wide; becauſe, in this poſition, the balance has its greateſt momentum, and the direction of the only jolt that can unlock the wheel tends to increaſe this momentum relatively. In ſhort, conſidering it theoretically, it ſeems an almoſt perfect ſcapement; and the performance of many of theſe watches abundantly confirms that opinion. They are known to keep time for many days together, without varying one ſecond from day to day; and this even under conſiderable variations of the maintaining power. Other detached ſcapements may equal this, but we ſcarcely expect any to exceed it; and its ſimplicity is ſo much ſuperior to any that we have ſeen, that, on this account, we are diſpoſed to give it the preference. We do not mean to ſay that it is the beſt for a pocket watch. Perhaps the ſcapement of Dupleix or Graham may be preferable, as being ſuſceptible of greater ſtrength, and more able to withſtand jolts. Yet it is a fact that ſome of the watches made in this form by Arnold and others have kept time in the wonderful manner abovementioned while carried about in the pocket.

Mr Mudge of London invented, about the year 1763, another detached ſcapement, of a ſtill more ingenious conſtruction. It is a counterpart of Mr Cumming's ſcapement for pendulums. The contrivance is to this effect. In fig. 18. *a b c* repreſents the balance. Its axis is bent into a large crank EFGHIK, ſufficiently roomy to admit within it two other axes M and L, with the proper cocks for receiving their pivots. The three axes form one ſtraight line. About theſe ſmaller axes are coiled two auxiliary ſprings, in oppoſite directions, having their outer extremities fixed in the ſtuds A and B. The balance has its ſpring alſo, as uſual, and the three ſprings are ſo diſpoſed that each of them alone would keep the balance at reſt in the ſame poſition, which we may ſuppoſe to be that repreſented in the figure. The auxiliary ſprings A and B are connected with the balance only occaſionally, by means of the arms *m* and *n* projecting from their reſpective axes. Theſe arms are catched on oppoſite ſides by the pins *o*, *p*, in the branches of the crank; ſo that when the balance turns round, it carries one or other of thoſe arms round with it, and, during this motion, it is affected by the auxiliary ſpring connected with the arm ſo carried round by it.

Let us ſuppoſe that the balance vibrates 120° on each ſide of its quieſcent poſition *a b c*, ſo that the radius E *a* acquires, alternately, the poſitions E *b* and E *c*. The auxiliary ſprings are connected with the wheels by a common dead-beat pendulum ſcapement, ſo that each can be ſeparately wound up about 30°, and retained in that poſition. Let us alſo ſuppoſe that the ſpring A has been wound up 30° in the direction *a b*, by the wheel-work, and that the point *a* of the rim of the balance, having come from *c*, is paſſing through *a* with its greateſt velocity. When the radius E *a* has paſſed *a* 30° in its courſe toward *b*, the pin *o* finds the arm *m* in its way, and carries it along with it till *a* gets to *b*. But, by carrying away the arm *m*, it has unlocked the wheel-work, and the ſpring B is now wound up 30° in the other direction, but has no connection with the balance during this operation. Thus the balance finiſhes its ſemivibration *a b* of 120°, oppoſed by its own ſpring the whole way, and by the auxiliary ſpring A through an angle of 90°. It returns to the poſition E *a*, aided by A and by the balance ſpring, through an angle of 120°. In like manner, when E *a* has moved 30° toward the poſition E *c*, the pin *p* meets with the arm *n*, and carries it along with it through an angle of 90°, oppoſed by the ſpring B, and then returns to the poſition E *a*, aſſiſted by the ſame ſpring through an arch of 120°.

Thus it appears that the balance is oppoſed by each auxiliary ſpring through an angle of 90°, and aſſiſted through an angle of 120°. This difference of action maintains the vibrations, and the neceſſary winding up of the auxiliary ſprings is performed by the wheel-work, at a time when they are totally diſengaged from the balance. No irregularity of the wheel-work can have any influence on the force of the auxiliary ſprings, and therefore the balance is completely diſengaged from all theſe irregularities, except in the ſhort moment of unlocking the wheel that winds up the ſprings.

This is a moſt ingenious conſtruction, and the neareſt approach to a free vibration that has yet been thought of. It deſerves particular remark that, during the whole of the returning or accelerated ſemivibration, the united force of the ſprings is proportional to the diſtance from the quieſcent poſition. The ſame may be ſaid of the retarded excurſion beyond the angle of impulſe: therefore the only deviation of the forces from the law of cycloidal vibration is during the motion from the quieſcent poſition to the meeting with the auxiliary ſpring. Therefore, as the forces, on both ſides, beyond this angle, are in their due proportion, and the balance always makes ſuch excurſions, there ſeems nothing to diſturb the iſochroniſm, whether the vibrations are wide or narrow. Accordingly, the performance of this ſcapement, under the ſevereſt trials, equalled any that were compared with it, in as far as it depended on ſcapement alone. But it is evident that the execution of this ſcapement, though moſt ſimple in principle, muſt always be vaſtly more difficult than the one deſcribed before. There is ſo little room, that the parts muſt be exceedingly ſmall, requiring the moſt accurate workmanſhip. We think that it may be greatly ſimplified, preſerving all its advantages, and that the parts may be made of more than twice their preſent ſize, with even leſs load on the balance from the inertia of matter. This improvement is now carrying into effect by a friend.

Still, however, we do not ſee that this ſcapement is, theoretically, ſuperior to the laſt. The irregularities of maintaining power affect that ſcapement only in the arch of impulſion, where the velocity is great, and the time of action very ſmall. Moreover, the chief effect of the irregularities is only to enlarge the excurſions; and in theſe the wheels have no concern.

Mr Mudge has alſo given another detached ſcapement, which he recommends for pocket watches, and executed entirely to his ſatisfaction in one made for the Queen. A dead beat pendulum ſcapement is enterpoſed, as in the laſt, between the wheels and the balance. The crutch EDF (fig. 19.) has a third arm DG, ſtanding outwards from the meeting of the other two, and of twice their length. This arm terminates in a fork AGB. The verge V has a pallet C, which, when all is at reſt, would ſtand between the points A, B of the fork. But the wheel, by its action on the pallet E, forces the fork into the poſition B *g b*, the point A of the fork being now where B was before, juſt touching the cylindrical ſurface of the verge. The ſcapement of the crutch EDF is not accurately a dead beat ſcapement, but has a very ſmall recoil beyond the angle of impulſion. By this circumſtance the branch A (now at B) is made to preſs moſt gently on the cylinder, and keeps the wheel locked, while the balance is going round in the direction BHA. The point A gets moving from A to B by means of a notch in the cylinder, which turns round at the ſame time by the action of the branch AG on the pallet C; but A does not touch the cylinder during this motion, the notch leaving free room for its paſſage. When the balance returns from its excurſion, the pallet C ſtrikes on the branch A (ſtill at B), and unlocks the wheel. This now acting on the crutch pallet F, cauſes the branch *b* of the fork to follow the pallet C, and give it a ſtrong impulſe in the direction in which it is then moving, cauſing the balance to make a ſemivibration in the direction AHB. The fork is now in the ſituation A *g a*, ſimilar to B *g b*, and the wheel is again locked on the crutch pallet E.

The intelligent reader will admit this to be a very ſteady and effective ſcapement. The lockage of the wheel is procured in a very ingenious manner; and the friction on the cylinder, neceſſary for effecting this, may be made as ſmall as we pleaſe, notwithſtanding a very ſtrong action of the wheel: For the preſſure of the fork on the cylinder depends entirely on the degree of recoil that is formed on the pallets E and F. *Preſſure* on the cylinder is not *indiſpenſably* neceſſary, and the crutch ſcapement might be a real dead beat. But a ſmall recoil, by keeping the fork in contact with the cylinder, gives the moſt perfect ſteadineſs to the motion. The ingenious inventor, a man of approved integrity and judgment, declares that her Majeſty's watch was the beſt pocket watch he had ever ſeen. We are not diſpoſed to queſtion its excellency. We ſaw an experiment watch of this conſtruction, made by a country artiſt, having a balance ſo heavy as to vibrate only twice in a ſecond. Every vibration was ſenſibly beyond a turn and a half, or 540°. The artiſt aſſured us, that when its proper balance was in, vibrating ſomewhat more than five times in a ſecond, the vibrations even exceeded this. He had procured it this great mobility by ſubſtituting a roller with fine pivots in place of the ſimple pallet of Mudge. This great extent of detached vibration is an unqueſtionable excellence, and is peculiar to thoſe two ſcapements of this ingenious artiſt.

Very ingenious ſcapements have been made by Ernſhaw, Howel, Hayley, and other Britiſh artiſts; and many by the artiſts of Paris and Geneva. But we muſt conclude the article, having deſcribed all that have any difference in principle.

The ſcapement having been brought to this degree of perfection, we have an opportunity of making experiments on the law of action of ſprings, which has been too readily aſſumed. We think it eaſy to demonſtrate, that the figure of a ſpring, which muſt have a great extent of rapid motion, will have a conſiderable influence on the force which it impreſſes on a balance *in actual motion*. The accurate determination of this influence is not very difficult in ſome ſimple caſes It is the greateſt of all in the plane ſpiral, and the leaſt in the cylindrical; and, in this laſt form, it is ſo much leſs as the diameter is leſs, the length of the ſpring being the ſame. By employing many turns, in order to have the ſame ultimate force at the extremity of the excurſion, this influence is increaſed. A particular length of ſpring, therefore, will make it equal to a given quantity; and it may thus compenſate for a particular magnitude of friction, and other obſtructions. This accounts for the obſervation of Le Roy, who found that every ſpring, *when applied to a movement*, had a certain length, which made the wide and narrow vibrations iſochronous. His method of trial was ſo judicious, that there can be no doubt of the juſtneſs of his concluſion. His time-keeper had no fuzee; and when the laſt revolution of the main wheel was going on, the vibrations were but of half the extent of thoſe made during the firſt revolution. Without minding the real rate of going, he only compared the duration of the firſt and laſt revolution of the minute hand. An artiſt of our acquaintance repeated theſe experiments, and with the ſame reſult: But, unfortunately, could derive little benefit from them; becauſe in one ſtate of the oil, or with one balance, he found the lengths of the ſame ſpring, which produced iſochronous vibrations, were different from thoſe which had this effect in another ſtate of the oil, or with another balance. He alſo obſerved another difference in the rate, ariſing from a difference of poſition, according as XII, VI, III, or IX, was uppermoſt; which difference plainly ariſes from the ſwagging of the ſpring by its weight, and, in that ſtate, acting as a pendulum. This unluckily put a ſtop to his attempts to leſſen this hurtful influence by employing a cylindrical ſpiral of ſmall diameter and great length.

WATER-Blowing Machine, called in French *Soufflet d'eau* or *trompe*, is a machine which, by the action of falling water, ſupplies air to a blaſt furnace. It conſiſts of an upright pipe, through which a ſhower of water is made to fall; and this ſhower carries down with it a maſs of air, which is received beneath in a kind of tub, and conducted to the furnace by means of a pipe. The firſt idea of ſuch a machine was doubtleſs ſuggeſted by thoſe local winds, which are always produced by natural falls of water over precipices, and in the mountains (ſee page 278 of this Volume); but perhaps we are indebted for the firſt accurate theory of it to Profeſſor Venturi.

That philoſopher, in his experimental reſearches concerning the lateral communication of motion in fluids, proves that the water-blowing machine affords air to the furnace, by the accelerating force of gravity and the lateral communication of motion combined together. He begins with an idea, which, he candidly acknowledges, did not eſcape the penetration of Leonardo Da Vinci. Suppoſe a number of equal balls to move in contact with each other along the horizontal line AB (Plate XLVI. fig. 1.). Imagine them to paſs with an uniform motion, at the rate of four balls in a ſecond. Let us take BF, equal to 16 feet Engliſh. During each ſecond four balls will fall from B to F, and their reſpective diſtances in falling will be nearly BC = 1, CD, = 3, DE = 5, EF = 7. We have here a very evident repreſentation of the ſeparation, and ſucceſſive elongation, which the accelerating force of gravity produces between bodies which fall after each other.

The rain water flows out of gutters by a continued current; but during its fall it ſeparates into portions in the vertical direction, and ſtrikes the pavement with diſtinct blows. The water likewiſe divides, and is ſcattered in the horizontal direction. The ſtream which iſſues out of the gutter may be one inch in diameter, and ſtrike the pavement over the ſpace of one foot. The air which exiſts between the vertical and horizontal ſeparations of the water which falls, is impelled and carried downwards. Other air ſucceeds laterally; and in this manner a current of air or wind is produced round the place ſtruck by the water. Hence the following idea of a water-blowing maching:

Let BCDE (fig. 2.) repreſent a pipe, through which the water of a canal AB falls into the lower receiver MN. The ſides of the tube have openings all round, through which the air freely enters to ſupply what the water carries down in its fall. This mixture of water

Watch-work

and air proceeds to ſtrike a maſs of ſtone Q ; whence rebounding through the whole width of the receiver MN, the water ſeparates from the air, and falls to the bottom at XZ, whence it is diſcharged into the lower channel or drain, by one or more openings TV. The air being leſs heavy than the water, occupies the upper part of the receiver ; whence being urged through the upper pipe O, it is conveyed to the forge.

It has been ſuppoſed by ſome eminent chemiſts, that the air which paſſes through the pipe O is furniſhed by the decompoſition of water. To aſcertain whether this be the caſe or not, our author formed a water-blowing engine of a ſmall ſize. The pipe BD was two inches in diameter, and four feet in height. When the water accurately filled the ſection BC, and all the lateral openings of the pipe BDEC were cloſed, the pipe O no longer offered any wind. It is therefore evident, that in the open pipes the whole of the wind comes from the atmoſphere, and no portion is afforded by the decompoſition of water. It remains, therefore, to determine the circumſtances proper to drive into the receiver MN the greateſt quantity of air, and to meaſure that quantity.

1. To obtain the greateſt effect from the acceleration of gravity, it is neceſſary that the water ſhould begin to fall at BC, (fig. 2.) with the leaſt poſſible velocity ; and that the height of the water FB ſhould be no more than is neceſſary to fill the ſection BC. Our author ſuppoſes the vertical velocity of this ſection to be produced by an height or head equal to BC.

2. We do not yet know, by direct experiment, the diſtance to which the lateral communication of motion between water and air can extend itſelf; but we may admit with confidence, that it can take place in a ſection double that of the original ſection with which the water enters the pipe. Let us ſuppoſe the ſection of the pipe BDEC to be double the ſection of the water at BC ; and, in order that the ſtream of fluid may extend and divide itſelf through the whole double ſection of the pipe, ſome bars, or a grate, are placed in BC, to diſtribute and ſcatter the water through the whole internal part of the pipe.

3. Since the air is required to move in the pipe O with a certain velocity, it muſt be compreſſed in the receiver. This compreſſion will be proportioned to the ſum of the accelerations, which ſhall have been deſtroyed in the inferior part KD of the pipe. Taking KD = 1,5 feet, we ſhall have a preſſure ſufficient to give the requiſite velocity in the pipe O. The ſides of the portion KD, as well as thoſe of the receiver MN, muſt be exactly cloſed in every part.

4. The lateral openings in the remaining part of the pipe BK may be ſo diſpoſed and multiplied, particularly at the upper part, that the air may have free acceſs within the tube. We will ſuppoſe them to be ſuch that 0,1 foot height of water might be ſufficient to give the neceſſary velocity to the air at its introduction through the apertures.

All theſe conditions being attended to, and ſuppoſing the pipe BD to be cylindrical, it is required to determine the quantity of air which paſſes in a given time through the circular ſection KL. Let us take in feet KB = 1,5 ; BC = BF = a ; BD = b. By the common theory of falling bodies, the velocity in KL will be 7,76 $\surd\,(a + b - 1{,}4)$; the circular ſection KL = 0,785 a^2. Admitting the air in KL to have acquired the ſame velocity as the water, the quantity of the mixture of the water and air which paſſes in a ſecond through KL is = 6, 1 $a^2 \surd\,(a + b - 1{,}4)$. We muſt deduct from the quantity $(a + b - 1{,}4)$ that height which anſwers to the velocity the water muſt loſe by that portion of velocity which it communicates to the air laterally introduced ; but this quantity is ſo ſmall that it may be neglected in the calculation. The water which paſſes in the ſame time of one ſecond thro' BC is = 0.4 $a^2 \surd\,(a + 0{,}1)$. Conſequently, the quantity of air which paſſes in one ſecond through KL, will be = 6, 1 $a^2 \surd\,(a + b - 1{,}4) - 0{,}4\,a^2 \surd\,(a + 0{,}1)$, taking the air itſelf, even in its ordinary ſtate of compreſſion, under the weight of the atmoſphere. It will be proper, in practical applications, to deduct one-fourth from this quantity ; 1. On account of the ſhocks which the ſcattered water ſuſtains againſt the inferior part of the tube, which deprive it of part of its motion ; and, 2. Becauſe it muſt happen that the air in LK will not, in all its parts, have acquired the ſame velocity as the water.

Watch-work, Weaving.

If the pipe O do not diſcharge the whole quantity of air afforded by the fall, the water will deſcend at XZ ; the point K will riſe in the pipe, the afflux of air will diminiſh, and part of the wind will iſſue out of the lower lateral apertures of the pipe BK.

We ſhall not here examine the greater or leſs degree of perfection of the different forms of water-blowing machines which are uſed at various iron forges ; ſuch as thoſe of the Catalans, and elſewhere. Theſe points may be eaſily determined from the principles here laid down, compared with thoſe eſtabliſhed in the articles *Resistance of Fluids (Encycl.)*, and Dynamics (*Supplement.*).

WEAVING (ſee *Encycl.*) is an operation, which, by means of a well-known inſtrument called the *weaving-loom*, has hitherto been performed by bodily labour. That labour is pretty ſevere ; and Mr Robert Millar, an ingenious calico-printer in the county of Dumbarton, Scotland, wiſhing to leſſen it, invented, ſome years ago, a weaving-loom, which may be wrought by water, ſteam, horſes, or any other power. For his invention he received a patent, dated June 26th 1796 ; and though truth compels us to ſay, that we do not think it likely to emulate the ſpinning machine of Arkwright, it is ſufficiently ingenious to deſerve notice in a Work of this kind. The following is his own deſcription of his patent weaving-loom :

Fig. 1. (Plate L.) repreſents a ſide view of the loom, AA, BB, CC, DD, being the frame. *a* is an axis (which we ſhall call the ſpindle) acroſs the frame. On this axis is a ſheeve *b*, two inches thick, having a groove round it, two inches deep, and half an inch wide. The bottom of this groove is circular, except in one part *c*, where it is filled up to the top ; a lever *d* reſts on the bottom of this groove, and is lifted up by it when the elevation *c* comes round to the ſituation repreſented in the figure. By this motion, the lever *d* acts on the ratchet wheel *e* by the catch *f*, and draws it forward one tooth, each revolution of the ſheeve. This ratchet wheel is in an iron frame *g g*, which alſo properly carries the two catches *t* and *u*, which are connected with it at *v*. The catch *u* holds the ratchet-wheel in its poſition, while the lever *d*, and the catch *t*, are moved by the groove *c* in the ſheeve. On the arbor

of the ratchet is a ſmall pinion *h*, working in the wheel *f*; this wheel is fixed on the end of the roller *e* of fig. 3. On the ſide of the ſheeve *b* is fixed a wiper *k*, which lifts the treadle *l*. This treadle turns on its joints in the ſheeve E, which is fixed to the ſide of the frame A and D; it is kept preſſing on the bottom of the groove in the ſheeve by a ſpring *m*, fixed to the frame ſide A, and having a ſlender rod *n* from its extremity, joining it with the treadle at *l*. From the point of the treadle there goes a belt *o*, which paſſes over the pulley *p*, which is ſeen edgewiſe in this figure, and is joined to the top of the fly pin *q*, of fig. 2. At the end of the frame A is the ſhort poſt F; on this reſts the yarn beam *j*, having a ſheeve *r*, over which paſſes a cord, having a weight *s* ſuſpended to it. The other end of this cord is faſtened to the ſpring *v*: the weight cauſes the yarn-beam to ſtretch the web from the ratchet wheel *e*, with its catch *u*; and the ſpring *v* allows the rope to ſlide on the ſheeve as the ratchet is drawn round during the working.

Fig. 2. is a front view of the loom. *a a* is the ſpindle which carries the ſheeve *b*, and the wipers *d* and *d*, which move the treadles *w*. *w*. of fig. 1. Theſe uſe the treadles of the headles, with which they are connected by cords from the ſhafts of the headles *s*, *s*. From the upper ſhaft there go two leathern belts *f*, *f*, to the roller *y*, furniſhed each with a buckle, for tightening them at pleaſure. The two wipers *c*, *c*, on the ſhaft *a*, which ſerve for taking back the lay, have the two treadles *x*, *x*, in fig. 3. with a belt from each paſſing over the roller *h* 2 of fig. 1. and fixed to the ſword of the lay. From the ſwords of the lay forward is fixed a belt to each end of the roller *i*; from this roller there goes a cord to the ſpring *j*, which ſerves for taking forward the lay which is hinged on the rocking tree *t*. The ſtar-wheel *b* of fig. 3. and the ſheeve *b* of fig. 1. are fixed to the oppoſite ends of the ſpindle *a* without the frame; and both the wheel and ſheeve have a wiper *k* fixed to them for moving the treadles. In order to drive the ſhuttle, the belts *o*, *o*, go from the points of the treadles, over the pulleys *p*, *p*, to the top of the fly-pin *q*: This turns on a pin joint in a rail *r*, which goes acroſs the loom. From its lower end there go two ſmall cords to the ſhuttle drivers *g*. *g*, which ſlide on the iron rods *n*, *n*. A long iron rod *v* goes acroſs the lay, and is hung on two centres at the ends. In this rod *v* are fixed two ſmall crooked wires *w*, *w*, which are more diſtinctly marked in the little figure *w* above, which repreſents a ſection of the lay. The dot at the lower end of the wire *w*, in this figure, is the ſection of the rod *v*. The ſhuttle paſſes between theſe wires and the lay every ſhot, and lifts them up, cauſing the rod *v* to turn round a little. But if the ſhuttle ſhould not paſs theſe wires, nor lift them, it would be drawn home by the lay, and deſtroy the web. To prevent this, there is fixed on one end of the rod *v* a ſtout crooked wire *z*, having a broad or flat head, which naturally reſts on a plate of iron, marked and fixed to the back of the lay. This plate has a ſlit in its middle about an inch deep. In this ſlit reſts the rod *a* 2 of fig. 3. on which is a ſhort ſtud, which is caught by the wire *z* when the wire *w* is not lifted back by the paſſing ſhuttle. This will ſtop the lay from coming home, and will ſet off the loom.

Fig. 3. is another ſide-view of the loom oppoſite to fig. 1. On the ſpindle *a* is the ſtar wheel *b*, on the outſide of the loom frame, on the arms of which wheel is fixed the wiper *k*, as the ſimilar wiper is fixed to the ſheeves on the other end of the ſpindle. The wipers which drive the ſhuttles are fixed on oppoſite ſquares of the ſpindle, and work alternately. Below the ſtar-wheel is a pinion *c*, which is on a round ſpindle, turned by the water-wheel, by means of a wheel on this ſpindle. In a wheel on this ſpindle are two ſtuds, on which the pinion *c* ſlides off and on as the loom is ſet off and on by the lever *d*. At the farther end of this lever is the weight *s*, hanging by a cord which paſſes over a pulley *t*, fixed at the outer end of the ſpring-catch on which the lever *d* reſts; and thus the loom is drawn in at the upper end of the lever *d*. But when the ſhuttle does not lift the wire *z*, it catches on the ſtud on the rod *a* 2, which is connected with the ſpring-catch, and the lever *d* flies off with the weight *s*, and the loom ſtops working. On the head of the poſt F is the yarn-beam. The rollers *e* and *f* are cylinders, preſſed together by a ſcrew-lever, and take away the cloth between them at a proper rate. In the roller *f* is a groove for a band for driving the roller *g*, on which the cloth winds itſelf as it is wrought. Wherever ſprings are mentioned to be uſed in the above deſcription, weights may be uſed in their ſtead, and to the ſame effect, and more eſpecially upon the treadle of fig. 1. for driving the ſhuttle.

WEIGHTS AND MEASURES, in commerce, are ſo various, not only in different countries, but even in different provinces of the ſame country, and this variation is the ſource of ſo much inconveniency in trade, that writers on political and commercial economy have propoſed various methods for fixing an univerſal and immoveable ſtandard of weights and meaſures for all ages and nations. Sir James Stewart Denham's ſpeculations on this ſubject have been noticed in his life publiſhed in this *Supplement*; Mr Whitehurſt's ingenious contrivance for eſtabliſhing a ſtandard of weights and meaſures has been mentioned under the title MEASURE (*Encycl.*); and the new table of weights and meaſures, which the French republicans wiſh to impoſe upon all Europe, is given (*Encycl.*) under the title REVOLUTION, n° 183.

As theſe meaſures occur frequently, even in Engliſh tranſlations of French books of value, we ſhall here give ſuch an account of them as may enable the reader to reduce them with eaſe to the Engliſh ſtandards. They are of five kinds; *meaſures of length*, *of capacity*, *of weight*, *of ſuperficies for land*, *and of wood for fuel*. For every kind, there are many meaſures of different ſizes, one of which has been taken as the baſis of all the reſt, and its name aſſumed as the root of their names. Thus METRE is called the principal meaſure of length; LITRE, of capacity; GRAMME, of weight; ARE, of ſuperficies of land; and STERE, of wood for fuel. Theſe words being the radical terms of the names of other meaſures of length, capacity, &c. a relation is hereby preſerved between the names.

The meaſures of length above the *metre*, are ten times, a hundred times, a thouſand times, ten thouſand times, greater than the metre. The meaſures of length below the metre, are ten times, a hundred times, a thouſand times, leſs. To form the names of theſe meaſures, other words which indicate the relations of *ten times*, a

hundred

hundred times, greater; and of *ten times*, a *hundred times*, leſs, &c. are placed before the word *metre*. The ſame annexes have been uſed to form the names of meaſures, greater or leſs, than the *litre*, the *gramme*, &c. It is neceſſary, therefore, to ſtate in this place the Engliſh equivalents of only the *metre*, the *litre*, the *gramme*, the *are*, and the *ſtere*.

The METRE = 3.28084 feet Engliſh.

The LITRE = 61.0243 cubic inches, or $1\frac{103}{141}$ pint ale meaſure.

The GRAMME, or cubic *centi-metre* of water, at the freezing point, = $\frac{1}{443}$ lb. averd. or $\frac{1}{28}$ of an ounce, or $\frac{26}{45}$ of a dram nearly.

The ARE = $1076\frac{2}{5}$ ſquare feet, or $119\frac{3}{5}$ ſquare yards, or $\frac{1}{40}$ of an acre nearly.

The STERE, or cubic metre = 35.31467 cubic feet.

The better part of our countrymen, not chooſing to adopt the weights and meaſures preſcribed to them by the French Convention and the National Inſtitute, Sir George Shuckburgh Evelyn, Bart. turned his attention to this ſubject, and publiſhed, in the Philoſophical Tranſactions for 1798, an account of ſome endeavours to aſcertain a ſtandard of weights and meaſures. The principles upon which he proceeded are the ſame with Mr Whitehurſt's; but he has carried his experiments much farther than his predeceſſor, and ſeems to have conducted them with greater accuracy. His memoir is hardly ſuſceptible of abridgment; and our limits do not permit us to inſert it entire. This is indeed unneceſſary, if it be true, as another ingenious gentleman alleges *, that we are in the actual poſſeſſion, and the conſtant uſe, of a ſtandard both for weight and meaſure, as invariable as that now uſed in France. This ſtandard he finds in the foot meaſure, and in the avoirdupoiſe, or, as he thinks it ought to be called, the *decade* ounce weight.

The decade ounce weight of pure rain, or diſtilled water, at 60° of heat, is generally allowed to be equal in bulk to the one-thouſandth part of the cubic foot. Were 44.3511 parts out of 10000, or about $\frac{1}{225}$th part added to the preſent Wincheſter buſhel, that buſhel would then contain exactly 10 cubic feet or 10000 oz. of diſtilled water, at 60° of heat.

Our author then gives comparative tables between this ſyſtem and that which is now eſtabliſhed in France. Taking the metre at 3 French feet, and 11.296 lines †, and the French foot to be to the Engliſh as 1 : 1.065752004 ‡, one French foot will be equal to 10.65752004 Engliſh decades, or tenths of an Engliſh foot: hence he calculates the following

COMPARATIVE TABLES, Engliſh with French.

LONG MEASURE.

Long decade.	Metre.		Metre.		Long decades.
1 =	0.03047983	ferè	1 =		32.808583358, &c. or inches 39.3703.

SQUARE MEASURE.

Square decades.	Ares,		Ares.		Square decades.
1 =	0.0000092902	ferè	1 =		107640.3142, or ſqr. inch.155002.052448

CUBE MEASURE.

Cube decades.	Litres.		Litre.		Cube decades.
1 =	0.02831637	fere	1 =		35.3152622, &c. or cub.inch.61.0247727

WEIGHTS.

Avoird or decade oz.	Grammes.		Gramme.		Decade oz.
1 =	28.31637	ferè	1 =		0.03531526, &c. or grains, 15.45042625

$$\left.\begin{matrix}\text{Long,}\\ \text{Square,}\\ \text{or}\\ \text{Cube,}\end{matrix}\right\}\begin{matrix}\text{decades are}\\ \text{reduced to}\end{matrix}\left\{\begin{matrix}\text{Long,}\\ \text{Square,}\\ \text{or}\\ \text{Cube,}\end{matrix}\right\}\begin{matrix}\text{English}\\ \text{inches by}\\ \text{multiply-}\\ \text{ing by}\end{matrix}\left\{\begin{matrix}1.2\\ 1.44\\ 1.728\end{matrix}\right.$$

and decade ounces are reduced to grains,

$$\text{containing}\left\{\begin{matrix}7000,\\ \text{or}\\ 5760,\end{matrix}\right\}\text{to the lb.}\left\{\begin{matrix}\text{Avoird.}\\ \\ \text{Troy,}\end{matrix}\right\}\text{by}$$

multiplying the ounce by 437.5 = the number of grains in an avoirdupoiſe ounce.

Our author, who ſeems to have paid much attention to weights and meaſures, obſerves, that a ſtandard meaſure for the purpoſes of trade, in particular, as well as for others, that would uniformly give an accurate reſult, and could be eaſily made, examined, and aſcertained, by common mechanics, which neither our preſent liquid nor dry meaſures evidently can, would ſurely be an acquiſition of great value. Such an one, he preſumes, would be the following: A ſquare pyramid, whoſe perpendicular height is exactly thrice the length of the ſide of the baſe: for ſuch an one, and every ſection of it, made by a plane parallel to its baſe, would, in the firſt inſtance, poſſeſs, and, in every ſubdiviſion, retain theſe remarkable properties.

1ſt, Similar comparative dimenſions to thoſe above given, for the original pyramid, *i. e.* every ſmaller pyramid, formed by the above-mentioned parallel ſection, would have its perpendicular height thrice the length of the ſide of its baſe; and,

2dly, The length of the ſide of each baſe will always indicate, or equal the cube root of the ſolid content of the pyramid; *e. g.* If the length of the ſide of the baſe be 3, the ſolid content will be the cube of 3, *viz.* 3 × 3 × 3 = 27.

We do not perceive very clearly the great value of this ſtandard; but Mr Goodwyn ſays, that he has been many years in the habit of uſing a pyramid meaſure to examine corn; and is perfectly convinced that ſuch a one will indicate a far more accurate reſult than can ariſe from the manner in which corn is meaſured by the buſhel. This we are bound to believe; for it is abſurd to oppoſe theories to a fact aſcertained by experience.

WESTRINGIA, a new genus of plants deſcribed by J. E. Smith, M. D. preſident of the Linnæan Society of London. It was firſt diſcovered in New Holland by Dr Solander, who called it *Cunila Fruticoſa*, though it is totally different from the CUNILA (ſee that article, *Encycl.*), and more reſembles roſemary, from which, however, it is likewiſe different. Its peculiar character is: *Calyx ſemiquinquefidus, pentagonus; corolla reſupinata, limbo quadrifido, lobo longiore erecto, bipartito: Stamina diſtantia, duo breviora (inferiora) abortiva.* Dr Smith aſſigns it rather to the *didynamia-angioſpermia*, placing it immediately after the *Teucrium*, than to the *diandria* claſs of plants.

WHEAT (ſee TRITICUM, *Encycl.*) has for ſome years paſt been at ſo very high a price, that every hint for increaſing its quantity or improving its quality is intitled to notice. In the Leiceſter Journal for the 6th of December 1799, there is an ingenious paper on the ſubject of tranſplanting wheat, as a means of providing againſt

---

* H. Goodwyn Eſq; in *Nicholſon's Journal*, vol. ii. p. 163, &c.

† *Journal de Phyſ.* vol v. p. 460.

‡ *Phil. Tranſ.* 1798, p. 326. and *Connoiſſance des Temps*, 1795.

againſt the expected ſcarcity of that neceſſary of life. It is recommended "to ſow, in dry land, at the uſual ſeaſon, as much corn as may be deemed neceſſary to plant in the ſpring any number of acres which may be occupied with that article in the following year. When the ſoil is prepared, a furrow is to be made with a very ſmall plough and one horſe, in the centre of the ridge or land, returning back in the ſame track (this time only of every ridge); then turn towards the left hand, and plough another furrow, about eight or nine inches from the firſt furrow, turning always to the left hand, till the whole ridge is finiſhed; it will then be formed into trenches, in parallel lines of about eight or nine inches aſunder, and imitate what gardeners term drawing of drills. In theſe furrows the plants are to be laid." Mr John Ainſworth of Glen, the experienced author of this communication, ſays he has practiſed this method with the moſt complete ſucceſs.

It has been likewiſe practiſed, on a ſmall ſcale, with equal ſucceſs, but we know not in what county. About the end of Auguſt 1783, that gentleman threw a ſmall quantity of wheat, which near two years before had been ſteeped and limed (ſee WHEAT, *Encycl.*) into an unmanured corner of his garden. In the beginning of February following he had a piece of ground (alſo unmanured) dug in an open part of his orchard, and he tranſplanted it on beds of ſix rows wide, at nine inches aſunder every way. It tillered, and ſpread over the ground ſo completely, as to prevent even a weed growing among it. It produced admirable corn, and at the rate of near four quarters per acre.

From accurate calculations which he then made, he found that an acre, ſuppoſing the ſeed to be very good, and the plants ſet at the diſtance above mentioned, would require only *half a peck* of ſeed.

Beſides the ſaving of the ſeed, there are two other material advantages which attend ſuch a method; one is, that ſome ſuitable crop may be on the ground all the winter for uſe; and the other is, that ploughing the ground ſo late as February, will effectually bury and deſtroy thoſe weeds which were beginning to vegetate; and before others can ſpring up, the corn plants have taken to the ground, and ſo ſpread over it that the weeds cannot riſe, by which means there is a very clean crop, and all the cuſtomary expence for weeding is ſaved.

This author ſeems to think that wheat will thrive as well, and produce as full a crop, when ſown in the ſpring, as if it had been committed to the ground in the preceding autumn. In the ſouthern counties of England we doubt not but it may; but the caſe is otherwiſe in Scotland, where the ſpring is not ſo early, and where, from the narrowneſs of the iſland, the froſt is ſeldom ſo ſevere. We agree, however, with Dr Pike, in thinking it a pity that the way of ſetting wheat (as done in Norfolk and Suffolk) is not every where more general. The proceſs is indeed tedious and troubleſome; and we have often wondered that, among the numberleſs machines lately contrived to leſſen manual labour, none has been invented for dibbling wheat expeditiouſly and accurately. We are therefore pleaſed to learn, that Dr Pike himſelf has turned his attention to the ſubject, and hopes in the courſe of this year (1800) to preſent the public with a *method of ſetting wheat at* PERFECTLY EXACT *diſtances through a whole field, and as* EXPEDITIOUSLY *as the common broadcaſt ſowing, which can therefore be applied to farms of any magnitude;* and when a peck of ſeed is found to be ſufficient for an acre (and in ſome land much leſs), the ſaving on a large farm muſt be immenſe. We truſt to the liberality of his profeſſion, that he will not take out a patent for his invention.

Though we have elſewhere given the uſual recipes for preventing ſmut in wheat, it would be improper to conclude this article without mentioning the very ſimple one which Mr Wagſtaffe of Norwich has uniformly found attended with complete ſucceſs. This conſiſts in nothing more than immerſing the ſeed in pure water, and repeatedly ſcouring it therein, juſt before it is ſown or dibbled in the ſoil. Whether well, ſpring, or river water be uſed, is indifferent; but repeated ſtirring and change of water is eſſential to remove the particles of infection that may have imperceptibly adhered to the ſeeds thus purified. The ſubſequent crop will be perfect in itſelf, and its ſeeds, he ſays, ſucceſſively ſo likewiſe, if there are no adjacent fields from whence this contamination may be waſted. He recommends the ſame waſhing, and for the ſame reaſon, of barley and oats before they be ſown.

WILKIE (William, D. D.), the author of an heroic poem, intitled the *Epigoniad*, was born in the pariſh of Dalmeny, in the county of Weſt-Lothian, on the 5th of October 1721. He was deſcended of an ancient family in that county, though his father rented only a ſmall farm, and was poor and unfortunate through life. He was able, however, to give his ſon a liberal education; and that ſon, it is ſaid, diſcovered ſo early a propenſity to the ſtudy of poetry, that he began to write verſes in his tenth year.

As this wonderful prematurity of genius was never heard of during Wilkie's life, it will probably be conſidered as a ſtory fabricated to raiſe the Scottiſh poet to the ſame eminence with Pope, whoſe verſification he is allowed to have imitated with ſucceſs. We have no doubt but that Wilkie wrote in early life the deſcription of a ſtorm, which is publiſhed in the 9th volume of the Statiſtical Account of Scotland; but that he wrote it in his tenth year is not proved, and is highly improbable. The poem diſplays a notion—a confuſed notion indeed—of the laws of electricity, which a boy in his tenth year, and at a period when electricity was little underſtood, could not have acquired.

Having learned the rudiments of the Latin tongue at the pariſh-ſchool of Dalmeny, young Wilkie was, at the age of thirteen, ſent to the univerſity of Edinburgh, where he was ſoon diſtinguiſhed by his originality of thought, and by his rapid progreſs in erudition and ſcience. Among his fellow-ſtudents he was moſt cloſely aſſociated with Dr Robertſon the hiſtorian, Mr John Home the poet, Dr M'Ghie (A), who afterwards obtained

---

(A) According to Sir John Hawkins, this man bore arms on the ſide of government at the battle of Falkirk 1745. After which, taking a degree in phyſic, he went to London in hopes of employment through the intereſt tained the friendſhip of Johnſon, and became a member of the Ivy-lane Club; and a Mr Cleghorn, who promiſed be an ornament to the univerſity, in which he was afterwards a profeſſor, but died before he had time to realize the fond hopes of his friends. During the courſe of his education, Wilkie became acquainted with the celebrated David Hume and Dr Ferguſon, and at a later period with Dr Adam Smith, the far-famed author of "The Wealth of Nations." Of all thoſe men he regarded Dr Ferguſon with the greateſt affection, and Dr Smith with the greateſt admiration. This laſt writer he conſidered as equal to Robertſon and Hume in erudition, and vaſtly their ſuperior in originality and invention; and this opinion he cheriſhed to the day of his death.

Before he had completed his education, his father died, leaving him no other inheritance than the ſtock and unexpired leaſe of his farm, and the care of his three ſiſters. Wilkie, therefore, turned much of his attention to agriculture, in which he became eminent, not merely as a theoriſt, but as a practical farmer. He had too much ſcience to be the ſlave of ancient prejudice, and too much judgment to be hurried into hazardous experiments by the charms of untried ſpeculation. One of his ſiſters being married to a ſkilful, though unlettered farmer, he availed himſelf of his brother's experience; and upon the facts and maxims derived from him built a ſyſtem of practical farming, which fully anſwered his own expectation, and obtained the applauſe of all his neighbours.

He ſtill proſecuted his ſtudies in the univerſity, and without ceaſing to be a farmer became a preacher in the church of Scotland. For ſome years this made no alteration in the mode of his living. He preached occaſionally for the miniſters in his neighbourhood; cultivated his farm; read the claſſics; and, enamoured of the ſimple ſublimity of Homer, projected an epic poem on the Homeric model. The ſubject of his intended poem he drew from the fourth book of the *Iliad*, where Sthenelus gives Agamemnon a ſhort account of the ſacking of Thebes; and as that city was taken by the ſons of thoſe who had fallen before it, Wilkie gave to his poem the quaint title of *Epigoniad*, from the Greek word επιγονοι, which ſignifies *deſcendants*. It is not our buſineſs to write a criticiſm upon this poem. The ſubject was ill-choſen; for the learned reader has enough of the heroic ages in the immortal poems of Homer and Virgil, and in thoſe ages the unlearned reader can feel no intereſt. The Epigoniad, therefore, though compoſed in ſmooth and elegant verſe, with due attention to ancient manners, and conſtructed on the moſt regular plan, has fallen into neglect, from which no critic or biographer will ever reſcue it.

In the year 1753, Mr Wilkie was ordained miniſter of Ratho, in conſequence of a preſentation from the Earl of Lauderdale, who knew his worth and admired his genius. Without neglecting his favourite amuſements of huſbandry, or the ſtudy of the belles lettres, he diſcharged with fidelity the duties of a Chriſtian paſtor, was famed for his original and impreſſive mode of preaching, and ſoon came to be loved as well as eſteemed by his rural flock.

In the year 1757 the Epigoniad was publiſhed, the reſult of fourteen years ſtudy and application, which might ſurely have been more uſefully employed on ſome other work; and in 1759 a ſecond edition was called for, to which he added *A Dream in the manner of Spenſer*. He was, the ſame year, choſen profeſſor of natural philoſophy in the univerſity of St Andrew's; an office for which it is difficult to conceive how he could have been fitted by the ſtudy of epic poetry, and cloſe attention to the cultivation of his farm. He was, however, a man of a vigorous mind, and we never heard that he diſgraced his electors.

When he removed to St Andrew's, his whole fortune exceeded not L. 200 Sterling; a proof that his Epigoniad had not enriched him. With this ſum he purchaſed a few acres of land in the neighbourhood of the city, carried his two unmarried ſiſters with him, and continued to live in the univerſity exactly as he had lived at Ratho. In his profeſſorial career there was nothing remarkable. He patroniſed genius, eſpecially poetical genius, in the young men who attended his lectures, and by them was, of courſe, loved and eſteemed: (See Fergusson in this *Suppl*). In the year 1768 he publiſhed a volume of fables of no great value, previous to which the univerſity conferred upon him the degree of D. D.; and he died, after a lingering illneſs, on the 10th of October 1772.

The manners of Dr Wilkie were ſingular, and in ſome reſpects diſguſting. He has been ſeverely blamed for his penuriouſneſs, but, in our opinion, unjuſtly. His father had left him in debt, with nothing but the profits which he might make of a ſmall farm to diſcharge that debt, and to ſupport himſelf and three ſiſters. In him, therefore, rigid economy was, for many years, a virtue; and he knows little of human nature, who can blame a man for not breaking habits which it had been the duty, as well as the buſineſs, of a great part of his life to form. Amidſt his moſt rigid and offenſive economy, he was liberal in his donations to the poor.

He had been ſeized, while miniſter of Ratho, with an unformed ague, of which he never got entirely rid. For this complaint he thought an extraordinary perſpiration neceſſary, and generally ſlept, in winter, under twenty-four blankets. He had an utter averſion from clean linen, and has been known to bargain, when he ſtaid a night from home, not only for the proper quantity of blankets to his bed, but alſo for ſheets, which had been uſed by ſome other perſon, and rendered ſufficiently dirty to pleaſe his feeling. It will eaſily be conceived that ſuch a man was, to the laſt degree, ſlovenly in his dreſs.

Suſpicions have been thrown out by his lateſt, and we believe his only, biographer, that Dr Wilkie's belief of the Chriſtian religion was neither orthodox nor ſteady. Not having had the pleaſure of his acquaintance, we cannot poſitively ſay that theſe ſuſpicions are groundleſs; but the writer of this article has converſed much about the author of the Epigoniad with a clergyman

---

reſt of his countrymen, and perhaps in return for his loyalty. He was a learned, ingenious, and modeſt man; but ſo little ſucceſsful in his profeſſion, that he died of a broken heart, and was buried by a contribution of his friends.

man who knew him well, and who would have been glad to accuſe him of infidelity, if he could have preferred ſuch an accuſation with truth. He was a very abſent man, apt to forget what he was about even when diſcharging the moſt ſolemn parts of his clerical duty, and uſed to ſay of himſelf that he never could conduct a ſacrament. From this abſence of mind, and thoſe confeſſions of it, may have ariſen the ſuſpicion that he was not a firm believer; but no ſuch ſuſpicion was ever thrown out to this writer by the clergyman already referred to.

He had one very extraordinary defect in a poet: He could not read aloud the ſmootheſt verſes, ſo as to preſerve either the meaſure or the ſenſe of them. Of this Dr Anderſon has produced very complete proof in his life of Wilkie, prefixed to his poetical works in the Edinburgh edition of the Britiſh Poets. With all his defects, however, and all his foibles, he was unqueſtionably a genius, and, we are inclined to believe, a good man.

WINES (ſee that article, *Encycl.* and *Vegetable* SUBSTANCES, *Suppl.*) are ſo often adulterated with minerals prejudicial to the health, that various methods have been deviſed for detecting the adulteration. The property which liver of ſulphur (alkaline ſulphures) and hepatic air (ſulphurated hydrogen) poſſeſs of precipitating lead in a black form, has been long ago made public; and this property has been employed to determine the quality of wines by means of the *liquor probatorius Wirtembergenſis*, or Wirtemberg proving liquor. But in trying wines ſuppoſed to have been adulterated, this proof does more hurt than ſervice, becauſe it precipitates iron of the ſame colour as the pernicious lead. Many wine-merchants, therefore, of the greateſt reſpectability, rendered by theſe means ſuſpected, have been ruined.

The following is recommended by M. Hanhemann as a better teſt of ſound wines than the proving liquor of Wirtemberg. Mix equal parts of oyſter ſhells and crude ſulphur in a fine powder, and put the mixture into a crucible. Heat it in a wind furnace, and increaſe the fire ſuddenly, ſo as to bring the crucible to a white heat, for the ſpace of 15 minutes. Pulveriſe the maſs when it is cool, and preſerve it in a bottle cloſely ſtopped.

To prepare the liquor, put 120 grains of this powder, and 120 grains of cream of tartar (acidulous tartarite of potaſh), into a ſtrong bottle; fill the bottle with common water, which boil for an hour, and then let it cool; cloſe the bottle immediately, and ſhake it for ſome time: after it has remained at reſt to ſettle, decant the pure liquor, and pour it into ſmall phials capable of holding about an ounce each, firſt putting into each of them 20 drops of muriatic acid. They muſt be ſtopped very cloſely with a piece of wax, in which there is a ſmall mixture of turpentine.

One part of this liquor, mixed with three parts of ſuſpected wine, will diſcover, by a very ſenſible black precipitate, the leaſt traces of lead, copper, &c. but will produce no effect upon iron, if it contains any of that metal. When the precipitate has fallen down, it may ſtill be diſcovered whether the wine contains iron, by ſaturating the decanted liquor with a little ſalt of tartar (tartareous acidulum of potaſh), by which the liquor will immediately become black. Pure wines remain clear and bright after this liquor has been added to them.

WOOD CUTS are engravings on wood, commonly on box, which, in many caſes, are uſed with advantage inſtead of copper-plates. The art of cutting or engraving on wood is undoubtedly of high antiquity; for Chineſe printing is a ſpecimen of it. (See CHINA, n° 127. *Encycl.*) Even in Europe, if credit be due to Papillon, this art was practiſed at a period conſiderably remote; for he mentions eight engravings on wood, entitled, "A repreſentation of the warlike actions of the great and magnanimous Macedonian king, the bold and valiant Alexander; dedicated, preſented, and humbly offered, to the moſt holy father, Pope Honorius IV. by us Alexander Alberic Cunio Chevalier, and Iſabella Cunio, &c." This anecdote, if true, carries the art of cutting in wood back to 1284 or 1285; for Honorius occupied the papal throne only during theſe two years. Even this is not the remoteſt period to which ſome have carried the art in Europe; for the uſe of ſeals or ſignets being of very high antiquity, they imagine that the invention of wood-cuts muſt be coeval with them. The ſuppoſition is certainly plauſible, but it is not ſupported by proof. The earlieſt impreſſion of a wooden-cut, of which we have any certain account, is that of St Chriſtopher carrying an infant Jeſus through the ſea, in which a hermit is ſeen holding up a lantern to ſhew him the way; and a peaſant, with a ſack on his back, climbing a hill, is exhibited in the back ground. The date of this impreſſion is 1423.

In the year 1430 was printed at Haarlem, "The hiſtory of St John the evangeliſt and his revelation, repreſented in 48 figures in wood, by Lowrent Janſon Coſter;" and, in 1448, Jorg Schappf of Augſburg cut in wood the hiſtory of the Apocalypſe, and what was called *The poor man's bible.* (See ENGRAVING, *Encycl.* page 668.)

A folio chronicle, publiſhed 1493 by Schedal, was adorned with a vaſt number of wood-cuts by William Plydenwurff and Michael Wolgemut, whoſe engravings were greatly ſuperior to any thing of the kind which had appeared before them. Wolgemut was the preceptor of Albert Durer, whoſe admirable performances in this department of art are juſtly held in the higheſt eſteem even at the preſent day.

About this period it became the practice of almoſt all the German engravers on copper to engrave likewiſe on wood; and many of their wood cuts ſurpaſs in beauty the impreſſions of their copper-plates. Such are the wood-cuts of Albert Aldtorfer, Hiſbel Pen, Virgil Soles, Lucas van Cranach, and Lucas van Lyden, the friend and imitator of Albert Durer, with ſeveral others.

It appears that the Germans carried this art to a great degree of perfection. Hans or John Holbien, who flouriſhed in 1500, engraved the *Dance of Death*, in a ſeries of wooden-cuts, which, for the freedom and delicacy of execution, has hardly been equalled, and never ſurpaſſed.

Italy, France, and Holland, have produced many capital artiſts of this kind. Joan. Tornæſium printed a bible at Lyden, in 1554 (a copy of which we have ſeen), with wooden-cuts of excellent workmanſhip. Chriſtopher Jegher of Antwerp, from his eminence in the art, was employed by Rubens to work under his inſpection,

inſpection, and he executed ſeveral pieces which are held in much eſtimation; the character of theſe is boldneſs and ſpirit.

The next attempt at improvement in this art was by Hugo da Carpi, to whom is attributed the invention of the *chiaro ſcuro* Carpi was an Italian, and of the 16th century; but the Germans claim the invention alſo, and produce in evidence ſeveral engravings by Mair, a diſciple of Martin Schoen, of date 1499. His mode of performing this was very ſimple. He firſt engraved the ſubject upon copper, and finiſhed it as much as the artiſts of his time uſually did. He then prepared a block of wood, upon which he cut out the extreme lights, and then impreſſed it upon the print; by which means a faint tint was added to all the reſt of the piece, excepting only in thoſe parts where the lights were meant to predominate, which appear on the ſpecimens extant to be whitened with white paint. The drawings for this ſpecies of engraving were made on tinted paper with a pen, and the lights were drawn upon the paper with white paint.

There is, however, a material difference between the *chiaro ſcuros* of the old German maſters and thoſe of the Italians. Mair and Cranach engraved the outlines and deep ſhadows upon copper. The impreſſion taken in this ſtate was tinted over by means of a ſingle block of wood, with thoſe parts hollowed out which were deſigned to be left white upon the print. On the contrary, the mode of engraving by Hugo da Carpi was, to cut the outline on one block of wood, the dark ſhadows upon a ſecond, and the light ſhadows, or half tint, upon a third. The firſt being impreſſed upon the paper, the outlines only appeared: this block being taken away, the ſecond was put in its place, and being alſo impreſſed on the paper, the dark ſhadows were added to the outlines; and the third block being put in the ſame place upon the removal of the ſecond, and alſo impreſſed upon the paper, made the dim tints, when the print was compleated. In ſome inſtances, the number of blocks were increaſed, but the operation was ſtill the ſame, the print receiving an impreſſion from every block.

In 1698, John Baptiſt Michel Papillon practiſed engraving on wood with much ſucceſs, particularly in ornamental foliage and flowers, ſhells, &c. In the opinion, however, of ſome of the moſt eminent artiſts, his performances are ſtiff and cramped. From that period the art of engraving on wood gradually degenerated, and may be ſaid to have been wholly loſt, when it was lately re-invented by Mr Bewick of Newcaſtle.

This eminent artiſt was apprentice to Mr Bielby, an engraver on metal of the very loweſt order, who was ſeldom employed in any thing more difficult than the cutting of the face of a clock. Application having been made to this man for a wood-cut or two of the moſt trifling deſcription, the job was given to Thomas Bewick; by whom it was executed in ſuch a manner, that Mr Bielby, who was accuſtomed to employ his apprentices in ſuch work, adviſed him to proſecute engraving in that line. The advice was followed; and young Bewick inventing tools, even making them with his own hands, and ſawing the wood on which he was to work into the requiſite thickneſs, proceeded to improve upon his own diſcoveries, without aſſiſtance or inſtruction of any kind. When his apprenticeſhip expired, he went to London, where the obſcure wood-engravers of the time wiſhed to avail themſelves of his abilities, while they were determined to give him no inſight into their art. He remained ſome years in London; and during that time, if we miſtake not, received from the *Society for the Encouragement of Arts, &c.* a premium of conſiderable value for the beſt engraving in wood. Returning to Newcaſtle, he entered into copartnerſhip with his old maſter; and eſtabliſhed his reputation as an artiſt by the publication of his admirable Hiſtory of Quadrupeds. This was followed by his Hiſtory of Birds, of which only one volume has yet (1800) appeared.

John Bewick, brother to Thomas, learned the art of him, and practiſed it for ſeveral years in London with great applauſe. His abilities, however, though reſpectable, were not, by the beſt judges, deemed ſo brilliant as his brother's; and owing to bad health, and the nature of his connection with the bookſellers and others, he ſeems not to have advanced the art beyond the ſtage at which he received it. He died, three or four years ago, at Newcaſtle.

Mr Neſbit, who executed the admirable Hudibras publiſhed by Vernor and Hood (A), and Mr Anderſon, whoſe beautiful cuts adorn the poem entitled *Grove Hill*, were the next, and hitherto have been the laſt of Thomas Bewick's pupils, who have appeared before the public as artiſts. By theſe gentlemen we are authorized to ſay, that the method practiſed by the ancient engravers on wood, whoſe works are ſtill admired, muſt have been different from that of Bewick and his pupils. What that method was ſeems to be altogether unknown. Papillon, who writes the beſt hiſtory extant of the art, gueſſes indeed in what manner the old engravers proceeded ſo as to give to their works the ſpirit and freedom for which they are famed; but that his gueſſes are erroneous ſeems evident from the ſtiffneſs of his own works. The principal characteriſtic in the mechanical department of the productions of the ancient maſters is the croſſing of the black lines, which Papillon has attempted with the greateſt awkwardneſs, though it ſeems to have been accompliſhed by them with ſo much eaſe, that they introduced it at random, even where it could add nothing to the beauty of the piece. In Bewick's method of working, this croſs hatching is ſo difficult and unnatural, that it may be conſidered as impracticable (B).

The engravers of Bewick's ſchool work on the end of the wood which is cut acroſs the trunk of the tree,

---

(A) The deſigns were by Thornton; and the cuts from them have been compared to Holbein's far-famed Dance of Death.

(B) Mr Neſbit has indeed introduced ſomething of it into two or three of his pieces, merely to ſhew that he *could* do it; but ſo great was the labour, and ſo little the advantage of this improvement, if ſuch it can be called, that probably it will not be attempted again.

in pieces of the proper thickneſs. As wood-cuts are generally employed in the printer's preſs amidſt a form of types, this thickneſs muſt be regulated by the height of the types with which they are to be uſed. The tools employed are nearly the ſame with thoſe uſed in copperplate engraving, being only a little more deep, or lozenge, as engravers call it. They muſt have points of various degrees of fineneſs for the different purpoſes to which they are applied, ſome of them being ſo much rounded off at the bottom as to approach to the nature of a goodge, whilſt others are in fact little chiſſels of various ſizes. Theſe chiſſels and goodges, to which every artiſt gives the ſhape which he deems moſt convenient, are held in the hand in a manner ſomewhat different from the tool of the engraver on copper, it being neceſſary to have the power of lifting the chips upwards with eaſe. To attempt a deſcription of this in writing would be in vain; but it is eaſily acquired, we are told, by practice.

The pupils of the ſchool of Bewick conſider it as quite improper to ſpeak of his invention as a revival of the ancient art. Some old prints, it is true, have the appearance of being executed in the ſame way with his; but others have certainly been done by a method very different. It is therefore not fair to appreciate the preſent art by what has been done, but by what may be done; and that remains yet to be ſhewn. The art is in its infancy; and thoſe who are diſpoſed to compare it with the art of engraving on copper, ought to look back to the period when copperplate engraving was of as recent invention as Bewick's method of engraving on wood. Marc Antonio, who engraved under the direction of the great painter Raphael, thought it no mean proof of his proficiency in his art, that he was able to imitate on copper plates the wood-cuts of Albert Durer; and Papillon is highly indignant that there ſhould have been perſons ſo very blind as to miſtake the copies for the originals. If copper has its advantages over wood in point of delicacy and minuteneſs, wood has, in its turn, advantages not inferior in regard to ſtrength and richneſs. Thoſe prints which were executed under the auſpices of Titian and Rubens, will always remain a monument of the ſpirit and vigour natural to wood-engraving; and if there be not found in them all the attention to *chiaro ſcuro*, which the preſent age demands, it muſt not be attributed either to defect in the art, or to want of abilities in the artiſts, but to the taſte of the times when *chiaro ſcuro* was little underſtood. It remains for ſome enterpriſing artiſt to ſhew that the vigour of the ancient art may be attained by the preſent one, and at the ſame time to add to that vigour thoſe gradations of ſhade which are ſo much admired in good copperplates. As there ſeems to be a more perfect, or at leaſt a more pleaſant black produced by wood than by copperplate printing, and certainly a more perfect white (c), who will ſay that any intermediate ſhade whatever may not be produced by wood-cuts? To attempt this on a ſmall ſcale would indeed be vain, becauſe the ſlighteſt variation, produced by a little more or leſs ink, or a harder preſſure in printing, bears ſuch a proportion to a very ſhort line, as muſt neceſſarily render the attempt abortive. Wood-engraving, therefore, muſt always appear to diſadvantage while it is confined to ſmall ſubjects, and will never reach its ſtation *as a fine art*, till thoſe who are engaged in its cultivation improve upon the diſcoveries of one another, and apply to ſubjects to which it is properly adapted. As an *economical art* for illuſtrating mechanics and other ſubjects of ſcience, it is too little employed even in its preſent ſtate.

The works of Bewick and his pupils, which have hitherto been publiſhed, are not numerous. Beſides his quadrupeds and birds, the Hudibras by Neſbit, and the Grove Hill by Anderſon, which have been already noticed, we are acquainted with none but the following:—Goldſmith's *Traveller* and *Deſerted Village* with elegant plates, all by Thomas Bewick, except one or two which were executed by John; Somerville's *Chace* by the ſame artiſts, executed in a ſtyle of elegance which perhaps has never been ſurpaſſed; a View of St Nicholas's Church, Newcaſtle, 15 inches long, by Mr Neſbit, who received for it a ſilver medal from the Society for the Encouragement of Arts, and an honorary letter from the Society of Antiquaries.

WOOL-COMBING, a well known operation, which, when performed by the hand, is laborious, tedious, and expenſive. The expence of it through all England has been calculated at no leſs a ſum than L. 800,000; and to leſſen this expence, the Rev. Edmund Cartwright of Doncaſter in Yorkſhire bethought himſelf, ſome years ago, of carding wool by machinery. After repeated attempts and improvements, for which he took out three patents, he found that wool can be combed in perfection by machinery, of which he gives the following deſcription:

Plate L.

Fig. 1. Is the crank laſher. A is a tube through which the material, being formed into a ſliver, and ſlightly twiſted, is drawn forward by the delivering rollers. B, a wheel faſt upon the croſs-bar of the crank C, a wheel, on the oppoſite end of whoſe axis is a pinion working in a wheel upon the axis of one of the delivering rollers.

Note, When two or more ſlivers are required, the cans or baſkets, in which they are contained, are placed upon a table under the laſher (as repreſented at D), which, by having a ſlow motion, twiſts them together as they go up.

Fig. 2. Is the circular clearing comb, for giving work in the head, carried in a frame by two cranks. Fig. 3. The comb-table, having the teeth pointing towards the centre, moved by cogs upon the rim, and carried round upon trucks, like the head of a windmill *a*, *b*, the drawing rollers *c*, *d*, callender, or conducting rollers.

Note, Underneath the table is another pair of rollers, for drawing out the backings.

In the above ſpecification, we have omitted the frame in which the machine ſtands, the wheels, ſhafts, &c. Had theſe been introduced, the drawing would have been crowded and confuſed; beſides, as matters of information, they would have been unneceſſary, every mechanic, when he knows the principles of a machine, being competent to apply the movements to it.

The wool, if for particular nice work, goes through three operations, otherwiſe two are ſufficient: the firſt

---

(c) The parts of the print intended to be white are not even touched by the wood-block.

WATCH WORK. PLATE XLVIII.

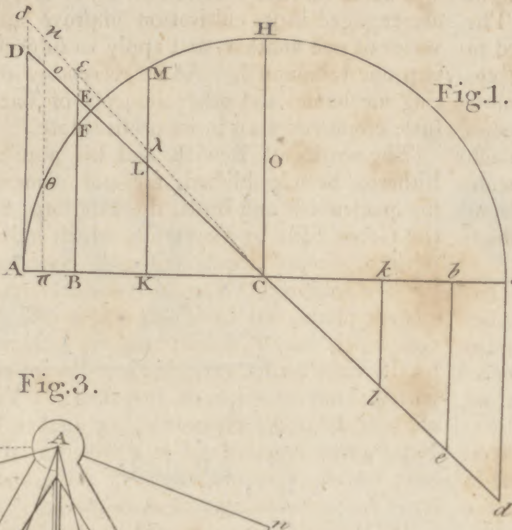


Fig. 1.

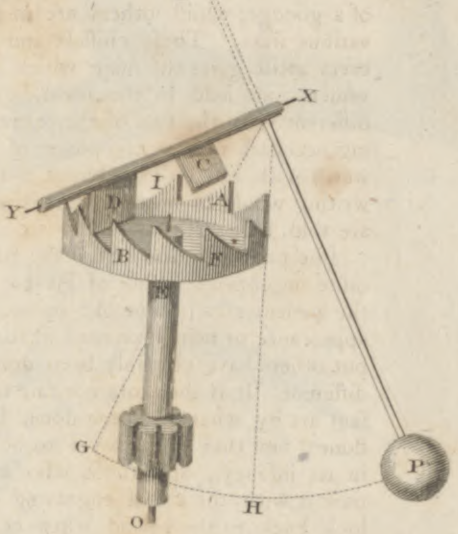


Fig. 2.

Fig. 3.

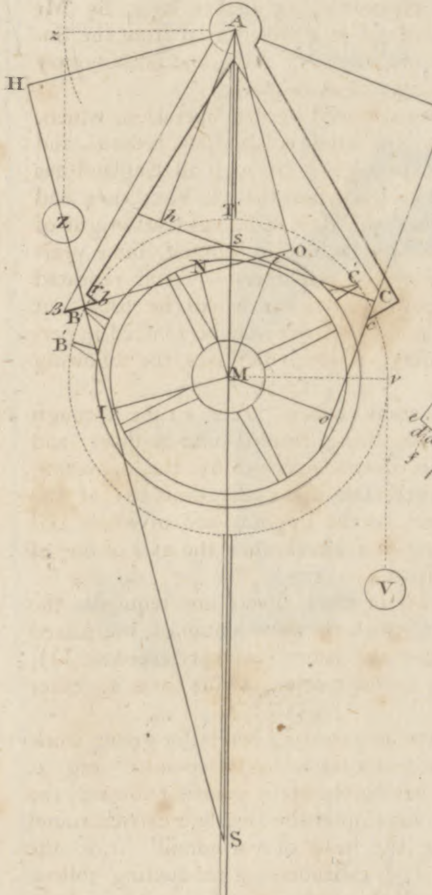


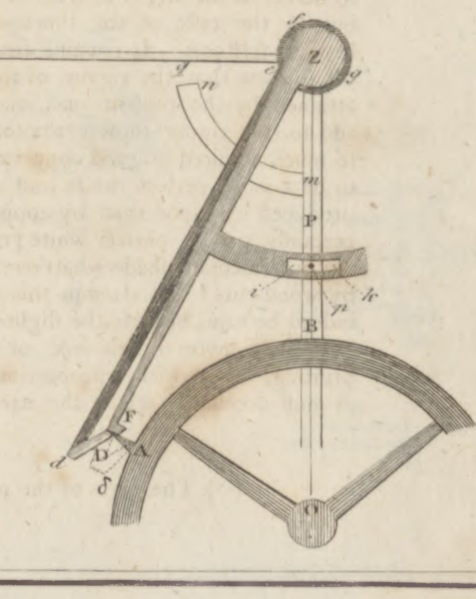

Fig. 4.

Fig. Z.


Fig. 5.

Fig. 8.

Fig. 9.



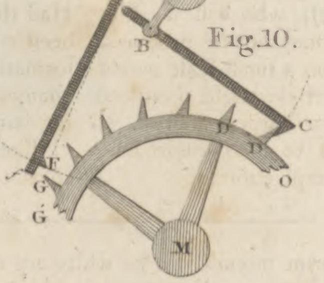


Fig. 10.


Fig. 6.

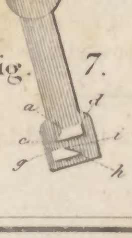


Fig. 7.

D. Lizars Sculpt

WATCH WORK. PLATE XLIX.

Fig. 11.

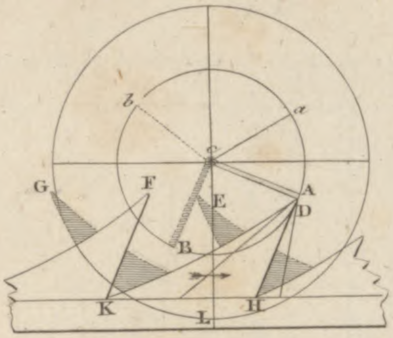


Fig. 12.

Fig. 13.

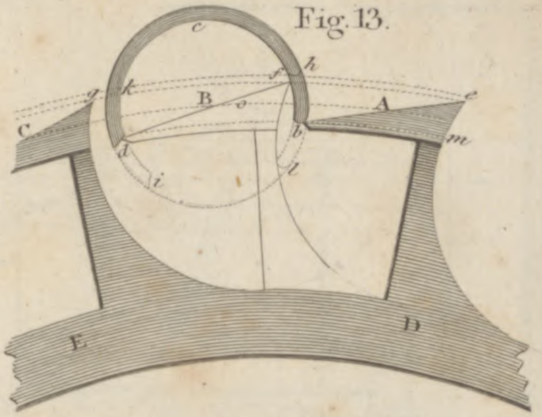


Fig. 14.

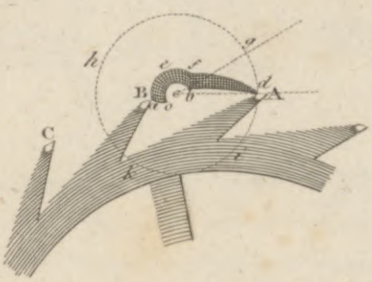


Fig. 15.

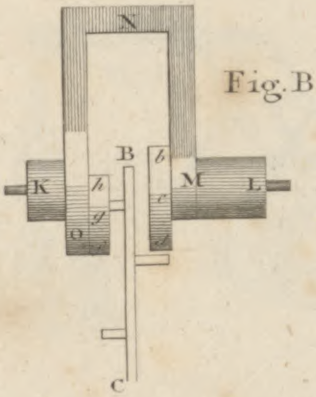


Fig. B. 15.

Fig. B. 13.

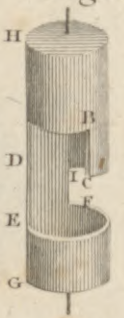


Fig. C.

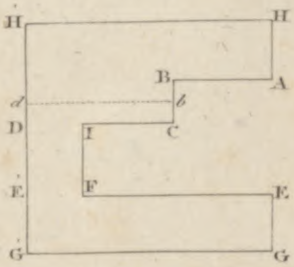


Fig. 17.

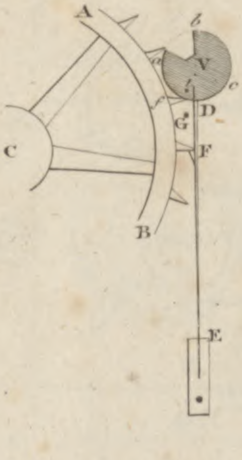


Fig. 19.

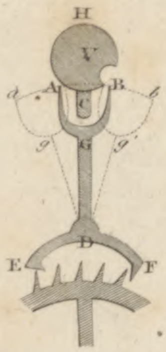


Fig. 16.

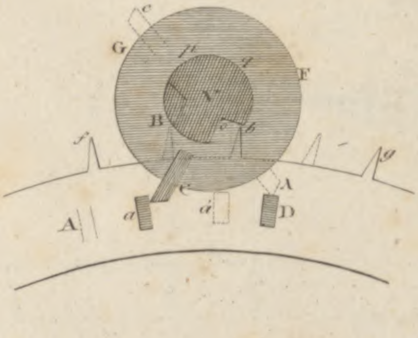
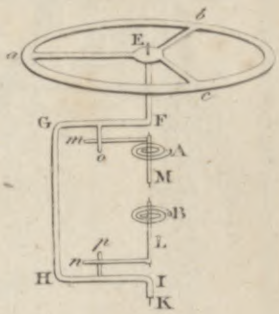
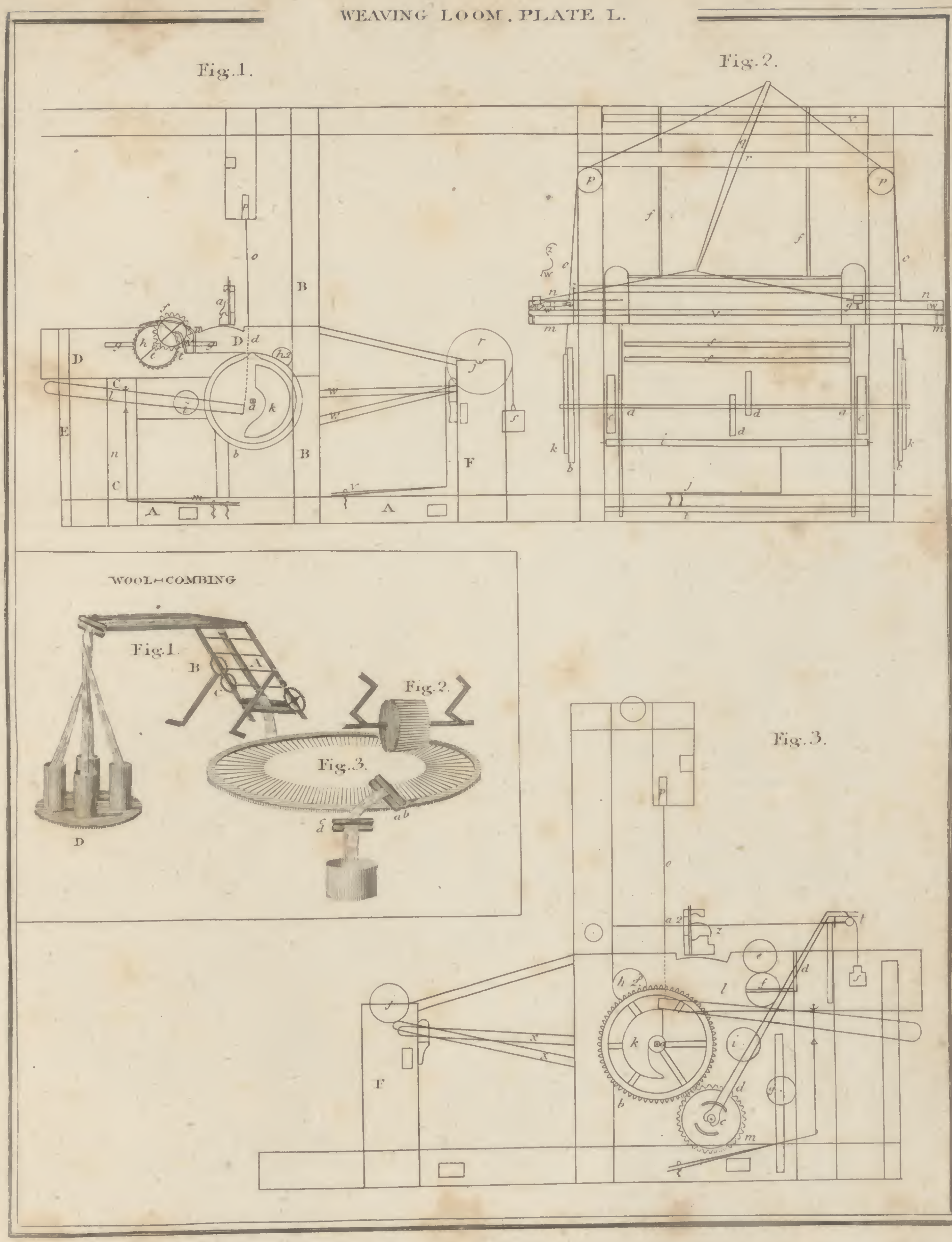


Fig. 18.



D. Lizars, Sculpt

WEAVING LOOM. PLATE L.



Wool-combing.

operation opens the wool, and makes it conduct to gether into a rough fleece, but does not clear it. The cleaning is performed by the second, and, if necessary, a third operation. A set of machinery, consisting of three machines, will require the attendance of an overlooker and ten children; and will card a piece of [illegible] [illegible] [illegible] [illegible] machine performing the taking of [illegible] fire alone, will, in general, pay the wages of the overlooker and children; so that the actual saving to the manufacturer is the whole of what the combing costs, by the old imperfect mode of hand-combing. Machine-combed wool is better, especially for machine-spinning, [illegible] at least [illegible] per cent. being all equally mixed, and the fibres uniform, and of any required length.

Zemindary.

ZAMINDARY, or ZEMINDARY,

This is the [illegible] more [illegible] [illegible] [illegible] [illegible]

[illegible]

The [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of office [illegible] [illegible] and [illegible] [illegible] the word [illegible] [illegible] is [illegible] in the Dewanny [illegible] for a [illegible].

[illegible] of the [illegible] the [illegible] the [illegible] [illegible] were [illegible] by the government. [illegible] [illegible] of the rights of [illegible] [illegible] a [illegible] on sovereignty, and [illegible] the [illegible] of the Emperor, [illegible] for the office of Zemindary were granted to the children of the deceased Zemindar; and as [illegible] [illegible] was accepted, [illegible] [illegible] never [illegible] for any [illegible] the [illegible] and [illegible] which they naturally [illegible] the [illegible] of the Zemindar, and would have been [illegible] [illegible] [illegible] been put over them. For this [illegible] the [illegible], considering it as a means of [illegible] the [illegible] of the people, graciously [illegible] and [illegible] the [illegible] of the deceased Zemindar in the [illegible] their fathers and grandfathers, by [illegible] [illegible] [illegible] the possession to them. [illegible] [illegible] [illegible] became their heritable property, which [illegible] [illegible] transferred by gift or sale from one [illegible] to another. They could likewise be [illegible] the [illegible] by the Zemindar [illegible] from his [illegible], or [illegible] to pay his tribute, or to discharge the duties of his station.

It is observable, however, that Sir Charles Rouse Boughton, that, when the provinces of Bengal, Bahar, and Orissa, were ceded to the English East India Company, the country was distributed among the Zemindars and Talookdars, [illegible] who paid a stipulated revenue, by twelve instalments, to the sovereign power or its delegates. They attended at the capital in the beginning of every Bengal year, commencing in April, in order to complete their [illegible] yet [illegible], and make up their annual accounts. [illegible]

Wool-combing

operation opens the wool, and makes it connect together into a rough ſliver, but does not clear it. The clearing is performed by the ſecond, and, if neceſſary, a third operation. A ſet of machinery, conſiſting of three machines, will require the attendance of an overlooker and ten children, and will comb a pack, or 240lb. in twelve hours. As neither fire nor oil is neceſſary for machine-combing, the ſaving of thoſe articles, even the fire alone, will, in general, pay the wages of the overlooker and children; ſo that the actual ſaving to the manufacturer is the *whole* of what the combing coſts, by the old imperfect mode of hand-combing. Machine-combed wool is better, eſpecially for machine-ſpinning, by at leaſt 12 *per cent.* being all equally mixed, and the ſlivers uniform, and of any required length.

Z.

Zaminy, Zemindars.

ZAMINY, in the language of Bengal, ſecurity.

ZEMINDARS, the great landholders of Bengal. This is the original ſenſe of the word; but it is now more ſtrictly applicable to thoſe who have their title conſtituted or confirmed by a patent or charter from government, by which they hold their lands or Zemindaries upon certain conditions. As far as can be aſcertained from the narrations of hiſtory, it appears that, in times prior to the irruptions of the Mahomedans, the rajahs who held their reſidence at Delhy, and poſſeſſed the ſovereignty of Hindoſtan, deputed officers to collect their revenues (Kherâje), who were called in the Indian language *Choudheries*. The word *Zemindar* is Perſian, and that language can have had no currency in the countries of India, until it was introduced by the people of Perſia. When the Emperor Shehâb ul Dien Ghory conquered the empire of Hindoſtan (A), he left Sultan Cutub ul Dien to be his viceroy at Delhy, and adminiſter the government of Hindoſtan. From that time the cuſtoms and practices of the Mahomedans began gradually to be eſtabliſhed in India: their armies were ſent into the countries of the reduced Rajahs, under the command of Omrahs, in order to preſerve the conqueſt; and lands were allotted to them to defray the expence. From hence aroſe the ſyſtem of Jaghiredarry in Hindoſtan. But when theſe Omrah Jaghiredars had eſtabliſhed their own ſtrength, ſeveral of them rebelled againſt the imperial authority, and aſpired at the crown. Thus circumſtanced, the emperors, in order to obviate theſe miſchiefs, thought it would be more politic to commit the management of the country to the native Hindoos, who had moſt diſtinguiſhed themſelves by the readineſs and conſtancy of their obedience to the ſovereign power.

In purſuance of this plan, diſtricts were allotted to numbers of them under a reaſonable revenue (Jummah Monâſib), which they were required to pay in money to the governors of the provinces, deputed from the Emperor. And in caſe any one of the Omrahs or provincial governors ſhould ſwerve from his allegiance, the Zemindars of that country were to exert themſelves in ſuch a manner as ſhould check rebellion, and reſtore good government. For this purpoſe, grants of Zemindary were ſeverally conferred upon ſuch of the Hindoos as were obedient; deſcribing their apportionment of the country; and every perſon who had received a grant under the authority of the crown was thereby fully inveſted with the functions of Zemindar.

The functions of a Zemindar are, 1ſt, The preſervation and defence of their reſpective boundaries from traitors and inſurgents; 2dly, The tranquillity of the ſubjects, the abundance of cultivators, and increaſe of his revenue. 3dly, The puniſhment of thieves and robbers, the prevention of crimes, and the deſtruction of highwaymen. The accompliſhment of theſe objects is conſidered in the royal grant as the diſcharge of office to the ſovereign; and on that account the word *office* (Khidmut) is employed in the Dewanny Sunnud for a Zemindary.

It was a rule in the times of the ancient emperors, that when any of the Zemindars died, their effects and property were ſequeſtrated by the government. After which, in conſideration of the rights of long ſervice, which is incumbent on ſovereigns, and elevates the dignity of the employer, Sunnuds for the office of Zemindary were granted to the children of the deceaſed Zemindar; and no other perſon was accepted, becauſe the inhabitants could never feel for any ſtranger the attachment and affection which they naturally entertain for the family of their Zemindar, and would have been afflicted if any other had been put over them. For this reaſon, the emperors, conſidering it as a means of conciliating the minds of the people, graciouſly fixed and confirmed the children of the deceaſed Zemindar in the office of their fathers and grandfathers, by iſſuing new ſunnuds to transfer the poſſeſſion to them. By degrees Zemindaries became truly heritable property, which, however, could be transferred by gift or ſale from one family to another. They could likewiſe be forfeited to the ſovereign, by the Zemindar's deviating from his allegiance, neglecting to pay his tribute, or to diſcharge the duties of his ſtation.

It is univerſally known, ſays Sir Charles Rouſe Boughton, that, when the three provinces of Bengal, Bahar, and Oriſſa, were ceded to the Britiſh Eaſt India Company, the country was diſtributed among the Zemindars and TALOOKDARS (ſee that article in this Vol.), who paid a ſtipulated revenue, by twelve inſtalments, to the ſovereign power or its delegates. They aſſembled at the capital in the beginning of every Bengal year (commencing in April), in order to complete their final payments, and make up their annual accounts; to

ſettle

(A) This event took place towards the cloſe of the 12th century. N. B. *Kherâje* ſignifies ſpecifically the tribute paid by a conquered country.

Zemindars. ſettle the diſcount to be charged upon their ſeveral remittances in various coins for the purpoſe of reducing them to one ſtandard, or adjuſt their concerns with their bankers; to petition for remiſſions on account of ſtorms, drought, inundation, diſturbances, and ſuch like; to make their repreſentations of the ſtate, and occurrences of their diſtricts: after all which they entered upon the collections of the new year; of which, however, they were not permitted to begin receiving the rents from their own farmers, till they had completely cloſed the accounts of the preceding year, ſo that they might not encroach upon the new rents, to make up the deficiency of the paſt. Our author proves, we think completely, the right of the Zemindars to transfer their poſſeſſions, either by inheritance to their children, or, with the conſent of the ſovereign, to other families; and he argues ſtrenuouſly and ſucceſsfully againſt the bad policy, as well as injuſtice, of interfering with thoſe rights, as long as the Zemindars diſcharge the duties of their ſeveral ſtations.

Zemindar

FINIS.

DIRECTIONS FOR PLACING THE PLATES.

PART I.

Plate XXX.	to face Page	82
XXXI.		
XXXII.		
XXXIII.	-	110
XXXIV.	-	158
XXXV.		
XXXVI.	-	262
XXXVII.		
XXXVIII.	- -	312
XXXIX.		
XL.	- -	380
XLI.		

PART II.

Plate XLII.	to face Page	522
XLIII.	-	670
XLIV.		
XLV.	- -	722
XLVI.	-	734
XLVII.	- -	758
XLVIII.	-	802
XLIX.		
L.		

Edinburgh:

PRINTED BY JOHN BROWN, ANCHOR CLOSE.

1801.