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CONTENTS OF VOLUME XXI.

NUMBER I.

MISCELLANIES.—FOREIGN AND DOMESTIC.

CHEMISTRY.

NATURAL HISTORY.

MECHANICAL PHILOSOPHY.

STATISTICS.

NOTICE OF JOURNALS, MEMOIRS, &C.

OTHER NOTICES AND COMMUNICATIONS.

APPENDIX.

NUMBER II.

MISCELLANIES—FOREIGN AND DOMESTIC.

CHEMISTRY.

MECHANICAL PHILOSOPHY.

NATURAL HISTORY.

ERRATA.

p. 71, l. 3 from bot. for stone read stove.—p. 75, l. 21 from bot. for their read these l. 17 from bot. for 11th read 12th and insert a, before geometrical.—p. 84 l. 12 from bot. for 100 "down to 18" read 100″ down to 18″—p. 85, in the table against mean in the 5th series, for 226 read 266.

ALTERATIONS FROM COPY.

p. 76, line 5 fr. top, omit the words axis of the.—p. 81, l. 3 fr. bot. add—The first six experiments are projected in the order of their magnitudes, beginning with the greatest, though this was not precisely that of their occurrence, as will be seen by recurring to the commencement of the 8th series in the table.

p. 136, l. 24 from top, after C. quadrigeminum, read C. hexagonum; same page, l. 25 from top, for six read seven.—p. 137, l. 26 fr. top, for Catenipora auleticon, read escharoides; same page, l. 22 fr. top, place Sarcinula auleticon, after T. affinis? in the last line before the note on p. 136.

THE

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JOURNAL OF SCIENCE, &c.

Art. I.—Principles of Geology.

We presume, that to many of the readers of this Journal, a perspicuous and condensed account of the principles of geology, must prove both interesting and instructive.

Such an account as corresponds, in the main, with the views of at least a majority of both British and American geologists, is prefixed by Mr. John Phillips to his Illustrations of the Geology of Yorkshire.

This excellent work, a quarto of 200 pages, is accompanied by a map, by sections, and by numerous plates of fossil plants and animals, especially of shells, contained in the strata of Yorkshire, which is one of the most interesting districts of Great Britain; a country which has proved fruitful in geological facts of great value, both in an economical and scientific view. Great Britain contains a large number of gifted and active cultivators of geology, and many of them are not stinted either as to leisure or means. Numerous quarries, gravel pits and mines, and an extensive, and frequently lofty, precipitous and broken coast, have multiplied the sources of observation in that country, and so well have they been employed, that great progress has been made, chiefly in the present century, in exploring and elucidating the local geology of Britain. Numerous districts have been carefully surveyed, and the Geological Transactions, the Scientific Journals, and separate memoirs and treatises, present an astonishing amount of information, on a subject which is however both unexhausted and inexhaustible. Among these accounts of local facts, no one, except that of Mr. Mantell on the strata of Sussex, can come into competition with the late work of Mr. Phillips. A very good analysis of it may be found in the Philosophical Magazine for May and June of the present year. It is not our intention to present either an analysis or a critique of this work, but rather to republish, the lucid and attractive account of the Principles of Geology which we have already named, and which, notwithstanding differences of opinion on theoretical topics, will we presume, be decidedly acceptable to many persons who may not have access to the original work. Without committing ourselves to an agreement with the author on every point, we are free to say, that we know not of any sketch, comprised within the same limits, which may be studied by the general reader with more advantage, and even a learned geologist will find it a useful review of the outlines of his knowledge.

Condensed view of the discoveries respecting the structure of the earth, which have produced the modern practical system of Geology.

Extracted from Phillips's Geology of Yorkshire. (1829.)

The most extensive subject which falls within the range of human acquirement, is the study of nature. To comprehend the phenomena of the material world, and to illustrate the secret laws by which they are governed, requires the joint labor of many minds. To facilitate this investigation, nature is conceived to be divided into distinct sections, each of which gives title to a science. Geology is one of these, and its professed object is to develope the natural history of the earth. It aspires to learn the various materials of which our planet is composed, and to determine the manner, and, as far as secondary causes are concerned, the means of its construction. Mineralogy, chemistry, botany, zoology, are all associated with geology; their advancement keeps pace with its progress, and every discovery which rewards the cultivation of them, throws new light on the revolutions which have visited the earth. Even the astronomer, who employs himself in observing other planets and other systems, and the mathematician, who determines the forms and densities of spheroids, are fellow-laborers with the practical observer of the strata.

If, then, so many delightful themes of human study are directly or indirectly connected with the earth, there is no need to assert the interest, it would hardly be possible to display all the advantage, which is to be expected from the study of geology. It must be evident that not only our daily wants are supplied, and our comforts provided, by various productions which acknowledge the earth for their common parent, but that the charms of scenery, and all the lovely variety of nature, are so intimately dependent on peculiarities in the structure of the earth, that no one can think uninteresting a science which embraces the contemplation of so many sources of human enjoyment. Let us, then, be spared that question which is clamorously repeated to the authors of new discoveries, "What is the use of it?" To those who direct the thousands that labor in the mine or the coal pit, I refer the question. What is the use of the principles which have extended our control over the subterranean riches of our country? In the extension of mines and collieries, and in the construction of roads and canals, we experience the value of a science, which, though noiseless in its career, and with no pretension in its appearance, lends strong support to national wealth and individual happiness;—a science which, under many discouragements, has gradually uplifted and spread itself around, till there is perhaps, no corner of the earth which contains not a man desirous of investigating its physical history.

Geology, as a system of observation and induction, is decidedly of modern origin. Some of the more obvious facts connected with it, could not, indeed, be overlooked in the most inattentive age. Such are the sinking of rivers into the ground, and their gliding along subterranean channels, of which such elegant descriptions ornament the poems of antiquity. Nor did the ancients pass, without a momentary reflection, those fossil shells which are inclosed in rocks, and buried in mountains, far removed from the sea. The lines of Ovid are known to every one; and the simple conclusion he draws of the dry land having once been sea,* has served as the basis of many later hypotheses which contain no more information. The Pythagorean doctrine of the intermutations of the substance, and repeated revolutions in the nature of all created things, of which this is urged as an example, has not a little resemblance to some of Dr. Hutton's speculations on cosmogony, whilst in Ovid's description of chaos, we really seem to behold the germ of a Wernerian theory.

We may pass the centuries of darkness which succeeded the splendid era of Rome, and fix our attention on times more approaching our own. The discoveries of Newton, in celestial mechanics, introduced a new order of inquirers concerning the history of the earth; but, unhappily, few of them followed the steps of their illustrious leader. The "theories," as they were arrogantly termed, of

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* ———— vidi factas ex æquore terras,
Et procul a pelago conchæ jacuere marinæ.

Burnet, Whiston, Woodward, and Buffon, are now remembered only as the splendid errors of illustrious men, and the systematic hypothesis of Whitehurst, though far better supported by the practical knowledge of its author, has shared the same unregretted fate. To rank with these neglected dreams, the respected opinions of Hutton and Werner, would be unjust; the former, a man of capacious intellect and original genius, has combined in his system much that is excellent and much that is extravagant; but its errors have been corrected by the progress of inquiry, and its truths illustrated even by his opponents. Werner's fame rests secure on accurate observation and sagacious generalization of facts. From an examination of a small tract of country, he deduced principles which are found to be universally applicable. He first taught that the earth is constructed after a regular plan, and composed, near the surface, of rocks laid on one another, in a constant order of succession. His theoretical views, though zealously embraced by his numerous disciples, were of little value, and rather obscured the real utility of his practical system.

Geologists have commonly placed Mr. William Smith in comparison with Werner; and have agreed that in England one was accomplishing what occupied the attention of the other in Germany, and that both were unconsciously acting on the same plan, and producing the same results. This is strictly true as far as relates to their practical opinions; but Mr. Smith is no *theorist* in the ordinary sense of the word. His whole life has been spent in practical researches, to prove the truth, and extend the benefit, of those general laws of structure which he was the first to promulgate in England. Besides discovering, at nearly the same period as Werner, the principle of the arrangement of secondary strata, he added the important doctrine, that organic fossils are distributed in the earth according to regular laws, and may be employed to discriminate and identify the rocks. Werner and Smith are, therefore, the leaders of the modern school of geology, and whilst every fresh investigation illustrates the truth of their general principles, their names will be honored with increasing respect, though every "theory" should be forgotten.

The methodical developement of first principles in geology, attempted in the following pages, is the result of repeated reflections on the subject, for the purpose of public instruction. It is a condensed abstract of parts of my lectures. Hoping that this account of the strata of the Yorkshire coast would be read by others besides professed geologists, I thought it desirable to furnish them with a plain distinct introduction to the science, in order to avoid obscurity and tedious repetition.

Formerly, the materials near the surface of the earth were thought to be every where alike, just as agriculturists now speak of the vegetable mould; and the internal parts were supposed to be a mere heap of minerals confusedly blended together; a very little experimental investigation was sufficient to overthrow so groundless a notion. One district has beneath the surface, chalk; another, oolitic limestone; a third, coal; a fourth, granite; and these are never mixed or confounded together; so that the most careless observer finds himself constrained to admit that not disorder, but method, appears in the situation of different rocks.

A person proceeds from London to North Wales. After passing low diluvial plains about London, he climbs, by a long slope, the chalk-hills of Oxfordshire and Berkshire; then crosses vales of clay and sandstone, ascends a range of oolitic limestone; traverses wide plains of blue and red marl; arrives in districts where coal, iron, and limestone abound; and finally sees Snowdon composed of slate. And if, in proceeding from London to the Cumberland lakes, he finds the same succession of low plains, chalk-hills, clay vales, oolitic limestone ranges, blue and red clays, coal, iron, and limestone tracts, succeeded by the slate rocks which compose the well-known summit of Skiddaw, will he not conclude that something beyond mere chance has brought together these rocks in such admirable harmony? Will he not have reason to conjecture, that, in the interior of the earth, regularity of arrangement must prevail?

To such a conclusion we are forcibly impelled by exploring the relative position of rocks, as it is displayed in wells, quarries, and mines, the works of human industry, or laid bare in cliffs and ravines by the hand of nature. Here every one has seen the rocks formed in layers or tabular masses, placed one upon another, like the leaves of a book. These layers are called strata.

The sea-coast of Yorkshire affords excellent opportunities of examining into this matter; for there cliffs of great altitude, in prominent and accessible situations, are composed of several distinct layers of rock, which are piled one upon another in a regular order, preserve a definite thickness, and appear under the same circumstances in many distant places. But though one tract of country exceeds another in opportunities of this nature, yet the principle of stratification among rocks is confined to no country; for whether in the new or the old world, in continents or in islands, it is sò remarkable and so constant, that colliers sink deep pits, and miners undertake expensive levels, in full confidence that no exception to its generality will affect the success of their enterprises. It is not a speculative truth, but a practical law of nature, and is, probably, the fact of most extensive influence in the whole system of geology.

The Wernerian school of geology held it to be a universal law of structure, and even Cuvier says, "All rocks are stratified." But such expressions are incorrect. How can the term strata be applied to basalt, porphyry, and other unconformed masses? That granite is sometimes internally stratified, has been asserted,—an appearance I never witnessed,—but every geologist knows abundance of examples in which it displays no trace of such a structure. These rocks, and some few others, are exceptions to the law of stratification; and if, as appears probable, their origin is different from that of stratified rocks, we need not wonder that they assume other modes of arrangement. But, neglecting these particular rocks, it is certain that stratification is the most general phenomenon hitherto discovered by geologists. Recognised by observers of different opinions, and in opposite quarters of the globe, it well deserves to be considered a fundamental doctrine. Let us inquire how these strata are combined in the crust of the earth; for so, perhaps, we may best designate the very limited depth to which it has been explored by human enterprise and science.

To ascertain the manner in which strata are placed in the crust of our globe, is certainly the great object of practical geology. The first rudiments of this knowledge should be early implanted in the mind of the student, by leading him to the contemplation of some well-marked natural section. Let him visit the sea-coast, and observe for himself whether or not the following proposition is true.

That, in a local tract, strata are superimposed on one another in a certain constant order of succession, like the leaves of a book.

Let us take the Yorkshire coast for an example. Gristhorpe cliff is crowned by calcareous sandstone rocks, which lie upon a thick argillaceous stratum; under this is a brown ferruginous rock; and still lower is a thin calcareous layer full of fossils. The same calcareous sandstone is found on the top of Red cliff, and it rests in the same manner upon the argillaceous stratum, brown rock, and fossil bed. In Scarborough castle hill, the same calcareous sandstone, argillaceous stratum, brown rock, and fossil bed, occur in the very same order of succession. It is needless to multiply examples, or every part of the coast from Flamborough to Saltburn might be cited in proof of the above important proposition. And though we only refer to a particular district, yet, without doubt, any part of the world, where the strata are distinctly visible, would equally illustrate the doctrine of local constancy in the order of succession among rocks; because in every country this conclusion has been drawn from actual observations. But it may be inquired: How can the strata be thus traced across provinces and kingdoms? we see them, indeed, exposed on the sea-coast, but how are we to guide our inquiries inland, when wells and pits fail us? I answer, that as the different rocks lie not quite horizontal, but gently sloping into the interior, the surface of the earth is formed on their edges. Thus, observe the chalk rising uninterruptedly from Bridlington to Speeton, when—another stratum, the blue clay, having risen from beneath it to the surface—that rock passes off inland, and keeps a regular course through the country. In the same manner, the calcareous grit rises from the sea at Filey, ascends to the summits of Gristhorpe and Red cliffs, afterwards attains the heights of Oliver's mount, and ranges away in a direction parallel to the chalk. The same is the case with all the other strata. Thus, the surface of the earth is formed on the edges of the strata, a wise and admirable provision, whereby mankind, though till lately regardless of the benefit, are provided with so great a variety of mineral matter, suited to the various and increasing wants of civilized life. To trace the rocks through the interior of a country, demands, it must be confessed, greater diligence and caution, than when we see them exposed on the sea-side; but the result, thus prudently obtained, may be as absolutely trusted. Nor are facilities wanting to the practised inquirer. To him, the forms of hills, the character of surface, the very herbage and color of the soil, afford most valuable data, and when corrected by the accounts of wells and pits, and observations of roads and water-courses, leave little room to doubt the accuracy of his deductions.

This being proved, we may now inquire if there be a conformity of rocks over large districts, an accordance of composition, a similarity of succession, and a connexion of strata, sufficient to unite together observations in distant countries: without doubt there is such conformity. The series of strata in Yorkshire, taken in a general way, is the following: chalk, gault?, Kimmeridge clay, coralline oolite, calcareous grit, Oxford clay, Kelloways rock, cornbrash, the Bath oolite rocks, lias, red marl and sandstone, magnesian limestone, coal series, mountain limestone, and slate rocks. The series in the south of England is precisely accordant, except that the magnesian limestone is there deficient, and that the Kimmeridge clay is covered by some strata which do not reach into Yorkshire. Besides, we find the Yorkshire strata actually united with those of the same name in other parts of England, so that there can be no doubt of the general continuity of the strata, and of constancy in their order of succession. The same conclusion is upheld by independent research in foreign countries. There, as in England, it is demonstrated, that, to as great a depth as can be accurately examined, various rocks are laid on one another, in a certain consecutive series, by which it is not difficult to assign to each its unvarying place in the scale; and that these rocks are not formed in insulated patches, but in widely-extended strata, which hold their courses across provinces and kingdoms.

This encourages us to inquire whether there be not some general analogy of the rocks, not only across islands and kingdoms, but even across whole continents; for if this should prove to be the case, we shall be enabled to propose general laws of structure, applying equally to every part of the globe. For the purpose of this comparison, we must not think to employ the characters of individual rocks, however remarkable they may appear, but we must group together analogous formations, and look only on the greater features of nature. We must consider the *physiognomy* of the earth, and, amidst many local variations, trace lines of general agreement.

Reviewing the series of British rocks, we shall observe three great divisions, of which two are extremely obvious; the rocks of the mountains and the strata of the plains: the third division possesses, perhaps, quite as definite characters, but they are not manifested without more research. The mountainous regions of Britain are composed of hard, often crystallized rocks, variously associated and related to one another, commonly stratified at high angles of declination, and for the most part destitute of organic remains. Such are granite, gneiss, mica slate, quartz rock, primitive limestone, serpentine, and slate. From the Shetland Isles to Cornwall, a general conformity in character unites the mountain groups. From these elevations, the rocks above-named dip or decline on all sides into the earth, sink deep under the more level regions, and are there covered up and buried beneath various deposits of limestone, sandstone, coal, clay, chalk, and other strata of inferior hardness, and not crystallized, but amply stored, nay filled to admiration, with plants, corals, shells, and other remains of organized beings. Besides these, there is a third division of rocks; viz. sienite, porphyry, basalt, &c. which are of local occurrence, appear in peculiar forms, and present particular phenomena. They repose indiscriminately upon the rocks of the mountains or those of the plains, and occasionally divide them by dykes, yet have only an accidental connexion with either. Such is the general character of the geology of Britain. And I may appeal to the progress of the science for proof, that such is the general character of the whole face of the earth.

In every country the great mountain ranges are composed of the lowest rocks with which we are acquainted. There may be other rocks below the granitic series, but we have not yet found means to observe them. Therefore, as being the lowest, and consequently the most ancient rocks, included in the compass of our observation, we call them *Primary.* Those more horizontally deposited rocks which fill wide plains, and rest upon the subterranean slopes of the former series, composed of various alternations of calcareous, siliceous, and argillaceous substances, with local deposits of coal, and generally abounding in shells and other organic remains, are universally termed *Secondary.* Those rocks which rest indiscriminately on the primary or the secondary series, lie in irregular patches, and send off veins or branches into both primary and secondary, being in fact superadded to both, yet conjoined to neither, receive the name of *Independent* or *Overlying.*

Freed from theoretical views, or rather under the influence of very opposite and contradictory theories, all parties confirm this relation of facts, and agree in the conclusion, that the earth exhibits every where the same principles of structure. It is now universally admitted, that, to as great a depth as we can ascertain, our planet is composed of various but definite rocks, possessing constant characacters, whereby they may be distinguished, and that they are arranged upon one another in a constant relative order.

The mode of investigation by which this result has been obtained, appears to me satisfactory. Beginning at home, we find certain regularity of structure to prevail; extending our views, we perceive that the rocks of our district are not insulated deposits, but portions of wide-spread formations; and finally combining together observations made in distant regions, we ascend to a grand principle of universal analogy in the construction of our planet. If, then, such analogy pervades the structure of different regions, it will be necessary, in stating general laws, to call in the aid of extensive research; but particular laws for each country can only be derived from local investigation.

Possibly those who are accustomed to trace across our island the wonderful regularity of strata, or who know the strong resemblance which they exhibit in countries far removed from each other, may have expected more sweeping assertions than I have thought it correct to maintain. They might, perhaps, have been little surprised at a bold declaration, that all our secondary rocks may be discovered with their proper characters over all the continent, when the labors of foreign geologists have been as successful as our own. But this would be an unjust view of the matter; in several instances it is absolutely disproved. The utmost that can be expected, is to trace a general conformity and universal analogy of deposits. To what extent this conformity reaches, much as geologists have done, they have not yet demonstrated. It is ascertained that there are certain formations which possess a mineralogical character, and a geological position so uniform in all parts of the world, as to allow no doubt of their cotemporaneous origin, and even in some of their subordinate beds an astonishing affinity prevails; but neither these beds, nor the formations themselves, are in all places, continuous in extent, nor constant in thickness, nor identical in chemical composition. Hence arise differences in the geological structure of different countries, and the more distant from each other the points of comparison, the less perfect is the agreement of the rocks. Some writers, overlooking these differences, have erroneously asserted the universality of formations; others, not understanding the simple and beautiful gradation of nature, have absurdly denied the regular construction of our planet.

The organic fossils commonly found in the earth are plants, corals, crusts of radiaria, shells of mollusca, the hard coverings of crustacea, scales and bones of fishes; reptiles, cetacea, birds, and mammiferous quadrupeds. From very early times, the wonder of mankind has been excited by those fossil shells which are inclosed in rocks, and buried in mountains, far removed from the sea. To find the cause of this phenomenon was an object of interest, long before any settled system of geological observation and induction was thought of. The study of organic fossils was prosecuted with various success by different naturalists, but it was reserved for our own times to demonstrate their high importance in elucidating the history of the earth. Undoubtedly it is possible to acquire a competent notion of fossil plants and animals, without particular reference to geology; but no one can be a geologist who disregards the natural history of fossils.

The slightest practical examination of rocks demonstrates that whilst some strata abound with these remains, others contain very few, and some are absolutely void of them. The absence of fossils was once used as a character of the primary rocks, but incorrectly; for several of the secondary, and all of the independent rocks, are as destitute of fossils as granite and mica slate. Since, then, among the secondary rocks, some contain, and others do not contain, organic remains, they may thus be sometimes distinguished. But when we consider the immense variety of organic remains, and learn that in a very limited district of England, many hundreds of species can be collected, and in the whole kingdom several thousands, it becomes evident that a more important branch of the inquiry remains: viz.—in what manner the different species are distributed in the interior of the earth. Whether, for instance, they are arranged according to geographical position, as is partly the case with existing races, or according to the order of the different rocks, or mixed confusedly together.

That they are not mixed confusedly together, is decisively proved by many cases like the following: the fossils of the chalk cliffs near Bridlington, are numerous and well known; so are those of the lias shale in the cliffs near Whitby; and also those of the mountain limestone near Skipton; and on comparison, it becomes evident that no one fossil of the whole number is found in two of the strata enumerated! each of these three strata has its own peculiar fossils distinct from those in the others. By prosecution of such comparisons, Mr. Smith discovered that organic fossils are distributed in the earth, not in proportion to depth from the surface, nor even according to chemical composition, but according to the order and succession of the rocks. He has the great merit of establishing the facts, That *different* strata contain generally *different* fossils; but that the *same* stratum over a very large extent of country, contains generally the *same* fossils. Hence he deduced the important conclusion,

That strata may be discriminated and identified by their organic contents.

Since then, rocks of different antiquity contain different fossils, it is possible to class the organic remains according to their respective periods of existence. They may thus be successively compared with the analogous beings now living, and with one another. This comparison elicits most curious and interesting results.

First, we perceive that nearly all the immense multitude of buried beings belongs to species different from any that now exist! but in this difference between fossil and recent specimens, are several degrees; some species are allied, others are analogous, and the remainder so discrepant, as to bear hardly any mutual resemblance.

Now, it is an established fact, that the greater number of fossils which nearly resemble living objects, belongs to the most recent of all the strata, viz. those above the chalk; and that many of the extinct genera are confined to the lowest and oldest part of the series. Place together, for instance, existing species of shells, and the fossils of the least ancient of British strata, as those of Hordwell and the Isle of Wight,—the resemblance is obvious and decided; but on a similar comparison between recent specimens and the fossil productions of the mountain limestone, one of the oldest of the secondary rocks, the difference is evident and remarkable. Considered in this manner, the living and fossil tribes constitute one mighty series of organic productions, formed upon one general plan, but called successively into existence, to suit the changing conditions of the earth and the ocean. The striking contrast between the imbedded fossils of different rocks, has given rise to an opinion, that, whilst the strata were successively deposited, many races of organic bodies became extinct, and others were created to supply their place, more and still more nearly assimilated to the present productions of nature.

We must now attend to certain phenomena, in the relative positions of rocks, which demonstrate that the internal parts of our planet have been shaken by often-repeated convulsions. Rocks appear generally in planes, deviating but little from the horizontal, but sometimes they decline at great angles into the earth, and in several instances are placed directly vertical. The planes of strata are usually continuous and uninterrupted over large spaces, but occasionally they are broken by *faults*, and divided by *dykes*. It has been a question whether these unusual positions have existed from the first accumulation of rocks, or been caused by subsequent convulsions.

It is agreed among geologists that many of the primary, and all the secondary rocks were deposited by subsidence from water. Matter, so deposited, in some degree accomodates itself to the surface on which it drops; but it must especially tend to form horizontal layers; and it is well known that strata have generally only a moderate inclination. If the bottom be level, so will be the deposit; if gently sloping, the deposit will be inclined; but if there be a perpendicular subaqueous cliff, no sediment can fall upon it. A perpendicular layer arising from sediment is impossible. Whenever, therefore, we behold vertical strata which contain evidence of deposition, we may be quite sure that they were not deposited in that form, but have been displaced by some violent internal motions in the earth. There are some remarkable instances of contorted stratification, which require the same explanation. It is absurd to maintain that such flexures are original; assuredly they have been occasioned by operations subsequent to the accumulation of the rocks in question. But the most remarkable case of unusual position is when strata, either horizontal or inclined, are broken, and their planes interrupted, so that on one side of the line of fracture the rocks are higher than on the other: this difference of level sometimes amounts to one hundred or even two hundred yards, as on the coast at Red cliff, Scarbrough castle, and the Peak, near Robin Hood's Bay. The succession of strata is, on each side, the same, and it seems hardly possible to doubt that they were once connected in continuous planes, and have been at a subsequent period forcibly broken and disjoined. This opinion is, and deserves to be, universal. The line of separation between the elevated and depressed portions of strata is generally nearly vertical, and distinguished by a fissure, which in *faults* is filled with mixed fragments of stone; in *dykes*, by basalt or other rocks; but in *mineral veins*, with sparry and metallic minerals.

The convulsions within the earth which have thus changed the inclination, altered the position, and broken the continuity of rocks in so remarkable a manner, happened, of course, since the deposition and induration of *all* the strata which have been thus dislocated. But such progress has been made in inductive geology, as to render it evident that some of these irregular operations had been completed in certain strata before the next rocks were deposited upon them. For in Somersetshire, coal measures, highly inclined, lie beneath and are concealed by horizontal beds of red marl. Therefore, their highly sloping position must have been determined before the deposition of that rock: and in the same country great faults, which elevate the coal seams seventy yards, produce not one inch of displacement in the red marl which lies above. Assuredly then, internal convulsions of the earth occurred at intervals during the deposition of rocks; and by studying their relative antiqnity, we obtain plain evidence of the lapse of time between the formation of the several strata. Examples of the same kind are well known in Yorkshire, where inclined coal measures are covered (as at Garforth) by nearly horizontal magnesian limestone, which is unbroken by the vast dykes in the subjacent coal. There are good grounds for believing that the highly inclined position of the primary strata is not original: it is extremely probable, and, indeed, generally admitted, that these stupendous ranges of mountains have been uplifted by some mighty interternal agency. It is certainly true that the greatest dislocations of the secondary strata are in the vicinity of primary mountains; and, though it must not pass as a general or established rule, we may sometimes refer the disruption of secondary to the same agency which produced the elevation of primary rocks.

Having considered the internal structure of our planet, and shewn how the rocks succeed one another in a fixed order, and rise successively to the surface; how variously they are filled with the monumental reliquiæ of organic beings which existed during the remote ages, when the secondary strata were deposited beneath the ocean; and also examined the effects of convulsions within the solid substance of the earth; it becomes necessary to turn our views to the surface.—The external features of the earth afford many interesting subjects of reflection, and are replete with memorials of mighty changes. Though it cannot be supposed that, by investigation of its present appearance, we should be able to determine completely its former condition, enough is known to assure us that after the earth was dried and made habitable, its whole surface was again submerged and overwhelmed by an irresistible flood. Of many important facts which come under the consideration of geologists, the "Deluge" is, perhaps, the most remarkable; and it is established by such clear and positive arguments, that if any one point of natural history may be considered as proved, the deluge must be admitted to have happened, because it has left full evidence in plain and characteristic effects *upon the surface of the earth.*

Formerly, indeed, when geology was in its infancy, a wrong method was followed, and the fossil shells and other organic remains, which were certainly deposited in the rocks *before* the deluge, were appealed to as evidence of that event. This mistake was natural enough in that early period of the science, but at present cannot be maintained, without a gross anachronism. Examine where we may the action of moving water, whether in little mountain rills, lakes ruffled by the wind, flowing rivers, or on the margin of the sea, we every where perceive the same effects; stones smoothed and rounded, masses crumbled and disintegrated. We may trace old channels of rivers by the pebbles left in them, and the set of the tide by their accumulation on the shore; in a word, the action of moving water is known by its effects. As the old channel of a rapid stream is filled with pebbles that declare the force of the current, so the whole earth is covered by pebbles, the wreck of a general flood. Filling the vallies, overspreading the plains, and covering the hills, rounded stones, of all sizes and all kinds, mixed together in as much confusion as pebbles on the sea-shore, (fragments of all the known rocks which compose the interior of the earth,) are profusely scattered on its surface.

It is impossible to account for the vast heaps of this gravel by supposing that it might be laid in its present situation by any streams such as now water the earth. For it occurs abundantly in places where streams do not run, where, indeed, they never did run; neither is it confined to such narrow paths as serve for the passage of rivers, nor is it laid in such forms, but it is casually and unequally spread over all the face of the country. The blocks of stone which have been thus rolled from their native sites, are, in some cases, of so vast a magnitude, and have been so strangely carried, even a hundred miles or more, over hill and dale, that in vain do we think to assign any other cause for the phenomena, than a great body of water moving upon the earth. With regard to the force of this water, various facts, which have fallen under my repeated examination, may give some idea. On Shap fells in Westmoreland, a reddish granite is well known, and its blocks are at once recognized by large interspersed crystals of felspar. Now, by the force of the great currents of water, blocks of this granite have been scattered over a large tract of country to the south, where masses, some tons in weight, rest on high ground near Sedbergh; and, when the Lancaster canal was made, such were found of great size in deep cutting, near the town of Lancaster. Eastward, this granite has been carried by other currents of the same water, over the deep vale of Eden, and the lofty range of hills which extend along the western border of Yorkshire and Durham, across Stainmoor forest, down the vallies of Durham, and the northern dales of Yorkshire, across the vale of York, and the hills of the eastern point of the county, to Scarborough and Flamborough head, where it rests on the summit of the cliff one hundred miles from its ancient situation. This is one of many instances. The dispersion of sienitic rocks from Carrock fell, Cumberland, of granite from Ravenglass, and of whinstone from Teesdale, is not less remarkable. Such facts cannot be seen without astonishment, nor contemplated without full conviction. As to the height of this flood in our own country, the sides of Ingleborough, on which rest fragments of rocks transported from Keswick; the brow of Stainmoor, which supports large masses of granite; and the top of Carrock fell, from which so large a quantity of sienite has been removed, demonstrate that our proudest hills were overflowed; and as to the extent, all countries acknowledge the wide-spreading visitation:—the deluge covered the whole earth.

The deluge is a great feature in the natural history of the earth, and it is highly desirable to fix the period of its occurrrence; not to estimate how many centuries have passed away since it happened, nor how long it remained upon the earth; (such knowledge must be gathered from other sources;) but its relative place in the succession of phenomena which have visited the earth: for, in my mind, those geologists have been ill-advised, who, in the present state of science, affect to form a chronology of nature for comparison with the records of history. But the order and series of events may be read in the books of nature, and by inspection of them, two propositions are demonstrable.

First: That the deluge happened after the stratification of the earth was completed. The proof is easy: whoever will examine gravel-pits will be soon convinced of its truth. For in some part or other, the diluvial accumulations contain fragments of every known rock; masses of the old rocks carried many miles and dispersed over the more recent; and again, pieces of the more recent washed upon those which are more ancient. Either of these examples is sufficient, because it proves that all the strata were completed before the period of the deluge.

Secondly: The deluge happened after parts of the earth were dry, and inhabited by land animals. On this point the evidence is so plain, simple, and convincing, that he must be indeed strongly armed in scepticism who does not yield to its force. For we find in gravel accumulated by the deluge, the bones of many land animals, as the elephant, hippopotamus, horse, ox, deer, &c. Therefore, it is perfectly plain, that such animals lived before the flood.

What a noble field of inquiry does this comprehensive truth open before us! To study the remains of a multitude of creatures which have been extinct for some thousands of years, and whose living analogues dwell only in distant and different countries. Cold as is our climate, and now utterly unfit to maintain the existence of such animals, the time has been, if we rightly understand the history of the earth, when elephants and hippopotami, tigers and hyænas, lived here together, and here together met the common doom of all the inhabitants of earth, destruction by overflowing water. And not inconsiderable was the number thus destroyed; for almost every gravel pit and diluvial cliff, and limestone cavern, abound with their remains; some of which, by their unusual proportions, indicate the gigantic size and formidable strength of antediluvian quadrupeds. By comparing them with existing species, we are enabled to conjecture the antediluvian condition of the world, with what vegetables it was clothed, and with what climate it was blessed. No scope need be given to fancy, the truth of analogy, the known conformity of nature, are sure guides to the geologist.

To discuss the interesting questions arising out of this magnificent subject, would be deviating from the elementary plan of this chapter. We must, therefore, refer to the works of Cuvier and Buckland for full illustrations of the forms and habits of antediluvian animals, and the circumstances under which they are discovered; whether in gravel-pits inland, and in cliffs by the sea; or in caves and fissures of limestone, into which they were dragged to death by their ravenous contemporaries, or fell by accident, whilst browzing among the rocks, whose open chasms the deluge has since concealed.

But it will be demanded, What changes in the surface of our planet were occasioned by these devastating waters? Was the antediluvian earth diversified by the same hills and vallies, the same precipices and cliffs as we now behold, or was all this beautiful variety of surface occasioned by that flood, or is it the result of subsequent causes? These points have been resolutely debated by different theorists, and the most furious contests happened, as usual, whilst the facts were but half understood. But the controversy has been gradually quieted; and geologists having learned to agree upon facts, have ceased to dispute about opinions, the time is come when the observers of nature have imbibed a spirit of calm and limited induction, which leads to candid agreement or modest dissent.

No one who considers the extensive tracts formed of the diluvial detritus, can doubt that great alterations were occasioned in the features of the earth's surface, at the period of the deluge. All the solid land of Holderness is an accumulation of this kind, from the ruins of other parts of England and Scotland, and perhaps Norway. If hills were known before the flood, their present peculiar shapes must be dated from that event; and if vallies were then in existence, they must have been deepened and widened, or possibly filled up and obliterated. But that the whole antediluvian surface of the world was even and uniform, is altogether improbable. For, to a very considerable extent, the great features of the earth's surface are determined by peculiarities in its internal construction. Its highest ranges of mountains are composed of one set of rocks, but its widely extended plains are based on another. Obviously, therefore, these great distinctions are not only antediluvian, but aboriginal. There are, also, many lesser features of this kind, which must be carefully selected from the phenomena ascribed to the deluge. Many great natural depressions or wide vales are produced, evidently by the convergence of opposite declinations of strata; as the great vale of the Thames is occasioned by meeting dips from Hertfordshire and Surrey; and such are, doubtless, antediluvian. Many geologists believe that, from some unexplained causes operating during their deposition, some strata were originally deposited at higher elevations than others; that, for example, the lower part of the coal series was made to attain elevations not reached by the upper part of the same series; and that the new red sandstone was never in England placed at so great an altitude as some of the strata which lie above it and below it. In these instances, therefore, it has been concluded that the antediluvian features of the earth were not very different from what we now witness: and these instances admitted to their full extent, actually include the most striking variations in the surface of the earth; for it is certainly true, that the great mountain ranges which seem to compose the skeleton of the earth; the wide oceans, plains, and level tracts, and even the remarkable lines of secondary hills and most extensive vallies, are placed in accordance to the interior structure of the earth. Hence, it follows that we must limit our inquiry, as to the changes produced on the surface of the earth by the deluge, to the vallies and hills which seem evidently to have derived their peculiar features from currents of water, since the consolidation of the strata. Even thus limited, the subject is ample, fertile, and instructive. Many vallies in a secondary country are excavated through several strata, as limestone, clay, and sandstone, which appear on the opposite sides in most exact agreement as to thickness, composition, and mode of arrangement. That such rocks were originally deposited in continued planes, and, therefore, once connected across the chasm or valley which now divides them, can hardly be doubted. The vallies themselves bear marks of their origin; their bottom is a continued plane; their sides correspond with answering sinuosities; and their every peculiarity suggests the action of decurrent water. From the time of Pythagoras to the present day, every unprejudiced observer of nature has concluded that such vallies were cut out of the planes of the consolidated strata, through one, two, or more rocks, according to the depth of the excavation, and in this or that direction, according to the facility with which the materials were abraded. These are called vallies of denudation, and they are very numerous and extensive. In western Yorkshire, the great mining vallies of Teesdale, Swaledale, Yoredale, and Wharfdale, are magnificent examples, and strongly impress the mind with the power of the currents which occasioned them. In the eastern part of the county, the vallies of the Derwent below Malton, Rievaulx and Bilsdale above Helmsley, Newton Dale above Pickering, and Hackness near Scarborough, are remarkable and beautiful instances.

There is one circumstance of common occurrence, which yields so absolute a proof that vallies were formed at periods subsequent to the deposition of the strata, and is in itself so curious, that though few will seek more satisfactory evidence than in each case each valley furnishes, it deserves to be mentioned. Some valleys cross and cut through vertical strata, which must necessarily have been at first deposited nearly horizontal. Therefore, such vallies were not produced till after the displacement of the rocks.

No one has carried his speculations on this subject so far as Dr. Hutton, who maintained that vallies were, in all cases, scooped out by the streams which run in them.* This is a characteristic part of his system of decaying and renewing worlds, and whoever views the minute, though not imperceptible effects of our rivers, need not cavil at the ample time he allows for their producing such effects as the denudation of vallies. But this opinion clashes so directly with plain facts, as to be wholly inadmissible. How can we apply such an hypothesis to those numerous vallies in the plains of chalk in Yorkshire, Wiltshire, and Dorsetshire, which have never carried water in the memory of ages, down which, indeed no trace of a channel can be seen? Yet they are branched like the vallies of other districts, have all their sinuosity of course, and regular declination, but the soil and stratum are too absorbent to be moistened by the most hasty rain.

The excavation of vallies can be ascribed to no other cause than a great flood of water which overtopped the hills, from whose summits those vallies descend. Such a flood, put in violent motion, might, we may suppose, by its currents and eddies, scoop hollows which afterwards, on its retreat, would be extended in long connected vallies. From the best and most independent evidence we have shewn, that such a flood has once overflowed the earth since the consolidation of its surface; and as we have no proof of more than one such flood, and as there seems to be no contrary evidence, it is probably to the deluge we must ascribe the excavation of vallies.

But the deluge has long passed away, and other events have materially changed the face of the earth. Did not the voice of history and tradition teach us the great antiquity of that catastrophe, we yet might assure ourselves of it by the contemplation of nature. For when we find the diluvial deposits of clay, pebbles, and bones, covered by shell-marl, silt, peat, and large uprooted trees,—accumulations which proceed so slowly in our days, as to be hardly perceived in operation,—there is reason to conclude that a long period separates us from the date of the deluge. And when, in these new accumulations, we find the bones of postdiluvian animals, which have become extinct through accident or persecution, as well as of others, whose successors still exist in the neighborhood, we may, perhaps,

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* Quodque fuit campus, vallem decursus aquarum
Fecit. ———— OVID, METAM. XV.

think that little is wanting to complete the evidence of this portion of the physical chronology of the earth.

Werner, and most of the moderns, consider the phenomena which have been unfolded by geological research, as the effects of causes no longer in action. But Dr. Hutton believed that all the revolutions which have visited the earth, were but the result of the ordinary operations of nature, continued through very long periods of time. He was of opinion that what is now sea, was formerly dry land; and that by the action of rains and rivers, materials are accumulated on the bed of the sea, to produce the strata of new continents, which by some convulsion, like many that have happened before, will be uplifted and laid bare, whilst that part of the earth which we inhabit, will be sunk under the new ocean.* To this hypothesis it may be objected, that it ascribes to the ordinary agents of nature, effects which appear much beyond their power. *General changes* in the relative situation of sea and land have been often supposed, but never established by evidence; for Cuvier's conclusions drawn from the alternations of marine and fresh water formations, apply only to limited districts; and since well-conducted inquiries into the natural history of antediluvian quadrupeds, have shewn satisfactorily that they lived before the flood over a very large portion of the present continents, we have proof that at *the period of the deluge*, the sea and land did not change their relative situations.

The natural agents now employed in altering the face of the globe, are fire and water. The former forces fluid matter from the interior, and spreads it around the volcanic mountains; the latter is incessantly occupied in lowering heights, wasting and smoothing precipices, filling up vallies, and equalizing the surface.

Action of the sea and tide rivers.—The records of history declare what large tracts of inhabited country have been lost in the sea, and what extensive surfaces of new land have arisen to contract the dominion of water. Observation shews on our own shores much of the reciprocal process of demolition and augmentation; and thus we are enabled to form a correct estimate of the effects of this "war of sea and land."† Every sea-coast, and especially every great estuary, furnishes examples for contemplation; and these effects are so similar in all parts of the world, that the mode of ex-

* ——— Eluvie mons est deductus in æquor.
OVID, METAM. XV.

† Hutton.

planation which is suggested by consideration of one coast, will apply, with almost equal accuracy, to all. Sea-cliffs, composed of solid rocks like mountain limestone or basalt, are liable only to that wearing of surface which is produced on the hardest stones by the impulse of water, and may remain, perhaps for ages, without any obvious reduction. Those composed of alternating strata suffer greater waste; for the softer parts are worn away by the unremitting attacks of the sea, and the harder ones being undermined and unsupported, fall in awful ruin. But where a cliff consists of gravel, sand, or clay, the destruction proceeds with alarming rapidity. The Holderness coast is of this kind, and the records of its history shew the terrible devastations which it has endured. Almost within the memory of men now living, a church and church yard, having some land and buildings between them and the sea, have been swallowed up in the insatiable waves.* The substances which fall from the cliffs are angular stones of different sizes, gravel, sand, or clay. According to their bulk and specific gravity, they are sorted and disposed of by the tide.

Whoever has observed the sea-shore, with attention, is aware that the sand and pebbles, which constitute the beach, undergo continual change of place. The little heaps of gravel which are sometimes ranged in lines according to the height of the tide, are at other times strewed over the sand. According as the tide sets along the shore, the pebbles are driven onward progressively, accumulated in little quiet recesses of the cliffs, and heaped together in profusion in the larger bays. The large angular stones usually remain near the spot where they fell, but the smaller ones, after being rolled about by the waves till they become pebbles, are subject to the same progressive motion as the ordinary gravel; the sand travels in the same direction, and the finer particles of clay, mixed with and suspended in the water, are transported far away, and finally deposited on the marshes; and thus by the fall of the heights, materials are provided for the extension of the lower ground. The wasted cliffs of Holderness have furnished the pebbles which compose the long projecting point of Spurn, and part of the silt which enriches the marsh land along the rivers Ouse, Aire, Dun, and Trent. The sea engulphs but little of what falls from the ruin of its boundaries; its effect is to abate the high, and to raise and extend the low parts of its shores. When the

* ——————— et adhuc ostendere nautæ
Inclinata solent cum mœnibus oppida mersis. OVID, METAM. XV.

latter part of this process has proceeded so far that the marshes are dry at intervals, man exerts his enterprising industry, and defends the new land by a bank. If this be made too abrupt, the ocean indignantly washes it away, and reclaims his ancient domain; but a long gradual slope of pebbles and sand averts the fury of the sea, and protects, though with a moving barrier, the lands within, above which, in storms, the waves hang suspended and threatening destruction, but dash their spray and fling their foam in vain.

Action of rivers, &c.—Imperceptible as is the reduction of mountains and hills by rains and rivulets, yet the matter thus collected, by constant attrition, assumes an important character, when concentrated along the margins of rivers, and changes the appearance of the vallies. In proportion to the magnitude of the stream, the altitude of its sources, and the nature of the country through which it flows, the effects are more or less considerable. But they every where tend to the same result; the raising of the level of the valley by horizontal layers of sediment. This accumulation is most rapid where rivers approach the sea, because there the current is languid, and often weakened or neutralized by the opposition of the tide. From the point where the tide ceases, to the sea, the natural tendency of every land flood, and every muddy tide, is to heighten and extend the low alluvial lands, whilst, by the same process, the bed of the river is raised, and its mouth carried further into the sea. The "new land" thus produced, being but feebly consolidated, opens new channels to the rivers, which, changing at intervals their mouths, raise towns into temporary distinction, and again, if not prevented by art, take a fresh course, and carry away at once their harbors and their opulence.

Subterranean forests, &c.—Under the alluvial deposits of silt or clay, it is common to find, at various depths, great quantities of trees of several kinds, in different states of preservation. They are frequently accompanied by peat: sometimes they lie under the deposits of rivers and the tide, as along the great rivers of Yorkshire and Lincolnshire; and sometimes they are covered by the shelly sediment of ancient lakes. In many instances they are broken to fragments, and so irregularly disposed, as to make it probable they were swept together by violent land-floods; but in other cases they are stated to be regularly prostrated in a particular direction, and to vary in their kinds according to the nature of the subterranean soil on which they are placed. It is reported that oaks are found lying on clay, and firs, alder, and birch upon sand; and, as in the present condition of nature, such soils suit such trees, these circumstances have led to an opinion that the trees grew near the spots where they lie buried. If this be thought sufficiently probable, we arrive at a startling conclusion; for as these trees are often buried some yards below the usual level of the sea, and are sometimes, as on the shore of South Wales, covered thirty feet deep by the tide, it would appear that the sea has risen so much on our coasts. If the levels of Yorkshire were once covered with forests of oak, the sea must have been debarred access to them, and it would seem, therefore, that its general level has been since much raised; for those trees are below the present height of the tide.—Alluvial sediments near the sea, on the banks of rivers, and on the site of ancient lakes, enclose shells such as now live in our fresh waters, and bones of the stag and the ox.

Volcanoes.—The alterations in the features of the globe, produced by sudden eruptions of volcanoes, are less considerable than those occasioned by the slow and continued action of water. It is along mountain chains, and among mountain groups, that the melted rocks of the interior of the earth are poured forth upon its surface. How deep is the seat of volcanic fire, what is the chemical history of its origin and support, are subjects of philosophical inquiry too extensive to be here discussed. Perhaps the simplest explanation is that suggested by Sir H. Davy's splendid discovery of the metallic bases of the alkalies and earths; for if to such metals, deep in the earth, water be supposed admissible, the combustion which would be so occasioned may be thought equal to produce the phenomena which we behold.

The most important considerations, which volcanoes suggest to geologists, relate to the substances which they emit; for some of these fused substances assume, when cold, the appearance of well known rocks. Some "lavas" closely resemble basalt, others are like pitchstone, and others almost identical with porphyry. Now, these are among the most characteristic of the rocks called independent or overlying; and it therefore appears probable, *a priori*, that such rocks are of igneous origin. On examining the circumstances which accompany them, we find that, where they are in contact with other rocks, particular phenomena appear, which strongly confirm this reasoning. Thus, where basalt passes through coal, this mineral has lost its bituminous portion, as effectually as if it had undergone distillation. Ordinary limestone, divided by basalt, exhibits a crystallized texture, such as Sir J. Hall produced in it by great heat and pressure combined. From an extensive series of such facts, it is inferred that the overlying or independent series of rocks derive their peculiar appearances, and have produced the remarkable phenomena which accompany them, from the agency of fire; they are, therefore, said to be of igneous formation. Granite, though different in position, agrees with them so closely in its structural characters, and in the phenomena which accompany its contact with other rocks, that it is now admitted to have been in a state of igneous fusion.

Numerous facts of a different kind, generalized with equal caution, leave not a shadow of doubt that all the secondary strata, and many of the primary, were deposited from water. The shells which fill so many of the rocks, and the clear traces of watery agency in others, make this absolutely certain. From the different characters of these shells, we can clearly determine, in many instances, whether they belonged to marine, fluviatile, or terrestrial species; and we may thus, with great probability, conjecture the nature of the aqueous fluid which deposited so many rocks. In the application of this last method of reasoning, however, too much caution cannot be used; for, surely, fresh water shells may have been as easily swept down to the sea, and buried in its deposits, as the wood which lies in so many secondary rocks, and it would, therefore, be hazardous to conclude that a great primæval lake of fresh water existed over every spot where such fossils occur; and even where they superabound, as in the coal districts, we must not change a prudent doubt for an insecure conclusion.

Having thus traced the outlines of a practical system of geology, I shall conclude with a very brief sketch of the series of changes which appear to have visited the earth. From chemical researches it seems highly probable that the whole crust of the earth is to be viewed as originally produced by oxidation of fluid metals and metalloids. From a careful study of the effects of heat, under different circumstances, and of the habitudes of earthy compounds under its influence, it seems probable that the granitic rocks, which are the lowest of the primary series, owe their present condition and appearance to the effect of partial or general fusion. Above this granitic series we find, certainly, the effects of deep and overruling water. Many of the primary, and all of the secondary rocks, owe their present appearances and arrangements to the action of water. These strata exhibit the results both of agitated and of tranquil waters—mechanical aggregates—sedimentary deposits—and chemical precipitates, in frequent repetition. This circumstance, combined with the facts relating to organic remains, teaches us, that during a long period, the sea flowed rich in living beings over rocks which contain no relics of life. At times tranquil, at intervals tumultuous, this ocean, perhaps of elevated temperature, even in the northernmost regions, varied its deposits at different periods, yet preserved among them a general conformity of arrangement, from the oldest to the most recent, and a similarity over large regions. The aquatic animals and other remains, which are entombed in the earth, exhibit a long series of beings, whose origin dates from some of the earliest strata, and whose forms, differing according to the antiquity of the rocks, successively come nearer and nearer to the modern productions of the land and the ocean. During this process, at intervals, vegetable forests swept into estuaries, or lakes, furnished the materials of coal, and the intermitting action of submarine volcanoes frequently broke the consolidated strata, and formed basaltic and other overlying rocks. At times, too, more violent exertions, probably of the same cause, uplifted groups and ranges of mountains with great disruption and dislocation. Operations of the same kind are to this day continued, but so feebly,* that we commonly speak as if the causes which concurred to produce the crust of our planet, had ceased to exist. They appear, however, to have been gradually weakened, and when the last series of the secondary beds, partly marine, partly lacustrine, was deposited, a large portion of preconsolidated rocks become tenanted by land animals. But again the waters returned and overflowed the inhabited world; removed rocks, excavated vallies, and destroyed the terrestrial inhabitants, from whose anatomical construction, as displayed in their remains, it may be inferred that the antediluvian face of the earth was like our own, diversified by lakes, and forests, and mountains.

This transient flood retires from the desolated continents; again the forest is clothed with foliage; birds fly in air, and animals roam the earth; the mountains gather clouds, rain falls, the streams flow down their new channels, the sea resumes its appointed boundary; cliffs are wasted, low shores are extended, vallies are filled up, volcanoes are in action; nature revives again, and man, by contemplation of the phenomena, reads the awful history of his birth-place, gathers ideas of the immense agency exerted in the construction of the earth, compares this planet with the other members of the solar system, and views the solar system itself as only a small part of the immeasurable works of God!

* ——— Absumptis per longum viribus ævum.

ART. II.—*On some of the Vegetable Materials from which Cordage, Twine and Thread, are made;* by JAMES MEASE, M. D., Member of the American Philosophical Society, &c. &c.

(Communicated for this Journal.)

THE two first vegetables that deserve to be noticed, as being most generally known to the countries in which christianity prevails, are, 1. Hemp, *Cannabis sativa;* 2. Flax, *Linum usitatissimum.* On these no farther remarks are necessary.

In India the fibres of several vegetables, and different vegetable productions, are extensively employed for the same purpose; the principal of which are the following.

1. *Crotalaria juncea, L.;* sana,* or sun-plant. This is extensively cultivated throughout India, and also in the island of Sumatra, according to Marsden, to make small ropes and twine. The Rev. Mr. Carey says there are two varieties of this plant, one of which grows ten or twelve feet high: the seeds of another are sown in October, and rises to the height of four or five feet. The first variety is preferred.† The reason for this preference, according to Milburn, is, 1st, the difference in the size of the two plants; and 2d, the circumstance of the lateral branches which shoot out from the smaller variety, and which render the fibres very difficult to be separated from the woody part. The mode of separating the fibre is extremely simple, as are all the mechanical operations in India. When the seed vessels have nearly attained their full size, the plants are cut, tied in bundles, and steeped in water for two or three days; then taken out, and the stalks broken about a foot from the lower end by a man standing up to his knees in water, who, holding a few of the stalks with the large ends from him, threshes the water with them, till the broken pieces are separated, and fall off. Then turning them, he takes hold of the fibres which have been freed, and beats the small ends in the same manner, until the fibre is entirely separated from the stalks. A few strokes are sufficient. It is then dried and pack-

* Dr. Francis Buchanan gives two Indian names to this plant, viz. *Janupa*, Travels, Vol. i. p. 226, and *Shanapu*, Vol. ii. p. 227. Milburn says that the large variety is called *Ghore sunn:* the fibre is called *Jute*. Oriental Commerce, Vol. ii. p. 210.

† On the Agriculture of Dinajpur. Trans. Asiatic Soc. Vol. x. p. 11.

ed up for market. Dr. Buchanan gives a somewhat different mode of treating the plant to procure the fibre, which it is unnecessary to copy. (Travels, Vol. i. p. 227.) The apparatus commonly used in the United States to break and prepare hemp, would answer much better than any Indian mode. The twine made in India from the sun-plant, has long been an article of regular importation into the United States, and is much used when a strong ligature is not required. It is also extensively employed for fishing seines; for although it is weaker when dry, than the twine from flax, yet is stronger than it, when wet; on this account, and being but half the price of flax twine, it is in great demand by the Delaware fishermen, as one of them recently informed me.* The twine-fibre is also the material from which the well known gunny bags are made, as I have long since stated,† and has been converted into strong demy, crown and cartridge paper: a specimen of the first I received from the late Dr. Lettsom of London, in the year 1803,‡ and still possess it. The value of the sun-plant induced me to recommend the importation of the seeds for sowing in Louisiana, and I repeat the recommendation. The climate of Florida would be equally congenial to it, and from the greater ease with which its filamentous fibre is separated, than hemp, it would doubtless become a favorite with the cultivators. Paper makers will find it profitable to work up the worn gunny bags and old sun cordage, for coarse strong wrapping paper. The specimen I have of the paper is much stronger than that made from straw.§

* Dr. Roxburgh gives the results of several hundred experiments, to show the comparative strength of numerous vegetable fibres used in India for cordage and twine, under the following circumstances. 1. In a fresh state; 2. dry; 3. wet with fresh water; 4. tanned; 5. tarred; 6. after one hundred and sixteen days maceration in fresh water. The result was, that tan in general added strength, while tar, although it preserved cordage, diminished its strength; and in no instance was this more clearly evinced, than in the common hemp, (*Cannabis*) cultivated in Bengal. Wetting cords with fresh water, invariably increased their strength greatly. A dry cord of sun-plant sail twine broke with one hundred and forty eight pounds weight, but required seventy four pounds more, or a weight of two hundred and twenty two pounds to break it when wet with fresh water. Thirty two pounds more were required to break a hempen cord when wet, than to break another cord of the same size when dry.

† Domestic Encyclopedia, article "Gunny bag," 1803.

‡ Domestic Encyclopedia, article "Paper," 1803.

§ The foreman of a rope walk, in which the fibre of the sun-plant is largely worked up, informed me, that when hackled "closely," for twine or lines, it would not yield more than one half "tier," that is, long hemp. The rest was tow, and only fit

Milburn says that the island of Salsette produces two sorts of hemp, one resembling the sun-plant, but preferred thereto, when great strength is required; it is the best substitute for hemp yet known. (Vol. 1. p. 283.) The botanical name of the plant yielding it, is not given.

2. *Musa textilis.*—For several years past, a fibrous material under the name Manilla hemp, has been largely imported into the United States, and worked up into glossy white cordage for hawsers and running rigging. Having four years since, accidentally met with a store full of it, I was led to attempt to find out the vegetable that yielded it, but failed to obtain the least information. The mercantile men made no inquiries in the port where they shipped the article, and were satisfied with the good returns derived from bringing it home. I knew it could not be the fibre of the hemp of Europe and North America, having been long familiar with the fact, that neither hemp nor flax are cultivated in any part of India, or the Indian islands, for cordage,* but the particular vegetable yielding the fibre, could not be ascertained. Having however been recently consulted on a question arising at the Philadelphia custom house, respecting the nature of some Indian cordage, and a cordage material from the same quarter, I determined to renew my inquiries, and despairing of acquiring any knowledge from men, I resolved to consult every book on India, within my reach. The second work I examined, was "Crawfurd's account of the Indian Archipelago," and the first volume of it relieved me from my ignorance. According to this author, the fibre of Manilla hemp is obtained from the *Musa textilis,*† a species of wild banana, growing abundantly in the northern spice islands, and in the Phillippines, particularly in Mindanao. The length

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for plough lines, halters, bed cords, &c. The "tier" was also full of shaws, and weak. These defects doubtless arise in part from the slovenly preparation of the fibre. The brake and hackle would certainly turn it out in a more perfect state, although they could not alter the strength of the fibre.

* Hemp and flax have been cultivated in India from the earliest times, for the oil produced from the seeds; but the chief object of attention to the first, is owing to the general use made of the leaves for smoking in pipes, either alone or mixed with tobacco; and for making an intoxicating preparation from them called *bang*, which is smoked with tobacco. In Sumatra, according to Marsden, the same practice prevails, and hemp is there extensively cultivated for this purpose.

† Dr. Roxburgh says, that "the species of *Musa*, which we call *Coccinea*, yields what is called Manilla hemp; at least it was sent to me from China as that plant." —Trans. Soc. Arts, Vol. xxiv, p. 153.

of it when imported into the United States, is from six to eight feet. From many inquiries at the proper sources of information, on the qualities of this cordage, I am authorized to say, that it is stronger, more durable, and more elastic than that made from common hemp.

The elasticity of the Manilla hemp cordage is one of its greatest recommendations, and on this account is highly prized by our seamen. On one occasion a few years since, a New York packet ship in the harbor of Liverpool, during a heavy blow, dragged two anchors, and was driving fast towards a pier against which she would have been dashed with great violence, had not the captain ordered a hawser of Manilla hemp to be carried on shore, and made fast. This being done, the progress of the ship was arrested, but it was not until the hawser had been stretched to one half its original diameter, that she was brought up. The master of a Philadelphia packet, who witnessed the scene with great anxiety, determined immediately on his return home, to order a hawser of the same material.*

3. *Woody fibre inside of the coco-nut husk.*—The short, woody, and apparently intractable, husky fibres, lining the inside of the husk of the coco-nut, constitute the material which Hindoo ingenuity has long since converted into excellent cordage. They are first soaked in water, until they become soft, (and to effect this, Dr. Buchanan says six months are required,) then beaten to separate the woody substance connecting them, which falls away like saw-dust, leaving only the strings. A commercial friend states, that these are spun by hand into yarns of a foot or more in length, and brought in bulk from the Maldive, Laccadive, and other islands on the Malabar coast, to Calcutta, and there made up by the native workmen. There are two statements on the subject of the stage of maturity of the coco-nut, proper for the preparation of the coir fibre. Dr. Buchanan says,† that the rope made from the strings of the husk when the nuts are ripe, is very bad, and that the green nuts yield the best material. People, he says, of the low caste of *Williarue*, collect those that have been cut for juice, or thrown down by monkies; but another author asserts, that the fibres "can only be procured from

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* He has recently informed me, that had the hawser of the New York packet been made of hemp, it would have parted. The Manilla cordage like that of coir, recovers its elasticity, after being stretched, until considerably worn.

† Vol. II, p. 50. London, 1807.

the fruit in its greatest maturity."* The circumstance of the color of the cordage being precisely that of the inside of the husk of the ripe nut, would seem to sanction this last opinion. It is singular, that the accurate and observant Mr. Marsden should be entirely silent on this point. With respect to the superiority of a coir cable to that of hemp, in salt water, there is but one sentiment among those who have used both. The experienced navigator Forrest says, that the "coir cable gives so much play to a ship riding at anchor, that with a cable of one hundred and twenty fathoms, the ship retires or gives way sometimes half of its length, when opposed to a heavy sea, and instantly shoots ahead again: the coir cable, after being wire-drawn, recovering its size and spring. It is usual for valuable ships leaving the Ganges in August and September, against the south west monsoon, to have a coir cable fresh made, under the eye of the chief officer, for a stand-by. Hempen cables are strong and stubborn, and ships often founder that ride by them, because nothing stretches or gives way; the coir yields and recovers." He says further, that "it is preferable for small cordage for running rigging, as it passes much freer through the blocks than hempen rope, which if wet, becomes hard and does not run free, owing to the tar casing it, by the heat of the climate, and the rope is stubborn, especially after a rain."† Other advantages of coir cables, consist in their floating like wood; never rotting in consequence of being soaked in salt water; not exhaling those unpleasant and unwholesome odors which are perceived from hempen cables when wet, and in their being comparatively light and easily managed. But in fresh water, hempen cordage is more durable. Mrs. Graham states, that "the rigging of a country ship of eight hundred tons, in which she made a voyage from India to Ceylon, consisted entirely of coir rope, and that fresh water rots it to such a degree, that the standing rigging was covered with wax cloth and hempen yarn."‡ A commercial friend confirms the statement of this keen and observant female traveller, and says, that when the operation is neatly performed, the cordage intended for the standing rigging is deprived of its elasticity, (technically, "the stretch taken

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* Letters annexed to Heyne's Tracts on India, p. 15, 4to. London, 1814. The author, whose name is not given, says he resided twenty years in India.

† Voyage from Calcutta to the Mergui Archipelago; introduction, p. vi. London, 1792.

‡ Residence in India, p. 86. Edinburgh, 1812.

out,") then "served," and finally covered with the Indian dubbing called *dammer*. Thus protected, rigging will last for years. European and American ships hire coir cables when in an Indian port, to save their own. The article (coir) constitutes a grand staple of India, the value of which is considerable.

4. *Agave Americana.*—While I was engaged in examining a coil of Manilla rope, in the course of my inquiries about that article, my attention was drawn to another parcel of glossy white cordage, which I was informed by the ship chandler, had been made from *Sisal hemp*, and was much used. Of the vegetable producing it, and the reason of the specific name attached to the raw material, he knew as little, as respecting the Manilla hemp, which he had been working up for several years. But by continued inquiry, I heard of the merchant who first introduced the article into Philadelphia, and from him I learnt, that having been told by a mariner of the rope made from the prepared fibre in Yucatan, he imported a cargo of it in the year 1825, from Sisal, referring me to my old acquaintance Capt. Patrick Hayes, for further information, he having attended to the process of preparing the article for sale in Yucatan, and seen the plants in the open lot before the Pennsylvania hospital! Upon visiting that institution with Capt. H., and entering the green house, he pointed out the plant, which I immediately recognised as the well known Agave Americana—that eminently useful plant to the people of the countries in which it is native, and whose distant periods of flowering when removed therefrom, have given rise to a popular error, which will require ages to remove.* According to my informant, the preparation is extremely simple. By means of two sharp corners made by hollowing out the ends of a wooden tool like a flat ruler, the fleshy leaves are slit into two or three longitudinal strips, and the pulpy substance being scraped off, the fibrous material appears, which is then shaken loose, tied in a knot, and when dried in the sun, is put up in bales for ex-

* I allude to the idle story of the plant (the popular name of which is the American aloe) flowering only once in an hundred years.—In Mexico they flower every ten years, according to Bullock, p. 282. In the year 1804, an Agave flowered at the Woodlands, the seat of the late Wm. Hamilton, which grew from a sucker of one that flourished thirty six years before, (1778) at Springetsbury, (Bush-Hill) both near Philadelphia.

portation.* Great quantities are sent to Cuba to make coffee-bags, and since the year 1825, numerous cargoes have been imported into the United States, and worked up into hawsers, running rigging, and small ropes. Much of the late importation I am informed, has been of a quality far inferior to the early stock. In Yucatan, about Merida, the most beautiful sewing thread is made of the fibre, some of which Capt. Hayes brought home, and used in his family. The coarsely prepared fibre for ropes and hawsers, resembles the Manilla hemp, but is harsher to the touch: this may be owing to the great size of the leaves, and to a careless preparation of them, for the fibre from Hayti is much finer than that from Sisal, and the small ropes made from it are beautiful and glossy.

The plant has a very extensive range in Asia, South America, Mexico, and the West Indies, and wherever found, is applied more or less to the same purposes as hemp or flax. In Yucatan the fibre is called "hennequin:" in other places "pita,"† the name by which the thread and twine made of it are also known. In Colombia the prepared fibre is called "coquise," and the name *pita*, given to that of a tree, called *marichi*.‡ The cordage from the *Agave* plant is said to be liable to mildew, and to lose its pliability after being wet, faults that do not attach to the Manilla rope. It is also thought to be inferior in strength to this last. Hawsers made of it are much less durable than those composed of Manilla hemp.

I was led to the preceding investigations by the following occurrence, to which I have already alluded.

In the autumn of 1829, Mr. F., a merchant of Philadelphia, imported a quantity of "coir cordage," and also a large parcel of the

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* "The leaves vary from five to eight feet in length, but some considerably exceed these dimensions."—Ward's Mexico, Vol. I. p. 55.—Mr. Bullock measured some ten feet long, fifteen inches wide, and eight inches thick.—Residence in Mexico, p. 71.—In Hayti they seldom exceed five feet in length. Humboldt has given a very interesting account of the various uses to which the plant is applied, in his *Political Essay on the Kingdom* of New Spain. Mr. Ward, in the account of his mission to Mexico, has also stated some of them, and given a fine plate of the plant.

† This is its name in Guatimala, according to Dunn, p. 241.

‡ The fibre of this tree is said to be ten or twelve feet long, and finer and more silky than that of the Agave. It is used for sewing half boots and shoes.—Notes on Colombia, by Lieut. Bache, U. S. Army, p. 89, 1827.—It is to be regretted that no further account is given of so valuable a tree or its produce, and that no specimen of the fibre has been brought home.

fibre of the "sun-plant" for rope makers; and a question arose on the duties to be charged on each. Mr. F. said that in importing them, he had been influenced by the edition of the tariff law of 1828, republished in that year by two clerks of the custom house, and revised by the late collector, in which the duty on coir rope, is charged at 15 per cent. ad valorem; and the "sun-plant" not being mentioned at all, he concluded that the duty would be the same as on the other "non-enumerated articles," viz. 15 per cent. It was however determined to charge the coir at the same rate as that paid by imported hempen cordage, viz. five cents per pound, and Mr. F. accordingly paid that duty. Sometime after, another parcel of coir rope was imported into Boston, and the owners resisting the attempt to class it with foreign hempen cordage, the collector finally assented to their construction of the tariff law. The extra duty, therefore, which had been paid by Mr. F., amounting to seven hundred and seventy five dollars, was refunded to him. With respect to the sun-plant fibre, the question was, whether it should be charged with the duty of imported hemp, which was fifty dollars per ton, or be classed with the non-enumerated articles, paying an ad valorem duty of 15 per cent. and which, in the case of the sun-plant fibre, would lower the duty to nine dollars and ninety cents per ton. This last sum was finally fixed on. The decision of the Boston collector as to the coir, and that of the Philadelphia collector on the sun fibre, were in strict accordance with justice, propriety and reason; for the framers of the tariff law of 1828, when fixing the high rates on imported cordage and hemp, had alone in view, the hemp of Europe, (*Cannabis sativa*,) and cordage made from it, never dreaming of any other material for cordage than that yielded by this vegetable. The officers of the customs, therefore, might with as much propriety have classed a cargo of Paraguay tea (maté) with some of the varieties of green or black tea of China, and charged the duty accordingly, merely because the daily beverage is prepared for millions of people in South America, from one of these vegetables, and from the others in China, Europe and North America, as to equalize the duties on two articles made from substances so opposite in their natures, as the coco-nut husk strings and the hemp fibre. The same remark is applicable to the hemp and sun-plant. It would have been quite as unreasonable to charge at the same rate, two raw materials, such as hemp and the fibres of the sun-plant, which are the produce of vegetables so different, and from opposite quarters of the globe, for no reason, except that they can be worked up into the same articles, and applied to the same mechanical purposes. In the case of the coir and hemp, however, this equalization subsequently took place; for upon refunding the amount of extra duty paid by Mr. F., an order was issued by the treasury department, to charge in future, the same duties on hemp and coir cordage, viz. five cents per pound, and this duty was actually paid on a quantity a few weeks after. This order cannot be justified by the terms of the tariff law, and must be considered as the result of a forced construction of it, for the reasons just given. Coir cordage, and that from other Indian vegetables, ought to be classed with the sun-plant twine, and with the fibres of the Agave, (Sisal hemp,) until an express law on the subject be passed, to fix their rates of duty.

A discussion on the subject of the twine made from the sun-plant, had taken place at the custom house of Philadelphia, in the year 1808, in consequence of the arrival of a ship from Calcutta, with a quantity of that article on board. By a law then recently passed, hempen cordage was prohibited, and the surveyor of the port being informed of the twine on board of the ship, showed samples of it to several persons all of whom pronounced it to be made of hemp. He therefore gave his opinion that the law had been contravened, and that the ship had incurred the penalty expressed in it. But on a reference to the collector of the port, he was overruled, for one of the supercargoes, had the foresight to obtain letters from Mr. Wm. Roxburgh, jr. the superintendent of the botanic garden near Calcutta, and from the Rev. Mr. Carey, to show the nature of the plant from which the twine had been made, and that neither hemp nor flax were ever used in India, as materials for cordage or twine, a fact since frequently confirmed. Although such authorities required no support, yet the supercargo to increase the chance of a favorable decision on the question, thought proper to consult me, and I referred him for a confirmation of their statements to the articles I had published five years before, (1803,) in the work already mentioned. A gentleman who had resided for ten years in Calcutta, added the weight of his testimony to the same points, and the ship was released from the custom house seals. I annex the letters of Mr. Carey, and Mr. Roxburgh, which the supercargo put into my hands at the time.

5. The most singular vegetable fibre convertible into cordage, is the production of a Sago Palm, first named *Saguerus* by Rumphius,* who gives a long and interesting account of it, and an excellent plate of the tree, showing the mode of growth of the fibre. The common name of the fibre in India is Ejoo. In the Island of Sumatra, according to Marsden,† it is called *Anou.* It resembles black horse-hair. "Each tree produces six leaves in the year, and each leaf yields ten and a half ounces of the fibre, which makes the annual produce of each tree nearly four pounds. Some of the best trees produce full one pound of the fibres in each leaf. They grow from the base of the footstalks of the leaves, and embrace completely the trunk of the tree. The fibres and leaves are easily removed without injuring the tree."‡ Crawfurd says "It is used for every purpose of cordage in India, domestic and naval, and is superior in quality, cheapness and durability, to the cordage manufactured from the fibrous husk of the coco-nut." Cables made of this unique production, are occasionally brought from India, but not as an article of commerce, into the U. States. It is presumed that this was the cordage brought by the ship Ajax a few years since into New York, and called "Palm tree cordage."

6. In Italy, the *Hibiscus roseus*, *Thore*, has been within a few years employed for small cordage, by Signor Barbieri, curator of the botanic garden at Milan, who two years since sent a specimen of a cord made of it, with some of the seeds of the plant, to "the Philadelphia Society for promoting agriculture," which were distributed. The plant abounds in the marshes of Italy, and grows twelve feet high. It is a perennial, and as it is therefore not liable to the same expense and attention required by common hemp or flax, it may lay claim to some exclusive advantages over these plants. S. Barbieri did not state the comparative advantages of flax and the *Hibiscus roseus*, as to the separation of the fibre, a point by the way, of great consequence. The people of Cumberland Co. New Jersey, have long

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* Herbarium Amboynense, Vol. 1. p. 57, plate 13. It is the *Borassus gomutus* of Loureiro, Flora Cochin Chinensis, p. 618; and *Arenga saccharifera* of Labillardiere, according to Dr. Roxburgh. This last work, I have not seen. Rumphius says it is found on the coast of Java, about Grissek and Samarang, and in the islands of the Molucca Archipelago. It abounds in Amboyna, p. 59.

† History of Sumatra, p. 77.

‡ Roxburgh, Trans. Soc. Arts. Lond. Vol. 24, p. 152.

been in the practice of making ropes and plough lines of the *H. palustris*, the growth of their marshy districts.

7. The *Sida abutilon*, treated as hemp, yields a fibre, from which very excellent ropes are made. It abounds in the United States, particularly in Pennsylvania and Virginia.

8. *Phormium tenax;* New Zealand Flax. We owe the knowledge of this valuable plant to the first voyage of Capt. Cook. All the attempts to cultivate it in Europe and the U. States, in the open air, have failed. Cables and ropes formed of it, are said to be not only much lighter, but far stronger than those made from hemp, (*Cannabis*,) viz. in the proportions of $23\frac{5}{11}$ to $16\frac{1}{3}$. The missionaries might render an essential service to the objects of their spiritual care in the New Zealand group of islands, by urging them to cultivate extensively this valuable production of their soil. The growth, preparation of the raw material, and its exportation might be made greatly auxiliary to their civilization, by inducing habits of regular industry, and by furnishing them with the means of procuring every article of clothing, and for domestic use, books, and the various things connected with the arts of civil life, all of which moreover, have hitherto been supplied at the expense of the friends to missions in Europe, and the United States.

Philadelphia, December, 1829.

P. S. I send herewith specimens of the fibres of

1. *Crotolaria juncea*, sun-plant of India, the material of Calcutta twine.
2. *Musa textilis*, Manilla hemp.
3. Coir fibre, from the inside of the coco-nut husk.
4. *Agave Americana*, from Tampico and Hayti. Sisal hemp.

Letters on the Sun-Plant of India, referred to in page 35.

Dear Sir—In reply to your inquiries, concerning the material of which gunnies, twine, &c. are manufactured, and which you say are thought in America, to be manufactured from hemp, I observe that hemp, (*Cannabis*,) is no part of the material used in those goods.

I have written a paper on the state of agriculture in the district of Dinajpur, which is printed in the volume of the Asiatic Society, now in the press, and in it, I have taken some notice of the cultivation of the plants used in the manufacture of gunnies, &c.; but as that volume will not perhaps be published in less than another year, I cannot refer you to it. I therefore observe, that there are several plants indigenous to India, the fibres of which are used for the manufacture of cordage, twine and gunnies, the principal of which are the *Crotalaria juncea*, (called sun by the Hindoos) and two species of *Corchorus*, (Paat or Kosta of the Hindoos.) Several species of the *Hibiscus*, furnish a durable fibre, but are cultivated in too small quantities to be brought to market. *Robinia* or *Millingtonia cannabina*, is used by the natives to make ropes, but is seldom brought to market.

Hemp (*Cannabis*) grows in most places throughout Hindostan; but the Hindoos are ignorant of its uses for cordage, cloth, &c., and only cultivate it in very small quantities, on account of its narcotic qualities. Flax is also cultivated in large quantities for its seed, but the natives know nothing of its use in the manufacture of linen cloth, &c.

The East India Company, have tried to extend the cultivation of hemp (*Cannabis*,) and flax (*Linum*,) but the attempt has not been attended with the desired success. The natives are loth to venture upon the cultivation of a plant (hemp) which has never been tried by them as a crop, or to strip the bark from the feeble stalks of the flax, while they find the cultivation of *Crotalaria* and *Corchorus*, so easy and effectual for cordage, sail cloth, &c., and that of Cotton so proper for cloth.

You may therefore assure yourself, that neither gunnies, twine, rope, nor any other article of Indian manufacture, which is brought to market, is made of hemp (*Cannabis*,) or of flax (*Linum*.)

I am, dear Sir, yours very truly,

WM. CAREY.

To Mr. Henry Drinker.
Calcutta, July 22, 1807.

Botanic Garden, near Calcutta, July 22, 1807.

Dear Sir—The principal material of which twine and other sorts of cordage are made in India, besides the coarse bags and canvas, is sun (the fibres of *Crotalaria juncea*;) also Paat is used (the fibres of *Corchorus capsularis*,) and several other substances, all of which are different from hemp, (*Cannabis sativa*,) and flax, (*Linum usitatissimum*.

WM. ROXBURGH, Jr.
In charge of the Botanic Garden.

To Mr. Drinker.

ART. III.—*Results of Experiments and Observations on* NARCOTINE, *and* SULPHATE OF MORPHINE;* *by* WILLIAM TULLY, M. D. Professor of Materia Medica and Therapeutics in the Medical Institution of Yale College.

IT is now many years since the discovery of that proximate principle of Opium, commonly called Narcotine, and even a considerable number since it has been known to be capable, in certain doses, of destroying brute animals, with the phenomena usually produced by a *narcotic;* and yet, I have no knowledge of any experiments or observations, hitherto, that can be considered as contributing much, if indeed any thing, towards the determination of its medicinal powers upon the human subject. As far as I know, most of the late writers upon Materia medica have concurred in ascribing all the remedial properties of Opium, to some salt of Morphine, (another proximate principle of this drug) although it is admitted that Opium contains only about seven *per centum* of Morphine, and that a given quantity of Morphine is very far from being fifteen times as active as the same quantity of Opium, which ought to be the fact, were Morphine its sole medicinal principle. According to the best observations, a given quantity of Morphine, instead of possessing fifteen times the activity of the same quantity of Opium, can at most be considered as possessing only about four times the activity, and perhaps there is room for just doubt, whether there is even as much difference as this. Now it cannot be reasonably supposed that as

* It is well observed by a distinguished pharmaceutist, that the original ending in *ina*, (*ine* in English,) of the names of the vegetable salifiable bases, *must* be retained by physicians, to the exclusion of the termination in *a* simply, or *ia*, which has been recently adopted by the chemists, since the similarity of *Atropia* to Atropa—of *Daturia* to Datura,—of *Brucia* to Brucea,—of *Sanguinara* to Sanguinaria,—of *Cinchonia* to Cinchona,—of *Gentiania* to Gentiana, etc. (the former of which are the present fashionable names for the active principles, and the latter the long established names for the vegetables from which they are obtained,) is altogether incompatible in prescription with the safety of patients. In all the editions of Magendie's Formulary,—in Anthony Todd Thomson's Conspectus of the British Pharmacopœias,—in Rennie's Supplement to the British and French Pharmacopœias,—and (as has been said,) in some of the latest Pharmacopœias of the continent of Europe, the termination in *ina* is retained. It was to be hoped that the responsibility of a useless change in nomenclature which, if adopted, would endanger so many lives, would never be assumed by any practitioner of medicine.

much as eighteen *per centum* of the Morphine is lost, in the process for its separation from Opium, and therefore it is altogether probable *a priori*, that there is another principle, upon which its virtues may in part depend, more especially as the Strychnos Nux-Vomica, and several species of Cinchona are now well known to contain two principles, possessing medicinal powers, similar in kind, and differing mainly in degree. Nothing else beside Narcotine, and another very doubtful substance called extractive matter, having, as is said, an intensely bitter taste, has yet been obtained from Opium, which can reasonably be suspected of contributing to its remedial effects.

For the purpose of ascertaining the precise powers of Narcotine, I have recently instituted a course of experiments, fourteen in number, upon healthy subjects it is true;* but they have afforded results much more satisfactory, and without doubt much more analagous to what will be its effects in disease, than could possibly be obtained from experiments upon brute animals, and especially on those which have suffered the lesion of a ligature upon the esophagus, immediately after being forced to swallow the agent, whose powers are to be ascertained. As a detail of the experiments themselves would probably be incompatible with the general plan of this Journal of Science, it will be reserved for some journal exclusively medical, and this communication will contain only a summary of the results obtained by the experiments in question, preceded by a few definitions, which are necessary to show the precise acceptations in which I employ the terms, that will be applied to the several operations of the Narcotine.

In regard to the subjects of my experiments, it is not necessary to make any further statements, than barely to say that one was a young physician belonging to the State of Massachusetts,—that another belonged to the State of New York,—that two others belonged to Connecticut,—and that I was myself the fifth subject. The four gentlemen above mentioned, happened to be in New Haven together and at leisure for about a week, and they therefore volunteered their assistance in this business, entering into it with a degree of interest and zeal, which fully evinced that with them, their profession is not

* It is altogether probable that the state of health may be taken as a medium state of susceptibility to the influence of this article. Under certain circumstances, much more may be required, and under certain other circumstances, much less, in order to produce given effects.

viewed as a mere trade, to be followed only for the purpose of obtaining a support, or as a means of acquiring wealth, but is rather esteemed a liberal art, which they cultivate with much more generous and honorable motives.

It may be proper to state in this place, that I once made a series of experiments of the same sort, upon the Sulphate of Morphine; and that a subsequent employment of that article in my medical practice, has abundantly confirmed all the conclusions to which I then arrived,—and, it is true, has led to some others, which could not be obtained upon a healthy subject. The results of my experiments upon the Sulphate of Morphine, and of my subsequent observations upon its operation in disease, will be subjoined to this paper on Narcotine, as in some instances, my descriptions of the effects of each, have necessarily been comparative.

DEFINITIONS.

A *narcotic* operation consists of four parts, stages, or degrees, viz.

1st. An *antirritant* stage, in which morbid irritability and irritation, and irritative action generally;—morbid sensibility, restlessness and jactitation, (when connected with a non-phlogistic, or a positively atonic condition of the system,) are allayed;

2d. An *anodyne* stage, in which pain, (when connected with a non-phlogistic, or a positively atonic condition of the system,) is relieved;

3d. A *soporific* stage, in which sleep is produced: and

4th. *Ultimate narcosis*, in which there is vertigo, headache, faintness, dimness or imperfection of vision, nausea and retching, epigastric uneasiness, small and irregular pulse, cold extremities, cold clammy, or slippery sweats, delirium, stupor, convulsions, (either common, epileptic, or tetanic,) coma, and death. I am confident, from multiplied observations, that there is no sort of foundation for the dogma, that all *narcotics* are necessarily *stimulants*.

A state of prostration, (not exhaustion or debility, as is commonly, but erroneously supposed,) sometimes takes place, as an indirect effect, and rather a remote consequence, of a single dose, of certain *narcotics*, too large for the susceptibility of the patient. This state is characterized by vertigo, nausea and vomiting on motion, and headache and faintness. Although these symptoms constitute a part of what I have described as *ultimate narcosis*, yet *ultimate narcosis* takes place, while a patient is under the fullest operation of the *narcotic* agent, and this sort of prostration takes place only after all the direct effects of the *narcotic* agent have passed off, and it is rather a sequel, than a direct effect of such an agent.

Different *narcotics* vary very much, in the relative degree of each of these states or stages of a *narcotic* operation, which they respectively produce. Each state or stage of a pure *narcotic* operation, may be considered as a strictly sedative operation.

A *nervine* operation consists exclusively of four states, stages, or degrees, viz.

1st. A moderate antirritant stage, indicated by more or less relief of the same symptoms, that are obviated by the first degree of a *narcotic* operation. I do not suppose that the *antirritant* effects of a *nervine* are identical with the *antirritant* effects of a *narcotic*;—they appear to constitute distinct sorts of *antirritant* effects;

2d. The production of a peculiar calm, placid, and pleasurable sensation;

3d. The production of a peculiar preternatural wakefulness: and

4th. The production of more or less positive exhilaration, sometimes amounting even to delirium.

Different *nervines* also vary very much, in the different relative degree of each of these states or stages of a *nervine* operation, which they respectively produce; and many are altogether incapable of producing the fourth state, or stage, in any appreciable degree.

Pure *nervines* may be pushed to any extent whatever, within the capacity of the stomach to contain, without producing a single individual of those symptoms, which I have detailed under the denomination of *ultimate narcosis*, and without the least increase of the vital energies generally, or of the strength of arterial action, which is a test always adequate to the perfect distinction of pure *nervines* from pure *narcotics*, and pure *stimulants*.

It is very common to confound a *nervine* operation with a *stimulant* one; but, they are perfectly distinct. All the parts of a *nervine* operation, (as I have just said) may be produced without any increase of the vital energies, and without any increase of the strength of arterial action. Indeed, I have very often seen the fullest *nervine* operation connected with an extreme reduction of all the vital energies, and with such a diminution of the strength of arterial action, that the pulse could scarcely be felt.

A *stimulant* operation consists exclusively in a quickly diffused, and transient increase of the vital energies generally, and a similar increase of the strength of arterial action. *Stimulants* usually diminish atonic morbid frequency of the pulse, but, in perfect health, they usually (though not invariably) increase the frequency a few beats. *Stimulants* also commonly diminish in a slight degree, both morbid irritability and irritation, and irritative action generally;—morbid sensibility and sensation;—morbid mobility, restlessness, and jactitation; but, they do this, in a less degree, even than the *nervines*, and still less than the efficient *narcotics*, and, as I think, doubtless in a manner different from either. Pure *stimulants* never produce the least trace of the last three states or stages of a *nervine* operation, nor a single symptom of what constitutes *ultimate narcosis*, with the occasional exception of nausea and vomiting, and perhaps headache, from the mere irritation of excessive doses or quantities; nor do they ever produce any condition at all analogous to the secondary and rather remote sort of *prostration*, which, I have already mentioned, as sometimes the sequel of too large a single dose of certain *narcotics*. These circumstances afford absolute tests of pure stimulant powers.

It must be remarked that *narcotic* and *nervine* powers are principally exerted upon the nervous system, while *stimulant* powers are mainly exerted upon the sanguiferous system; and, particularly that the first three states or stages of a *narcotic* operation,—the whole states or stages of a *nervine* operation,—and a perfect stimulant operation, are by no means incompatible with each other. Thus for example, a full and complete *antirritant* operation, as produced by Opium,—a perfect *anodyne*, and a prominent *soporific* effect, may take place, at one and at the same time with a most decided increase of the vital energies generally, and of the strength of arterial action; and either, or both of these operations may, or may not be accompanied, at one and the same time, with all the states or stages of a *nervine* operation. *Sedative* effects then, are by no means incompatible with *stimulant* effects. What is called *ultimate narcosis*, at least in any prominent degree, does in fact seem to be incompatible, either with positive *nervine*, or *stimulant* effects.

The conjunction, at one and the same time, of full *stimulant* effects, with the three first states or stages of a *narcotic* operation, may be witnessed in a prominent degree, by the use of moderate and uniform doses of Opium and Alcohol, at regular and short intervals, for a certain length of time, in any case to which both are appropriate remedies.

That *narcotic*, *nervine*, *and stimulant* operations, as here defined, are perfectly distinct operations, is abundantly proved, by the fact that there are numerous articles, which possess each individually, without any trace of the others; and the circumstance that two of these groups of effects, or even the whole three, are not unfrequently produced by the same articles, no more proves their identity, than the circumstance that Tobacco is both *narcotic* and *cathartic*, proves that these two effects are identical.

RESULTS OF EXPERIMENTS WITH NARCOTINE.

1st. In the same quantities, Narcotine is far less operative upon the human system, than the Sulphate of Morphine, and even less so than Opium.

2d. Narcotine possesses the same degree of activity, when given pure and in substance, as in any other way tried, its virtues not being either enhanced or diminished by solution in oil, or in dilute Acetic acid.

3d. From two to five grains of Narcotine appears to constitute a medium full dose, where only a single dose is to be taken, i. e. such a dose as will just fall short of producing any disagreeable effects, in a person of ordinary susceptibility.

4th. One grain of Narcotine appears to constitute a medium moderate dose, to be repeated at regular and short intervals;—and three hours appear to constitute a medium suitable period of repetition for such a dose, for a person of ordinary susceptibility.

5th. Narcotine is slower, though it is less permanent in its effects, than the Sulphate of Morphine. The period required for the first manifestation of the several effects of Narcotine, is intermediate between that required for the effects of Sulphate of Morphine, and that required for the effects of Opium; and the period of their duration is intermediate between that of the effects of Opium, and that of the effects of Sulphate of Morphine.*

6th. Narcotine appears to be more or less *nervine*. The general *nervine* operation of Narcotine, I think is decidedly less than that produced by Sulphate of Morphine, but I am not certain that it is less than that of Opium. Narcotine does not appear to produce any

* It is remarkable that Morphine, which is much more speedy in its operation, appears to be more permanent in its effects even than Opium.

of that preternatural watchfulness, which so often results, both from Sulphate of Morphine, and from Opium. From the circumstance that Sulphate of Morphine possesses this last mentioned property in an eminent degree, and that Narcotine is destitute of it, it follows that the same property of Opium is dependent upon its Morphine, and not upon its Narcotine. In short, the quality of the nervine operation of Narcotine is considerably different from that of Sulphate of Morphine, and consequently more or less different from that of Opium.

7th. Narcotine appears to be considerably diaphoretic, and it commonly produces more or less itching of the whole surface, which is first perceived, and is most considerable, on the inside of the thighs, and about the nose.

8th. Narcotine is most prominently and most decidedly narcotic.

As soon as it begins to produce a decided effect upon the system, it occasions a very peculiar expression of the countenance, which is more easily recollected than described. There seems to be a peculiar elongation of all the features, and a kind of lateral shrinking of the whole face, which, together with the effect upon the eyes, and particularly the contraction of the pupils, more unequivocally indicates the operation of a *narcotic*, than any expression of the countenance, which is produced within my knowledge by any other agent. While in the early stages of its operation, and before my family knew any thing of the experiments, one individual of them after another, noticed this expression, and made remarks upon it. One said I appeared as if about to be attacked with some acute disease—another inquired if I had got *Sick-headache*, (to which I am subject,) and each made some comment. Similar remarks were made to the other gentlemen. One was met in the street by another physician, who immediately pronounced that he was under the influence of some active *narcotic*.

Narcotine very materially and very greatly reduces the frequency of the pulse; it allays very effectually certain sorts of cough; it occasions indistinct vision, or the sensation of a blur before the eyes; and when a person is strongly under its influence, it occasions a contraction of the pupils. It produces also a sensation of dryness and clamminess in the mouth, though it appears sufficiently moist to the eye; and it produces not only a change in the sound of the voice, (while a person is under its influence,) but likewise very considerable hoarseness. These effects occasionally take place quite early in its operation. It produces not only a considerable diminution of the natural excretion by the renes, but also a deficiency of contractile power, or torpor of the bladder.

Whether Narcotine is constipating or not, may perhaps be considered as somewhat uncertain, but it is most probable that it is so. While experimenting upon it, one of the gentlemen had a regular daily alvine discharge, but on account of a much greater susceptibility, he took considerably less of it than the other gentlemen. On the contrary, one gentleman had none for three days, while taking it; and another gentleman had none for five, and I think six days, while under its use. Since the completion of the experiments, I have known it taken twice, for a moderate Diarrhœa, with perfect relief of the disease. It may however possess the power of relieving Diarrhœa, i. e. of obviating morbid irritability, and irritative action of those muscular fibres, which produce the peristaltic motion of the intestines, without being liable to produce constipation; i. e. to lessen healthy excitability, and natural peristaltic motion. The resin of the *Zanthorrhœa hastilis* operates in this manner.

The *antirritant* effects of Narcotine appear to be greater, in proportion to its other powers, than the *antirritant* effects of Opium; and also, as appears to me, than the *antirritant* effects even of Sulphate of Morphine. Its great power of diminishing the frequency of the pulse, seems to indicate this, as well as its power of allaying certain sorts of cough. No opportunity has occurred of testing the *anodyne* powers of Narcotine. It will be obvious that this cannot be determined upon a healthy subject. The *soporific* effects of Narcotine appear to be considerably greater, in proportion to its other powers, than the *soporific* effects of Sulphate of Morphine, or than the *soporific* effects of Opium. The sleep produced by it, even when taken in a moderately excessive dose, is peculiarly calm, light, placid, and easy;—and even when it is the most intense, the subject of its influence is easily roused; and by voluntary bodily motion and exertion, he can easily keep himself awake, and apparently very much diminish its general influence upon his system; and yet, as soon as he sits down, and remains quiet for a short time, its full influence speedily returns. During the deepest sleep produced by Narcotine, the respiration is light and easy, like that of a person in health, who has been some time perfectly at rest. When the subject of its influence awakes spontaneously from the sleep which it produces, he feels no heaviness, and nothing unnatural, but much as on awaking in the morning from an ordinary night's rest, except that he has a slight sensation of dryness and clamminess in the mouth, a considerable hoarseness, diminished renal secretion, and diminished contractility of the bladder.

In a moderately excessive dose, in relation to the susceptibility of the system, Narcotine produces a mazy and confused state of the head, vertigo, nausea and vomiting. Too large a quantity in the twenty four hours operates in the same manner. But the effects of a moderately excessive dose of Narcotine, are much less disagreeable than the effects of an excessive dose of the Sulphate of Morphine, or of Opium. The mazy and confused state of the head, and even the vertigo which it produces, are attended with a decidedly pleasurable state of the feelings; and even the nausea and vomiting which it occasions, are by no means distressing, and are far less unpleasant than the similar symptoms produced by Sulphate of Morphine, and by Opium. The nausea and vomiting which a moderately excessive dose of Narcotine produces, begin almost instantaneously, and terminate as suddenly; and, in a very short time, no sensations remain, which indicate that nausea and vomiting have occurred at all,—there is no violent straining, no weakness, soreness, or stiffness afterwards.

According to Magendie, and others, the *ultimate narcosis* of Narcotine is made up of the following symptoms, viz: signs of fright; backward movements, with incapacity of advancing; frothing at the mouth; agitating or tremulous convulsions of the jaws; general convulsions of the common sort; tetanic spasms of the extensor muscles of the neck, throwing the head backwards upon the spine; a stupor, in which the eyes remain open, but from which the subject cannot be roused, and under which he dies in the course of twenty four hours. These last seem to be the only effects of Narcotine that have been heretofore fairly determined, either in Europe or this country, at least within my knowledge. It is obvious that these could not be verified on the human subject, nor is it necessary to know them, for the therapeutic application of this agent, in the treatment of human diseases. Magendie says that these effects are similar to those produced by fatal doses of Camphor; and what is remarkable, he pronounces them to be mere *stimulant* effects, and not at all indicative of any *narcotic* powers! I wish that Magendie had given us his precise views of the true nature of an *ultimate narcotic* operation, for I cannot conceive of a purer one, than is indicated by this aggregate of symptoms. I venture to assert on the one hand, without the least fear of contradiction, that if no articles which are capable of producing effects of this general character, are suffered to retain their place among the *narcotics*, our catalogue of this class of agents will become extremely meager; and on the other, that there is not a pure and unequivocal *stimulant*, that is capable of producing any such symptoms.

9th. Narcotine appears to be entirely destitute of all *stimulant* powers, whether it is given in single full doses, or in moderate and uniform doses, at regular and short intervals. My attention, during the whole of my experiments, was particularly turned to the question of its *stimulant* operation, and in no case, while under its influence, was there the least perceptible increase of the vital energies, or of the strength of arterial action, or even of animal heat; nor was there any sensation of fullness or throbbing in the head; nor indeed, did any symptom whatever occur, which could by any means be construed into an effect of this sort. On the contrary, there was invariably a great reduction in the frequency of the pulse, in two cases as great as twenty six beats in a minute, and in none less than eighteen, in the same time. In some of the cases, there was a decided diminution, both in the force of the pulsation, and the fullness of the artery, and probably more or less in all, though in some, it was so inconsiderable as to be of very little consequence. These effects, I repeat, occurred equally, whether the agent was given in single full doses, or in moderate and uniform doses, at regular and short intervals; and whether taken in substance, or dissolved in dilute Acetic acid, or in Olive oil. The power of producing preternatural watchfulness, even were it possessed by Narcotine, would not indicate any *stimulant* properties, but rather mere *nervine* ones, which are entirely distinct. The power of producing vertigo, headache, faintness, nausea, vomiting, irregular pulse, cold extrmities, etc. is not the result of a *stimulant* operation, but of a *narcotic* one; and both Morphine and Narcotine are capable of producing all of these last effects, though Morphine more eminently than Narcotine.

If these results can be considered as at all correct, (and I cannot discover where there is any possible source of fallacy,) the futility of what is called *denarcotizing* Opium, as a means of improving its medicinal operations, will at once be manifest. However, as the effects of Morphine and Narcotine differ considerably, not only from each other, but also from Opium, it is undoubtedly useful to have each of these proximate principles in a separate state, that we may be able, the more accurately to adapt our remedial agents, to the peculiar circumstances of a given case.

What quantity *per centum* of Narcotine is contained in Opium, I know not.* As, in a given quantity, it is less active than Morphine, and even less so than Opium itself, no quantity of it, however large, will account for the full effects of Opium, upon the supposition that we are correct as to the proportion of Morphine. But I do not esteem it by any means impossible, that the *bitter principle* already referred to, as being called by the vague name of *extractive*, (if indeed there is any such distinct principle,) or perhaps some other part of this complex drug, may yet be found to contribute something to its medicinal effects.

RESULTS OF EXPERIMENTS WITH, AND OBSERVATIONS UPON, SULPHATE OF MORPHINE.

The only series of experiments for the purpose of determining the precise medicinal powers of Morphine, of which I have any knowledge, are those of Dr. Bally, (of France,) and even with these, I am acquainted only through what I take to be a mere summary of his results, abstracted from a European periodical. As far as I can ascertain from the summary in question, Dr. Bally seems to have employed uncombined Morphine. My own experiments were made entirely with the Sulphate of Morphine, and I have generally employed this salt in my subsequent practice, so that my results must be understood as having been obtained with that preparation. I am not aware that there is supposed to be any difference between the number and the quality of the operations of Morphine and its salts, though there may be more or less in the degree of their effects. It is my purpose to refer to the conclusions of Dr. Bally, in immediate connexion with my own.

Dr. Bally says that the action of Morphine upon the system, is very similar to that of Opium. This is certainly the fact with the Sulphate of Morphine. Several of my professional friends, to whom I have recommended the use of it, have informed me that they could perceive no difference between its effects and those of Opium. To this conclusion, however, I cannot entirely agree. Dr.

* It has been said, (but upon how good authority I cannot decide,) that Opium usually contains about twice as much Narcotine as Morphine.

Bally says that the brain and nervous system are the parts of the animal economy, upon which Morphine appears to exert its principal operation. This may be also true in general with the Sulphate; but, according to my observations, it would be very incorrect to understand it as excluding all effects upon the circulating, secretory, and absorbent systems. The Sulphate of Morphine produces a very considerable degree of the calm, placid, and pleasurable sensation; the peculiar wakefulness, and even inability to sleep; and the mental exhilaration, which constitute a nervine operation. I am satisfied that its nervine effects are considerably greater, in comparison with its other operations, than the nervine effects of Opium. Whenever I have taken a single full dose of the Sulphate of Morphine, (which, with me, is about a quarter of a grain,) I have invariably been entirely unable to sleep, for a period between four and six hours afterwards. My wakefulness has always been calm, placid, and pleasurable. Thus, when I have taken the dose, the beginning of the evening, I have usually been kept awake by it, till about two o'clock the next morning, though the sleep obtained during the remainder of the time, has seemed to refresh me as much, as if I had slept the whole night.

Sulphate of Morphine appears to possess more or less diaphoretic power; though, as far as I am able to judge, less than Opium, and of course less than Narcotine. Sometimes also, it produces a troublesome itching of the skin, which, in some cases, is universal, but in others, confined to the nose, the neck, the loins, and the inside of the thighs. According to Dr. Bally, this itching is occasionally, but rarely, accompanied with an eruption.

In single full doses, the Sulphate of Morphine, under my observation, has invariably produced more or less hoarseness.

The Sulphate of Morphine powerfully allays morbid irritability and irritation,—morbid sensibility and sensation,—morbid mobility, restlessness, and jactitation, and irritative actions generally, provided they are connected with a non-phlogistic, or a positively atonic diathesis. This is substantially stated by Dr. Bally, though with less precision. He however asserts that this agent is incapable of allaying cough. Now I have been long in the habit of using it, for this purpose, not only upon my patients, but upon myself, and I consider it as the most effectual article, in the whole Materia medica, perhaps with the exception of Narcotine only.

The Sulphate of Morphine is speedily and powerfully anodyne; and I believe it is more so, in proportion to its soporific powers, than

Opium. It is also soporific; but under my observation, it has invariably been more speedy in producing its nervine, antirritant and anodyne operations, and less speedy in producing its soporific effects, than Opium. It is probable, that a variation in dose, and method of management, might occasion some variation in this respect. However, its soporific effects appear to me to be considerably less, in proportion to its other operations, than the soporific effects of Opium. When deep or sound sleep is produced by this article, it seems to be more laborious, respiration is more affected, the subject of it is less easily roused, and more heaviness, and more disagreeable sensations remain after the sleep passes off, than occur from the operation of Narcotine; but, I am inclined to think, less than result from the operation of Opium. However, the observations that I have had opportunity to make, on a powerful degree of the soporific operation of Sulphate of Morphine have been few, and are therefore not absolutely conclusive.

Dr. Bally says that Morphine occasions dimness of sight, and that in brutes it occasions dilatation of the pupils, but not in man. He admits that this effect is produced only by large doses. I have never witnessed either dimness of sight without dilatation of the pupils, or dilatation of the pupils, from the Sulphate of Morphine; but as every active narcotic, when taken to a sufficient extent, seems to be capable of producing the former of these operations, I think it may be fairly presumed that this will not be found to be an exception.

When taken in full doses, Dr. Bally says that Morphine sometimes produces slight, but transient, or fugitive, (neuralgic?) pains, in the umbilical region; which however, he says, do not occur, when the system has become a little accustomed to it. I have never witnessed this operation from the Sulphate of Morphine. Dr. Bally also informs us, that Morphine sometimes produces nervous tremors, and sometimes muscular agitations, neither of which have I ever observed, from the Sulphate.

When taken either in a single large dose, or in moderate and uniform doses, at regular and short intervals, and for a sufficient length of time, the Sulphate of Morphine diminishes the contractility of the urinary bladder, and thus occasions difficulty in passing urine. Sometimes even a complete retention or suppression takes place. This effect passes off, when the influence of the agent upon the system is completely at an end. Dr. Bally mentions this effect, from large doses of Morphine, but he supposes that men only are susceptible of it, and that it *never* occurs in women. Now I have very often witnessed this operation from the Sulphate, and quite as frequently in women as in men. Dr. Bally thinks that Morphine neither increases nor diminishes the secretion of urine, nor changes its qualities in any way. Perhaps this is strictly correct of the Sulphate, though it has always appeared to me to diminish this secretion moderately. However, I do not consider my observations as decisive on this point.

Dr. Bally says that an occasional dose of Morphine produces torpor of the intestines, but that its continued use renders the intestines lax. A regular and continued use of the Sulphate of Morphine, in uniform doses, and at equal intervals, has been as liable, under my observation, to produce costiveness, as a similar use of Opium, though I have not generally found a single full dose of it to produce this effect. On the contrary, it has, in many cases, been followed, after about twelve hours, with a single loose evacuation. On my patients, and on myself, I have uniformly found the Sulphate of Morphine to be both speedy and effectual, in checking Diarrhœa. In my hands, it has always radically cured all cases, in which I have employed it. I have never used it however, in any case requiring extremely large quantities of medicine for its relief.

In single large doses, the Sulphate of Morphine produces only sedative effects; but, in moderate and uniform doses, at regular and short intervals, and continued for some time, it certainly produces stimulant effects, i. e. it occasions a rapidly diffused and transient increase of the vital energies generally, and particularly of the strength of arterial action. What proportion its stimulant operation may bear to its other effects, in comparison with Opium, is not perhaps well settled. Dr. Bally expressly denies that Morphine "excites" the vascular system at all, even in small doses, and certainly not in large ones. Does he suppose that it would be admissible in a truly phlogistic, sthenic, or entonic disease? Has he ever employed it, in moderate and uniform doses, at regular and short intervals, and for a considerable time? If not, he has not tried it fairly. But Dr. Bally supposes that a "*disturbance of the functions of the circulating system*," by large doses, has been mistaken for a stimulant effect. Cullen also supposed that an "*irritation of the sanguiferous system*," which he admitted was the "first operation" of Opium, was mistaken for stimulation. Now it matters not, by what name this operation is called, so long as it is admitted that it exerts this operation, for this is undoubtedly the operation that augments phlogistic diathesis, and diminishes the atonic. It is an operation which is essentially attended with an increase of the vital energies generally, and an augmentation of the strength of the arterial action. A highly distinguished physician of the present day, in our own country, considers it a strange misnomer to call Opium a stimulant. If the name of this operation must be changed, and the Sulphate of Morphine not allowed to be a stimulant, Opium itself must share the same fate. Dr. Bally's notions in respect to the stimulant operation of Morphine seem to be only a revival of the exploded theory of Cullen, in regard to the stimulant operation of Opium. Whether the Sulphate of Morphine proves at one and at the same time both stimulant and sedative, or whether it proves sedative only, depends, according to my observations, as much upon the manner in which it is administered and managed, as it does whether Opium operates in one or both of these ways.

Dr. Bally declares that Morphine will not produce *headache*, nor any other of the symptons of *excitement* (*!*) which follow the use of Opium. Now I have as often known headache produced by the Sulphate of Morphine, as by Opium, in proportion to the number of times that I have used each. It seems to me extraordinary that the headache, which sometimes results from Opium, even when given in an appropriate case, should be considered as a symptom of excitement.

Dr. Bally concludes that Morphine occasions no thirst, no loss of appetite, and no disorder of the digestive organs. Now, in certain cases, I have repeatedly witnessed each and all these effects, from Sulphate of Morphine; and, in certain cases, where they previously existed, I have known them obviated by it. Whether it occasions these effects or not, depends, according to my observations, upon the disease, the general condition of the system for the time being, the temperament of the patient, and above all, the manner in which it is managed. In a very great majority of the cases in which I have employed the Sulphate of Morphine, certainly no such effects have occurred.

When administered in full doses, the Sulphate of Morphine is extremely liable to produce nausea and vomiting. Dr. Bally insists especially upon this, but he adds that by beginning with small doses, and gradually and slowly increasing their size, a full dose may, at last, be taken without these effects. The first dose that I ever took myself, consisted of only a quarter of a grain, and in about six hours, it produced a very disagreeable vertigo and nausea, and it would doubtless have produced vomiting, had I not confined myself to my bed, till the whole effect of the article entirely passed by. Even now, after having taken this dose for a great number of times, for the relief of an habitual Dyspnœal cough, it seems to be full as much as I can bear, without the production of disagreeable symptoms. The first two or three doses that I ever took in the evening, caused a head-ache, for some hours, the next morning. Mrs. M—— T——, for pain in the stomach, took one fourth of a grain of Pelletier's Sulphate of Morphine, with relief of the pain, for which it was prescribed, within ten minutes. In about three hours, it caused so much vertigo, faintness, and nausea, as to confine her to the bed, for the remainder of the day, which was seven or eight hours. A night's sleep, as is usual, entirely removed these symptoms. Miss M— A— M—, of an exquisitely nervous and susceptible temperament, took, at bed-time, for irritation in the alvine canal, one eighth of a grain of Pelletier's Sulphate of Morphine, made into a pill with extract of Gentian, and the same quantity the next morning, before rising. For the whole day, she had very troublesome vertigo, faintness, and nausea, and also frequent retching, which symptoms did not leave her, till after another night's sleep; and even the day following, she had very great languor and lassitude. H— R— P—, a young lady aged 14, on account of a Diarrhœa, took, at 10 o'clock A. M. one fourth of a grain of Sulphate of Morphine, made into a pill with extract of Gentian, which entirely suspended the Diarrhœa, so that there was even no threatening of a return. Between one and two o'clock P. M. she began to complain of vertigo, epigastric uneasiness, and nausea, which, in a short time, in consequence of some exertion and motion, produced vomiting. After this, the vertigo, epigastric uneasiness, and nausea, increased considerably, and were attended with a distressing faintness, which soon confined her to the bed, where she was obliged to remain, the whole afternoon. About 6 o'clock P. M. she got up, which increased all the disagreeable symptoms, and again produced vomiting. She again went to bed, had cool skin and irregular pulse, and about seven o'clock, even whilst upon the bed, had another paroxysm of vomiting. After this, she got up, merely for the purpose of undressing. After a night's sleep, all disagreeable symptoms entirely disappeared, and the next day, she was as well as usual. Dr. S— F—, for pain and distress in the stomach, connected with long protracted functional derangement of the digestive organs, took one fourth of a grain of Sulphate of Morphine, which gave perfect relief, in a very few moments, but, in two or three hours, occasioned vertigo, faintness, and nausea. Dr. Baxter, one of the translators of Magendie's Formulary, says, "I have lately used the Acetate of Morphine, with good effect, in Dysentery, the pain and tenesmus were allayed, the complaint in some measure checked, and sleep was produced." He adds, "I have however been considerably disappointed in another case, where effects were produced, which I must leave to Mr. Magendie to explain." "I gave to a gentleman laboring under continued and troublesome general irritation of the system, half a grain of Acetate of Morphine, prepared by Messrs. Pelletier and Caventou." "This dose was taken at night, on going to bed, and in pill, but no sleep was produced; there was great restlessness, a desire to rise, or as he expressed it, an inability to keep himself down, giddiness, partial delirium, and, in fact, all the symptoms of intoxication," (*an extremely inappropriate term in application to these effects,*) "from Opium, were produced." "The next day, headache, heat of the palms of the hands, lassitude, and some febrile symptoms were the consequence." Three doses of Morphine of half a grain each, dissolved in Alcohol, it is said, produced on Sertuerner, and three of his pupils, a decided stimulant effect, which was followed by prostration, numbness, and faintness. In one delicate individual, who swallowed vinegar, while in this condition, violent vomiting was immediately excited, which was followed by profound sleep, and the next day, by headache, heaviness, anorexia, nausea, retching, and torpor of the intestines. From such observations as I have been able to make, I am inclined to think that the quantity of Morphine which is required to relieve an extremely severe degree of pain, is more likely to be followed by vertigo, nausea, faintness, vomiting, and headache, than the quantity of Opium, which would be adequate to the production of the same anodyne effect; though perhaps my opportunities for determining this, have not been sufficiently extensive to enable me to decide. But, whether Sulphate of Morphine produces disagreeable and unpleasant effects or not, appears to me to depend always upon the manner in which it is administered and managed, just as is the fact with Opium; and I consider it certain that such effects from either, depend upon some sort of injudicious management, in relation to the temperament, and susceptibility of the patient, and the circumstances of the disease.

Dr. Bally imagines that there is some reason to conclude that Morphine is anthelmintic, because worms have been rejected, when it has occasioned vomiting. I have known worms rejected by vomiting when produced by the irritation of the fauces with a feather, but, I did not, on that account, suspect that process of being anthelmintic.

Art. IV.—*Letter addressed to M. Cordier*, Member of the Royal Academy of Sciences, *on certain new Bone Caves; by* Marcel De Serres, Professor of Geology, &c. at Montpelier.

(Abstracted from the Annales des Mines, by J. Griscom.)

Sir—You know that I have stated the belief that the presence of bones in caves was dependent on certain conditions, the non-existence of which is an almost sure indication of the absence of animal remains, which otherwise are found to be very numerous. You know also that I have insisted, particularly, on the number of bones entombed in the caves of Bize, which are found there in such quantities as to induce me to believe that these remains of terrestrial mammiferæ could not be limited to the three caves already discovered. I have presumed the more on this from the fact, that vertical fissures and longitudinal clefts or caves are very common in the secondary mountains which bound the valley through which flows the river Cesse. It has appeared to me that in ascending the Cesse above Bize, the number of these cavities becomes more and more considerable, and that they present the conditions under which we are justified in believing that bones will certainly be found.

M. Pittore, a young physician, zealous in the cultivation of natural science; has pursued these indications, and his researches have been crowned with the most happy success. Of thirty caves which he has discovered in the secondary limestone which borders the two shores of the Cesse, five of those which he has explored contain bones. These bones relate to species considered as *fossil* and *antediluvian*, terms which are no longer appropriate, since here, as well as elsewhere, they are confounded in the same mud in which are discovered fragments of pottery ware. The prevailing kinds in these new caves are the *Ursus spelœus* and *arctoideus*. By dint of patient perseverance, M. Pittore has had the satisfaction to discover an entire femur of the *Ursus spelœus*. This femur, which is in perfect preservation, has a total length of 18.43 inches; its width, taken in the middle of its body, is 1.89 inches, whilst in the lower part it is 3.95 inches, dimensions which accord perfectly with those given to the femur of this species by M. Cuvier. This specimen enables us to give a more complete description of the femur of the *Ursus spelœus* than this great naturalist has been able to give, as that which he has drawn was destitute of its head.

Besides this femur, we have a heap of bones which belong to the two species of bears before mentioned, and among them some which are more characteristic: such, for example, are some maxillary bones furnished with their teeth. The greater part of these bones, shattered and fractured, have their angles blunted and their contours rounded, although in general they do not appear to have been brought from a great distance nor to have suffered a prolonged and violent transport. Like the bones of other caves, they still preserve their natural character; they are not petrified, though they are rather more solid than the bones found in the caves of Bize and of Lunel-Vieil.

They are buried in a reddish mud or sediment, intermingled with rolled pebbles, or fragmentary rocks of a small size. The mud through which they are scattered, assumes occasionally a dark or grayish shade, arising from the decomposition of animal matter; hence the color is deeper in places where the bones are most accumulated. This circumstance does not prove that the greater portion of the bones buried in caves were not introduced after the skeletons of the animals were broken up. At least, these bones, like those of Lunel-Vieil, are covered with fissures, and cracked more or less deeply. The mud containing bones is sometimes covered with a layer of stalagmite; but as this is not observed in all caves, it is possible that some of them may have been dug up at different times, for some of the caves have been used as sheep-folds.

Our new bone caves, all situated in the department of L'Hérault, on both sides of the Cesse, in ascending towards the hamlet of Fauzan, a mile or more north of Cesseras, have this peculiarity, that they are united in the same valley. They are, in fact, very near each other, even those on each side of the river, and as they are all less distant from high mountains than those of Bize, it appears equally probable that large forests existed formerly in their vicinity.

From this may it not be inferred that the species buried in the caves, were, at the period in which they were entombed, distributed as we now find them? At any rate they seem to agree with the stations to which they have been restricted since the existence of man. In fact, the remains of large species of bears are more numerous, and essentially dominant relatively to other terrestrial mammiferæ, in the caves of northern or mountainous countries than in those more level, or which in our southern countries are found in drier and warmer situations.

The new bone caves then, which M. Pittore has just discovered, are, as it were, united at the foot of the calcareous chain which precedes, in a manner, the primitive mountains of the neighborhood of Saint-Pons. These caves, situated in a wild valley, in the center of a wood which formerly was in all probability a great forest, are principally characterized by bears of the largest and strongest form. They are the *Ursus spelæus* and *arctoideus*, which are found in great quantities in the caves of Germany and the north of France. Deer, (animals which frequent similar stations and indicate the same sort of region,) are mingled with their remains. Both of them are associated with animals of the rabbit genus, with different kinds of birds, and with reptiles of the tortoise kind. But with all these different species, there is not discovered that immense quantity of horses whose remains compose the greater part of the population driven into the caves of Bize; from which the caves of Fauzan are nevertheless but a few leagues distant.

Is not this circumstance to be explained on the principle that the horses were masters of the vast marshes and the plain, in the neighborhood of Narbonne; while the bears, banished to the mountains, as they would be at the present time, if they still existed, frequented the forests and the woods of the north, at a great distance from the Mediterranean? At all events, the accumulated bones in the caves of Fauzan are not of the same kind as those in the caverns of Bize. The number of animals driven into the former is considerably less than that in the latter, particularly in relation to the number of individuals. The bone mud of Bize is a sort of bony paste. In the subterranean caves of Fauzan the bones are sufficiently distinct to show that the animals have been brought thither at very different ages, some having their teeth almost entirely worn out, and others presenting numerous epiphyses, the teeth not having issued from their alveoles.

Two of the bone caves examined by M. Pittore are on the left bank of the Cesse and three on the right. The latter are the only ones, which in consequence of their imposing aspect, as well as from their grandeur and importance, have received particular names, and attracted the attention of naturalists. The first, known in the country under the name of *Baume d'Aldenne*, and designated by Gensanne under that of *Baume de la Coquille*, had struck this naturalist, on account of the pottery which he had observed in the slime which covered the surface; but as, at the time when Gensanne visited these caverns, no attention was paid to the subject of fossil bones, he did not regard them, although he must have discovered some of them, for he worked among the mud sufficiently to discover the earthen ware.

The second of these caverns is called *Baume Rouge*, from the fragments of red argillaceous marl disseminated through the mud, and which, from their lively hues, have given to the mud of this cavern its intense color. It is the same with the *Baume de Marcouire*, which has long served as a sheep-fold, in which the flocks of the neighborhood are sheltered in unfavorable weather.

The bones, therefore, in the caves of Fauzan, (the number of which is really remarkable,) consisting of terrestrial mammiferæ, reptiles and birds, are accompanied by various specimens of pottery. Some of these appear to have been made of argillaceous marl, which prior to the manufactory had not been washed, and which had been dried only in the sun or before a fire. Others, of less thickness, had been made with more care. Thus at Fauzan, as at Bize, Pondres and Souvignargues, species, considered hitherto as antediluvian, are entombed in the same mud or sediment in which are found objects of human fabric,—facts which induce the hope that we may find the bones of our own species.

These observations confirm then fully what we have advanced, relative to the novelty of the phenomena of the filling up of bone caves,—phenomena which appear to have been posterior, not only to the existence of man, but to the inventions of art; for besides the pottery, you know that our caves contain bones of species supposed to be lost, worked anteriorly to their interment, by the hand of man.

The caves of Fauzan are not the only ones which we have discovered, since I had the pleasure of showing you my collections. I had presumed that the caves of Vigan, an account of which you have given to the Academy, were certainly not the only ones of the valley of l'Herault in which bones existed. I have, in fact, discovered others much nearer to Montpelier than those of Vigan; I shall have the pleasure of acquainting you with them hereafter. I allude to them now merely to prove to you that bone caves depend upon geological phenomena, which, like all phenomena of this nature, have an extensive generality and an important bearing upon science. May these new researches prove worthy of your attention, as well as that of the Academy of Sciences, to which I beg you to communicate them, if you deem them of sufficient interest.

Art. V.—*Description of a newly modified Apparatus for obtaining Potassium, accompanied by remarks on the Redistillation and Preservation of this metal;* by L. D. Gale, M. D. Assistant to the Professor of Chemistry in the College of Physicians and Surgeons in the city of New York.

TO PROFESSOR SILLIMAN.

Dear Sir.—Since you did me the honor to publish in this Journal an account of some experiments performed in the laboratory of the College of Physicians,* &c., I have repeated those experiments with the view of improving some part of the apparatus, and particularly the receiver. It will be recollected that the receiver of the apparatus above alluded to, consists of an inch and a half tube of wrought iron screwed into the retort.

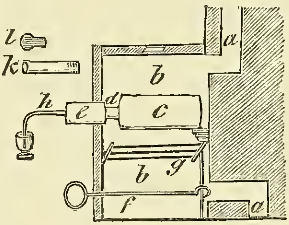
A serious objection to this receiver is, that it becomes clogged, long before the operation is finished; and notwithstanding we can clear it once or twice, by means of an iron rod, adapted to the purpose, yet it soon becomes completely filled, and impermeable to the rod, thus obliging us oftentimes to stop the process before it is half completed. The first substitute for the tube receiver consisted of a common quicksilver bottle connected with the retort, (also a quicksilver bottle,) by a straight piece of wrought iron, screwed into the mouth of each bottle. A small hole was bored in the opposite end of the receiver, for inserting a smaller iron tube, termed the safety tube, for discharging the uncondensed gases.

The advantages proposed in this kind of receiver over that formerly used were, 1st. To avoid any interruption of the process, until all the metal contained in the retort had distilled over. 2nd. To make use of the receiver for redistilling the potassium. This is done by unscrewing the end of the tube next to the retort, stopping the hole for the safety tube by an iron plug, and lastly inverting the receiver into the furnace to redistil its contents, without the trouble and expense of using naphtha, transferring the materials to another vessel for redistillation, and heating the furnace a second time. My first object was completely achieved by this apparatus. The second, was not so happily accomplished. The receiver was too large, affording so much surface of iron (which in these bottles is always more or less oxidated) that the potassium acquires oxygen from

* See Vol. XIX, p. 205.

the receiver, and thus a great portion of metal is lost in the redistillation; besides, the receiver is so large that it is exceedingly difficult to manage in separating it from the retort, for the purpose of redistillation, unless it has previously cooled, at least, considerably below redness. A third objection, greater than either of the others, is, that much less metal is obtained by this process, than when the materials are detached by means of the naphtha and iron scraper,* previous to the redistillation.

To obviate these objections as far as possible, I ordered to be made a thick wrought iron cylindrical bottle, in form, like that of the quicksilver bottle, holding a little more than a pint, beer measure. In one end of this bottle, to be used as a receiver, was bored a hole an inch and a half in diameter for receiving the connecting tube *d*, (see the figure,) which is three inches long, and in the opposite end, another hole was bored half an inch in diameter, for receiving the safety tube. A tolerably correct idea of this apparatus may be obtained by examining the annexed figure, in which is represented a side view of a section of the furnace containing the apparatus; *a*, *a*, passage for the air coming from a room below; *b*, *b*, interior of the furnace; *c*, the retort in its place; *d*, the connecting tube; *e*, the receiver; *h*, the safety tube; *i*, glass cup containing spirits of turpentine; *g*, grate with its prop; *f*, the hook for pulling down the grate when the operation is finished; *k*, the tube to be attached to the receiver *e*, in redistillation; *l*, iron plug to be used also in redistillation.



With this apparatus I was enabled to keep up the operation, uninterruptedly, until all the metal had distilled over. This being done, I proceeded to distill the contents of the receiver without detaching them, by unscrewing the connecting tube from the receiver and supplying its place by the tube *k*; the safety tube was also unscrewed, and its place supplied by the iron plug *l*. The receiver was now coated, and placed horizontally in the furnace, with the tube *k*, projecting in front, and a little inclined. The heat which had considerably diminished, was raised by additional fuel, until the bottle was heated nearly to whiteness, before any signs of metal appeared.

* A good one may be formed of a stiff iron rod, flattened at the end, and bent in the form of a scraper; the same is made more durable of steel.

At this temperature, however, the green vapor began to be seen by looking through the tube. I kept up the heat regularly and uniformly for nearly three hours, during the whole of which time, the vapor of the metal could be seen in the retort, but, to my great surprise, did not obtain ten grains of potassium. I attributed my failure, in this case, to the possibility that there might have been but little potassium in the receiver, though the operation had been, apparently, a successful one. To ascertain whether this was probably the case, I repeated the operation of distilling and redistilling three successive times, with fresh materials. In each distillation were used twelve ounces of potassa, and the redistillations performed as above described, but in no case did I obtain a drachm of the metal. In the last of the above experiments, after giving up the case as hopeless, I removed the receiver from the fire, let it cool, and filled it with naphtha, after which I detached its contents by means of the iron scraper, and finding they contained some potassium, I coated the receiver again, replaced it in the furnace, and obtained, at a full red heat, nearly a drachm and a half of the metal.

From these facts, I think we are justified in concluding that the redistillation, or purification of potassium is not successfully performed without first detaching it from the receiver; which circumstance seems to facilitate the operation much in the same manner as minute mechanical division affects some other chemical changes. Hence the chief advantages of this receiver are, that it enables us to continue the process, without interruption, for an unlimited time, or until no potassa remains in the retort; and secondly, it may be used for redistillation of the product after it has been detached; the operation is much more successful when the materials (after being wet with naphtha) have been previously broken into small fragments, which is easily done by means of a clean iron mortar.

I have not yet attempted to ascertain the largest quantity of metal which can be procured at a single operation with this apparatus, but am confident, that, by careful management, two ounces are not too high an estimate. Yet it must be remembered that much depends on the practical skill of the operator; he must watch narrowly every step of the operation, and keep up a regular and uniform heat; there is also much danger of fusing the retort, from the cracking open, or fusing of the lute which covers it; hence it is necessary to have good clay, to dry it very moderately, and to use much caution in luting. The redistillation is performed with much less difficulty than the first operation, provided a few particulars, which I neglected to mention in my former paper, be attended to. The heat should not be carried beyond full redness, otherwise it will carry over a portion of carbon, rendering the metal impure; whenever this occurs, the process is at an end; for the tube is clogged, and all the metal, subsequently sublimated, is condensed over the carbonaceous deposit, requiring a full red heat to separate it. Hence, when we redistil, care is necessary as to the proper temperature. If the tube should chance to be clogged, from too high heat, the only remedy is to remove the apparatus from the fire, unscrew the tube from the receiver, and, when cool enough, detach the contents, according to previous directions, and put them into the receiver. Clean the tube by washing and wiping till perfectly dry;—if any oxide of iron remain on the inside, remove it by friction with sand and soap, and when the iron is clean and bright, replace the tube, insert the apparatus into the furnace, and distil as directed. It was stated in my former paper, that the first operation, or distillation, is known to be going on well when gas is uniformly evolved; if this is suddenly diminished, the retort is cooled by throwing in fresh materials fused by the heat, or the tube may be clogged. But if the gas gradually diminishes, it was supposed that the process must be nearly ended, that is, that the potassa was exhausted. This however is not always the case; these appearances may arise from the fusion of the retorts, as occurred to me in two instances; the hole at first being very small, but gradually enlarging so as to emit the vapor of the metal as fast as sublimed. There is, however, one sure indication, that the potassa in the retort is exhausted, that is by withdrawing a few of the card-teeth or iron turnings; if there be a supply of potassa, they will be bright and clean, but if it is exhausted they will be blackened by oxidation.

If an excess of carbon have been used in the operation, though the heat required is less, I have often thought the product of metal was greater; at any rate it is more impure, requiring a second redistillation before all the carbon is separated. That the carbon has not been removed, is ascertained by the appearance of the naphtha in which it is preserved, which after standing some days becomes of a light or dark brown, according to the proprotion of carbon contained. This effect seems to arise from the slight oxidation of the metal, by which the carbon, in a state of minute division, is set free and suspended in the liquid. It is stated, in a note to the third American edition of Turner's Chemistry, that potassium may be effectually preserved in the essential oil of copaiva, on which authority I mentioned that article in my former paper. Since that, however, I have made experiments, hoping to verify the same result, but did not succeed. With the oil four times distilled, having specific gravity .883, the metal was oxidated quite rapidly. Ten grains in the oil, during three months, lost two; the liquid in the mean time became thickened, and of a dark brown color. The oil of copaiva, it seems, contains oxygen, which, uniting with the metal, forms potassa; this, in its turn, is taken up by the oil forming a peculiar species of soap; the oxide being taken up as fast as formed, leaves the surface bright and metallic, whenever the film of soap is removed. To ascertain whether the balsam from which I obtained the oil was pure, I obtained specimens from different druggists in this city for trial, and, with those considered the purest from the ordinary tests, arrived at the same result as above stated. Hence it appears, judging from my own experiments, that no substance hitherto used will supply the place of naphtha in preserving potassium. If I am in error, I shall be happy to be corrected.—*July*, 1831.

ART. VI.—*New mode of preparing a spirituous solution of Chloric Ether; by* SAMUEL GUTHRIE, of Sackett's Harbor, N. Y.

Mr. Editor—As the usual process for obtaining chloric ether for solution in alcohol is both troublesome and expensive, and as from its lively and invigorating effects it may become an article of some value in the *Materia Medica*, I have thought a portion of your readers might be gratified with the communication of a cheap and easy process for preparing it. I have therefore given one below, combining these advantages with unerring certainty in the result.

Into a clean copper still, put three pounds of chloride of lime and two gallons of well flavored alcohol, of sp. gr. .844, and distil. Watch the process, and when the product ceases to come highly sweet and aromatic, remove and cork it up closely in glass vessels. The remainder of the spirit should be distilled off for a new operation. These proportions are not essential—if more chloride of lime be used, the etherial product will be increased; nor is it necessary that the proof of the spirit should be very high, but I have commonly used the above proportions and proof, and have every reason to be satisfied with them. From the above quantity I have usually obtained about one gallon of etherial spirit.*

* The affinity of chlorine to lime, is so weak, and to alcohol so strong, that the chlorine is all taken up, long before the distillation is over; hence, the absolute necessity of watching the process, so as to know when to set aside the etherial portion.

By re-distilling the product from a great excess of chloride of lime, in a glass retort, in a water bath, a greatly concentrated solution will be obtained. This new product is caustic, and intensely sweet and aromatic. By distilling solution of chloric ether from carbonate of potash, the product is concentrated and refined. By distilling it from caustic potash, the ether is decomposed, and muriate of potash is thrown down, while the distilled product consists of alcohol.

During the last six months, a great number of persons have drunk of the solution of chloric ether in my laboratory, not only very freely but frequently to the point of intoxication; and so far as I have observed, it has appeared to be singularly grateful, both to the palate and stomach, producing promptly a lively flow of animal spirits, and consequent loquacity; and leaving, after its operation, little of that depression consequent to the use of ardent spirits. This free use of the article has been permitted, in order to ascertain the effect of it in full doses on the healthy subject; and thus to discover, as far as such trials would do, its probable value as a medicine. From the *invariably* agreeable effects of it on persons in health and the deliciousness of its flavor, it would seem to promise much as a remedy in cases requiring a safe, quick, energetic, and palatable stimulus. For drinking, it requires an equal bulk of water.

Remarks.—Mr. Guthrie states in a letter to the editor, that his attention was called to this subject by the suggestion in Vol. II, p. 20, of the Yale College Elements of Chemistry, that the alcoholic solution of the chloric ether is a grateful diffusive stimulant, and that as it admits of any degree of dilution, it may probably be introduced into medicine. Mr. Guthrie's method of preparing it is ingenious, economical and original, and the etherized spirit which he has forwarded as a sample, is exactly analogous, in sensible properties, to the solution made in the manner described in the above work. We shall take care to distribute portions among our medical friends for experiment, and as chlorine possesses so many peculiar powers, it is not impossible that this combination may prove curative or restorative, beyond what belongs to properties merely stimulating.

In this latter respect, Mr. Guthrie's experiments have certainly been *quite sufficient;* and we ought to discountenance any other than a medical use of this singular solution; unless indeed it should be found of utility in some of the arts. He would be no benefactor to his species, who should add a new attraction to intoxicating spirit.—EDITOR.

Art. VII.—*On Central Forces; by* Prof. Theodore Strong.

(Continued from Vol. XX, p. 294.)

I will now reverse the question which I have considered in Vol. XVII, p. 329. Put A= const. and F=Ar: but the general form of F (given at the place cited) is $F=-\frac{c'^2}{2}\frac{d\left(\frac{1}{p^2}\right)}{dr}$, hence by comparing these values of F, I have $-c'^2 d\frac{1}{p^2}=2\mathrm{A}r\,dr$, and by integration $c-\frac{c'^2}{p^2}=\mathrm{A}r^2$, or $\frac{c}{\mathrm{A}}-\frac{c'^2}{\mathrm{A}p^2}=r^2$, (1); (1) is the equation of the curve described by the particle, the origin of r being at the centre of force, and $p=$ the perpendicular from the centre of force to the tangent at the extremity of r; the arbitrary constant c is easily found in terms of A, c', and the initial values of r and p.

Put $a^2=\frac{c}{2\mathrm{A}}+\sqrt{\frac{c^2}{4\mathrm{A}^2}-\frac{c'^2}{\mathrm{A}}}$, $ap'=\frac{c}{2\mathrm{A}}-\sqrt{\frac{c^2}{4\mathrm{A}^2}-\frac{c'^2}{\mathrm{A}}}$, $\therefore a^2+ap'=\frac{c}{\mathrm{A}}$, $a^3p'=\frac{c'^2}{\mathrm{A}}$; hence (1) becomes $a^2+ap'-\frac{a^3p'}{p^2}=r^2$, (2), which is evidently the equation of an ellipse, the origin of r being at the centre, $a=$ half the greater axis, and $p'=$ the semiparameter. If the force is repulsive, the sign of A must be changed; which requires that the odd powers of a have a contrary sign from what they have when the force is attractive; hence (2) becomes in this case $a^2-ap'+\frac{a^3p'}{p^2}=r^2$, (3), which is the equation of an hyperbola, the origin of r being at the centre, $a=$ the semiaxis, $p'=$ the semiparameter. It is evident that the equation $a^3p'=\frac{c'^2}{\mathrm{A}}$, (4), has place, whether the curve is an ellipse or hyperbola; in the ellipse, F=Ar becomes, by substituting the value of A from (4), $F=\frac{c'^2r}{a^3p'}$; and in the hyperbola, F=−Ar becomes $F=-\frac{c'^2r}{a^3p'}$. If the centre of force is removed to an infinite distance, the ellipse denoted by (2) becomes a parabola, and F= const., the direction of its action being in lines parallel to the axis of the parabola. (Prin. B. I. prop. 10.

cor. 1. and scholium.) Put $\frac{a^3p'}{p^2}=r^2\times\left(\frac{a^2\sin.^2 v+p'^2\cos.^2 v}{ap'}\right)$; then (2) is easily changed to $r^2=\frac{a^2p'}{a-(a-p')\cos.^2 v}$, (5), and (3) to $r^2=\frac{a^2p'}{(a+p')\cos.^2 v-a}$, (6); and it is evident that $v=$ the angle made by r and a.

By substituting in (4), for c'^2 its equal $\frac{r^4dv^2}{dt^2}$, I have $dt=\frac{r^2dv}{\sqrt{Aa^3p'}}$, (7); $dt=$ the element of the time (t), and $dv=$ the element of the angle v, supposing v to increase with t: I shall also suppose that t and v commence when the particle is at the extremity of a. Substituting in (7), for r^2 its value as given by (5), there results $dt=\frac{a^2p'dv}{\sqrt{Aa^3p'}\times(a-(a-p')\cos.^2 v)}$, which by putting $\tan. v=\sqrt{\frac{p'}{a}}\times\tan. v'$, (8), becomes $dt=\frac{dv'}{\sqrt{A}}$, or by integration $t=\frac{v'}{\sqrt{A}}$, (9), which needs no correction, for when $t=0$, $v=0$, and by (8) when $v=0$, $v'=0$. By (9) $v'=t\sqrt{A}$, which substituted in (8) gives $\tan. v=\sqrt{\frac{p'}{a}}\times\tan. t\sqrt{A}$, (10); hence, and by (5), $r^2=a^2\cos.^2 t\sqrt{A}+ap'\sin.^2 t\sqrt{A}$, (11); by knowing when the particle is at the extremity of a, its position is easily found at any other time (t), for v and r are easily found at that time by (10) and (11), and hence the place of the particle becomes known at the same time. Let P = the semicircumference of a circle rad. = 1, and T = the time of revolution of the particle. Now when the particle has made a fourth part of a revolution, $v=\frac{P}{2}$, and $t=\frac{T}{4}$, and (10) becomes $\tan.\frac{P}{2}=\sqrt{\frac{p'}{a}}\times\tan.\frac{T}{4}\sqrt{A}$, but $\tan.\frac{P}{2}=$ infinity, ∴ $\tan.\frac{T}{4}\sqrt{A}$, is also infinite, hence $T=\frac{2P}{\sqrt{A}}$, (12); it is evident by (12) that the time of revolution (T) will always be the same, whatever the axes of the ellipse may be, (provided A is invariable;) because T, as given by (12) is independent of the axes. (Prin. B. I, prop. 10, cor. 3.) If the semiparameter p', is supposed to be indefinitely diminished, (a remaining invariable,) the ellipse will coincide with its axis very nearly, and the particle may be considered as falling from the extremity of a, in the right line a, towards the centre of force, and (11) becomes $r=a\cos.t\sqrt{A}$, (13); hence $\frac{dr}{dt}=V=$ the velocity, (at the distance r,) $=a\sqrt{A}\times\sin.t\sqrt{A}$, and $a-r=a$ versin. $t\sqrt{A}=$ the space fallen through; $t\sqrt{A}$ being an arc, such that $\cos.t\sqrt{A}=\frac{r}{a}$, or $t\sqrt{A}=\text{arc}\left(\cos.=\frac{r}{a}\right)$. (Prin. B. I, prop. 38.)

Again, it is evident by (13), that when $r=0$, $\cos.t\sqrt{A}=0$; $\therefore t\sqrt{A}=\frac{P}{2}$ or $t=\frac{P}{2\sqrt{A}}$, (14); the time t as given by (14) is the time of the descent of the particle from the distance a to the centre of force; but as the value of t does not involve a, t will be the same whatever a may be; by (12) and (14), I have $t=\frac{T}{4}$. (Prin. cor's 1 and 2, same prop.) It is evident by (13) that when $t\sqrt{A}=P$, or $t=\frac{P}{\sqrt{A}}$, (15), $r=-a$; which shows that the particle has descended below the centre to a distance, which is equal to the distance a, from which it fell above the centre, and the time as given by (15) is twice the time as given by (14); it is evident that the particle will return from the distance $-a$ to the distance $+a$, in the time $t=\frac{T}{2}=\frac{P}{\sqrt{A}}$, and that it will oscillate after the manner of a pendulum, the time of a whole descent and its subsequent ascent being $T=\frac{2P}{\sqrt{A}}$: if F is given at the distance a, then $F'=Aa$, or $A=\frac{F'}{a}$, hence $T=2P\times\sqrt{\frac{a}{F'}}$, (16), is a formula by which T is easily found; $F'=$ the value of F at the distance a. By substituting the value of r^2, as given by (6), in (7); then putting $\tan.v=\sqrt{\frac{p'}{a}}\times\tan.v'$, there results $dt=\frac{d\tan.v'}{\sqrt{A}\times(1-\tan.^2v')}$, whose integral is $t=\frac{1}{2\sqrt{A}}\times h.l.\left(\frac{1+\tan.v'}{1-\tan.v'}\right)$, ($v$, v', t, commencing when the particle is at the extremity of a;) let $h.l.e=1$, then $\tan.v'=\frac{e^{2t\sqrt{A}}-1}{e^{2t\sqrt{A}}+1}$, $\therefore \tan.v=\sqrt{\frac{p'}{a}}\times\frac{e^{2t\sqrt{A}}-1}{e^{2t\sqrt{A}}+1}$, (17); hence, and by (6), $r^2 = \left(\frac{a^2 + ap'}{4}\right) \times \left(e^{2t\sqrt{A}} + e^{-2t\sqrt{A}}\right) + \frac{a^2 - ap'}{2}$, (18); (17) and (18) are sufficient to find the place of the particle at any given time, supposing the time when it is at the extremity of a to be known. If p' is indefinitely diminished, so that the particle may be considered as moving in a right line, (18) becomes $r = a\left(\frac{e^{t\sqrt{A}} + e^{-t\sqrt{A}}}{2}\right)$; $\therefore \frac{dr}{dt} = V$, the velocity, (at the time t,) $= \frac{a\sqrt{A}}{2} \times \left(e^{t\sqrt{A}} - e^{-t\sqrt{A}}\right)$ and $r - a = \frac{a}{2}\left(e^{t\sqrt{A}} + e^{-t\sqrt{A}}\right) - a =$ the space described in the time t.

Art. VIII.—*Notice of the Vesicating Principle of Cantharides; in a letter from* G. W. Carpenter, *dated Philadelphia, July 2d,* 1831.

TO THE EDITOR.

Dear Sir—I beg leave to inform you that I have succeeded in separating the vesicating principle of Cantharides, which I have dissolved in oil, and have denominated it "Oil of Cantharidin." This is a new and valuable article, and I have no doubt, from the many advantages which it possesses, that it will entirely supersede the common mode of blistering. A few drops, rubbed two or three times on the part, will effectually draw a full and complete blister, with little or no pain, and without the necessity of applying any thing on it to assist the operation. This is certainly preferable to applying a plaster which often gets removed from one place to another, and thus frequently vesicates a greater surface than was intended or required, and sometimes, from the frequent transition, only partially vesicates and causes considerable pain, without having produced the effect intended or being of any benefit whatever to the patient. A piece of paper which has been made to imbibe this oil, forms an excellent blister, which may be accommodated accurately to the shape of any part, however irregular. The vesication thus produced is so exactly circumscribed, that the blister corresponds with the sharpest angles, which may be given to the paper employed.

One drop is sufficient to make a blister of the size of a quarter of a dollar. On places where the skin is thicker or more solid than on those which are covered with clothing, and therefore less exposed, it requires that the oil be applied two or three times in the course of an hour or two, or that the part to be blistered be covered rather more perfectly with the oil; this however will seldom be necessary, as blisters are most frequently applied on parts which do not require this particularity. It begins to draw in four, five or six hours, according to the place where it is applied.

In some cases, where the part is liable to get rubbed, it may be advisable to cover it with a little soft paper or linen, but in general no protection whatever is necessary. After the blister is cut and the lymphatic water discharged, press the epidermis close to the skin, and in most instances it heals in from twenty to forty eight hours.

When a rubefacient is wanted, one drop dissolved in ten or fifteen drops of sweet oil, or mixed with lard, will answer that purpose, and for convenience and ready application, will be better adapted than any preparation I am acquainted with. One ounce of this oil contains the vesicating properties of nearly one pound of Cantharides.

*Preparation of the Oil of Cantharidin.**

The vesicating properties of the Cantharides, reside in a peculiar crystalline principle, which has been denominated Cantharidin. It is separated from the Cantharides by boiling them in sulphuric ether, which takes up, with the Cantharidin, a greenish colored oil, sometimes combined with fatty matter. This may be separated from the Cantharidin by washing the crystals in cold ether; it is, however, unnecessary to do this, as when it is thus combined, it produces the epispastic effect equally well. Cantharidin, when thus washed, presents beautiful prismatic crystals, entirely colorless. Combined with an oil, it communicates to the latter, in a high degree, its vesicating properties. It is well to dissolve the crystals in strong sulphuric ether, and mix the ether and oil together, which will make a clear solution. They are with difficulty soluble in oil alone; the sulphuric ether is also an advantage, by its evaporating on the part where it is applied, thus leaving the oil more circumscribed.

I have tried this oil repeatedly on my own person, and found it invariably to produce a blister, in about the same time as the ordinary blistering ointment, and it is so mild that it generally produces very little sensation, except on those places where muscles, nerves or tendons, are in a state of compression. The experiments already made, by several eminent members of the faculty in Philadelphia, have resulted in the most satisfactory manner, and leave little doubt that this preparation of Cantharides will prove a valuable acquisition.

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* Sold at 301, Market Street, Philadelphia.

Art. IX.—*Observations and Experiments on the variable rapidity of action, between water and hot iron; by* Walter R. Johnson, Professor of Mechanics and Natural Philosophy in the Franklin Institute, Philadelphia.

The several series of experiments heretofore detailed, in relation to the actual *quantity* of vapor yielded by red hot metal, and to the *time* employed in producing it, have furnished some of the data for calculating the effect of overheating a steam boiler and immediately furnishing it with water. It is evident, that even with the same temperature in the metal, certain circumstances may exist at one time which shall modify the result exhibited at another. The tenth experiment in the fourth series,* in which 60 ounces of metal continued red for 82 seconds, beneath the surface of boiling water, and afterwards occupied 46 seconds in parting with the excess of heat above 212° which then remained, might possibly lead to the inference, that the quantity of heat disengaged in the former part of the operation was at least twice as great as that which was given out in the latter. This would imply that the temperature, (omitting difference in specific heat,) had been at first three times as much above 212°, as it was at the moment when redness disappeared. But the whole of the fourth series, as well indeed as all the other series heretofore given, had manifested in the performance of the experiments, a much more vigorous action subsequent to the disappearance of redness, than before that period. It was therefore necessary, in order to obtain some degree of clearness on this head, to perform several *courses*, each consisting of a number of *series* of experiments.

The general fact that red hot metal repels water, or at least does not appear to exercise upon it any *contiguous* attraction, has long been familiar. The smith who plunges a piece of iron, at a white heat, into his trough, sometimes sees with astonishment that scarcely any agitation of the liquid occurs for the first few seconds; and he perceives that this is not due to the coldness of the water, requiring it to be heated up to boiling temperature, before it can undergo the agitation consequent upon the formation of steam; for by plunging another piece of metal at a black heat into the same liquid, the action becomes immediately and distinctly perceptible.

When water is sprinkled upon a stone plate, even below redness, the drops are often observed to roll, apparently with little or no adhesion, from side to side, until slowly dissipated, or until they at length

* See Vol. XX, p. 311, of this Journal.

become attached and finally disappear, amidst a rapid ebullition and a violent hissing noise.

In the use of his generators, somtimes at the temperature of redness, Mr. Perkins had occasion to notice the fact above described, and to observe that the repulsion, between the metal and the water, sometimes becomes intense, amounting to a force greater than that of the elasticity of the steam, and that a small pipe heated red hot, might become entirely choked up, so to speak, with caloric, and incapable of transmitting any water or steam.

It may also be mentioned, that Klaproth has performed some experiments on a small scale, illustrative of one part of the subject now under consideration. But they seem to have given rise to some erroneous deductions in regard to the action of metal. It appears to have been inferred, that, as in cooling his *spoon* down from a white to a black heat, he passed from the time of 40″ to 0″ in the evaporation of six drops,—he had actually arrived at a point where the action of metal upon water would be *instantaneous*.

From his experiments, and those of Perkins, it has likewise been inferred that the point of *incandescence* is that from which the repulsion of water from the surface of metal commences; and that above redness, the augmentation of temperature is always attended by a corresponding diminution in the rapidity of evaporation. An opportunity will perhaps be embraced in a future paper to recur to these opinions.

The mode of performing the first of the following courses of experiments, was by procuring a basin of wrought iron about eight inches broad, one inch and three fourths deep at the center, and one fourth of an inch thick, made from a piece of rolled iron, and weighing three pounds and a half. This was heated, either over a spirit lamp, with an argand burner, in a stove of anthracite, capable of maintaining a heat near whiteness, or at a forge fire, urged by a powerful bellows. When deemed sufficiently hot, it was withdrawn from the fire, and care being taken that no dust or ashes adhered to the surface, a measured portion of water was laid upon the center, the time from the moment it struck the metal till the last drop disappeared being carefully noted from an accurate time keeper, and recorded by an assistant. The temperature of the water was marked by a good thermometer, or was kept boiling by remaining constantly over the fire during a whole series. The trials were continued as long as the metal remained hot enough to produce vapor of atmospheric elasticity. The proceeding has rendered it highly probable, that the rate of cooling after the period of most rapid action has been attained, varies considerably from that which precedes, and that possibly different stages of rapidity will be discovered, in different parts of the series following the time of most rapid vaporization.

First course, *comprising twelve series.*

Exhibiting the times in which given quantities of water of known temperature, may be successively converted into vapor, while the iron which produces it is cooled from redness to the point of ebullition.

No. of exp. in each series.	1st series, 1.7-8 oz. water at 194° Fahr.	2d do. 1-2 oz. do. 200° do. 8 experiments.	3d do. 1-4 oz. do. 178° do. 11 experiments.	4th do. 1-8 oz. do. 190° do. 13 experiments.	5th do. 1-8 oz. do. 188° do. 14 experiments.	6th do. 1-8 oz. do. 185° do. 14 experiments.	7th do. 1·8 oz. do. 190° do. 15 experiments.	8th do. 1-8 oz. do. 178° do. 17 experiments.	9th do. 1-8 oz. do. 188° do. 17 experiments.	10th do. 1-8 oz. do. 182° do. 18 experiments.	11th do. 1-16 oz. do. 175° do. 25 experiments.	12th do. 1-16 oz. do. 188° do. 29 experiments.
	″	″	″	″	″	″	″	″	″	″	″	″
1	50	105	93	173	126	134	121	66	111	78	66	80
2	55	25	23	19	14	15	16	18	13	12.5	17	37
3	176	15	12	9	9	6.5	7.5	9	9	5.5	7.5	14.5
4	.	21	14	14	11.5	10	9	9	9	7.5	7	9
5	.	31	19	17	14.5	14.5	12	11	10	9	6	6.5
6	.	41	25	22	17	16	15	14	11.5	11	5.5	6
7	.	69	30	24	19.5	19.5	16.5	15	15	14	5.5	5.5
8	.	150	43	28	21.75	20	19	19	17	14.5	5	6.5
9	.	.	57	37	26	27	22	20	19	17	5	7
10	.	.	67	50	31	30	26.5	22	23	19	5.5	8
11	.	.	135	63.5	38	38	30	25	27	22	5.75	8
12	.	.	.	99	49	49	39.5	31	30	24	6	8.5
13	.	.	.	174	70	66	54	38	41.5	25	7	9.5
14	.	.	.	.	89	99	72	45	50.5	33	7.5	11
15	.	.	.	.	.	.	107	68	72	40	8	11.5
16	.	.	.	.	.	.	.	95	93	50	13	13
17	.	.	.	.	.	.	.	190	183	82	18	14
18	.	.	.	.	.	.	.	.	.	135	20	15
19	.	.	.	.	.	.	.	.	.	.	22	15.5
20	.	.	.	.	.	.	.	.	.	.	25	17
21	.	.	.	.	.	.	.	.	.	.	34	19
22	.	.	.	.	.	.	.	.	.	.	42	22
23	.	.	.	.	.	.	.	.	.	.	50	26
24	.	.	.	.	.	.	.	.	.	.	83	30
25	.	.	.	.	.	.	.	.	.	.	140	36
26	.	.	.	.	.	.	.	.	.	.	.	44
27	.	.	.	.	.	.	.	.	.	.	.	59
28	.	.	.	.	.	.	.	.	.	.	.	89
29	.	.	.	.	.	.	.	.	.	.	.	156.5

RESULTS.

1st series. $5\frac{5}{8}$ oz. generated in 281″
2 intervals, 60″ each 120

whole time of the series, 401

2d series. 4 oz. generated in 457″
7 intervals 10″ each 70

whole time of the series 527

3d series.	$2\frac{3}{4}$ oz. generated in	518″
	10 intervals, 6.5″ each	65
	whole time of the series	583
4th ser.	$1\frac{5}{8}$ oz. generated in	727.5″
	12 intervals, 6.8″ each	82.5
	whole time of the series	810
5th ser.	$1\frac{3}{4}$ oz. generated in	536″
	13 intervals, 12.9″ each	169
	whole time of the series	705
6th ser.	$1\frac{3}{4}$ oz. generated in	534.5″
	13 intervals, 10.8″ each	140.5
	whole time of the series	675
7th ser.	$1\frac{7}{8}$ oz. generated in	567″
	14 intervals, 10″ each	140
	whole time of the series	707
8th series.	$2\frac{1}{8}$ oz. generated in	695″
	16 intervals, 6″ each	96
	whole time of the series	791
9th ser.	$2\frac{1}{8}$ oz. generated in	724″
	16 intervals, 11″ each	176
	whole time of the series	900
10th ser.	$2\frac{1}{4}$ oz. generated in	598.5″
	17 intervals, 16″ each	271.5
	whole time of the series	870
11th ser.	$1\frac{9}{16}$ oz. generated in	613″
	24 intervals, 7″ each	168
	whole time of the series	781
12th ser.	$1\frac{13}{16}$ oz. gener'd in	780.5″
	28 intervals, 8.2″ each	230.5
	whole time of the series	1011

As the water covered generally but a small part of the surface of the basin even at the commencement of the experiment, the heat in the latter terms of each series, must have been furnished to the water more slowly than in the preceding terms, both on account of the diminution of difference between the metal and the liquid, and on account of the necessity of depending on the conducting power of the metal, to bring the heat from the exterior to the center of the basin. Hence we might expect to find the terms obeying some law of geometrical progression. If we examine the last seven or eight experiments in each series, we shall clearly perceive such a progression. Omitting the last of each column, as presenting anomalies obviously derived from the final disappearance of vaporization, and the substitution of mere *evaporation*, we may divide the last number but one, by that which precedes it; this latter, by the next preceding, and so on, until we obtain five quotients. These quotients will constitute the ratios of the series, at the particular points where the experiments took place. The mean results for each series may then be obtained in the usual mode. But it will soon be perceived that if we extend the divisions beyond five or six, the ratio will be essentially varied in its character, and the series, in some instances, becomes almost exactly coincident with an arithmetical progression. Thus the 12th series, from the 11th to the 20th experiment, inclusive, may be regarded as composed of the numbers 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, while from the 23rd to the 28th, we have 26, 30, 36, 44, 59, 89, yielding the ratios $\frac{30}{26}=1.153$, $\frac{36}{30}=1.200$, $\frac{44}{36}=1.222$, $\frac{59}{44}=1.341$, and $\frac{89}{59}=1.508$, and the mean of all these ratios is 1.285.

By similar operations applied to the concluding part of every series in this course except the first and second, we obtain the following mean ratios for the several series respectively, viz.

for the	3rd	series	1.290
" "	4th	"	1.334
" "	5th	"	1.276
" "	6th	"	1.302
" "	7th	"	1.270
" "	8th	"	1.308
" "	9th	"	1.285
" "	10th	"	1.292
" "	11th	"	1.316
" "	12th	"	1.285

If we would know the mean of all their mean ratios, we have but to divide their sum by 10, the number of series considered, whence we obtain 1.296 for the general ratio of this part of the several series. It will, however be remarked that the five ratios belonging to the 11th series are themselves in geometrical progression, whose mean ratio is 1.07.

In order to present to the eye the whole range of experiments in some of the series, I have adopted the method of curvilinear projection, assuming as the unit of vapor, the amount actually employed at each trial, and as the unit of time, the number of seconds taken to vaporize it, at the period of most rapid action. Representing these units by equal vertical and horizontal lines respectively, the relative time of action in each experiment marked on the line *a c*, is denoted by the dotted lines, *a d*, *c g*, &c. Figs. 1, 2 and 3. Regarding *ab* as a constant quantity, we have the portions of time above the *minimum*, represented by that part of each vertical which is above the tangent *bf*. It will be seen by Fig. 1. that the arithmetical series exists in the 6th, 7th, and 8th experiments. Fig. 2d. shows the same feature at the 17th 18th, and 19th, while the 12th series, represented by Fig. 3, shows a straight line from No. 11, to No. 20, as already stated. See the plate at p. 71.

The next course of experiments was performed on a more extended scale, by using a cylinder of cast iron about seven inches long, and three inches in diameter; having at one end a cylindrical hole nine tenths of an inch in diameter, and three and three quarters of an inch in depth, concentric with the axis of the cylinder, and of course penetrating below the centre of the mass. The weight of the cylinder was about ten pounds. This cylinder, heated to redness, was placed on the solid base, and the water was deposited from a suitable measuring tube, in the hole at the upper end, due care being taken to clear the interior surface of scales and dust at the moment it was withdrawn from the fire. In this course, the red heat was maintained for a much longer period than was practicable with the rolled plate, when withdrawn from the fire. The time when redness disappeared, was generally noted, and is marked *b* against the number of seconds registered, at the experiment where it occurred. The *minimum* time is indicated in like manner by *m*.

SECOND COURSE, *containing nine series.*

To exhibit the rate of decrease, the time of most violent action, and the subsequent increase of time of vaporization in a cylinder of cast iron, employing an equal quantity of water at each trial in the same series.

Order of succession in the experiments of each series.	1st. series, 1-8 oz. of water, at 65° at each exp. Iron red hot when taken from the fire.	2d series, 1-8 oz. of water, at 80°. Iron very bright red.	3d series, 1-4 oz. of water, at 212°. Iron near whiteness.	4th series, 1-8 oz. of water, at 190°. Iron bright red.	5th series, 1-8 oz. of water, at 190°. Iron bright red.	6th series, 1-8 oz. of water, at 200°. Iron near whiteness.	7th series, 1-8 oz. of water, at 200°. Iron nearly white.	8th series, 1-16 oz. of water, at 212°, kept in rapid ebullition during the whole series. Iron white.	9th series, 1-16 oz. of water at 212°, kept briskly boiling Iron white.
1	31″	26.5″	27″	14″	14.5″	18″	20″	27.5″	17″
2	30	26	27	13	14	16	20	28	17
3	30	26	24	12	14	16	19	34	15
4	30	26	23	11.5	14	16	18	39	15
5	31	26	23	10.5	14	15.5	17.5	30	14.5
6	34	25	20	10.5	13	15	17	33	14.5
7	30	24	20	10.5	12	14.5	17	22	14.5
8	33	24	19	10	11	14	17	20	13
9	34	22	17	10	11	13	17	18	13
10	29	21	15	10	12	12	16	17	12
11	27.5	19	13	10	11	12	15	17	11.5

TABLE CONTINUED.

Order of succession in the experiments of each series.	1st series, 1-8 oz. of water, at 65°, at each exp. Iron red hot when taken from the fire.	2d series, 1-8 oz. of water, at 80°. Iron very bright red.	3d series, 1-4 oz. of water, at 212°. Iron near whiteness.	4th series, 1-8 oz. of water, at 190°. Iron bright red.	5th series, 1-8 oz. of water, at 190. Iron bright red.	6th series, 1-8 oz. of water, at 200°. Iron near whiteness.	7th series, 1-8 oz. of water, at 200°. Iron nearly white.	8th series, 1-16 oz. of water, at 212°, kept in rapid ebullition during the whole series. Iron white.	9th series, 1-16 oz. of water, at 212°, kept briskly boiling. Iron white.
12	″ 27.5	″ 18.5	″ 13	″ 9.5	″ 11	″ 11	″ 14.5	″ 16	″ 11.5
13	30	18	12	9.5	11	11	14	16	11
14	31	18.5	12	9	11	11	14	16	12
15	29	18	12	9	10	11	13	16	12
16	29	18.5	12	9	10	11	13	16	12
17	25	18	11	8.5	10	10.5	12	15	12
18	21	18	10	8	10	10.5	12	15	12
19	20*b*.	17.5	10*b*	8	10	10	12	15	11
20	20	17.5	10	8	10	10	11	14.5	11
21	20	17*b*	10	8.5	10	10	10	14.5	11
22	20	17	10	8	9.5	10	10	13	10
23	19	17	10	8	9.5	10	9.5	12	10
24	19	17	10	7.5	9.5	10	9.5	12	10.5
25	21	17	8.5	7	10	10	9.5	11	10
26	21	16.5	8.5	7	9.5	10	9.5	10.5	9
27	22	16.5	8	7	9.5	9.5	9	10	8.5
28	20	17	8	7	8	9.5	9	10	9
29	23	16.5	8	6.5*m*	8	9	8.5*b*	10	9
30	17	16.5	8	7*b*	8	9*b*	8	9	8.5
31	20	16	7	8	7*b*	9	7.5	9	8.5
32	18	16	7	8	6*m*	8.5	7	9	8.5
33	18	16	7	8	6	8	7	8.5	8
34	17	16.5	7	7.5	8	8	6.5	8.5	8
35	17	16.5	7	7.5	7	8	7	8	8
36	16.5	16	6.5	8	7	8	8	8	8
37	16	16	7	7.5	7	8	7	7	8
38	15	15	6.5	7	7	8.5	7	7*b*	8
39	15	14	7	8	7	8.5	7	7	7
40	15	14	6.5	7.5	8	7	6.5	7	7
41	14.5	14	7	7.5	8	7	6.5	7	7
42	18	14	6*m*	7.5	7	7	6	7	6.5*b*
43	16.5	14	7	7.5	7	7	6	6.5	7
44	15	14	7	8	7	7	6	6.5	7
45	16	14	7	7.5	8	7	6	6	7
46	15	14.5	6.5	7.5	8	6.5	6.5	6	6.5
47	15	14.5	7	8	8	6*m*	6.5	6	6.5
48	15	14	6.5	8	9	6.5	6.5	6	6.5
49	13*m*	14	7	8.5	9	7	6	6	6.5
50	13	13*m*	7	9	9	7	6	5.5	6.5
51	13	13	6.5	9	9	7	6	5.5	6.5

TABLE CONTINUED.

Order of succession in the experiments of each series.	1st series, 1-8 oz. of water, at 65° at each exp. Iron red hot when taken from the fire.	2d series, 1-8 oz. of water, at 80°. Iron very bright red.	3d series, 1-4 oz. of water, at 212°. Iron near whiteness.	4th series, 1-8 oz. of water, at 190°. Iron bright red.	5th series, 1-8 oz. of water, at 190°. Iron bright red.	6th series, 1-8 oz. of water, at 200°. Iron near whiteness.	7th series, 1-8 oz. of water, at 200°. Iron nearly white.	8th series, 1-16 oz. of water, at 212°, kept in rapid ebullition during the whole series. Iron white.	9th series, 1-16 oz. of water, at 212°, kept briskly boiling. Iron white.
	″	″	″	″	″	″	″	″	″
52	13	14	6.5	9.5	9	7	5*m.*	5*m.*	6
53	13	14	7	10	9.5	7	6	5	6
54	16	14	8	11	9.5	7	6	6	6
55	21	15	8	12	10	7	6	5	6
56	22	15	9	12.5	11	7	6	6	5
57	23	18	10	12.5	10.5	8	7	5	6
58	26.5	19	10	14	12	8	6	5	5.5
59	47	22.5	12	14	11	8	6	5	5.5
60	210	25	15	14	12	8	6.5	5	5
61	.	43	19	15	13	8	6.5	5	6
62	.	188	24	16.5	14	8	7	5	6
63	.	.	27	18	14	8	7	5	6
64	.	.	36	19	14	7.5	7	5	5
65	.	.	40	21	15	7.5	7	6	5.5
66	.	.	55	23.5	16	8	7	5·5	5
67	.	.	80	28	17	8	7	6	5
68	.	.	137	31.5	20	9	8	6	6
69	.	.	.	33	20	10	8	6	5.5
70	.	.	.	39	22	10	8	6	5
71	.	.	.	56	22	10	9	6	5
72	.	.	.	64	23	10	9.5	6	5
73	.	.	.	179	24	10	10	6	5
74	.	.	.	.	25	10.5	10	6.5	5
75	.	.	.	.	28	10.5	10	6.5	4.5*m.*
76	.	.	.	.	37	11	10	6	5
77	.	.	.	.	46	12	10	6	4.5
78	.	.	.	.	54	13	10	6	6
79	.	.	.	.	88	13	10.5	6	5
80	.	.	.	.	154	14	10.5	5.5	5
81	.	.	.	.	.	15	11	5.5	5.5
82	.	.	.	.	.	15	13	5.5	5
83	.	.	.	.	.	18	14	5.5	5
84	.	.	.	.	.	19	14.5	5.5	5
85	.	.	.	.	.	20.5	17.5	6	5
86	.	.	.	.	.	24	18	5.5	5
87	.	.	.	.	.	25.5	19	6	5
88	.	.	.	.	.	33	21	6	5
89	.	.	.	.	.	44	23	6	4.5
90	.	.	.	.	.	56	26	6.5	5
91	.	.	.	.	.	92	29	6	5

TABLE CONTINUED.

Order of succession in the experiments of each series.	1st series, 1-8 oz. of water, at 65° at each exp. Iron red hot when taken from the fire.	2d series, 1-8 oz. of water, at 80°. Iron very bright red.	3d series, 1-4 oz. of water, at 212°. Iron near whiteness.	4th series, 1-8 oz. of water, at 190°. Iron bright red.	5th series, 1-8 oz. of water, at 190°. Iron bright red.	6th series, 1-8 oz. of water, at 200°. Iron near whiteness.	7th series, 1-8 oz. of water, at 200°. Iron nearly white.	8th series, 1-16 oz. of water, at 212°, kept in rapid ebullition during the whole series. Iron white.	9th series, 1-16 oz. of water, at 212°, kept briskly boiling. Iron white.
92	.	.	.	.	.	″ 296	″ 38	″ 6	″ 4.5
93	.	.	.	.	.	.	60	6	4.5
94	.	.	.	.	.	.	163	6	4.5
95	.	.	.	.	.	.	.	6	5
96	.	.	.	.	.	.	.	6	6
97	.	.	.	.	.	.	.	6.5	5
98	.	.	.	.	.	.	.	6.5	5.5
99	.	.	.	.	.	.	.	6.5	5
100	.	.	.	.	.	.	.	6.5	6
101	.	.	.	.	.	.	.	6.5	5
102	.	.	.	.	.	.	.	7	5.5
103	.	.	.	.	.	.	.	7	5
104	.	.	.	.	.	.	.	7	5.5
105	.	.	.	.	.	.	.	7	6
106	.	.	.	.	.	.	.	7	5.5
107	.	.	.	.	.	.	.	7	6
108	.	.	.	.	.	.	.	7	6
109	.	.	.	.	.	.	.	7	5.5
110	.	.	.	.	.	.	.	7	6
111	.	.	.	.	.	.	.	7	5.5
112	.	.	.	.	.	.	.	7	6
113	.	.	.	.	.	.	.	7	5.5
114	.	.	.	.	.	.	.	7	5.5
115	.	.	.	.	.	.	.	7	5.5
116	.	.	.	.	.	.	.	7	5
117	.	.	.	.	.	.	.	7	6
118	.	.	.	.	.	.	.	6.5	5.5
119	.	.	.	.	.	.	.	6.5	5.5
120	.	.	.	.	.	.	.	7	5.5
121	.	.	.	.	.	.	.	6	6
122	.	.	.	.	.	.	.	6	6
123	.	.	.	.	.	.	.	6.5	7
124	.	.	.	.	.	.	.	6	6
125	.	.	.	.	.	.	.	6	6.5
126	.	.	.	.	.	.	.	6.5	6.5
127	.	.	.	.	.	.	.	7	6.5
128	.	.	.	.	.	.	.	6.5	7
129	.	.	.	.	.	.	.	7	7
130	.	.	.	.	.	.	.	6	7
131	.	.	.	.	.	.	.	6	6.5
132	.	.	.	.	.	.	.	6	6.5

TABLE CONTINUED.

Order of succession in the experiments of each series.	1st series, 1-8 oz. of water, at 65° at each exp. Iron red hot when taken from the fire.	2d series, 1-8 oz. of water, at 80°. Iron very bright red.	3d series, 1-4 oz. of water, at 212°. Iron near whiteness.	4th series, 1-8 oz. of water, at 190°. Iron bright red.	5th series, 1-8 oz. of water, at 190°. Iron bright red.	6th series, 1-8 oz. of water, at 200°. Iron near whiteness.	7th series, 1-8 oz. of water, at 200°. Iron nearly white.	8th series, 1-16 oz. of water, at 212°, kept in rapid ebullition during the whole series. Iron white.	9th series, 1-16 oz. of water, at 212°, kept briskly boiling. Iron white.
133	.	.	.	.	.	.	.	7″	6″
134	.	.	.	.	.	.	.	7	6
135	.	.	.	.	.	.	.	7	6
136	.	.	.	.	.	.	.	7	5.5
137	.	.	.	.	.	.	.	7	6
138	.	.	.	.	.	.	.	7.5	6
139	.	.	.	.	.	.	.	7.5	6
140	.	.	.	.	.	.	.	7.5	6
141	.	.	.	.	.	.	.	7.5	5
142	.	.	.	.	.	.	.	8	5.5
143	.	.	.	.	.	.	.	8.5	5.5
144	.	.	.	.	.	.	.	9	5
145	.	.	.	.	.	.	.	9	5
146	.	.	.	.	.	.	.	10	5
147	.	.	.	.	.	.	.	10.5	5
148	.	.	.	.	.	.	.	12	5
149	.	.	.	.	.	.	.	12	6
150	.	.	.	.	.	.	.	12	5.5
151	.	.	.	.	.	.	.	13.5	5
152	.	.	.	.	.	.	.	15	5
153	.	.	.	.	.	.	.	15.5	6
154	.	.	.	.	.	.	.	18	6
155	.	.	.	.	.	.	.	20	6
156	.	.	.	.	.	.	.	22	6
157	.	.	.	.	.	.	.	29	6
158	.	.	.	.	.	.	.	32	7
159	.	.	.	.	.	.	.	33	6
160	.	.	.	.	.	.	.	37	7
161	.	.	.	.	.	.	.	58	6.5
162	.	.	.	.	.	.	.	88	7.5
163	.	.	.	.	.	.	.	154	8
164	.	.	.	.	.	.	.	.	10
165	.	.	.	.	.	.	.	.	11
166	.	.	.	.	.	.	.	.	14
167	.	.	.	.	.	.	.	.	15.5
168	.	.	.	.	.	.	.	.	20
169	.	.	.	.	.	.	.	.	25
170	.	.	.	.	.	.	.	.	32
171	.	.	.	.	.	.	.	.	47
172	.	.	.	.	.	.	.	.	69
173	.	.	.	.	.	.	.	.	134

RESULTS.

1st *Series.*—Vaporized $\frac{6.0}{8}$ oz. of water in 2100″—viz.
water was on the metal 1497″
59 intervals 10.2″ each 603″
Black at No. 19.—Minimum, No. 49.

2d *Series.*—Gave $\frac{6.2}{8}$ oz. of vapor in 1800″—viz.
water remained on 1292.5″
61 intervals 8.32″ each 507.5″
Black at No. 21.—Minimum, No. 50.

3d *Series.*—Gave $\frac{6.8}{4}$ oz. of vapor in 1800″—viz.
water was on 1065.5″
67 intervals 10.9″ each 734.5″
Black at No. 19.—Minimum, No. 42.

4th *Series.*—Gave $\frac{7.3}{8}$ oz. of vapor in 1920″—viz.
water was on 1092″
72 intervals 11.5″ each 828″
Black at No. 30.—Minimum, No. 29. (Surface oxidized.)

5th *Series.*—Gave $\frac{8.0}{8}$ oz. of vapor in 2100″—viz.
water was on 1244.5″
79 intervals 10.8″ each 855.5″
Black at No. 31.—Minimum, No. 32. (Oxide.)

6th *Series.*—Gave $\frac{9.2}{8}$ oz. of vapor in 2100″—viz.
water was on 1420″
91 intervals 7.47″ each 680″
Black at No. 30.—Minimum, No. 47.

7th *Series.*—$\frac{9.4}{8}$ oz. of vapor in 2162″—viz.
water was on 1232″
93 intervals 10″ each 930″
Black at No. 29.—Minimum, No. 52.

8th *Series.*—Gave $\frac{16.3}{16}$ oz. of vapor in 2700″—viz.
water was on 1819″
162 intervals 5.44″ each 881″
Black at No. 38.—Minimum No. 52.

9th *Series.*—Gave $\frac{17.3}{16}$ oz. of vapor in 2700″—viz.
water was on 1510″
172 intervals 6.91″ each 1190″
Black at No. 42.—Minimum, No. 75.

The eighth series in the second course, is represented in projection by the curve, (Fig. 4.) of the accompanying plate. The reader will remark that the linear unit, assumed to represent the minimum time and its corresponding quantity of vapor, is one tenth of an inch in this figure, whereas it is two tenths in those which relate to the first course.

In addition to the results of the fourth and fifth series, where the most rapid action occurred almost simultaneously with the cessation of redness, numerous other facts had convinced me that the approach to this period is greatly accelerated by the adhesion of any non-conducting substance to the surface of the iron. Indeed, it often appeared sufficient for the water to find and seize upon a mere point of such material as a nucleus, to enable the fluid speedily to reduce the temperature of the surrounding surface. By detaching a scale of oxide, around which the effect just described had begun to take place, I have sometimes succeeded in arresting the progress of vaporization, and by giving the liquid once more a clean red surface, even with the scale floating loosely in the water, to establish once more the slow evaporation which belongs to that state of the metal.

To ascertain what effect the incrustation generally formed upon the interior of a steam boiler might be expected to produce, in augmenting the rapidity of action in a case of overheating, I performed the following course of nine series, employing for that purpose, the basin used in the first course, commencing with its surface clean, and having tried the effect of pure water at 212°, subsequently poured in a portion of cold water, into a pint of which about two ounces of clayey garden earth had been put, producing a degree of turbidness as great probably as any of our rivers possess in the time of freshets. The iron was kept constantly over a brisk fire, and, in some of the series, was permitted to come to bright redness before each experiment; while in others, the operation commenced with redness, but was continued in so immediate a succession, as to reduce the metal to a certain point of constant action; but never attaining the *most rapid* period.

It will be perceived that the first series was made in pairs, alternately—two with clean water at the boiling point and two with the muddy water above mentioned. The other series were made with similar alternations of single experiments, with the exception that both hot and cold water were free from impurities when laid upon the metal. The ratios placed among the results of this course, will prove that on an average, water at 212° laid upon hot metal under the circumstances described, requires 15½ per cent. longer for its evaporation than a like quantity of water at 60°. This result, which appears at first rather startling and paradoxical, is readily explained when we consider the efficacy of cold water in bringing the coating and even the surface of the metal down towards the temperature of most rapid action,—a point, at which the mere difference of temperature becomes an insignificant element in the calculation, compared with the vastly augmented speed with which the vapor is then generated.

Third course, *embracing nine series.*

To exhibit the effect of incrustations in augmenting the action of hot metal, during the first stages of vaporization from its surface, and also to show the relative efficacy of hot and cold water in this particular.

Order of experiments in each series.	1st *Series*.—Iron red—evaporated 1-8 oz. of water at each experiment, gradually coating the surface with clay.		2d *Series*.—Commenced with iron red—1-8 oz. alternately clear and muddy water.		3d *Series*.—Begun by evaporating 2 oz. of muddy water, forming a crust on the metal, on which put 1-8 oz. each time.		4th *Series*.—1-8 oz. laid on crust of clay, in immediate succession.		5th *Series*.—1-4 oz. of water used each time, begun at bright red and brought down to a temperature of constant action.		6th *Series*.—1-4 oz.—iron red hot before each experiment.		7th *Series*.—Begun by adding a third oz. of muddy water to the crust already formed. This evaporated in 45″—1-1 oz. each time—iron full red at every trial.		8th *Series*.—Added a 4th oz. of muddy water—took 35″—then iron red each time—hot and cold water applied—1-4 oz. at each experiment.		9th *Series*.—On the coat of clay from 4 oz. of muddy water, put 1 oz. of clean water at 60°, in immediate succession.
	Water, 212° (clean.)	Do. 60° (muddy.)	Do. 212° (clean.)	Do. 60° (muddy.)	Do. 212° (clean.)	Do. 60° do.	Do. 212° do.	Do. 60° do.	Do. 212° do.	Do. 60° do.	Do. 212° do.	Do. 60° do.	Do 212° do.	Do. 60° do.	Do. 212° do.	Do. 60° do.	
	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
1	95	.	23	.	14	.	13.5	.	21	.	30.5	.	21.5	.	15	.	30
2	100	.	.	21.5	.	12	.	10.5	.	18	.	23	.	19	.	14.5	26
3	.	72	20	.	14	.	13	.	18	.	28	.	24	.	18	.	25
4	..	52	.	20	.	13.5	.	11	.	15	.	26	.	21	.	15.5	24
5	53	.	20	.	15	.	12	.	14.5	.	30.5	.	24.5	.	.	.	25
6	50	.	.	20	.	13	.	10.5	.	14	.	25	.	20	.	.	24.5
7	.	45	19	.	15.5	.	12	.	13.5	.	35	.	22.5	.	.	.	25
8	.	31	.	18	.	13.75	.	10.5	.	12	.	25	.	20	.	.	25
9	26	.	17	.	17.5	.	.	.	13	.	39	.	24	.	.	.	.
10	24	.	.	17	.	14	.	.	.	13	.	29	.	21.5	.	.	.
11	.	26	16.5	.	17.5	.	.	.	13	.	.	.	24	.	.	.	.
12	.	27	.	16	.	14	.	.	.	11.5	.	.	.	21.5	.	.	.
13	19	.	15.5	.	.	.	.	.	13	.	.	.	24.5	.	.	.	.
14	23	.	.	15	.	.	.	.	.	11.5	.	.	.	21	.	.	.
15	.	22	13.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	21	.	14.5	.	.	.	.	.	.	.	.	.	.	.	.	.
17	19	.	13.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	18	.	.	13.5	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	13.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	13.5	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

RESULTS.

1st *series.*—Time reduced from 100″ to 18″ by the coat of earthy matter successively deposited from ⅝ths oz. of muddy water.

2d *series.*—Hot water constant at 13.5″
Cold water do. do.

3d *series.*—Mean time for hot water 15.6″—coated metal red hot, each time.
Mean time for cold water 13.37″.
Ratio of cold to hot 1 : 1.167.

4th *series.*—Hot water constant at 12″.
Cold water constant at 10.5″.
Ratio of cold to hot 1 : 1.143.

5th *series.*—Hot water constant at 13″.
Cold water constant at 11.5″.
Ratio of cold to hot 1 : 1.130.

6th *series.*—Mean time for hot water 32.6″.
Mean for cold water 26.2″.
Ratio of cold to hot 1 : 1.244.

7th *series.*—Mean for hot water 23.6″.
Mean for cold water 20.6″.
Ratio of cold to hot 1 : 1.145.

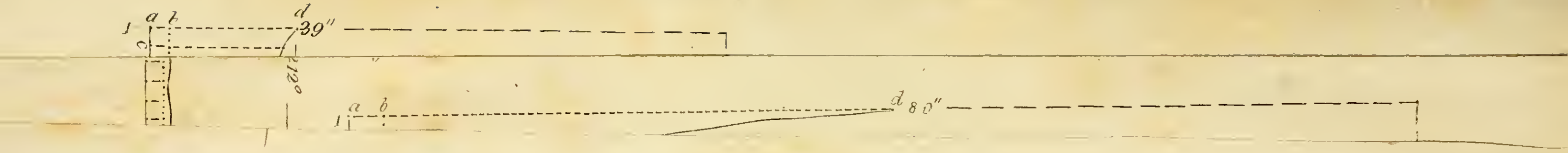
8th *series.*—Mean for hot water 16.5″.
Mean for cold water 15″.
Ratio of cold to hot 1 : 1.100.

9th *series.*—Constant at 25″ to the ounce.

The first series represents the gradual diminution of time from 100 " down to 18" and shows that here the impurity suspended in the water, retarded vaporization more than the depression of temperature could accelerate it. In the second series, the two effects became exactly counter-balanced and so remained through several experiments more than are given in the table.

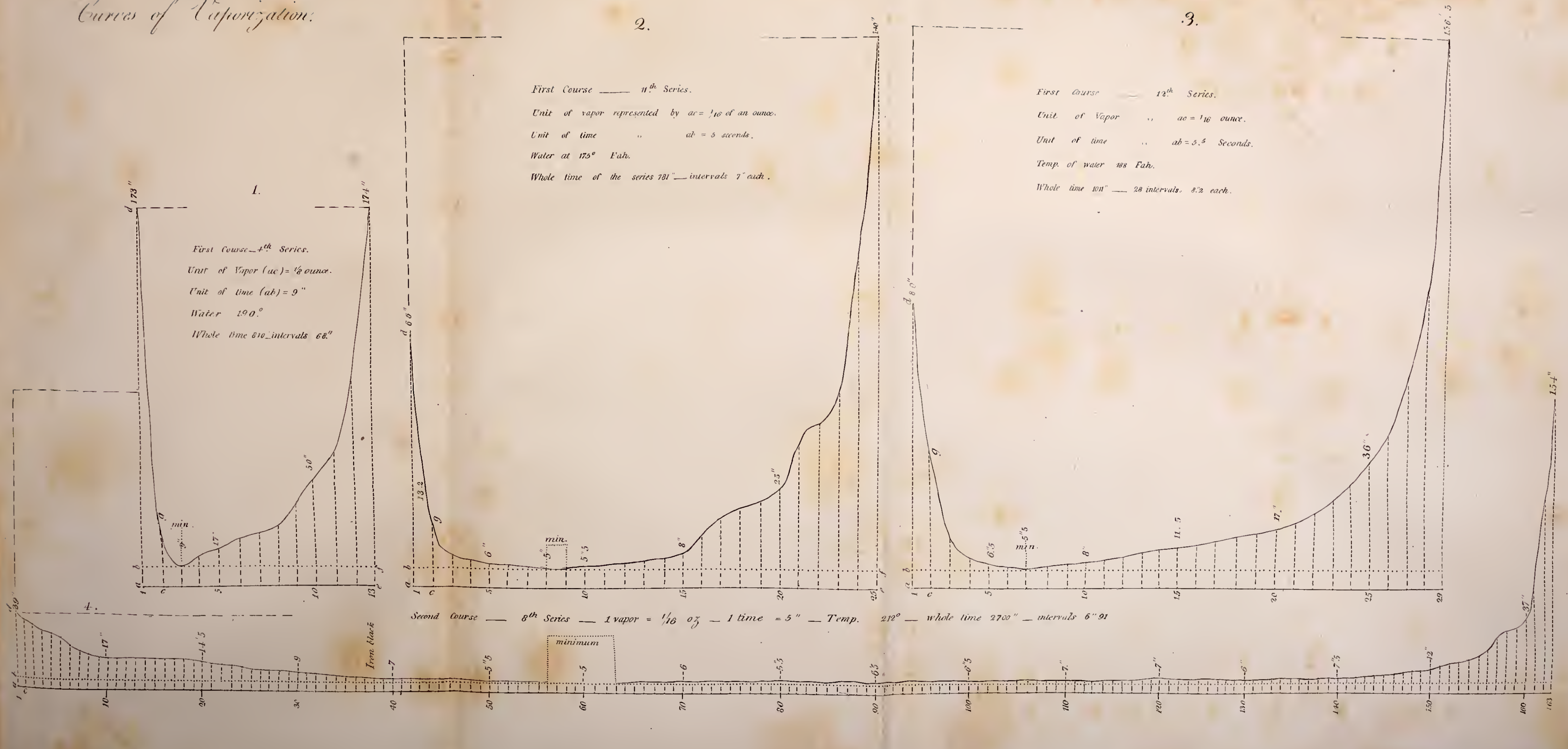
FOURTH COURSE, *consisting of six series.*

The sixth being intended to show the times required to evaporate, or to vaporize equal portions of water from the surface of iron when placed cold upon a vivid coal fire, with the delays necessary to raise the temperature up to the point of most rapid action and thence to the state in which the water ceases to moisten the surface ;—the other series being designed to exhibit the relation in time, between hot



1
a
b
c
d
39''
212°
1
a
b
d
80''

Curves of Vaporization.



and cold water upon a clean surface, varying the correspondent portions of each from $\frac{1}{8}$oz. to 2oz. at each experiment.

Order of experiments.	1st *Series.*—1-8 oz. at each experiment—hot and cold water alternately.		2d *Series.*—1-4 oz. at each experiment—hot and cold water alternately.		3d. *Series.*—1-2 oz. at each experiment—hot and cold water alternately.		4th *Series.*—1 oz at each experiment—hot and cold water alternately.		5th *Series.*—2 oz. at each experiment—hot and cold water alternately.		6th *Series.*—1-8 oz. put on the iron cold, and same quantity in immediate succession.
	Water 212°.	Do. 60°.	Water 212°.	Do. 60°.	Water 212°.	Do. 60°.	Water 212°.	Do. 60°.	Water 212°.	Do. 60°.	Water 60°.
	″	″	″	″	″	″	″	″	″	″	″
1	104		108		150		182		266		40
2		68		93		137		158		220	16
3	96		102		150						9
4		64		84		126					ceased 60″ 9
5	100										8
6		94									ceased 30″ 8
7	90										6.5
8		79									6
9	95										ceased 60″ 6
10		74									black 64
11	90										visibly red 60
12		80									75
13	80										clear red 73
14		74									" 80
Mean.	93.5	76	105	88.5	150	131.5	182	158	226	220	constant 80″
Ratio.	1.23 : 1		1.186 : 1		1.14 : 1		1.151 : 1		1.209 : 1		

The mean of all these ratios is 1.183 which shows that with a clean surface the limited quantity of hot water requires $18\frac{3}{10}$ per cent. longer to effect its vaporization from the red hot metal than an equal quantity of water at 60°; so that though the times are vastly different in this course from what were given in the last, the relation is nearly the same, being only 3 per cent. more favorable to the cold water, than when the surface was incrusted with earthy matter. Accidental circumstances sometimes vary or even invert the relative times for hot and cold water, but such discrepancies are easily referred to their proper causes. The limits of this paper compel the postponement of several courses of experiments.

Art. X.—*Electro-Magnetic Apparatus;* by Benjamin F. Joslin, M. D. Prof. of Nat. Phil. in Union College.

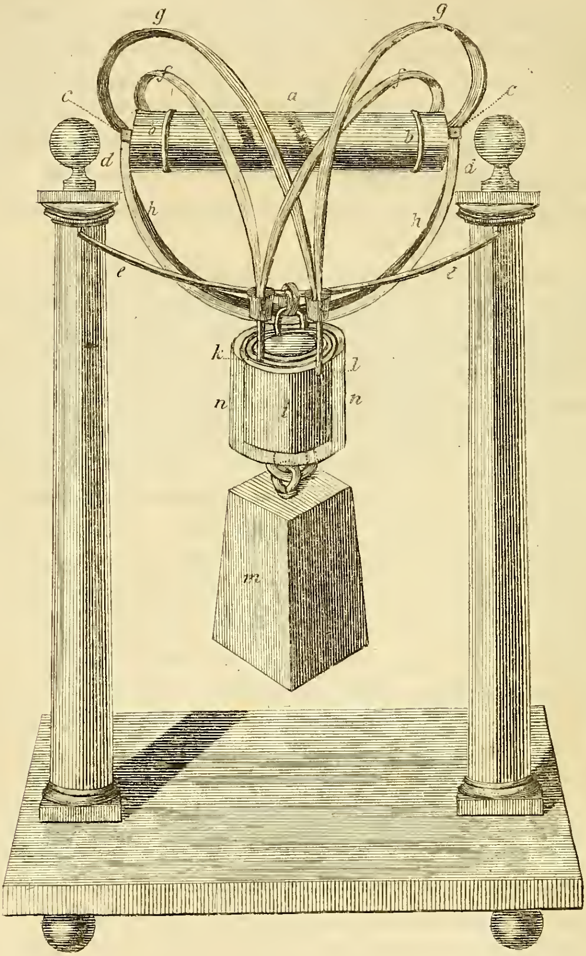
Professor Silliman.—*Sir*—In the construction of powerful electro-magnets, the spiral wire, with various modifications, has been hitherto universally employed for transmitting the magnetizing agent. I have recently taken a different route, with a success equal to my expectations. My method consists in applying to a bar of iron a single rectangular *sheet* of copper, of a width nearly *equal to the length* of the bar. The silk is simply laid on the copper and both wound simultaneously around the iron, *in a direction exactly transverse.*

A piece of gun barrel eight inches and one fourth in length, about three fourths of an inch exterior diameter, and varying in thickness from one sixteenth to one eight of an inch, and weighing five ounces and one seventh, was covered in this manner with a sheet of copper and silk, three feet in length and seven inches and three fourths in breadth, leaving one fourth of an inch of each end of the iron uncovered for the application of the extremities of a semicircular armature. The barrel was sustained by a brass rod passing through it and resting on a frame. The interior and exterior extremities of the metallic sheet were connected respectively with the zinc and copper plates of a single galvanic pair of half a square foot each. The weight sustained by the magnet was eleven pounds avoirdupois. After the addition of one foot and a half to the sheet, making four feet and one fourth in all, it sustained fifteen pounds, or nearly forty seven times its own weight. This, I believe, is several times as much as has ever been sustained by a magnet of this size with *so short a circuit.* The perfect symmetry of the transmitted current, and the preservation of this property during the numerous and gradual changes which may be readily made in its length, by attaching the wires successively to different parts of this metallic roll, may suggest new methods of investigating some of the laws of electro-magnetic action.

In the above experiment, one of the shorter edges of the rectangular sheet of copper was soldered to the barrel for the convenience of rolling it tight, and one wire connected with each of its four corners. In one instance the copper part of the galvanic element and of the roll composed one continued sheet. In this way all wires might be dispensed with. Some other laminated metals might probably be

Prof. Joslin's Electro-Magnet.

See pa. 87.



A. Doolittle sculp.

advantageously employed. A horse shoe magnet would require two such rolls or transverse coils, unless it were bent at right angles near each pole.

Will you do me the favor to insert this article in the forthcoming number of the American Journal of Science,* and oblige yours respectfully, B. F. Joslin.

Schenectady, June 25, 1831.

EXPLANATION OF THE PLATE.

a The roll composed of silk and copper laminæ, turning twelve times round a small hollow cylinder of soft iron, and prevented from uncoiling by the two copper bands or hoops *bb*. When the copper is exterior to the silk, the bands are made of some imperfectly conducting material.

cc The two projecting extremities of the hollow iron cylinder, which is a small piece of thin gun-barrel.

dd A brass rod passing through it, and resting at the extremities on the upright columns of the supporting frame.

ee A brass wire bent horizontally into a semicircular form, for supporting the small galvanic element *i*, composed of two connected copper cylinders and an intermediate one of zinc and immersed in a cup of acid *nn*, which last is drawn transparent for better illustration.

ff Two slips of sheet copper, the upper ends of which are soldered to the two corners of the outer extremity of the copper sheet, and the lower ends immersed in the mercury of the cup which is soldered to the zinc pole *k* of the galvanic apparatus.

gg Similar conductors connecting the copper pole *l* with the extremities of the iron cylinder *cc*, and consequently with the interior extremity of the copper sheet which is soldered to it.

hh A semicircular bar of soft iron, weighing 1 lb. and having at each end a semicircular notch, adapted accurately to the lower side of the uncovered part of the hollow iron cylinder *cc*.

At the middle of this armature or lifter *hh*, is a hook from which is suspended the 14 lb. weight *m*.

One peculiarity of my electro-magnet apparatus, above described, is the substitution of the roll for the helix. As I stated eight years ago, "it is the *transverse or circular* and not the spiral direction†

* The above arrived too late for the last No. (that for July, 1831.)

† Alluding to the oblique spiral or helix then employed.

which is essential, and the only advantage of the spiral direction is to keep the current for a *longer time,* in the vicinity of the needle."* Believing that the great advantages gained by Prof. Henry, in multiplying the wires and diminishing their length, were almost wholly resolvable into the superior effect of a large current compared with a small one, I have been induced to seek for similar advantages by a simpler method, by which moreover the resultant of the force is exactly transverse, and the current on arriving at the magnet, undergoes a sudden dilatation, and a consequent diminution of velocity. Prof. Henry, has ingeniously inferred from some of his experiments, that a certain degree of slowness may be favorable. This is also consistent with an opinion expressed in the above quotation.

Another peculiarity then of this apparatus, is the small dimensions of the channel which conducts the electricity to the magnet, in comparison with that in which it circulates around it. It was found by trying wires of different sizes and in different numbers, that within wide limits, a reduction in the magnitude of these uniting wires, occasioned but a slight diminution of the magnetizing effect. For instance, with the battery employed, the difference between the effect of four bell wires at each end of the sheet, and that of two at each end, was scarcely perceptible. Much more depends upon the length, breadth and proximity of the sheet along which the electricity circulates around the iron.

The conducting property of the silk fabric, produces a sensible diminution of the effect. Suspecting that in this and other electro-magnetic apparatus, there might be some transverse communication of a part of the electricity, I employed in one instance two layers of thick silk instead of one of the same kind, and found the power of the magnet to be thereby increased, notwithstanding the removal of the copper to a greater distance by the interposition of an additional layer of silk. It would seem from this fact, that regard should be had to the want of a perfectly nen-conducting property in the coating, when we attempt to establish some of the laws of electro-magnetic action. This would seem to be still more necessary in other apparatus, in which coated wires of great length are employed.

In the apparatus which has been described, although the electrical currents are symmetrical, and the resultant of their forces, exactly at right angles to the axis of the iron cylinder, and consequently in the

* Vid. American Journal of Science, Vol. XIX, p. 399.

most advantageous direction, yet as these forces are oblique, the resultant is not equal to the sum of the components. Some of the foregoing results, however, suggest a method of approximating them almost indefinitely. As an electrical current at right angles to the axis of a magnet is known to increase its magnetism, and one parallel to the axis to diminish it, the problem resolves itself into this; to cause the electricity to enter, in equal quantities at all points of one extremity of the sheet, and to pass out in a similar manner at the other extremity, and also to exert the least magnetic effect possible, in passing to and from these points respectively, in directions parallel to the axis. Now, from a comparison of some of the results which have been stated in this paper, we may infer that there is a vast disproportion between the magnetizing effect of an electric current, moving near the temporary magnet, by means of a broad sheet of metal, and the effect of the same quantity of electricity conveyed in an equal portion of time, and at the same distance from the magnet, by a wire or rod, of a length equal to that of the sheet, and of a size *adequate to the supply of the requisite quantity of electricity* to the sheet, when rods or wires are used merely as conductors between the extremities of the sheet and the battery, and not for producing electro-magnetic effects directly. This principle suggests the employment of a single cylindrical rod at each end of the sheet, for establishing a communication between the latter and the wires of the battery, each rod being parallel to the magnetic axis, and connected with the end of the sheet, either continuously or by numerous points or wires, the connecting parts being in either case so graduated in thickness, as to compensate for the variable intensity of the electricity in different sections of the rod, and thus transmit equal quantities to equal portions of one extremity of the sheet, and also equal quantities from equal portions of the other extremity of the sheet to the rod. The magnet itself should constitute the rod at the interior extremity, in order to avoid the removal of the current to an unnecessary distance.* For this purpose a solid cylinder of iron, would be preferable to a hollow one. I have shown the practicability of making the magnet itself a part of the circuit. The proper place for the direct attachment of the wires to a horse shoe magnet would be on each side of the middle of the arch.

* The only alteration necessary in the annexed drawing, if we wished to represent the apparatus with this improvement, would be a ridge on the roll to show the brass rod to which *ff* are attached.

Knowing that a current transmitted by a helix, has been found to influence the direction of a magnetic needle, placed exterior to it, it has occurred to me to ascertain whether any, (or how much,) magnetism could be excited in soft iron, by means of an interior roll. I am making some experiments on this subject, which may perhaps lead to some conclusions with regard to the depth of those electrical currents, on which the magnetism of the earth depends, or perhaps render it more probable that these are situated above the earth's surface, as conjectured in the paper, a part of which is above quoted.

Schenectady, Aug. 27, 1831.

Art. XI.—*Notice of the Vaporization of Mercury in the fumes of Nitric Ether; also, Notices of various chemical products—in letters to the Editor; by* S. Guthrie, of Sackett's Harbor, N. Y.

TO PROFESSOR SILLIMAN.

Dear Sir—Your very interesting suggestion,* that mercury may exist in the fumes arising during the formation of fulminating mercury, has induced me to examine these fumes with more care than I had hitherto done; and I beg leave to present you with the following results of my examination.

During the vehement action of a solution of mercury in nitric acid upon alcohol, in the formation of fulminating mercury, there arises a great quantity of dense white fumes, having the odor of spirits of nitrous ether. These fumes, by making them pass into a Woulfe's apparatus, are readily condensed into a fine transparent fluid. They are but partially condensible by traversing a refrigeratory worm, but in a Woulfe's apparatus, after some fifteen or twenty minutes, they will be found to be entirely condensed, and they will yield a fluid nearly equal in bulk to the alcohol employed.

This fluid has the flavor of nitric ether. On standing a few days, mercury is precipitated spontaneously, or it is thrown down at once by heat, or by the addition of potash, to neutralize a quantity of nitric or nitrous acid, and which is essential to the constitution of the fumes. Globules of mercury will most probably be detected at once in the precipitate; if not, rubbing the precipitate on paper

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* Made in answer to a letter from Mr. Guthrie, in which he informed me that he had found the condensed fumes mentioned in this paper to consist, chiefly of nitric ether.—Ed.

will most generally revive the mercury, and thus prove its existence. The effervescence which follows the addition of carbonate of potash to the condensed fumes, together with a crop of crystals of nitrate of potash which results from this addition, demonstrates the existence of the acid. Distillation of the fluid gives a fine, pungent and concentrated ether. Hence these fumes, so conspicuous in making fulminating mercury, may be regarded as a curious and peculiar combination, chiefly of ether, mercury and nitric acid.

Nitric oxide is always disengaged towards the end of the process, if not through its whole duration, and is, during the condensation, most probably converted into nitrous acid. The vapor of alcohol is probably present, though it may not be essential to the constitution of the fumes. I may, perhaps hereafter, give you the definite proportions of the substances composing these fumes, as I suspect this constitution will be found to be nearly uniform.

In preparing fulminating mercury in considerable quantities, as a business, I have, for the sake of economy and profit, pursued the following course, and can recommend it with confidence, as worthy of the attention of all who may have occasion to make this preparation on a considerable scale.

I use the *best* nitric acid I can obtain; but the alcohol need not be of less specific gravity than .840. In this case, heat will be necessary to bring on the specific action which attends the formation of the powder; and heat, if the acid be good, will always do it, although it may be necessary to continue the fluid at a boiling point for even ten minutes. The product will be found to be perfect; and it is easier to command heat than to obtain very high alcohol.

After condensing the fumes, I throw down the acid and mercury which they contain, with carbonate of potash, and decant the ether and distil it. The ether thus obtained is used as a medicine, when nitric ether is required; or, it is used in a lamp, combined with one seventh part of spirits of turpentine, for giving light—a purpose which it answers most admirably well.

After the subsidence of the powder, I decant the fluid and saturate it with potash; by which process I obtain nitrate of potash, equal in weight to ten per cent. of the acid originally employed. If the fumes be passed through alcohol, they become decomposed, and the alcohol, itself being acidulated, throws down mercury. The fumes passed through water, produce a curious clouded appearance, and the water, after a day or two, throws down mercury.

Chemical products formed by Mr. Guthrie.

I add a notice of the following facts, communicated by Mr. Guthrie in his letters, not for publication, but which I conceive are honorable to the rising chemical arts of this country. I presume it was little suspected that such things were doing in a remote region on the shore of Lake Ontario.—*Ed.*

Chlorate of Potassa and other products.

This remarkable salt, (olim, oxy-muriate of potassa) an object of much interest to the scientific chemist, is manufactured in great purity and beauty, by Mr. Guthrie; I have received from him more than a pound, and have never seen it more perfect. Mr. Guthrie has manufactured, within three or four years, twelve hundred pounds of this salt, and this enormous quantity is partly accounted for by the fact, that he sells one thousand ounces, per annum, of the priming powder, of which, the chlorate of potash is an indispensable ingredient. He makes two kinds; the red, which is water proof, and the black which is not. He has manufactured twenty five thousand ounce cannisters of percussion powder.

Mr. G. has made, and generally by processes peculiar to himself, one hundred and twenty thousand gallons of vinegar, and one hundred thousand of alcohol.

His experiments have exposed him to much danger; he has been in the midst of eleven tremendous explosions; he has been frequently burned, and twice almost fatally. Mr. Guthrie has made about three hundred pounds of the yellow powder, on which the following remarks are contained in a letter of May 8, 1831.

Some years ago, I introduced the "Yellow Powder" to the notice of sportsmen; I had long found much disappointment in my gunning excursions, from the slow fire made by using common gunpowder as priming; this induced me to melt the common fulminating powder, made of nitre, pearlashes and sulphur, and when in a state of fusion, to withdraw it from the fire, immediately before it should explode, and then to grain and use it as priming. The operation was of singular difficulty and danger, and although I met with frequent and terrible disasters, having been burned by it nearly to death, yet I pursued the business until improvement seemed to be nearly exhausted. The powder is eight times and a half quicker than the best black powder, and was going largely into use, when I discontinued the manufacture, and offered a substitute in the use of the chlorate of potassa. There is no vanity in saying that the difficulties and dangers overcome in conducting this process, are very seldom surpassed, and you cannot fail, I think, to be interested in the account I propose to present you. I will at an early day prepare and forward it.

Molasses from the Potatoe.

I have been for some time persuaded, says Mr. G. taking the data furnished by chemists as correct, that sugar might be advantageously made, in towns remote from the Atlantic coast, from the potatoe, and one year ago, Capt. E. G. Patter, at my instance, with great ingenuity, devised and constructed machinery, and apparatus for prosecuting the business. As this is the first attempt, within my knowledge, to make sugar from that, on any considerable scale, I propose giving you a full account of the business so far as it has proceeded. He has used in the manufacture three thousand five hundred bushels of potatoes. A fair sample of the sugar, or rather molasses, for no "crystallized" *pure* sugar could be obtained, is now sent to you.

The molasses forwarded by Mr. Guthrie is very rich, and apparently pure syrup, and has only a slight peculiarity of taste, a little like that of an oil, that could enable one to distinguish it from the best cane molasses. The syrup is nearly as rich as that from the sugar maple; and not improbably may yet afford crystallized sugar.

Gun Powder.

Mr. Guthrie has made gun powder on a *new* principle of his own invention; by which the danger of the manufacture is much diminished, the process greatly accelerated, and the constituents more intimately combined than has been done in any known process; hence, with good materials it is not unreasonable to expect important results. The sample forwarded is not yet received.

Pure Spirits or Oil of Turpentine.

Mr. Guthrie writes, date May 8, 1831.—One year ago, I discovered a process, by which much resin was abstracted from oil of turpentine after it had been "*redistilled from water.*" The oil of turpentine I send you is pure, or nearly so, and is, as I think, an article of considerable importance. It dissolves singly, caoutchouc, and the solution dries rapidly, and does not continue sticky like the solution made with common oil of turpentine. Mixed with alcohol, it burns in a lamp without leaving small *resinous* points upon the wick, or causing those scintillations, observable in the flame when common oil of turpentine is used. These two peculiarities give fine tests of the purity of the article; but an infallible test of absolute purity is furnished by dilute sulphuric acid, (equal weights of acid and water.) Should there remain any impurity in the oil of turpentine, by agitating the oil with acid, the resin will be charred, and thus discolor the acid. If the sample be pure, no discoloration should follow, although the oil should remain on the acid for some time. Generally oil of turpentine purified by distillation, from water, on being agitated with dilute sulphuric acid, give to the acid in a short time a beautiful claret colored tint.

The spirits of turpentine, forwarded by Mr. Guthrie, answers correctly to his description and must be valuable in several arts. Probably it would be useful in removing oil paints from clothes; the common spirits of turpentine often leave a stain, owing to the resin which they hold in solution.

Preference of Caustic Potassa over the Carbonate in forming Chlorate of Potassa.

In making chlorate of potassa, says Mr. Guthrie, I estimate the product by the quantity of sulphuric acid necessary to obtain one pound of crystals. With ten pounds of acid, I obtain, with caustic potassa, one pound of crystals; by using carbonate of potassa, I should require seventeen pounds of acid to produce the same quantity.

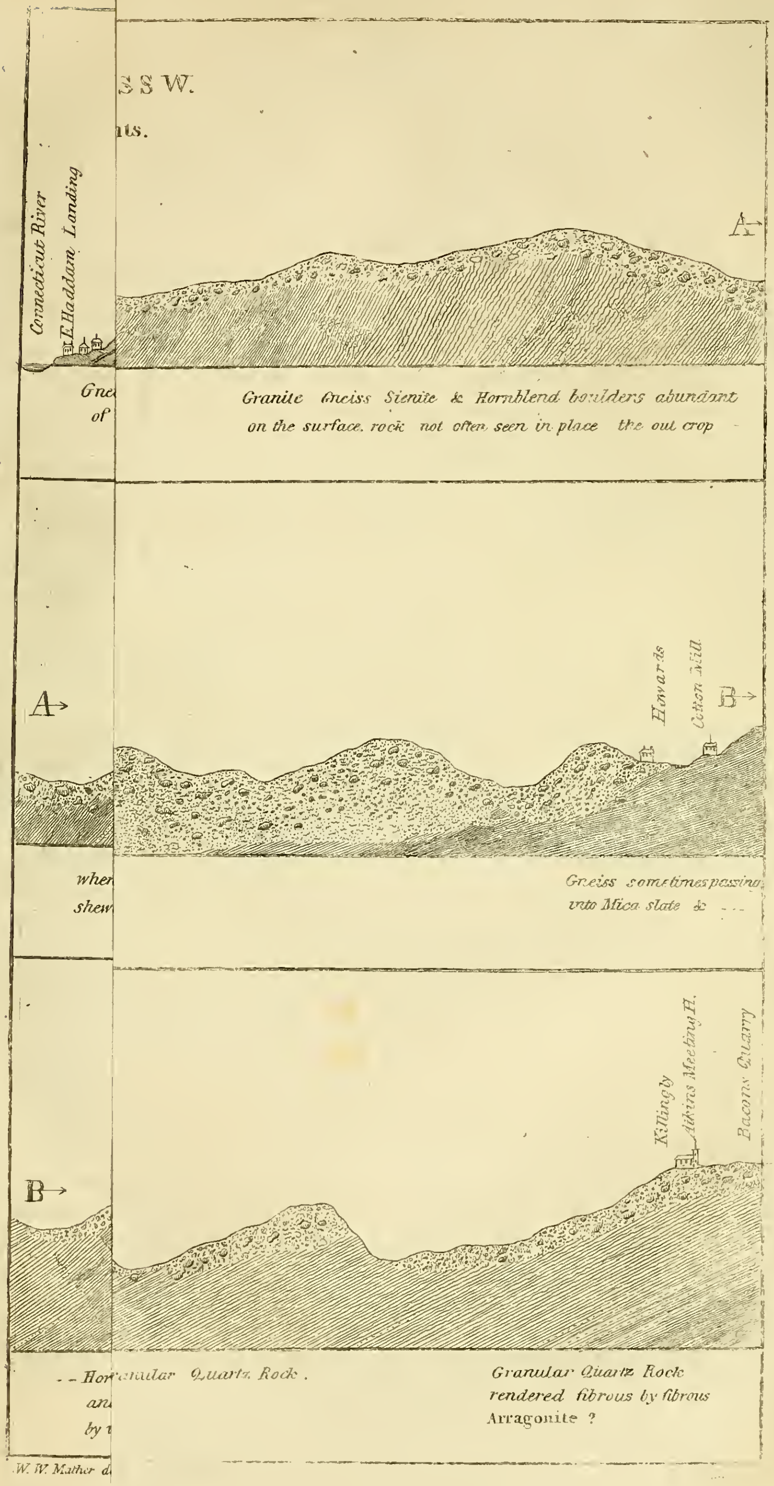
The above notices, as matters of fact, will probable be interesting to the chemical public of this country. Mr. Guthrie promises to make more detailed communications hereafter.

Art. XII.—*Geological Notices; by* Lieut. W. W. Mather, of the Military Academy at West Point.

1. *Illustrations* of a Section through a part of Connecticut, from Killingly to Haddam on Connecticut River.* (See the Section annexed.)

The granular feldspar rock, of the accompanying section, was first seen in place at Tyler's and Bolles' quarries, several miles north of the section; but it crosses the section about one and a half miles west

* From a paper communicated to the American Geological Society, by Lt. Mather, with a collection of specimens.


S S W.
nts.
Connecticut River
E Haddam Landing
A→
Gne
of
Granite Gneiss Sienite & Hornblend boulders abundant
on the surface. rock not often seen in place the out crop -
A→
Howards
Cotton Mill
B→
wher
shew
Gneiss sometimes passing
into Mica slate & ...
B→
Killingly
Aikins Meeting H.
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an
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Granular Quartz Rock
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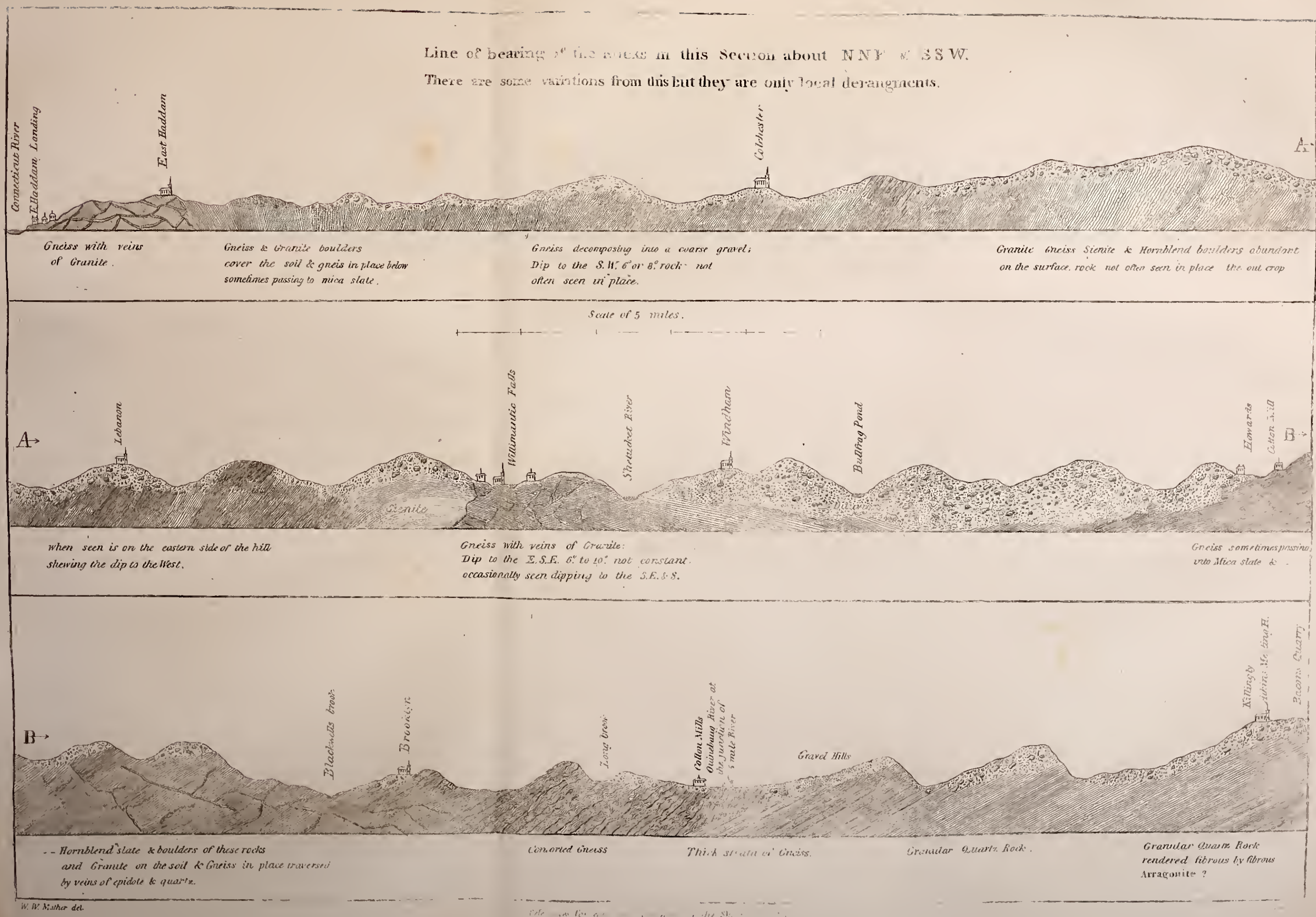


There are some variations from this but they are only local derangements.
Connecticut River
E. Haddam Landing
East Haddam
Colchester
A
Gneiss with veins of Granite.
Gneiss & Granite boulders cover the soil & gneis in place below sometimes passing to mica slate.
Gneiss decomposing into a coarse gravel; Dip to the S.W. 6° or 8° rock not often seen in place.
Granite Gneiss Sienite & Hornblend boulders abundant on the surface, rock not often seen in place the out crop
Scale of 5 miles.
A
Lebanon
Willimantic Falls
Shetucket River
Windham
Bullfrog Pond
Howards
Cotton Mill
B
Sienite
when seen is on the eastern side of the hill shewing the dip to the West.
Gneiss with veins of Granite: Dip to the E.S.E. 6° to 10° not constant. occasionally seen dipping to the S.E. & S.
Gneiss sometimes passing into Mica slate &c.
B
Blackwells brook
Brooklyn
Long brook
Cotton Mills
Quinebaug River at the junction of 5 mile River
Gravel Hills
Killingly
Bacons Quarry
Hornblend slate & boulders of these rocks and Granite on the soil & Gneiss in place traversed by veins of epidote & quartz.
Contorted Gneiss
Thick strata of Gneiss.
Granular Quartz Rock.
Granular Quartz Rock rendered fibrous by fibrous Arragonite ?
W. W. Mather del.

of Day's meeting-house in Killingly. The stone is used, to a considerable extent as a flagging stone, and nothing but its distance from a water communication, prevents a much more extensive use of it, for this purpose. It splits out in layers from an inch to a foot in thickness, and of almost any size that may be desired. It is very rare, that slabs containing one hundred square feet, do not exhibit to the eye, a perfectly plane surface. It dips about 15° to the north of west, and crops out wherever it is visible in place on the east side of the hills. The stratum, as seen at the quarries, has a thickness of at least three hundred feet, and probably much more. I was not able to find its junction with other rocks, which is concealed by diluvion. There are occasional thin partings of mica slate, in the stratum. About four miles from the quarries, this feldspar rock passes into well characterized kaolin. Some of the specimens shew the progressive changes from feldspar rock (petuntzè), to porcelain clay. At this locality, however, the clay does not seem to exist in sufficient quantity, to make it worthy of an exploration; but there are probably other beds in the range, that may perhaps be rendered available.

The granular quartz rock, with fibrous arragonite, is the stratum to the east of the latter. My attention was first drawn to it, by seeing it used in the towns around for hearth and jamb stones. It has not been regularly quarried, until within a few years. I am not positive that this constitutes more than a mere bed, as I did not trace it for more than half a mile. The dip and line of bearing of this stratum, as well as all to the west of it, for thirteen or fourteen miles, are about from 10° to 15° degrees to the W. N. W. for the former, and N. N. E. and S. S. W. for the latter.

The gneiss in thick strata, may perhaps with more propriety be called granite, as the same stratum a few miles north, (at Atkins's meeting-house in Killingly,) passes into well characterized granite.

A ridge of contorted gneiss, extends some miles north and south of the line of section, between Killingly and Brooklyn, and it continues to shew itself in place occasionally, so as to present a breadth of about two miles. The cliffs shew it on the large scale, but small masses not unfrequently shew it in a remarkably distinct manner. The zigzag and curve lines, pass in every direction, and the idea naturally occurs, that when in a soft state, the masses had been forced against, and bent and penetrated each other, in every direction.

Between this and the preceding stratum, much of the gneiss is porphyritic. In Brooklyn, the gneiss sometimes almost passes into hornblende slate, and is traversed in every direction by thin veins of epidote, generally accompanied by micaceous iron ore, in small quantity and sometimes also by sphene. Small beds of steatite, are sometimes found, and the surface has abundance of boulders of granite, and gneiss, scattered over it. The character of the rocks continues nearly the same to Willimantic falls, in Windham, except, that occasionally, the gneiss passes into mica slate. About four miles west of Brooklyn, the dip is barely sensible to the eye, but in the same direction as before; at Willimantic falls, the dip is in the reverse direction, viz. to the E. S. E. although it is not perfectly constant in its direction, for it is occasionally seen dipping to the E. S. E. and S. generally about 6° or 7°. Here the gneiss is traversed in every direction by veins of granite, in which the feldspar is frequently replaced by albite. The Clevelandite generally constitutes the mass of the veins. Phosphate of lime, and garnets, are found in these veins. A fine view of the strata can here be obtained on the river banks, and where the rock has been quarried, for building six or seven cotton mills, with the dwelling houses, and other necessary buildings.

In passing from Windham to Lebanon, the rock is not seen in place on the south road, but on the north one, soon after crossing Shetucket river, you see it often in place for several miles.

On the south road and for several miles to the south of it, the scattered debris are seen of the sienitic and hornblende rocks that form the ridges between Shetucket river and Lebanon. A mile or two west of Lebanon, the sienitic and hornblende rocks, pass into gneiss, and this rock continues with occasional passages into mica slate, to Connecticut river, at East Haddam. The dip is generally a little to the west of north, from the ridge west of Shetucket river, but is somewhat variable as to its quantity, generally not exceeding 20° until we approach the western part of East Haddam, where it approaches a vertical position.

To the west of Colchester, the gneiss is disintegrating into a stratified gravel, forming gravel hills, in some of which, the rock may be observed in its different stages of decomposition.

Passing from Millington, to the north society in Lyme, a beautiful section of the gneiss rock is seen. The strata dip uniformly about 10° to the N. of W. and are seen sometimes two or three hundred feet above the observer.

On the road from Colchester to East Haddam, near the Baptist church in the latter township, powerful veins of granite are observed traversing the strata of gneiss, and this character continues to be observed as far as into Old Haddam, on the west bank of Connecticut river, and south to Ely's ferry, opposite Essex, or Pettipaug. The granite is found here, not only in veins, but also in beds, as they appear to be, between the strata of gneiss, and in many places, the beds and veins appear to be contemporaneous. This granite contains some of our finest minerals, as the emerald, beryl, chrysoberyl, black tourmalines, terminated at both extremities, columbite, garnets, Clevelandite, and many others.

It is in the region traversed by these granite veins, that what are called "Moodus noises," that have figured in the history of Connecticut, have been, and still continue to be heard. They are called thus, from their having been first observed on the Moodus river, where they are still heard more distinctly than in other places. The inhabitants describe them as resembling the sound of a heavy log or timber falling upon the ground, and it is said that fissures of considerable extent, are often found on the surface of the ground, after hearing these noises. If any relation exists between the Moodus noises, the fissures and granite veins, it remains to be determined.

2. *Notices of the Geology of the Highlands of New York.*

Gneiss, sienite, gneissoid-hornblende, and granite constitute the principal masses of the Highlands. The gneiss sometimes passes into mica slate, and the sienite into gneissoid-hornblende.

Prof. Eaton mentions granite, gneiss, mica slate, and hornblende rock, as occurring at and in the vicinity of West Point, where they may be seen to advantage in place,* and he asks the question, "is granite to be found in New England, or in New York, other than in veins, or alternating layers (possibly beds) embraced in other primitive rocks?" I can answer, that so far as my observation has gone, I have not seen granite in the *Highlands* in place, except as beds and veins in other rocks. The granite in beds is frequently thirty feet in thickness, is of a coarse grain, with a base of red feldspar, and often contains adularia. The granite in veins, is generally of a much finer texture than that in beds, and rarely contains the red feldspar. There seems to be no regularity in the direction of the veins, but

* Geological and Agricultural Survey, pp. 28 and 29; Geological Nomenclature, pp. 20 and 21.

perhaps a majority of them intersect the strata, nearly at right angles. The dip of the strata is very variable. In many places the strata are nearly, or quite vertical, and in some others they approach the horizontal, and vary indefinitely between these limits, and in some localities they are bent or contorted so as in a short distance to assume every possible variety of dip. The general line of bearing of the strata, corresponds with the direction of the chain of mountains, which is about N. N. E. and S. S. W. Augite, serpentine, the primitive lime-stones, magnetic oxide of iron, and various mixtures of these with each other, and with other minerals, constitute almost innumerable beds, of small extent, scattered through the Highlands, in every direction, without any regularity in their disposition. Nearly all the varieties of pyroxene are found in our augite rocks. Silicious lime-stone occurs in but one locality, in place, in the Highlands, but is scattered in bowlders and gravel in every direction through them.

Pyrophyllite, (as it has been recently called in the scientific journals) occurs near West Point in a vein, a foot in width, traversing gray augite. A fragment of it, one eighth of an inch in thickness, exfoliates by heat to such a degree as to become an inch thick.

A conglomerate rock is now in process of formation, about one mile N. N. W. of West Point, and on the shore of the Hudson, a fine section of it is visible. The cliff rises nearly vertically from the shore from twenty to forty feet, and is composed of fragmentary matter, varying in size, from fine gravel, to bowlders weighing several hundred pounds. These materials are passing into the state of a solid aggregate, by the continual deposition of calcareous matter between the fragments. The gravel above, as well as the aggregate itself, is composed mostly of pebbles and pieces of various sizes, of slate, lime-stone, hornstone, granite, sienite, &c. The lime-stone is continually undergoing solution by the infiltration of water, and a skeleton of hornstone, or of loose silicious matter, frequently containing the impressions of terebratulæ, and some other species of shells remain. The calcareous matter dissolved in the upper part of the bed, is mostly deposited, as is evident on inspection, in the lower portion of it, and in some places, ordinary specimens of dog-tooth spar, (chaux carbonatée Métastatique of Haüy) may be obtained, investing the pebbles.

Scapolite and sphene are uniformly associated with the augite rocks in this vicinity. Hornblende exists as a constituent part of the sienitic rocks, but it not unfrequently occurs forming distinct beds. The summits of several of the hills in this vicinity, are capped with this rock, which seems to resist the action of the weather, better than those with which it is associated.

Magnetic iron ore is found in the Highlands, in very numerous beds and veins, in gneiss, and sometimes in other rocks. Copper and iron pyrites generally accompany it, in small quantity, as well as augite, hornblende and its varieties, and some other minerals. Four of these ore beds, only, are wrought to much extent.

Magnetic iron sand covers the shore, three fourths of a mile north of Cold spring landing; but it may be seen almost any where in the Highlands, after a rain, by examining where the water has washed. In the red limestones of the Highlands, scapolite, hornblende, and phosphate of lime, are usually associated, and in the white ones we find brucite, and spinelle, or graphite, mica, and hornblende; and where serpentine is in connexion with the limestone, we usually find diallage, amianthus, diopside, and the coccolites, white, red and green.

With the augite rocks, we find fine glassy feldspar and adularia, with mica, sometimes in six sided prisms, scapolite, crystallized and massive, sphene, and copper and arsenical pyrites in small quantities. Blende and carbonate of zinc are occasionally found, in loose masses, but I have never seen them in place.

Sulphuret of molybdenum is found in small quantity, and wherever I have seen it in place, in the Highlands, its matrix is a milky quartz, forming beds or partings of small extent between the strata of gneiss.

Sulphurets of lead and silver, are said to have been found; but I have never seen them in place.

I have said nothing concerning the order of superposition, in the rocks in the Highlands, because I am not perfectly satisfied as to their relative position.

Art. XIII.—*On North American Spiders; by* N. M. Hentz, Principal of the Female Seminary at Covington, Kentucky, and late Professor of Modern Languages in the University of North Carolina.

Letter to the Editor.

Amherst College, August 22, 1831.

PROFESSOR SILLIMAN,

Sir—Some time since I addressed a request to Nicholas M. Hentz, Esq., then Professor of Modern Languages in the University of North Carolina, and now Principal of the Female Seminary in Covington, Kentucky; that he would furnish me with a list of the Araneïdes found in Massachusetts; as I wished, in the execution of a commission from the government, to obtain as complete a zoological catalogue for the State as was practicable. He not only complied with my request, but sent so full a view of North American spiders, with so many valuable notes, that I immediately requested and obtained permission to send the whole for insertion in your Journal. If your views of the value of this paper correspond with my own, I shall hope you will give it a place in the next number.

With much respect,

EDWARD HITCHCOCK.

ARANEÏDES, (Latreille.) *Aranea*, (Linnæus.)

				No. of species.
TETRAPNEUMONES.	8 eyes; 4 mammulæ, 2 very short; tooth of the mandibulæ (chélicères) articulated downward, ...		Oletera	2
	6 or 8 eyes; 6 mammulæ; tooth of the mandibulæ articulated laterally, . . .		Filistata?	1
			Dysdera	1
			Segestria?	1
DIPNEUMONES.	Araneïdes forming no silken habitation, wandering; legs, 4th pair longest; eyes 8, in two rows, never both bent downward; 6 mammulæ, 2 very long, ...		Herpyllus	8
	Araneïdes spinning webs, or wandering; never with *all* the following characters united, 4th pair of legs longest, eyes in two rows both bent upward, and 6 mammulæ of which 2 very long.	Araneïdes making a web, sedentary, ...	Clubiona	6
			Tegenaria	2
			Agelena	2
			Theridium	5
			Pholcus	1
			Linyphia	5
			Tetragnatha	2
			Epeïra	26
			Mimetus	1
		Araneïdes making no web for a constant residence, . .	Thomisus	8
			Sphasus	3
			Dolomedes	6
			Lycosa	11
			Attus	29
			Epiblemum	2
			Species not included in Attus	3
				125

OLETERA, (Walckenaer.) *Atypus*, (Latreille.)

Eyes 8, °8 ○ ○ 8°; 4th pair of legs longest. 2 species. A male was found at Round Hill, which is totally black. A female of another species was found in North Carolina. It is of a glossy brown, except the abdomen, which is piceous. The palpi are so elongated as to have all the appearance of legs.

Filistata? (Latr.)

Eyes 8, nearly equal in size,  ; legs 1. 4. 2. 3. lingua surrounded by the maxillæ, which are bent and pointed at their apex. The mandibulæ (chélicerès) are united together, so as to have no reciprocal motion, except by means of their teeth, which are very short. This is a remarkable character, which induces me to believe this may not belong to Filistata, and in that case must be the type of a new genus. These spiders form white silk tubes, in walls and crevices of rocks; the orifices of those tubes are spread and closely fixed on the edges of the stones which make their abodes. I kept several alive under glass, and witnessed the reproduction of their legs. The part torn off does not grow gradually; but when the spider casts its skin, that part comes out with all its joints from the skin, only somewhat shorter than it was before. It is important to observe that, owing to this fact, the character derived from the respective lengths of the legs, is often deceptive, as spiders in their conflicts often lose their legs, and frequently offer the characters of two different genera on that account. It is therefore necessary to compare many specimens and the two sides of the spider; but that excellent character ought not to be given up. One species.

Dysdera, (Latr. Walck.)

Eyes 6,  ; legs 1. 2. 4. 3. lingua truncated. One species. A male and a female were sent to me by Dr. T. W. Harris, one of the most accurate and indefatigable entomologists in this country, who found them in a cavity under ground.

Segestria? (Latr.)

Eyes 6,  ; legs 1. 2. 4. 3. lingua longer than broad; maxillæ elongated, narrower above. One species, which is found under the bark of trees in silk tubes. I marked this with a point of interrogation, because Latreille in his last work* excludes this from his

* Familles Naturelles du règne animal. Paris, 1825. 1 Vol. 8vo.

Tetrapneumones. But the affinity to Dysdera is such that I think they ought not to be separated. And the next genus which I have established seems to me to be the link that unites the preceding to the Dipneumones and goes better after Segestria than before, in a natural arrangement.

Herpyllus, (Mihi.)

Eyes 8, ∘∘∘∘ ∘∘∘∘ *or* ∘∘∘∘ ∘∘∘∘ ; two rows, one or both curved upward; legs 4. 1. 2. 3. rather stout and short; lingua large, short, nearly triangular or slightly truncated; maxillæ straight, wider near the apex, not sensibly serrated, tooth moderately long; cephalothorax ellipsoid, gradually narrowed before, abdomen nearly of the same form. Making no web or tube for their dwellings, but wandering for prey, and running with great velocity. Eight species. I have never found their cocoon. The great affinity between this genus and Tegenaria and some Clubionæ requires that it should be placed here. This *may* belong to the *Diplotoxops* of Mr. Rafinesque; but as he makes the first pair of legs longest, and as his generic description is vague and incorrect in many respects, for instance, in its having a character derived from the palpi which he may not know is a mere sexual distinction, I could not and ought not adopt his name. Several species are common in the United States, particularly a small black one, found under stones in high ways; and a blackish one with a white band on the cephalothorax, a band on the abdomen, beginning at base and reaching the middle, and a spot near the apex white. This one attains a great size, and is found in houses, under stones, planks, the bark of decaying trees, &c. I call it *H. ecclesiasticus*, and the former *H. ater*.

Clubiona, (Latr.)

Eyes 8, in two rows curved variously; legs 1. 4. 2. 3. or 4. 2. 1. 3. or 4. 1. 2. 3. lingua truncated. Araneïdes forming silk tubes in leaves which they twist, or under the bark of trees. Six species. Most species fly about in the air, by means of a long thread, at the end of which they suspend themselves, and which is borne by the wind, sometimes raising them to a great height.

Tegenaria, (Walck.) *Aranea*, (Latr.)

Eyes 8, ∘∘ ∘∘ ∘∘ ∘∘ ; legs 4. 1. 2. 3. Making in houses, cellars and other dark places the common webs, which are spread horizontally, and have a tube, usually concealed in a hole or crevice, for the reception of the spider. This is the common house spider, the web of which is narcotic and has been administered internally in some cases of fever with success. It is also effectual in stopping the blood of cuts and slight wounds. Two species only are known to me.

AGELENA, (Walck.) *Aranea*, (Latr.)

Eyes 8, ooooooo ; legs 4. 1. 2. 3. Making in the fields, webs which are spread horizontally and at the upper part of which is a tube for the retreat of the spider. Two species. Differs from the preceding only in the arrangement of the eyes, and in its preferring the open air to dark retreats.

THERIDIUM, (Walck.)

Eyes 8, oooooooo *or* oooooooo ; legs 1. 4. 2. 3. lingua short; maxillæ elongated, inclined over the lingua. Making a web formed of threads crossed irregularly in every direction. Five species. One of them, THERIDIUM *verecundum*, (my catalogue,) is entirely glossy black, except two crimson spots under the abdomen, the last of which is sometimes continued on the back in the form of a band. It is common in the Southern States, and is well known, as the people there believe its bite is very poisonous. That spiders are all supplied with a poisonous fluid conveyed in their fangs, there can be no doubt; but I cannot assert that this is more dangerous than another, for persons who do not study Natural History, are apt to confound objects of a different nature. A respectable physician, however, pointed out this species to me as the one, and told me that in every instance he could arrest the violent symptoms arising from its bite, by inducing a reaction in the system, and frequently had produced instant relief with a glass of brandy. Most species of this genus are the common prey of the several species of SPHEX called *dirt-daubers* in the South, on account of their making clay nests, in which they enclose with their progeny from twenty to thirty spiders, which serve as food to the young larvæ.

PHOLCUS, (Walck.)

Eyes 8, oooooooo ; legs very long and slender, 1. 2. 4. 3. lingua short, triangular; maxillæ long, inclined over the lingua. Making a loose web. One species. Inhabiting the ceilings of houses. I seldom met with it at a distance from the Atlantic coast.

Linyphia, (Latr.)

Eyes 8, ; legs 1. 2. 4. 3. lingua, short triangular; maxillæ short, wider above. Making a horizontal web on bushes with another one, surrounding it above and below, constructed of threads crossed in every direction, as that of Theridium. The spider holds itself downward, under the horizontal web. Five species, all small.

Tetragnatha, (Latr.)

Eyes 8, in two rows nearly parallel; legs very long and slender, 1. 2. 4. 3. lingua short, rounded; maxillæ and mandibulæ very long. Making a spiral web with concentric threads. Two species, inhabiting the vicinity of water. The form of one of the species is rendered horrible, by the size of its mandibulæ which are longer than the cephalothorax, and armed with numerous prongs, and with fangs which are nearly as long, so that the jaws nearly equal in length the rest of the body. The males are better and more stoutly armed than the females.

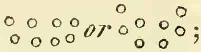
Epeïra, (Walck.)

Eyes 8, ; legs 1. 2. 4. 3. lingua short, rounded; maxillæ short, rounded. Making a spiral web with concentric threads. Twenty six species. These spiders are known to every body. They are seen towards night busily engaged in making their admirably contrived webs, in the middle of which they wait for their prey during the night, but usually take shelter during the day under some leaf or crevice, furnished with a tent made of loose threads. The endless variety of forms and habits, of the species of this genus, have given rise to natural subdivisions, which are useful, as the number of species is very great. Many have thorns, tubercles and various projections, which give them a fantastic appearance. The form of their cocoons also varies much. Some attach them to their web in a string.

Mimetus, (Mihi.)

Eyes 8, ; legs long, slender, 1. 2. 4. 3. lingua short, triangular; maxillæ long, slender, pointed at tip, inclined over the lingua; mandibulæ very long and slender. Making a double web, like that of Theridium and that of Epeïra connected. The spiral regular web is attached behind by innumerable threads to the irregular one, in the upper part of which a tent is constructed with dried leaves, under which the spider takes shelter in the day time. One species, M. *Syllepsicus* (my catalogue) of a pale green color varied with black on the cephalothorax and abdomen, tips of the four anterior thighs with a black ring, feet very hairy; inhabiting damp woods. The legs and the eyes correspond with Epeïra, but the trophi, except the mandibulæ are those of Theridium; and the web and habits participate of both. The long and slender mandibulæ are peculiar to this. The cocoons resemble a plano-convex lens, are of a pale brown color, and are attached in the middle, one above another, in the tent which the spider inhabits. It is evident that in a perfectly natural arrangement, Theridium should be placed near Epeïra, and this genus between the two. There is a true Epeïra, E. *Labyrinthea*, (my catalogue) which is found in the same locality and which makes a web of the same kind; and I at first suspected that this was a Theridium which had taken possession of the web of that Epeïra, but, besides the character from the legs which does not belong to Theridium, the difference in the cocoons settled my doubts. The cocoons of the Epeïra above mentioned are nearly conical; of an obscure color above, whitish blue beneath; they are hung in a string above the tent. The resemblance of habits in these two species, shows however the close affinity between the two genera and this.

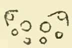
Thomisus, (Walck.)

Eyes 8, generally in two rows bent downward, ; legs variable, but the second generally the longest; lingua contracted at base, wider towards the middle; maxillæ inclined over the lingua. Making no web, but wandering after their prey on flowers, rails, trees, &c. Eight species. This genus, embracing very different species, is not natural. It should include only the Heteropodæ of *Walck.*, which have the two anterior pair of legs sensibly longer than the others. The other species ought to constitute other subdivisions.

Sphasus, (Walck.) Oxyopes, (Latr.)

Eyes 8, unequal in size, ; legs 1. 2. 4. 3. lingua long, rounded at its apex; maxillæ long, narrower at tip. Making no web, except when the female makes her cocoon. Three species. Nothing is known as yet in Europe about the habits of the spiders of this genus, and therefore I will state my observations. There is much similarity between them and the subdivision Sylvaria (Walck.) of Dolomedes, in point of manners and habitus. The three species of Sphasus, known to me, wander in quest of prey about the trunks of small trees or upright sticks, move with great rapidity, and when at rest, spread their feet like many species of Thomisus. On the first of September, a large female was brought to me in a glass vessel. I call it Sphasus *viridans*. It is of a pale grass color, with the disk of the abdomen yellowish, except an oblong longitudinal line in the middle, which has a double row of three or four oval oblique yellow spots, separated by a longitudinal blackish line; feet pale with yellow joints. Length 0.81 of an inch. It was impregnated and with eggs. After a few days, it made a web of very strong threads, like that of Theridium, in the middle of which was placed its cocoon, which is perfectly conical, made with great exactness, and is supplied around with little mammulæ from which depart the threads which bind it to the web. The mother watched it constantly, and never left it as long as she lived. The young were hatched on the 14th of October and continued together for many weeks during the winter, but gradually died; they were of a deep orange color and full 0.9 of an inch in length. The mother had previously been destroyed by an accident, which I regretted very much, for I have some reasons to think that the young are carried on the back of the mother as in Lycosa, and wished to have ascertained that fact.

Dolomedes, (Latr.)

Eyes 8, unequal in size,  *or* ; legs 4. 2. 1. 3. wandering near streams or ponds, often hiding under the surface of the water, or rambling on trees. Six species. Dr. T. W. Harris sent me a species, the female of which constructs a web not unlike that of Tegenaria; but that retreat is limited to one sex, and probably used only to protect the cocoon, until the young are hatched, and able to go abroad.

Lycosa, (Latr.)

Eyes 8, unequal in size, ; legs 4. 1. 2. 3. wandering about in quest of prey, found under stones, in holes, &c. bearing their cocoons attached to their anus, and carrying their young on their back. Eleven species, known to me. Dr. Charles Pickering, of Salem, Mass. presented me with a collection of Araneïdes, in which were six or perhaps seven new species from New England, but which are too much dried up to be well delineated or described. That single fact shows how far this is from being a complete list of North American Spiders. The famous TARANTULA of the South of Europe, the bite of which, for many years, was supposed to produce a disease that music alone could cure, belongs to this genus; and I found on Round Hill, Mass. a species (LYCOSA *fatifera*, my catalogue) which is probably very closely related to the European species, and which dwells in holes, nearly a foot deep. These holes seem to be dug by the spider, and to be increased gradually, as its size may require; the opening has a ring of filaments woven by the spider to prevent the filling up of the cavity by rain. It is in this genus also that we may witness astonishing instances of maternal tenderness and courage; and that too in the most cruel race of animals, a race in which ferocity renders even the approach of the sexes a perilous act, and condemns every individual to perpetual solitude, and apprehensions of its own kind. When a mother is found with the cocoon containing its progeny, if this be forcibly torn from her, she turns round and grasps it with her mandibulæ. All her limbs, one by one, may then be torn from her body without forcing her to abandon her hold. But if, without mangling the mother, the cocoon be skillfully removed from her, and suddenly thrown out of sight, she instantaneously loses all her activity, seems paralysed, and coils her tremulous limbs as if mortally wounded; if the bag be returned, her ferocity and strength are restored the moment she has any perception of its presence, and she rushes to her treasure, to defend it to the last.

ATTUS, (Walck.) *Salticus*, (Latr.)

Eyes 8, unequal in size,  ; legs usually short and proper for leaping, of different sizes; maxillæ erect, rounded. Wandering in quest of prey, and leaping. Making no web, but tubes of silk for shelter, in crevices, under bark, &c. Twenty nine species. The numerous species of this genus display skill and varied stratagems to seize their prey, which must be interesting to an observer of nature. I have preserved the name of ATTUS because the name ATTA previously given by Fabricius to a subdivision of FORMICA could not be mistaken for this, any more than the Romans would *casus* for *casa*, and a thousand such words.

EPIBLEMUM, (Mihi.)

Eyes 8, somewhat unequal in size, °· ·° ° o o ° ; legs 1. 4. 3. 2. or 1. 4. 2. 3; lingua short, triangular; maxillæ somewhat pointed above, and a little inclined over the lingua; mandibulæ nearly horizontal, slender, as long as the cephalothorax, tooth as long. Two species. These might be left with ATTUS, to which they are closely related, but as that genus is large, it needs divisions, and the mandibulæ of these offer a peculiar and striking character, I have concluded to make the first of the two following species the type of a new genus. EPIBLEMUM *faustum* obscure, cephalothorax edged with white, with two spots on the disk also white; abdomen edged at base, and with four short bands, white. E. *Palmarum*, deep ferruginous, with two bands on the cephalothorax and the abdomen, white; second, third and fourth pair of legs whitish.

Beside these, I have three species of ATTUS, all very small, which have the habitus of FORMICA; so much like ants in many respects, that for a long time, I neglected to collect them on that account. Their body is elongated, slender, nodose; and their legs also are slender, either 4. 3. 1. 2. or 4. 1. 2. 3. The cephalothorax in one, and the abdomen in all, are contracted in the middle, so as to give them the appearance of being divided in three or four joints. The other characters, coincide generally with ATTUS. They are found on plants. Should it be thought convenient, those and any other new species with those characters, might be collected under the generic name of SYNEMOSYNA.

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It will be observed, that, in the above arrangement, I have departed from that of Latreille in no essential point, but justice requires us to notice, that after the labors of the greatest living entomologist, the method of Walckenaer, may still be considered as somewhat more natural than that of Latreille. I have given a sufficient account of the American genera, known to me, to allow any person whose taste may lead him to study this branch, to pursue the subject to a certain extent, and to assist in bringing my Monographia to a less imperfect state, than that in which it now is. It is evident to me that if I had correspondents in the various states of this Union, who would be willing to send me specimens, I could double my collection in a few years. Some persons have been kind enough to send me several interesting species, particularly Dr. Harris of Milton, and Dr. C.

Pickering of Philadelphia, to whom I am much indebted; but, when stuck through with a pin, and dried as other insects, these become so shriveled as to make it sometimes impossible to recognize them, and always so to describe new species. Spiders should be preserved in diluted alcohol, or brandy, in which they preserve their form, though their colors are usually impaired in it.

The number of 125 species will appear very large, but I could have swelled the list to 150. Spiders differ from true insects, or at least *winged* insects, in their *growing*. They come out from their eggs very minute, and continue to increase in size, probably for several years in many species; whereas, with few exceptions, insects come out of their *pupa* state, at once, with the size which is peculiar to them. The ARANEÏDES, in their different ages, present differences of color and marking. The *seasons* also produce a change in the colors of some spiders; and, I am nearly convinced that the first frosts produce a total change in the dress of several described EPEÏRÆ which may be referred to one name. These are the considerations which have induced me to be very cautious in adopting new species, and comparing many specimens in different seasons, when possible, before I described them.

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APPENDIX.—EDITOR.

Juvenile Observations of President Edwards on Spiders.

Ever since the following article on spiders, appeared in the late* edition of the works of President Edwards, with a memoir of his life, I have intended to republish the following extract, and it seems to follow naturally in the train of the learned monograph of Professor Hentz. Without pretending at present, to discuss the merits of the theory of Edwards, the observations recorded by him present a very curious and interesting proof of philosophic attention, *in a boy of twelve years*, and evince, that the rudiments of his great mind were, even at that immature age, more than beginning to be developed. The first volume of his works, contains many other very curious and interesting speculations and observations on different subjects of physical science; on meteorology—on electricity—on crystallization—on geology—on chemistry—on an atomic theory, &c. They present indubitable evidence of that acuteness, vigor, precision and penetrating sagacity, which, had he devoted himself to physical

* 1829—S. Converse, New York, 10 Vols. 8vo.

science, might have added another Newton to the extraordinary age in which he commenced his career; for his star was just rising as Newton's was going down. The paper on spiders, appears to have been written in 1715.

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One characteristic, remarks his biographer, of which he has not generally been suspected, but which he possessed in an unusual degree, was a fondness, minutely and critically to investigate the works of nature. This propensity was not only discovered in youth and manhood, but was fully developed in childhood, and at that early period was encouraged and cherished by the fostering hand of parental care. This will be obvious from the two subsequent productions of his pen, which were written on the following occasion. His father had some correspondent of distinction, to whom in the course of his letters, he had given an account, of an interesting natural curiosity. This gentleman, who probably resided in England,* in the postscript of his reply expressed a desire, that he would favor him with any other information that he might possess of a similar kind. The son had not long before been busily engaged in observing, with deep interest and with a philosophic eye, the wonderful movements and singular skill of that species of Spider which inhabits the forest; and having written down his own observations, had doubtless read them in the hearing of the family. The father, gratified with this discovery of his son's talents and power of observation, and pleased with this early effort of his pen, encouraged him to turn it into the form of a letter, and to send it to his correspondent, in his own name, with an apology of his own. The apology and the account, which are copied from his own rough draught of both, in his earliest hand, after he had corrected the language of each with very great care, are contained in the two following letters; both of which, as left in the rough draught, are without the date and the name of the correspondent, and the latter, though in the form of a letter, has not the customary form of conclusion.

"*May it please your Honor*,—In the postscript of your letter to my father, you manifested a willingness to receive any thing else that he has observed worthy of remark, respecting the wonders of nature. What there is an account of in the following lines, is by him thought

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* No trace of the name or residence of the correspondent is preserved in the papers; but from the care taken by the son to inform him that the sea lay on the east of New England, he probably did not reside in this, but in the mother country.

to be such. He has laid it upon me to write the account, I having had advantage to make more full observations than himself. Forgive me that I do not conceal my name, and communicate this to you through a mediator. I do not state it as an hypothesis, but as a plain fact, which my own eyes have witnessed, and which every one's senses may make him as certain of as of any thing else. Although these things appear to me thus certain, still I submit the whole to your better judgment and deeper insight. And I humbly beg to be pardoned for running the venture, though an utter stranger, of troubling you with so prolix an account of that, which I am altogether uncertain, whether you will esteem worthy of the time and pains of reading. If you think the observations childish, and beside the rules of decorum,—with greatness and goodness overlook it in a child. Pardon me, if I thought it might at least give you occasion to make better observations, such as should be worthy of communicating to the learned world, respecting these wondrous animals, from whose glistening web so much of the wisdom of the Creator shines.

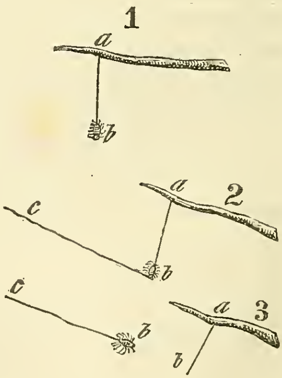
"I am, Sir, your most obedient, humble servant.

"JONATHAN EDWARDS."

"*May it please your Honor*,—There are some things I have happily seen of the wondrous way of the working of the spider. Although every thing belonging to this insect is admirable, there are some phenomena relating to them more particularly wonderful. Every body that is used to the country, knows their marching in the air from one tree to another, sometimes at the distance of five or six rods. Nor can one go out in a dewy morning, at the latter end of August and the beginning of September, but he shall see multitudes of webs, made visible by the dew that hangs on them, reaching from one tree, branch and shrub, to another: which webs are commonly thought to be made in the night, because they appear only in the morning; whereas none of them are made in the night, for these spiders never come out in the night when it is dark, as the dew is then falling. But these webs may be seen well enough in the day time by an observing eye, by their reflection in the sun-beams. Especially late in the afternoon, may these webs, that are between the eye and that part of the horizon that is under the sun, be seen very plainly, being advantageously posited to reflect the rays. And the spiders themselves may be very often seen travelling in the air, from one stage to another amongst the trees, in a very unaccountable manner. But I have often seen that, which is much more astonishing.

In very calm and serene days in the forementioned time of year, standing at some distance behind the end of a house or some other opake body, so as just to hide the disk of the sun and keep off his dazzling rays, and looking along close by the side of it, I have seen a vast multitude of little shining webs, and glistening strings, brightly reflecting the sunbeams, and some of them of great length, and of such a height that one would think they were tacked to the vault of the heavens, and would be burnt like tow in the sun, and make a very beautiful, pleasing, as well as surprising appearance. It is wonderful at what a distance, these webs may plainly be seen. Some that are at a great distance appear (it cannot be less than) several thousand times as big as they ought. I believe they appear under as great an angle, as a body of a foot diameter ought to do at such a distance; so greatly doth brightness increase the apparent bigness of bodies at a distance, as is observed of the fixed stars.

"But that which is most astonishing, is, that very often appear at the end of these webs, spiders sailing in the air with them; which I have often beheld with wonderment and pleasure, and showed to others. And since I have seen these things, I have been very conversant with spiders; resolving if possible, to find out the mysteries of these their astonishing works. And I have been so happy as very frequently to see their manner of working; that when a spider would go from one tree to another, or would fly in the air, he first lets himself down a little way from the twig he stands on by a web, as in Fig. 1; and then, laying hold of it by his fore feet, and bearing himself by that, puts out a web, as in Fig. 2, which is drawn out of his tail with infinite ease, in the gently moving air, to what length the spider pleases; and if the farther end happens to catch by a shrub or the branch of a tree, the spider immediately feels it, and fixes the hither end of it to the web by which he let himself down, and goes over by that web which he put out of his tail as in Fig. 3. And this, my eyes have innumerable times made me sure of.



"Now, Sir, it is certain that these webs, when they first proceed from the spider are so rare a substance, that they are lighter than the air, because they will ascend in it, as they will immediately in a calm air, and never descend except driven by a wind; wherefore 'tis certain. And 'tis as certain, that what swims and ascends in the air is lighter than the air, as that what ascends and swims in water is lighter than water. So that if we should suppose any such time, wherein the air is perfectly calm, this web is so easily drawn out of the spider's tail, that if the end of it be once out, barely the levity of it is sufficient to draw it out to any length; wherefore if it don't happen that the end of this web, *b c*, catches by a tree or some other body, 'till there is so long a web drawn out, that its levity shall be so great as more than to counterbalance the gravity of the spider, or so that the web and the spider, taken together, shall be lighter than such a quantity of air as takes up equal space, then according to the universally acknowledged laws of nature, the web and the spider together will ascend, and not descend, in the air: as when a man is at the bottom of the water, if he has hold of a piece of timber so great, that the wood's tendency upwards is greater than the man's tendency downwards, he together with the wood will ascend to the surface of the water. And therefore, when the spider perceives that the web *bc* is long enough to bear him up by its ascending force, he lets go his hold of the web *a b*, Fig. 3, and ascends in the air with the web *b c*. If there be not web more than enough, just to counterbalance the gravity of the spider, the spider together with the web will hang in equilibrio, neither ascending nor descending, otherwise than as the air moves. But if there is so much web, that its greater levity shall more than equal the greater density of the spider, they will ascend till the air is so thin, that the spider and web together are just of an equal weight with so much air. And in this way, Sir, I have multitudes of times seen spiders mount away into the air, from a stick in my hands, with a vast train of this silver web before them; for, if the spider be disturbed upon the stick by shaking of it, he will presently in this manner leave it. And their way of working may very distinctly be seen, if they are held up in the sun, or against a dark door, or any thing that is black.

"Now, Sir, the only remaining difficulty is, how they first put out the end of the web *b c*, Fig. 3, out of their tails. If once the web is out, it is easy to conceive how the levity of it, together with the motion of the air may draw it out to a great length. But how should they first let out of their tails, the end of so fine and even a string; seeing that the web, while it is in the spider, is a certain cloudy liquor, with which that great bottle tail of theirs is filled; which immediately, upon its being exposed to the air, turns to a dry substance, and exceedingly rarifies and extends itself. Now if it be a liquor, it is hard to conceive how they should let out a fine even thread, without expelling a little drop at the end of it; but none such can be discerned. But there is no need of this; for it is only separating that part of the web *b c*, Fig. 2, from *a b*, and the end of the web is already out. Indeed, Sir, I never could distinctly see them do this: so small a piece of web being imperceptible among the spider's legs. But I cannot doubt but that it is so, because there is a necessity that they should some way or other separate the web *a b*, Fig. 3, from their tails, before they can let out the web *b c*. And then I know they do have ways of dividing their webs by biting them off, or in some other way. Otherwise they could not separate themselves from the web *a b*, Fig. 3.

"And this, Sir, is the way of spiders going from one tree to another, at a great distance; and this is the way of their flying in the air. And, although I say I am certain of it, I don't desire that the truth of it should be received upon my word; though I could bring others to testify to it, to whom I have shown it, and who have looked on, with admiration, to see their manner of working. But every one's eyes, that will take the pains to observe, will make them as sure of it. Only those, that would make the experiment, must take notice that it is not every sort of spider that is a flying spider, for those spiders that keep in houses are a quite different sort, as also those that keep in the ground, and those that keep in swamps, in hollow trees, and rotten logs; but those spiders, that keep on branches of trees and shrubs, are the flying spiders. They delight most in walnut trees, and are that sort of spiders that make those curious network polygonal webs, that are so frequently to be seen in the latter end of the year. There are more of this sort of spiders by far than of any other.

"But yet, Sir, I am assured that the chief end of this faculty, that is given them, is not their recreation, but their destruction; because their destruction is unavoidably the effect of it; and we shall find nothing, that is the continual effect of nature, but what is of the means by which it is brought to pass. But it is impossible, but that the greatest part of the spiders upon the land should, every year, be swept into the ocean. For these spiders never fly, except the weather is fair and the atmosphere dry; but the atmosphere is never clear, neither in this nor any other continent, only when the wind blows from the midland parts, and consequently towards the sea. As here in New-England, the fair weather is only when the wind is westerly, the land being on that side, and the ocean on the easterly. And I never have seen any of these spiders flying, but when they have been hastening directly towards the sea. And the time of their flying being so long, even from about the middle of August every sunshiny day, until about the end of October; (though their chief time, as I observed before, is the latter end of August, and beginning of September;) and they never flying from the sea, but always towards it, must needs get there at last; for it is unreasonable to suppose that they have sense enough to stop themselves when they come near the sea; for then they would have hundreds of times as many spiders upon the sea-shore, as any where else.

"The same also holds true of other sorts of flying insects; for at these times, that I have viewed the spiders with their webs in the air, there has also appeared vast multitudes of flies, and all flying the same way with the spiders and webs directly to the ocean; and even such as butterflies, millers and moths, which keep in the grass at this time of year, I have seen vastly higher than the tops of the highest trees, all going the same way. These I have seen towards evening, without such a screen to defend my eyes from the sunbeams; which I used to think were seeking a warmer climate.

"The reason of their flying at that time of year, I take to be because then the ground and trees, the places of their residence in summer, begin to be chilly and uncomfortable. Therefore when the sun shines pretty warm they leave them, and mount up in the air, and expand their wings to the sun, and flying for nothing but their own ease and comfort, they suffer themselves to go that way, that they find that they can go with the greatest ease, and so where the wind pleases; and it being warmth they fly for, they find it cold and laborious flying against the wind. They therefore seem to use their wings, but just so much as to bear them up, and suffer them to go with the wind. So that without doubt almost all aerial insects, and also spiders which live upon trees and are made up of them, are at the end of the year swept away into the sea, and buried in the ocean, and leave nothing behind them but their eggs, for a new stock the next year."

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Miscellaneous Remarks and Citations.

The subject examined, so sagaciously, one hundred and sixteen years ago, by the philosophical child, remains nearly as he left it. Other and recent writers also adopt the hypothesis of the ascent of the thread of the flying spider, in consequence of the supposed inferior specific gravity of its web. It is however obvious that spiders' webs of all sorts are in fact specifically heavier than the atmosphere, and under given circumstances fall in that medium; of course they cannot, from mere inherent levity, rise in the air, and much less raise any weight attached to them. Upward currents in the atmosphere, when they exist, will it is true account for the ascent of the web, and it may perhaps ascend with sufficient power to elevate the spider. There is, however, under given circumstances, a remarkable constancy in the power exerted by this insect, in causing his own web to become buoyant, and often to such a degree that he mounts, sometimes, many hundred feet into the air, above the trees, and towers, and steeple tops, and he rides there with more security than an aëronaut in the car of a balloon; it seems scarcely probable that this upward tendency can arise entirely from currents, which, as we observe when feathers are afloat, carry light bodies very irregularly in every direction; a state of things that would be inconsistent with the economy and safety of the flying spiders. Perhaps the most plausible hypothesis, as to the cause of the ascent of the thread of the aëronautic spider, is that stated by Mr. John Murray:* he attributes it to electricity, and we cite the following statements from his work, as introductory to his conclusion, which we will presently cite, in his own words.

It appears that the ascent of the aëronautic spider is essential to its existence,† and the great numbers of these wingless insects sufficiently account for the abundance of the gossamer, and of the floating and fixed threads and tissues, that are so often seen. Sometimes large tracts of ground are covered with them; two thousand were once obtained in half an hour, and baskets full may be collected, as seen by Mr. White, Sept. 21, 1741: also, at Bewdley, in Worcestershire, Sept. 16, 1822, between 11 A.M. and 2 P.M., it was observed that the whole atmosphere seemed to be a tissue of cobwebs, falling rapidly; the temperature was 72° Fah. Some of the tissues

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* Researches in Natural History. Second edition. London: 1830.

† As it probably finds much of its food among the flying insects of the atmosphere.

were woolly films; but some of the separate filaments were from forty to fifty feet long. On the 19th of July, 1822, a *feu de joie*, fired at Kidderminster, in England, brought down immense numbers of the flying spiders.

They have the power of darting out their threads to a surprising distance and in any direction; one of them, by candle light, shot forth a thread of eight feet long to the ceiling of the room, and making an angle of about 80°, with the horizon. In another instance, during bright sun shine, in a warm day, while the spider was propelling threads to all points, it suddenly projected one horizontally, in the direction of the current* from an open door, to the distance of ten feet, and the angle of vision being particularly favorable, an *aura* or *electric atmosphere*, as was supposed, was observed about the thread.

"When swinging from a support, they will soon be perceived to ascend from the perpendicular into the horizontal plane, at each ascent projecting a thread into the atmosphere; and at length the insect breaks from its anchorage, and ascends. Sometimes aëronautic spiders will take their flight immediately from the surface on which they alight, if the day be warm and sultry: but they generally descend to from six to eighteen inches, perhaps the better to *insulate* themselves, and that, suspended by a pliant thread in free space, they may more freely propel their threads into the atmosphere. Not unfrequently the propulsion of a solitary thread will bear them aloft; but the air must then be very warm, the sunshine bright, and the electric character of the atmosphere considerable. Sometimes the ascent is so rapid that the eye cannot trace it; at other times slow and majestic. Occasionally the ascent is quite vertical, and at other times the insect sails on the bosom of the air, either in the horizontal plane, or at angles more or less open. It will be also found that there are *particular seasons* of the year best calculated for this singular exhibition: spring and autumn are these periods. In summer we have found it sometimes impracticable to determine their ascent: they have detached themselves, after several vibrations, and fallen to the ground. On one day, (May, 1823,) this remarkable fact was proved in the case of numbers. The insect seems to be sufficiently aware when the threads are buoyant, and perhaps the temporary suspension in the horizontal plane may communicate this information: aëronautic spiders make their appearance early in the season.

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* They sometimes project their threads directly in the teeth of the wind.

"Several circumstances concur to show the phenomenon of ascent to be *electric:* the propelled threads *do not* interfere with each other; they are divellent, and this divergence seems to proceed from their being imbued with similar electricity; and the *character* of that electricity appeared to us to be an interesting subject for subsequent research. When a conductor is brought near the thread by which it suspends itself, but, above all, to the flocculi or balls, they are considerably deflected from the perpendicular, and the horizontal fibre is attracted by the point: when a stick of excited sealing-wax was brought near the thread of suspension, it seemed to be *repelled;* consequently the electricity of the thread is *negative.* The descent of the thread is instantly determined by bringing over it the excited sealing-wax. On the 3d of July, 1822, at 4 P. M., thermometer 66° F., when two aëronautic spiders, on separate threads, were brought near to each other, a mutual repulsion supervened.

"In one experiment made, the ascent of the insect was so slow and tranquil, from the humidity of the lower atmosphere and wetness of the terrestrial surface, that I could easily catch it by following its progress: it moved in a plane parallel to the point of departure. On the 4th of August, 1822, at 3 P. M., thermometer 66°, the ascent was slow and beautiful, the little aëronaut rising regularly in the vertical plane. It was distinctly perceived, from the steady fixation of the eye and favorable angle of vision, until it had attained an elevation of at least thirty feet, and was finally lost in the vanishing point of elevation.

"A variety of phenomena unite their testimony in favor of the conclusions formed, and from what we consider the direct method of induction. Were the thread not electrical, we may be asked how it could be propelled through the atmosphere in the vertical plane, and remain there, contrary to the laws of gravitation? It is indeed remarkable, that the threads should always remain in the precise plane in which they are propelled, nor swerve from it. The constant relative separation finds an analogy in similarly electrified pith-balls, or the divergence of the filaments in a glass plume, placed on the conductor of an excited electrical machine, and the electric state of the atmosphere will always be found to modify the phenomena. The transit of the thread through a resisting medium, without its suffering deflection in its path, seems to prove it imbued with a power superior to, and able to overcome, that resistance."

"Bennet and other electricians have long ago proved, that the impulse of air on a delicate electroscope invested it with electricity; and this, if proved in the one case, must of necessity be admitted in the other. In the Mediterranean, Mr. Black appears to have ascertained that winds, or currents of vapor of some continuance, are negatively electrical, and the land breeze in a state of positive electricity. It seems deducible, therefore, that an electrical excitement may be the consequence of such currents; and it seems equally obvious that insects are sufficiently sensible to atmospherical electricity. Thus Huber seems to have proved, that the secretion of honey is intimately connected with electricity; and that bees are far more active and laborious before a storm, and when the wind is south and the air warm and humid, than at other times: and Kirby and Spence also observe, that 'insects seem particularly excited by a high electric state of the atmosphere, and are then found more numerous on the wing than at ordinary periods, and towards evening; and that, some time before the storm comes on, various kinds may be then seen, that do not appear at ordinary times: but immediately before the storm, all disappear.'* D'Isjonval observes, that 'animals are affected by natural electricity; but no one more than myself and my spiders.' He had found, by repeated observations, that the length of the spiders' threads corresponded with the electrical state of the atmosphere: for in wet and stormy weather they were short, and in fine weather were proportionably long. Now, as there *may* exist *other causes* sufficiently powerful to act as excitants, as well as a current of air, the question remains as it was: besides, apart from an effect analogous to electrical excitement, the *modus operandi* of a current of air seems most obsure and perplexing."

"Gay Lussac considers the ascent of clouds, in the regions of air, entirely ascribable to the impulse of ascending currents, arising from the difference of temperature between the surface of the earth and the atmosphere at great elevations." "But the fact proves that clouds are replenished with electricity, and the sunbeam which impinges on them may be the medium of supply." "When the gossamer tissue is woven on some aërial plane, its continued buoyancy is no more unaccountable than the floatage of the clouds, if the operative causes be similar: and as the 'cloud of night' sinks upon the plain, so does the gossamer spider revisit the earth; and as clouds

* The extraordinary activity of the swallow on these occasions is a manifest proof.

rise or fall, or distil their rains, agreeably to electric changes, so does the gossamer spider effect its ascent or descend to the earth."

"How does it happen that the ascent of the bird spider is slow at one time, and rapid as an electric flash at another? vertical at one period, and afterwards horizontal, or in variously inclined planes? on one day requiring the propulsion of numerous threads, and the next a solitary one affording buoyancy enough? ascending at any period of the day in one case, and on the following day incapable of effecting an ascent at all, whether at morn, noon, or night, even with multiplied threads, and when calorific emanations are assumed to be operative? In fact, that a single upright thread should carry up the spider in the vertical plane, on any such principle, seems to us utterly incomprehensible."

"A spider's thread is an electric, and any such thread projected through the air must necessarily become, by such resistance as is occasioned by the atmosphere and consequent friction, imbued with electricity. A thread of glass is electrified under such circumstances, and indeed Mr. W. Ritchie has proposed threads of glass as pendants in his new balance of Torsion. The current of air, or the sunbeam, is the primary exciting cause; and the electric character and condition of the thread are continued and preserved by the continuous action of the electricity of the solar ray. A cloud skreens the disc of the sun; and the exciting solar ray being thus intercepted, the buoyant cause is withdrawn, and the spider descends, at least when the entire electric energy is expended, though by the propulsion of other threads; and the temporary buoyancy thus obtained from a partial evolution of electricity, the consequence of atmospheric friction, its threads of attachment will then become a complete *parachute*, and the *rapid* fall of the insect prevented. We have made experiments and observations recently to ascertain this point, and find that a thread detached from the insect will receive electricity from the solar ray, and ascend in the atmosphere in the sunbeam, when without the sphere of attracting substances, while a similar thread in the shade will not ascend at all; and we also find very light flocculi will also, having absorbed electricity, ascend; and if such should enter the shade, they as immediately descend; and we have seen such in their descent brought by some casual circumstance into the sunshine again, and as immediately afterwards effect a rapid ascent. Sometimes the phenomenon of ascent is accompanied by one or two *divergent* fasciculi." "'Four or five, often six or eight, extremely fine webs, several yards long, which waved in the breeze, diverging from each other like a pencil of rays: one had two distinct and widely diverging fasciculi of webs, so that a line uniting them, would have been at right angles to the direction of the breeze.' Now such divergence in these fasciculi of fibres is utterly inexplicable, except on the supposition of their being invested with electricity; and they find a beautiful analogy in the divergence that ensues, in the fibres of a glass plume affixed to the conductor of an electrical machine, when in action."

"On board the 'Royal Adelaide' of 120 guns, then in ordinary at Devonport, they were annoyed with small spiders alighting on the ship, with a dry easterly wind.' 'Three aëronautic spiders were allowed to ascend from the same spot, when it was observed that each one moved in a different direction. Clouds afterwards collected and obscured the sky, and then our attempts to favor their ascent were unavailing; not one succeeded, and all fell like lead to the ground.'"

This electric theory is certainly ingenious, and not improbable; indeed it is certain that the suspended threads cannot remain unelectrified, and that both attraction and repulsion must ensue, but still the difficult question occurs—why does the repulsion, or repulsion and attraction combined, tend so frequently to project the thread upward or in any other given direction, correspondent with its length; we should look for the principal effect of attraction and repulsion to be exerted in a lateral direction, and this would not tend to project the thread, but rather to bend or turn it as the forces prevailed on the one side or the other; if it could be shown that prevailing electric attractions are exerted from above downward, or repulsions from below upward, the ascent of the web or fibre would be accounted for, and so of any other direction. In the English Magazine of Natural History, for the last two years, there is a protracted discussion between Mr. Murray and Mr. Blackwall, on the electricity of the spider's, and the subject appears to be involved in a degree of obscurity.

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Spiders, odious and disgusting as they are, have been petted; one was tamed by a prisoner in the Bastile, and made to come regularly at the sound of a musical instrument to receive his repast of flies; another man, also a prisoner, tamed eight hundred of them, which he kept in one apartment, and they too were accustomed to assemble regularly and receive their dinner of insects.*—In some countries they are eaten and esteemed a delicacy; their web has been manufactured into silk hose, and its use in stopping the bleeding of slight wounds is well known.

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The popular impression that the bite of the Tarantula can be cured only by music, as observed by Prof. Hentz, is justly exploded, but the following account of the application of the supposed remedy at a time when it was believed to be effectual is, perhaps, worthy to be cited.†

"This animal very much resembles house spiders, but the bite of it, especially in hot countries, produces very fatal and astonishing effects. The poison is not immediately perceptible, because its quantity is too inconsiderable; but then it ferments, and occasions very frightful disorders five or six months afterwards. The person who has been bitten, does nothing but laugh and dance, is all agitation, and assumes a gaiety full of extravagance, or else is seized with a black and dismal melancholy. At the return of that period of the summer season when the bite was given, the madness is renewed, and the distempered party constantly talks over the same inconsistencies, fancies himself a king, a shepherd, or whatever you please, and has no regular train of reasoning. These unhappy symptoms are sometimes repeated many years successively, and at last end in death. Those who have been in *Italy*, about *Naples*, tell us, this odd malady is cured by a remedy which is still odder; for, according to them, nothing but music, and especially an agreeable and sprightly instrument, as a Violin, for instance, can give relief; for which reason they are never without such in this country. The musician endeavors to find out a tone that may seem to bear some proportion to the temperament and disposition of the patient: he repeats his attempt, and if he touches a note which makes an impression on the distempered person the cure is infallible: the patient immediately begins to dance, and always rises and falls according to the modulation of the air. In this manner he continues till he has heated himself into a sweat, which drains off the venom that torments him, and at last gives him effectual relief."

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* Family library, quoting the French Dictionary of Natural History.

† Spectacle de la Nature, Eng. Trans. 3d edit. 1736, which cites for it authority the Memoires de l'Academ. des Sciences, 1708.

Art. XIV.—*An Attempt to prove the Existence of the Unicorn; by* J. F. Laterrade. *Translated from the first Volume of the Bulletin d'Histoire Naturelle de la Société Linnéenne de Bordeaux; by* Jacob Porter.

Man is naturally disposed to call in question that, of which he can not conceive, because his mind, brought down from the exact sphere of his knowledge, would see the limits of creative power within the narrow boundaries of human weakness; then, relying on this false principle of analogous consequences, as soon as he doubts, he has decided; as soon as he has decided, he hears no further; and so great is his error that he very soon exults in wandering from the truth, if it is common, because it does not agree with his pride to be like his equals, if they are of an opinion contrary to what he supposes to be the fruit of his genius.

Hence literary disputes, confident assertions, and denials a thousand times more injurious to science than doubt; hence that incredulity in natural history, which leads us to deny the existence of such species as have not come under our observation, and, particularly, that of the quadruped, that now engages our attention.

To say that it is impossible that there should be, or, at least, should have been such an animal as the land unicorn, would be to go astray from acquired knowledge, to credit an absurd fable, in a word, to affect singularity. Meanwhile, if we can show that the account of this animal has in it nothing remote from the ordinary laws of nature, that several authors have made mention of it, and that there is found no proof, that can overthrow the ideas, that have been formed respecting it, its existence is thereby established. Let us endeavor to illustrate our threefold proposition.

1. The account of the unicorn has in it no appearance of the fabulous. Let us hear our opponents themselves. "It is said," says the Dictionnaire des Sciences, "that this is a timid animal, inhabiting the depths of the forests, of the size of the horse, bearing in front a white horn five hands in length, and with brown hair hanging over that, which is black." The difficulty can fall only on the long horn, with which the front of our quadruped is armed. Its horizontal direction, its position, its being single, the form of the animal, that carries it; these, it is said, are by no means natural. But then the defense of the narwal, which has a horn fourteen feet in length, that has a hori-

zontal direction, proceeding from the upper jaw, and finally, belonging to an inhabitant of the waves, is certainly far less natural. Yet this is a cetaceous animal, concerning whose existence there is no doubt, and which is common in the northern seas; and the armed fox, which M. Duhamel, after M. de Mannevillette, made known to us, presents a phenomenon still more extraordinary, since it has a horn, small indeed, but placed on the backside of the head; a most singular character, and altogether peculiar to this species.

2. Several authors have spoken of the unicorn. First, if we open the sacred scriptures, we shall see that David and the prophets were well acquainted with it. But as the commentaries speak of this animal only in a figurative manner, we respect their silence, and pass over a proof, which alone would, perhaps, be sufficient for our purpose. It satisfies us to know that they have made mention of it.

Pliny, whom none will suspect of connivance with the sacred writers, gives a description of the unicorn in his eighth book, adding that it cannot be taken alive.

Accordingly, Hieronymus Lupus and Bathasar Tellez found, in Abyssinia, a quadruped of the size of a horse, and whose front was armed with a horn.

Finally, the respectable Leibnitz announces, in his Protogea, on the authority of the celebrated Otho Guérike, that, in 1663, there was dug up, from a quarry of limestone in the mountain of Zeuniqueslberg, in the territory of Quedelimburg, the skeleton of a land quadruped, flat on the back parts of the head, but the head itself elevated, and bearing in front a horn about ten feet in length and terminated in a point. This skeleton was broken up by the workmen; nevertheless, the head and some of the ribs were sent to the princess Abbesse. These details are accompanied with an engraving.

3. As yet there is no sufficient proof found of the nonexistence of the unicorn. The account of it has no appearance of fable, and several authors, at different times and among different people, have mentioned it in a positive manner, as we have just seen. What further objection then is there? That the ancients attributed to the horn of our quadruped properties so extraordinary and ridiculous, that every thing relating to it can be no more than a fable. What! it would be deemed sufficient then that falsehood or ignorance should add to real facts, compared with which they should be regarded as mere tales! it would suffice that malice should spread the poisonous venom of calumny over the sacred truth, for which it ought hence-

forth to have no affinity! Where then shall we be? But, without straying from our subject, what animal is there a little extraordinary, concerning which there have not been suspicions, when the night of time has removed it a little distance from us? The giraff is an example as striking as it is recent; and the mammoth, whose remains have been discovered, has fairly overthrown such reasonings; and the shells, the inhabitants of which we have not yet been able to determine, will tell us with silent but irresistible eloquence that nature loses nothing by growing old. Besides, the bezoards, to which have been attributed properties scarcely less ridiculous than to the horn of the unicorn, do they not exist? Do not such things occur still with respect to animals, that live in parched countries, where heat gives to vegetable juice a power, that is unknown in temperate regions? Nevertheless, it is unnecessary to dissemble that it would be in vain for all antiquity to testify in favor of this singular production, it would be in vain that the cabinets should furnish it to the curious, these recitals would be false, these productions would be the work of imposture, if the fact were not still repeated, or if our weakness could not perceive it!

Will it be objected that the moderns have never seen this animal? How many other species are there, which they have not noticed! New discoveries sufficiently prove this. Besides, the unicorn inhabits the interior of Africa, and precisely that part of it, of which we know the least; and in Africa, as well as in other countries, certain animals might well appear, at first, even on the coasts, and afterwards, when the number of inhabitants was increased, be confined to the center of the forests. A countless number of similar facts, sufficiently well known, may well excuse us from enlarging upon this. In short, let us, without being detained by unimportant discussions, come to the grand proof of the nonexistence of the unicorn; let us examine attentively and judge with impartiality.

For a long time there was exhibited a defense resembling ivory, white and channeled, of a very considerable length, and terminating in a point. It was asserted that it was the horn of a quadruped. Of this, however, notwithstanding all the researches, that were made, nothing could be discovered; from time to time these defenses became more numerous, no other part of the animal being united with it; finally, there was brought to Wormius the head of the narwal; then the question was decided, and because some too credulous persons had said that the tooth of a cetaceous animal was the horn of a quadruped, it was thence concluded that the unicorn had never existed, and consequently that it was only a fabulous animal, whose nonexistence was mechanically demonstrated by Kamper. Without detracting from the celebrity of this great anatomist, we do not cite his demonstration, persuaded that the beauties of nature and her admirable secrets cannot be explained by the laws of mechanics only.

Nevertheless, we may remark that Wormius, cautious in his inferences, is always in doubt; that he speaks of the unicorn as he had heard it described before the king of Denmark, by an embassador from Congo; that Gmelin is not sure that the fossil unicorn, which is sometimes found in the earth, is the defense of the narwal; that, finally, if the narwal were unknown till of late, the unicorn, after being seen by the ancients, may not yet have been discovered by us.

Finally, is it not the hight of error and blindness to maintain the nonexistence of our quadruped by the existence of the narwal? It must be confessed that this would be to disguise the process of nature, that seems to delight in repeating the particular animals in each class, and that it is to regard as favorable to an opinion that, which is almost sufficient to overthrow it. Thus, as the ostrich among birds, and the highbunched coffre, among the inhabitants of the seas, are the representatives of the camel, and the fish zebra is of the quadruped zebra, so the unicorn of the sea seems to prove the existence of the land unicorn.

We conclude, therefore, that we have satisfactory evidence, to say the least, that this animal may have existed, that it is possible that he exists still, and close by saying with the immortal Buffon: "It is not by contracting the sphere of nature and confining her within a narrow circle that we shall be able to understand her; it is not by making her act according to some preconceived ideas that we shall be able to judge of her or comprehend her; and we shall not be able to fathom the designs of the Creator by furnishing him with our ideas; instead of confining the limits of his power it is necessary to extend them even to immensity; it is necessary to consider nothing as impossible, to look for every thing, and to suppose that whatever can exist, really does."

Art. XV.—*Physical Geography.*

(Translated from the Bibliotheque Universelle, by Professor Griscom.)

G. F. Schouw, Professor of Botany in the University of Copenhagen, having for several years taught Physical Geography as a distinct science, embracing facts of the highest interest, and which ought not to be separated, as they are in most of the modern treatises of geography, nor connected with those statistical details for which they have no natural affinity and with which they are usually so much encumbered, has commenced the publication of his course of lectures, by a work in 4to of 65 pages, with three lithographic plates. He has chosen the Latin as the medium of his communications,—the Danish language not being sufficiently diffused throughout Europe to be generally understood by literary men. In this first specimen of his work, Prof. Schouw has chosen to exhibit a comparison of the three great mountain chains of Europe,—the Alps, the Pyrenees, and the Scandinavian mountains.

In the preliminary observations, he animadverts upon the method by which Geography is taught, in the numerous abridgments of that science usually employed in schools. "I do not fear to affirm (he remarks) that, paradoxical as the assertion may appear, our abridgments of geography do by no means describe the globe, or fulfill what ought to be expected from them, in relation to the science of which they profess to treat."—"The blending of Geography and Statistics is injurious, as it attempts to unite things which are necessarily distinct and separates things which have a necessary connection. Thus, the Alpine Region, which certainly forms one *whole*, is found in the books of geography in various places, under the heads of Switzerland, Italy, France, Germany, Hungary, &c.; so that that which forms a great unit cannot be seized at one view, and therefore the recollection of it cannot fail to be confused and imperfect. Spain and Portugal, so closely united by nature, are also separated;—in treating of Russia, Nova Zembla and the Crimea are taken into the account;—in describing Denmark, they speak of Iceland, Greenland and the Danish Colonies in Asia, Africa and America; and thus is produced a most singular confusion of countries and climates, the most diverse and opposite. These defects, in addition to that of introducing so much statistical matter that has little or no relation to geography, are such as to prevent the scholar's acquiring from them any just and faithful image of our globe.

"There are indeed treatises expressly on physical geography; but they contain only the most general notions of this science,—of seas, mountains, rivers, climates, &c.; but we do not find in them the globe divided into its natural parts, nor the examination and comparison of these different parts.

"A second defect of our treatises of geography, whether political or physical, is that the countries are not compared with each other. The comparative method has produced the most happy fruits in zoology, geognosy, and other sciences;—physical geography may, in like manner, be developed by a comparison of all countries, considered under all their physical relations."

The author thinks that, in order that geography may deserve the name of a science, the pupil should understand the relations which exist between the exterior form of the globe, the properties of the atmosphere,—of vegetables and animals, and in what manner the climate is connected with the soil, how it influences the vegetable and animal kingdoms, and how all these physical causes modify the character of the human race. He has often been surprised that teachers should so fatigue their pupils with a fastidious enumeration of the political divisions of foreign countries, and with a crowd of minute details relative to statistics, while they furnish them only with the slightest notion of the orographic structure of Europe, of climates, and of the distribution of the principal species of vegetables and animals.

Prof. Schouw then proceeds to the comparison of the three great chains of mountains before mentioned, first pointing out their natural limits, in the following manner:

"That vast chain (says he) which rises on the Scandinavian peninsula, (Sweden and Norway,) does not occupy the whole of it. In truth, an almost continuous series of large lakes, but little elevated above the sea, and a plain interspersed with low hills, separates the southern part of Sweden from the great chain. The isthmus also, situated between the Gulf of Bothnia, the Icy Sea and the White Sea, and uniting the peninsula to the continent, is so little elevated above the sea, according to De Buch and Wahlenberg, and the mass of Scandinavian mountains disappears so completely at its surface, that there is really no connection between these mountains and those of Finland; this isthmus is therefore the natural limit of the Scandinavian chain; on all the other sides this chain is surrounded by the North Sea, the Icy Sea and the Gulf of Bothnia.

"The natural limits of the Alps, it is rather more difficult to establish. The Appenines are so closely connected with the (so called) Maritime Alps, that they are justly considered as an arm of that chain. In like manner, towards the east, the Alps extend to the mountains of Croatia and Dalmatia, and even to those of Bosnia, the eastern portion of which formerly bore the name of Hemus. But as in physical geography we are allowed to consider, when we form subdivisions, not one alone, but a great number of different relations, each of those spurs ought to be separated from the principal branch, on account of the difference of climate and vegetation which characterises them; and even, independently of these, the change of direction which is evident at the points of junction of these branches with the Alps, the abasement of the ridges, and their geognostic character, would be sufficient to require or to admit of this separation. The Alps and the Pyrenees can be considered as a single chain of mountains, only by those who embrace the hypotheses of the connection of all possible chains. The Rhone is a natural limit of the Alps toward the west. With respect to the Jura, the question is more doubtful; nevertheless as it is separated from the Alps and united to other mountains, by geognostic as well as by other relations, and as the region between the Alps and the Jura is low, I am inclined to consider it as not belonging to the Alps. Still less can we admit as appertaining to them, the inferior mountains of the interior of Germany and France. Thus, the natural limits of the Alps are,—on the east, the plains of Hungary; on the south, the Adriatic Sea, the Lombardo-Venetian plains, (the Valley of the Po,) and the Mediterranean Sea; on the west, the Rhone; and on the north, Lake Leman, the Lake of Neuchatel, the Aar, the Rhine from its junction with the Aar to the Lake of Constance, and lastly the Danube.

"The Pyrenees are terminated on the east by the Mediterranean, on the west by the Atlantic; on the north by the low region, (a great portion of which is almost a perfect plane,) watered by the Adour, the Garonne, the Aude, &c. They have some connection, towards the south west, with the chain which extends into the Spanish peninsula along the southern coast, and with some other mountains of that peninsula. But the reasons which induce us to separate the Appenines from the Alps, are equally in favor of a separation of these chains from that of the Pyrenees."

The three chains being thus defined, the author examines and compares them under all imaginable points of view, namely, their geographical situation, their extent, their direction, their elevation, their slopes and inclinations, their summits, the vallies which they form, the rivers which flow from them, the lakes which they embosom, their geognostic formation, their climate and temperature, the height and limit of perpetual snow, the plants and animals which they nourish, and the races of men which inhabit them. Each of these points constitutes the subject of an article, replete with interesting facts; and it will be easily perceived that such a sketch is not susceptible of being extracted. We shall confine ourselves to the summary with which the author concludes this judicious comparison.

"1. The Scandinavian mountains occupy 13° of latitude, the Alps 4½°, the Pyrenees 1°.

"2. The Scandinavian mountains belong to a region altogether maritime; those of the Pyrenees less so, and those of the Alps not at all.

"3. The Scandinavian mountains are of greater extent than the Alps, and the latter greater than the Pyrenees.

"4. The Alps and the Pyrenees pursue a direction approaching that of the equator; the direction of the Scandinavian chain is rather that of the meridian.

"5. The Alps have the greatest elevation, next the Pyrenees and last the Scandinavian mountains. The most elevated summits are, in the Alps from fourteen to fifteen thousand feet, (French?) in the Pyrenees from ten to eleven thousand, and in the Scandinavian chain from seven to eight thousand. The mean height of the most elevated part is, in the Alps from ten to twelve thousand, in the Pyrenees from seven to eight thousand, and in the Scandinavian chain from four to five thousand.

"6. The chains undergo a very considerable depression in the passages of the Alps; but much less so in the two other groups.

"7. The inclination of the slopes is very various in Scandinavia; it is much less so in the Alps and Pyrenees. In these latter chains, the southern declivity is the most rapid, in the first it is the western.

"8. In Scandinavia the summits are almost flat; in the Alps, the ridges are not sharp; those of the Pyrenees approach more nearly to that condition.

"9. The longitudinal vallies are great and numerous in the Alps; they are almost nothing in the Pyrenees and Scandinavian mountains. Transverse vallies exist on both sides of the Alps and Pyrenees; they are found more particularly on the western slope of the Scandinavian chain.

" 10. The large rivers flow from the east side of the Scandinavian mountains, and the smaller currents from the western side. Three large rivers descend from the southern side of the northern Alps; in the Pyrenees, one only flows from the southern slope, and many of less importance take their source from the northern side. In Scandinavia the separation of the waters is sometimes interrupted.

" 11. Lakes of considerable size, and in great numbers, are found near the southern, northern and eastern bases of the Alps, and near the eastern bases of the Scandinavian mountains; there are none at the feet of the Pyrenees. High or elevated lakes are large and numerous in Scandinavia, they are small and rare on the Alps and Pyrenees.

" 12. In Scandinavia there are no secondary mountains, gneiss and schist are frequently met with, lime-stone much more rarely;—no thermal springs are found among them.

" 13. The western side of the Scandinavian chains enjoys a continental climate, and the eastern side, a maritime climate. At the south western bases of the Alps the temperature is high and the winter mild; on the southern and western sides the climate is continental; on the northern basis, the difference between the temperatures of winter and summer, goes on increasing as we advance towards the east. The difference diminishes as we ascend.

" 14. If we consider solely the bases of the mountains, the difference of the mean temperature is considerable in Scandinavia; it is less in the Alps, and still less in the Pyrenees. But if the height be taken into account, we find that it is the highest in the Alps and lowest in Scandinavia.

" 15. In approaching the Alps, the quantity of rain increases; it is very great on the southern side, and very small at the eastern extremity. The western side of the Scandinavian chain is under a pluvial sky, the eastern side enjoys a dry climate.

" 16. The limit of snow in Scandinavia desends from five thousand two hundred feet to two thousand two hundred, in advancing from north to south. In the northern Alps it is at the height of eight thousand two hundred; in the eastern Alps at eight thousand, and in the southern Alps eight thousand six hundred. In the Pyrenees of the north it is at seven thousand eight hundred, in those of the south eight thousand six hundred feet. The Alps present the greatest quantity of snow as well as the greatest and most numerous masses of ice.

" 17. The upper regions of the three chains much resemble each other. The limit of trees in Scandinavia is formed by the birch and descends, from south to north, from three thousand three hundred feet to one thousand five hundred; in the Alps it is formed by the fir, and is found at five thousand six hundred feet in the northern Alps, and at six thousand two hundred in the southern. In the Pyrenees it is also formed by the fir, and exists between six thousand five hundred and six thousand nine hundred feet. In Scandinavia, the region of birch is distinguished from that of fir; in the Alps and Pyrenees, that of fir is distinguished from that of beech and chesnut.

"18. The limit of the Cerealea, in Scandinavia, (60° to 61° N. Lat.) is found at two thousand, under the latitude of 70° it descends to the sea. In the northern Alps it is found at three thousand four hundred, in the southern at four thousand five hundred; in the northern Pyrenees at four thousand nine hundred, and in the southern, at five thousand two hundred. The limit of the region is at two thousand five hundred feet in the southern Alps."

"19. The varieties presented by the animal kingdom are of less importance.

"20. It is not possible to explain by physical causes, the differences which characterize the races of men who inhabit the three mountainous regions thus brought into comparison."

The paper of M. Schouw is accompanied by two lithographic plates, which represent the longitudinal and transverse sections of the three chains, and also exhibit to the eye many of the results above stated.

The specimen, which this author has given us of the book, which will comprehend the whole of his course, must create a lively desire for the prompt appearance of the entire work.

Art. XVI.—*Geological Equivalents; by* Prof. Amos Eaton.*

Relative position and mineral constituents, were deemed sufficient by Werner for determining geological equivalents. As relative position is the basis of the science, all other circumstances have always been received as auxiliaries only, so far as classification is concerned. But the frequent displacement of vast fields of strata, their concealment under detritus, their basseting and cuneiform termina-

* The organized remains quoted in this article, have been collected chiefly within the period of the last ten weeks; though a few similar ones had been before examined. As I was assisted by several students of the Rensselaer School, those who may be desirous to review the localities visited and to correct the errors which may be presumed

tions, their repetitions and original absence, often require intrinsic characters for determining the places in the system to which they should be referred. Werner himself found it necessary to resort to mineral contents in some cases. Hence we have a topaz rock and a diallage rock. His successors have given us, on the same principle, metalliferous, saliferous and carboniferous rocks. I found myself compelled to follow these examples, in describing the rocks in the state of New York, which embrace a stratum of argillaceous iron ore, more than two hundred miles in length. They seem not to occur on the eastern continent, excepting in very limited beds. Therefore, I ventured, seven years ago, to describe them under the name, Ferriferous rocks; to which I have heard no objections.

When rocks of great extent can be inspected *in situ*, neither mineral constituents nor contents are taken into consideration, as principal means for ascertaining their relative positions in a system. But by an acquaintance with such decisive cases, we may learn characters, to be usefully employed in doubtful cases. Rules founded on such characters are always to be corrected, however, when at variance with the laws of superposition, as shown by strata decidedly in place. Throughout the western part of the state of New York, and of the state of Pennsylvania, the rock strata are of vast extent, and their order of superposition is open to inspection. There no intrinsic characters are required for ascertaining their positions, in relation to each other, if nothing more is sought. Still there is great difficulty in making out their relative situation, when compared with European strata. It appears probable, that on and near the line of the Erie Canal, there are several rock strata of great extent, (some of them between two and three hundred miles in length,) which have basseting terminations on their northern sides, near the Lakes Erie and Ontario, and cuneiform terminations on their southern sides, near the Helderberg mountains, southwest from Albany. I represented these terminations in a profile sketch over a map, exhibiting the Economical Geology of the state of New York, and part of the adjoining states, published about a year and a half

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to exist, are referred for directions to the following students: Messrs. Edgerton of Utica, Richards of White creek, (the latter was most successful in finding amber in the New Jersey lignite,) H. H. Eaton of Lexington, Ken., Storrs of Lebanon, N. H. Livingston of Red Hook, White of Cherry Valley, (the three last, aided by Mr. Garret Schank of Middletown, N. J. were most successful collectors at the marl pits,) Barrows, Tuttle, Cannon, W. B. Eaton, of Troy, Sager of Bethlehem, Booth and Bolton of New York, Cobb of Galway, Hill of Worcester, Mass. Noble of Carbondale, Devol of Schaghticoke.

since.* Here is a case, therefore, where strata may be examined in place throughout a great extent of country; but intrinsic characters are still required for determining their true position as a general mass, compared with European strata or with those of other districts in America.

From a consideration of the cases here referred to, intrinsic characters, more definite than any left us by Werner, seem to be essential to the progress of the science. The enumeration of mineral constituents of rocks, can never be satisfactorily applied. Unorganized matter presents but few characteristics. Naturalists find it a more difficult task to describe, by external characters, about two hundred and seventy species of minerals, than fifty thousand species of plants, and a still larger number of animals.

It is a subject of high congratulation to students in geology, of our day, that the illustrious Cuvier, aided by the Brongniarts and their coadjutors, have extended the science of organic nature to the science of geology. We are no longer limited to the enumeration of mineral constituents. We find the same organized remains associated with equivalent strata, in every part of the earth; though they often extend into several adjoining strata, which are probably cotemporaneous, or nearly so. Were every species of organized remains examined, described, and figured; geologists could correspond as understandingly, as botanists can now correspond on the subject of plants. Great progress has been made in the science of animal relics; and the works of Sowerby, Goldfuss, and others, already begin to place students in geology on the real course towards the truth. M. Adolph. Brongniart will soon relieve them from all embarrassment among vegetable fossils.

As no attempt has hitherto been made for shewing the relationship between European and American strata, by a *general* enumeration of the organized remains in American strata, I offer the following imperfect list,† as an attempt towards the establishment of the most important starting points. I confine myself to those strata, which are acknowledged by the geologists of both continents—leaving out all

* The map referred to was prepared for this Journal, at the expense and direction of Gen. Stephen Van Rensselaer; and will appear in it as soon as I can prepare the necessary explanations. It has been inserted at the end of a small text-book, in a few copies only.

† The best specimens found in the shelly variety of carboniferous (metalliferous) lime-rock, and in the second graywacke, (coal grit,) did not arrive in season for this article. Our boxes were detained by a breach in a canal, and other contingencies. I hope soon to be able to add them, and the specific names of our vegetable fossils, collected chiefly in Pennsylvania.

questionable cases and controverted points. Perhaps I may hereafter occupy a few pages of this Journal with a condensed series of facts, in support of a general nomenclature of American geology. In this I intend to point out the agreement, announced to the public by myself, fourteen years ago, which was discoverable in almost all the deposits of both continents; and the few points of total disagreement—particularly the Chalk of Europe and Ferriferous rocks of America. I intend to refer chiefly to organized remains; the study of which, I believe I happened to be the first to introduce, into an American geological school, in the year 1818.*

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* Want of books, (or rather of persons qualified for making them,) in every part of the world, kept back this department of knowledge, several years after a taste for the study was strongly excited. Such however was the zeal of my students, that I was driven to the work of giving names to our specimens, excepting those which I could make out by the Linnean descriptions, (which I translated and published eleven years ago,) and a few labelled by Le Sueur. By these means we could understand each other, in our own school; while we waited, impatiently, for competent authorities. I must ask to be excused, for using some of my own descriptive names in this article, for our species of Encrinus; as the parts assumed by authors for characters are rarely present. A recent specimen in the Albany museum, found among the rubbish of the New Haven museum, formerly kept by Mix, (probably from the West Indies,) is the only one, whether a relic or recent, ever seen in America, as far as I know, which contains those characters. I have, I believe, two undescribed Trilobites and a Lichen, to which I give temporary names also. I will give the old names (if named) as soon as I am able.

ENCRINUS *transversus.*—Always perforates strata transversely; rings low. Found in the lowest and compact layer of metalliferous lime-rock,—called Encrinal rock by Conybeare, and bird's-eye marble by stone-cutters.

E. dicyclus.—Pairs of low rings alternating with single high ones. Found in second graywacke.

E. giganteus.—Branching, and of great length. Found in saliferous rocks.

E. interruptus.—High rings interrupted by single and double low ones. Found in coral rag.

E. teretiformis.—Tapering rapidly, rings even, generally pale or white. Found in coral rag.

E. curvatus.—Rings distinct, with their edges double; always curved, and lying between layers. Found in shell limestone, at Glenn's Falls.

CENOMICE *muscioides.*—Stipes cespitose, sub-cylindrical, fistulous, bearing leaves or processes, sometimes arranged spirally, or densely scattered on all sides. Found in stratified tufa, in layers, in and under shell marl.

CANCER *trilobioides.*—Length and breadth nearly equal; side lobes one sixth the breadth of the middle lobe; joints four, posterior one broadest and cleft on the upper side. About half an inch in length. Found in second graywacke slate (coal slate) on the Mohawk river, where the Erie Canal is cut through the rock. Bears a strong resemblance to the trilobites. A carbonate of lime covering is very entire on some specimens. The incurved tail of Brongniart's Cancer punctulatus resembles this petrifaction. Probably all the animal was very perishable, but the thick crustaceous tail; which is all that now remains.

Names of strata which are known to Geologists of both Continents, with some of their organic associations in North America.

I. PRIMITIVE.

GNEISS, slaty granite, GRANULAR QUARTZ, GRANULAR LIMEROCK.	Absence of all organized remains.

II. TRANSITION.

ARGILLITE.

Clay slate. Orthocera, Filices.

Wacke slate. Terebratula, (species not yet ascertained.)

FIRST GRAYWACKE.

Millstone grit, Old red sandstone.	No organized remains discovered.

METALLIFEROUS LIMEROCK.

Mountain, Encrinal. Encrinus transversus.

Shelly. Fungites polymorpha, CALYMENA *Blumenbachii,* Orthocera annulata, O. striata, O. undulata, Spirifer ambiguus, Ostrea, (nine inches long and three wide,) Asaphus, (large,)* OGYGIES *latissimus,* (found in a lias-like rock, between the shelly and cherty limerock.) Fungites discoidea, Columnaria sulcata, Productus hemisphericus, Scalaria semicostata, Encrinus curvatus, Lithodendron dichotomum.

Cherty. Cyathophyllum ceratites, C. vermiculosum, C. flexuosum, C. vesiculosum, C. helianthoides, C. quadrigeminum. This gives us six species of the Cyathophyllum, which we have found in the cherty or cornitiferous limerock. These horns, as they are called, (Ceratites, stone-horns of authors,) and the hornstone, entitle the rock to the appellation Cornitiferous. Orthocera paradoxica, Conularia quadrisulcata, Productus depressus, Gorgonia ripesteria, Gryphea Macullocha, Terebratula dimidiata, T. octoplicata, T. pectita? T. affinis? Spines of an Enchinus in abundance;

* This is found in the upper soft slaty variety of the rock, which has been so successfully used for the lias cement at Chitteningo, &c. Dr. Smith, of Lockport, sent me two specimens, taken from a continuation of the Chitteningo lias rock, immediately beneath the geodiferous limerock, on which the cherty (cornitiferous) reposes. For a temporary name, I call it OGYGIES *latissimus.* It contains twenty five joints; side lobes one half as broad as middle lobe; and the latter, half as wide as long: joints of the middle lobe curved obliquely backward and then forward at its edges, and extend to such a depth as almost to sever the side lobes. Its middle lobe is five inches and a half long. Remains of the original crust or shell appear to be present in one of the specimens; which are dark colored or black, and separated by double white lines of carbonate of lime. The dark colored part seems to be a substitution from the rock.

many of which have fourteen or fifteen prominent rings each. They are about half an inch in length. Syringopora ramulosa.

III. LOWER SECONDARY.

SECOND GRAYWACKE.

Coal slate and grit. Filices (ferns,) Equisetaceæ (rush-like,) Lycopodiaceæ (ground-pine-like,) Cycadæ (fan-palms,) Palmæ (palm-like,) Cannæ, (reed-like,) Cacti, (prickly-pear-like.)*

Rubble and slaty wacke. Encrinus dicyclus, Pentacrinites tuberculatus? Orthocera conica, CANCER *triloboides*, ASAPHUS *caudatus*, Spirifer Walcottii, Spirifer (not described,) Bellerophon tenuifascia? Coscinopora macropora, (taken from retipora,) Gorgonia bacillaris.

Millstone grit. No organized remains discovered.

New red and gray sandstone, Saliferous. Lingula mytiloides, Encrinus giganteus.

IV. UPPER SECONDARY.

OOLITIC ROCKS.

Shell grit, Calcareous grit. Bellerophon (two species, not ascertained,) Terebratula perovalis, T. ovoides, Spirifer attenuatus? S. trigonalis?

Coral rag. Encrinus interruptus, E. teretiformis, Orthocera circularis, Madrepora limbata, Astrea stylophora, A. porosa, Sarcinula auleticon, S. microphthalma, Diploctenium pluma, Lithodendron cespitosum, Columnaria alveolata, (most common of the petrifactions over the Pucker Street cavern, on the Helderberg,) Catenipora auleticon, Cyathophyllum hypocrateriformis, Gorgonia infundibuliformis, Asaphus Hausmannii; Terebratula spiriferoides, Nobis. Fine specimens of both are found along the south shore of Lake Erie, in the ledge; particularly, near Eighteen-mile creek.

V. TERTIARY.

Clay, plastic and marly. Charred wood or lignite, embracing small masses of amber, and large quantities of iron pyrites, iron stones and bog ore. Placatula pectinoides found in the pyrites. In a kind of green calcareous sand, in New Jersey, numerous organic relics are found, for which I refer to Dr. Mor-

* The figure published in Vol. XX, p. 122, of this Journal, will probably be called a vegetable fossil, as I there stated. As a "similar" one *had never been published,* and as *nothing resembling* the curvilinear processes, which appear like the rays of the dorsal and ventral fins of some species of the eel, and of other fish, had been observed, the subject demands further examination. The original specimen will soon be examined by M. Brongniart, whose decision will be final.

ton's excellent article on that subject, in Vols. XVII and XVIII of this Journal. I will add the Nautilus imperialis, which we took from the green sand with the Exogyra costata of Say. I mention this because it has never been found in Europe except in the Tertiary formation; and Say's species is not found in Europe, nor several other New Jersey relics which are assumed as secondary.

Marine sand (bagshot sand) *and Crag.* No remains found excepting those embraced in the green sand marl-beds.

Shell marl. Generally washed, or settled into depressions. Planorbis obtusa, P. alba, P. paludosa, P. annulata, Bulla rivalis, Limnea longiscata, L. minima, (probably a variety of longiscata.) Cenomice muscioides, (in the tufa, embraced in the shell marl as a stratum, along the Erie Canal, particularly from a mile west of Nine-mile creek.)

It will be perceived on comparing many of these eighty species, including the seven genera of vegetable fossils, with those set down in Woodward's synopsis, that the American strata here referred to, are the true equivalents of the strata of the same names in Europe.

I have not omitted to study the excellent and very interesting articles on what I treat as the New Jersey tertiary, by Messrs. Morton, Lea, and other indefatigable naturalists of the Philadelphia corps; but I satisfy myself with this short answer. The characters of the strata, the lignite, the amber, and the iron, compare perfectly with the European tertiary, when examined along the south bank of Amboy bay, and across to the Neversink; where they can be fairly inspected. I explain, to myself, the subject as follows:—We have no chalk; but the green sand which would, perhaps, have been embraced in chalk, is intermingled with the more recent deposits. For older deposits are often found extending into the newer. But organized beings, created since these deposits were made, cannot be embraced in them. The Nautilus imperialis, and other later relics are found in the green sand, intermingled with relics generally found in the chalk formation of Europe; which seems to prove merely that the New Jersey strata, in question, are made up of a commixture of old and new materials; for which analogies may be found among all geological depositions. * * * * *

The names of Mollusci were taken chiefly from Sowerby—of Radiata, from Goldfuss—of Crustacea, from Brongniart.

A less defective list of American petrifactions, with their particular locations and stratagraphical relations, may appear in a succeeding number of this Journal. A. E.

Art. XVII.—*On the Application of Galvanic Ignition in Rock Blasting; by* Robert Hare, M. D., Prof. of Chemistry in the University of Pennsylvania, &c. &c. &c.

I have ascertained that the process for blasting rocks may be rendered safer than the firing of a fowling piece, by a new application of galvanism. I was led to make this improvement in consequence of an application by a patentee (Mr. Moses Shaw,) for assistance in perfecting his patented mode of blasting rocks by an electrical discharge from a Leyden Jar.

In a letter dated June 1st, 1831, he says, "I have been engaged in blasting rocks by means of a fulminating powder introduced into several cavities, and ignited in all of them simultaneously, by a spark from an electrical machine, by which means masses of a much larger size, and of a much more suitable shape, for any object in view, may be procured, than by the old plan. I have, however, to lament my inability to succeed in this method of blasting during a great part of the year, when, in consequence of the unfavorable state of the weather, the ignition cannot be effected by electricity in any mode which I have devised, or which has been suggested by others, although I have consulted all the best informed professors to whom I have had access."

It occured to me as soon as this statement was made by Mr. Shaw, that the ignition of gunpowder, for the purposes he had in view, might be effected by a galvanic discharge from a deflagrator, or calorimotor, in a mode which I have long used in my eudiometrical experiments to ignite explosive gaseous mixtures. This process is free from the uncertainty which is always more or less attendant upon the employment of mechanical electricity for similar purposes.

The expectation thus arising has since been fully verified. I have ignited as many as twelve charges of gunpowder at the distance of one hundred and thirty feet from the galvanic machine employed. This distance is much greater than is necessary to the safety of the operator, as the deflagrator may be shielded so as not to be injured by the explosion, and by means of levers and pulleys, it may be made to act at any distance which may be preferable. There are no limits to the number of charges which may be thus ignited, excepting those assigned by economy, to the size of the apparatus employed.

These remarks have reference to the principal and highly important object of Mr. Shaw's project; which is, to ignite at once a great number of charges in as many perforations so drilled in a rock as to co-operate simultaneously in the same plane. By these means it is conceived that the stone may be separated into large prismatic or tabular masses, instead of being reduced to irregular fragments of an inferior size. The object to which I propose now to call attention more particularly is a modification of the common process of blasting by one charge, which renders that process perfectly safe.

This part of the subject I shall introduce by premising that almost all the accidents, which have taken place in blasting rocks, have occurred in one of the three following modes:

1st. The explosion has taken place prematurely, before the operator has had time to retire.

2nd. A premature explosion has ensued from a spark produced by the collision arising from ramming into the orifice of the perforation, containing the powder, the brick dust or sand employed to close it.

3rd. The fire not reaching the charge after the expiration of a period unusually long, and the operator returning to ascertain the cause of the supposed failure, an explosion ensues when he is so near as to suffer by it, as in the instance near Norristown, lately published.

The means of communicating ignition, to which I have resorted, are as follows:—

Three iron wires, of which one is of the smallest size used for wire gauze, the others of the size (No. 24) used by bottlers, are firmly twisted together. This is best accomplished by attaching them to the centre of the mandril of a lathe, which is made to revolve while the other ends of the wires are held by a vice, so as to keep them in a proper state of tension. After being thus twisted a small portion is untwisted, so as to get at, and divide the larger wires by means of a pair of nippers. In this way the smaller wire is rendered the sole mean of metallic connection between the larger ones. These are tied in a saw kerf, so made in a small piece of dog wood, as to secure them from working; which if permitted, would cause the smaller wire to break apart. At one end, the twist formed of the wires is soldered to the bottom of a tin tube of a size to fill the perforation in the rock to such a height as may be deemed proper. This tube being supplied with gun powder, the orifice is closed with a cork, perforated so that the twisted wire may pass out through it without touching the tube, at any point above that where the finer portion alone intervenes. To the outside of the tube a copper wire about No. 16 is soldered, long enough to extend to a stout copper wire proceeding from one of the poles of a galvanic deflagrator or calorimotor. The wire passing through the cork, from the inside of the tube, is in like manner made to communicate with the other pole. The connections between the wires, and the poles, should be made by means of soft solder, previously to which we must imagine that the tube has been introduced into a perforation made for its reception in a rock to be blasted. The tin tube may be secured within the rock by the usual method of ramming in brick dust or sand, by means of a punch, having holes for the protection of the wires of communication already described.

The apparatus being thus prepared, by a galvanic discharge, produced by the movement of a lever through a quarter part of a circle, the finer wire is ignited, in the place where it intervenes solely in the circuit, so as to set fire to the surrounding gunpowder.

As the enclosure of the gunpowder in the tube must render it impossible that it should be affected by a spark elicited by ramming, as no means of ignition can have access to the charge besides the galvanic discharge; and as this can only occur by design, without an intention to commit murder or suicide, or unpardonable neglect, it is inconceivable that an explosion can take place in this method of blasting, when any person is so situated as to suffer by it.

It must be obvious that in all cases of blasting under water, the plan of the tin tube, and ignition by a galvanic circuit, must be very eligible.

Mr. Shaw is now in Philadelphia, and I hope he may meet with the patronage which his project merits.

August, 1831.

Art. XVIII.—*Some account of the Hudson and Mohawk Rail Road; by* S. DeWitt Bloodgood, Corresponding Secretary of the Albany Institute.

Without disparagement to similar works which have preceded that of the Hudson and Mohawk Company, it may nevertheless be considered as the most important, from its position, of any yet constructed in the United States. Albany, when in its infancy, was called by the appropriate title of "the net," since it caught all the travel, and most of the business, of the northern and western parts of the state. The immense amount of transportation and commercial business, and the great number of passengers with which it unavoidably has to do, seem still to entitle it to its ancient name.

The Mohawk Rail Road is of course crowded with passengers, and it is thought will shortly be covered with cars bearing produce and merchandize. When it was first opened to the public, the cars traversed it six times a day; now they traverse it eight times a day.

Some account, therefore, of this interesting work, may not be entirely unacceptable.

The Company was chartered by the Legislature of New York, in 1826, with a capital of $300,000, with liberty to increase it to $500,000. This increase has recently taken place. Commissioners were appointed by the Governor under the act, to appraise the damages done by taking the land along the route of the road, and the amount of the appraisement was to be lodged in the bank to the credit of the owner.

Not till 1830 was any thing like a fair beginning made. By the spirited exertions of some few capitalists in New York, the stock was taken up and an impetus given to the project. The surveys were first made by Mr. Fleming, who left the employ of the Company in 1829. Mr. Jervis, the present intelligent engineer, succeeded him in 1830. He had previously acquired reputation in the service of the Hudson and Delaware Company. Lines were run at different periods north and south of the old Schenectady turnpike road, but all the surveys seemed to eventuate in favor of the southern route. There the approach to the river was easiest, the ground requisite for the termination of so important a work was to be had at a moderate price, and but one principal street of the city was crossed by the track. The route adopted by the Company upon the recommendation of Mr. Jervis, was generally three fourths of a mile north of Mr. Fleming's line, except at the two terminations. It is believed that no part of Mr. F.'s plan has been adopted.

In the month of June, 1830, an advertisement for contracts was published, and proposals were accordingly received on the 15th of July following. On the 17th of the same month, contracts were made for the grading, for the stone blocks, broken stone and part of the timber, &c. On the 12th of August, same year, the ground was broken at Schenectady, in the presence of a large concourse of people, and an address was delivered by C. C. Cambreleng, Esq. who throughout the whole work has proved a persevering and efficient agent of the Company.

The work was divided into thirty sections. A large number of laborers was immediately employed, who lived in temporary buildings along the line of the road, and have enjoyed good health during their employment.

The prices paid by the Company for the different items of work and materials are, as nearly as can be ascertained, as follows:

Excavation of sand, 7 cts. per cubic yard.
Do. clay, 9 " " "
Embankment of sand, 8 cts. per cubic yard.
Do. clay, 11 " " "
Broken stone, $2,00 per cubic yard.
Stone blocks, containing 2 cubic feet, 45 cts.
Castings for chains and runs, 4 cts. per lb.
Spikes, 9 cts. per lb.; 5 per cent. discount for cash.
Grading, $7,500 per mile, single track.
10,000 " " for the two tracks.

To meet the expenditures, the capital was called in by instalments of 6 and 10 per cent. and the whole of the original capital was paid in on the 1st of August, 1831.

Twelve miles of the road were finished about the same time, and the whole of the single track will be completed on the 1st day of December next.

The character of the road. With two slight exceptions, the road between the Albany and Schenectady planes is perfectly straight. It however commences at the termination of the city line on the Hudson River, and about thirteen acres of land are now owned by the Company, in its vicinity, part of which will include the wharves now being constructed for the accommodation of the transportation business, and the earth of which is brought in small cars upon a light wooden rail road, from a hill above, through which the inclined plane is to pass.

The road crosses South Pearl Street, under a fine stone arch of durable materials and handsome construction, thence it passes up the hill with an inclination of one foot in eighteen until it reaches the summit one hundred and eighty five feet above the Hudson. At this place a building is erected which contains a double stationary engine estimated at twelve horse power. It is of the high pressure kind with two cylinders seven inches and a half in diameter, twenty six inches stroke. To these is attached the apparatus for hauling up the cars which will presently be noticed.

The road then proceeds North Westerly up to the head of Lydius Street to strike which, it takes a curve of four thousand feet radius, and passes over two heavy and high embankments, and through some deep cuttings near the alms house.

From the head of Lydius Street, (where the travel at present terminates) it proceeds in the same direction, crossing the heavy embankment, called the Buel viaduct, ascending a plane for about three miles, of one foot in two hundred and twenty five. Afterwards ascending by two other planes at different points, and crossing several waterways, upon enbankments it proceeds to the Schenectady summit. There are in all six principal embankments.

About four miles from Schenectady, there is a curve in the road, (radius twenty three thousand feet) which with most people passes unnoticed. Just at the summit is a smaller curve with a radius of one thousand one hundred feet. Besides the plane last mentioned, there is another of three miles, where the ascent is one foot in two hundred and seventy, and another of one mile and a half, where it is one in four hundred and fifty feet. The descent from the Schenectady summit, to the level of the Hudson is three hundred and thirty five feet. At this point, to which we have in imagination conducted our readers, a beautiful view is obtained of the Canal, the Mohawk river, and the ancient city of Schenectady. A double stationary engine is placed here, and may thus be described. In the cellar of a house which is built on stone foundations across the road, and on the North side are placed the boilers. The steam is conducted into two horizontal cylinders, firmly secured, of the size already mentioned. The shackle bars are connected with an axis on the extremity of which is a crown wheel, working in another at right angles, on a shaft placed vertically. This vertical shaft carries at its upper end, which is near the surface of the road, and directly in its center, a larger wheel around the circumference of which the hauling ropes pass, and run on rollers placed at regular distances down the plane. The plane overcomes a height of one hundred and fifteen feet, with an inclination like that near the Hudson, and running down a heavy embankment, strikes the canal about half a mile from the principal street in Schenectady, but the track is prolonged upon a level to within sixty rods of the same.

The soil through which the road passes is generally sandy. Some considerable elevations are cut through, and several ravines crossed. The slopes left by the cutting or formed by the enbankments, are partly covered with sods, and will be entirely so in the course of another season. No settling of the road has taken place except to a very slight degree in some of the embankments which is easily rectified.

Construction of the Road.—After the grading was finished, the residue of the work was done in the following manner. Under each line of the rails, which is very accurately ascertained by means of a transit instrument, square holes are dug at the distance of three feet from center to center, capable of containing nine cubic feet of broken stone. In clay, the holes are connected by a neck, and in these holes, in either case, the broken stone is placed, and rammed down so as to form a solid mass. The stone which is principally grauwacke, is broken into pieces that will pass through a ring of two inches diameter. On this foundation the stone blocks are placed, quarried either on the canal twelve miles above Schenectady, or at Singsing on the Hudson, about double that distance from New York. They are dressed on the upper side only, but have a flat bottom in order to lie evenly upon the broken stone. They are very quickly laid down and leveled, and firmly seated. A little practice enables even an ordinary workman to adjust them to their places.

A massive wooden pounder, with four arms, managed by the united strength of four men is applied to them to bring them exactly to their level, after the broken stone has been moved in such a way as to give them their proper position. The next step is to drill the holes in the face of the stone, and by means of a simple adaptation of an old principle which may hereafter be noticed, four holes can be drilled at once, two in each block, with great ease and much economy of labor and time. In these drillings small plugs of locust wood, about four inches long, and about an inch in diameter, are loosely placed. Into these plugs, are driven the iron spikes which pass through, and hold down the cast iron chairs. The chairs are pieces of a peculiar shape, being double or single, secured to the stone block by a spike, and clasping the rail on each side. The double chairs are of sufficient length to pass across, beneath the rail, and are used in the proportion of one to three single chairs, which are on each side of the rail also, but do not pass under it.

The rails are pieces of wood from twenty one to twenty four feet long, and six inches square, hewed out of Norway and white pine* brought from the vicinity of Seneca lake, and which, in its quality, is considered, by the engineer, equal to yellow pine. These rails are placed in the iron chairs, and are wedged with wooden wedges on the outer side into a perfectly true line. On these lie the iron rails which are made of the best of wrought iron, and were manufactured at Wolverhampton, Staffordshire.

They are are two inches and a half wide at bottom, and rounded off to one inch and seven eighths on the top. Their thickness is only nine sixteenths of an inch. The weight is twenty one tons per mile. These bars are tongued and grooved, and are secured to the wooden rail by iron spikes driven through oval openings. The expansion and contraction of the metal are provided for in these openings, and also by the tongues and grooves. Where the bars join, an iron plate is placed underneath and it is remarked that although additional strength is gained by this, yet the iron rails seem to wear faster at these places than at any others. After the road was used, these bars upon examination made by the writer, were found to be magnetic.

At the distance of twenty one feet, tie pieces, as a farther security, are laid down, to bind the rails to each other and keep them in proper parallelism. Broken stone is also laid down between, and at the side of the rails, and this is again covered with earth.

Upon the embankments stone blocks have not yet been put down, in order to give time for them to settle. When any settling is observed, the timbers, on which the rails at present rest, are pryed up and secured, and the level is maintained.

The other track, which is on the south side of the one now in use, is in a state of active preparation.

Passengers are carried upon this road in coaches, drawn by horses, and by the locomotive engines, whose powers are not yet conclusively tested. The DeWitt Clinton, on the plan of Mr. Hall, is an American engine, from the West Point foundry, and the Robert Fulton, an English engine, is from the shop of Robert Stephenson. The former is about eleven feet six inches in length, and mounted on iron wheels of four feet eight inches diameter. The boiler contains one hundred and fifteen gallons of water, and will sustain a pressure

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* Pinus resinosa and Pinus Strobus of Linnæus, the latter known in England as the Weymouth pine.

of several hundred pounds to the inch, although it is intended to work at a pressure of fifty pounds only.

There are two cylinders, one on each side of the engine, towards the rear of the boiler, each of five inches and a half diameter, and sixteen inches stroke. The pistons move on the inside of the wheels, which is an improvement on some of the English engines. The shackle bars are connected with the axle of the front wheels, which is bent into the shape of a double crank. There is a safety valve on the top, of the usual description.

The power of the engine is over ten horses, and its weight is six thousand seven hundred and fifty eight pounds and a half, being much less in proportion than that of the best English engines. As it stands on the rails, it can be very easily moved by a single hand! The tender is a carriage mounted on smaller wheels, and carries a square box with an awning upon it, in which are apartments to hold an iron tank, and the requisite quantity of fuel. It is dragged next to the locomotive, and has a stout spring in front to keep it at the same distance relatively from the engine. Behind these come the coaches for the passengers. These run on iron wheels constructed like the rest, with a flange or inner edge, which makes it impossible for them to run off the rails.

The coaches are built like the common post coaches, peculiar to our own country, and will carry inside and out, about twenty passengers each. They are very comfortable and convenient, but others of the English pattern, are in contemplation.

The following difficulties occurred upon experimenting with this engine. The surging of the water in the boiler was so great, that it passed over into the cylinders. This was remedied by building a high steam chamber upon the top of the boiler. The eduction pipes terminated too low in the chimney, and injured the draft, and the chimney itself was too large. All this was remedied. The anthracite coal was found to pack, and required a blast. An artificial blast was given, and then the heat seemed too great in one place, and too little in others. It did not diffuse itself, but melted the grates, and the nozzle of the pipe from the wind reservoir. At present it consumes wood; the experiments are not complete, in relation to fuel. The *average* speed of this engine with three loaded cars, equal to about eight tons, is fifteen miles an hour, but it has frequently accomplished with the same load, *thirty miles an hour*. The writer of this communication, has travelled with it at that rate.

The Robert Fulton has a much more compact appearance, and weighs twelve thousand seven hundred and forty two pounds, of which eight thousand seven hundred and forty five pounds, rest on *one* pair of wheels. It was made as we have said, by Robert Stephenson, the celebrated English Engineer of New Castle upon Tyne. The frame is as long as that of the DeWitt Clinton, and is mounted on wooden wheels, strongly bound with iron. There are two cylinders each of ten inches diameter, and fourteen inches stroke; these are in the lower part of the chimney, and are kept warm by the smoke and hot air. The pistons are connected with the axis of the hind wheels. The fire is made in a cylindrical furnace, hanging down between them, and the heat passes directly through eight rows of horizontal tubes of the length of the boiler. The steam pipes pass through the boiler just above the tubes, and by a simple contrivance, the steam ascends to the top of a steam chamber, and there enters a funnel-mouthed tube, connected with the steam pipes. Any bad effects of the surging of the water are of course prevented. The safety valve is of the ordinary kind.

The eduction pipes, are carried partly up the chimney, and powerfully assist the draft. It has been tried and found to succeed admirably. Its great weight renders its usefulness somewhat problematical upon a wooden rail. There are yet some accurate experiments to be made on these subjects, and therefore we shall dismiss this part of our subject with a quotation from the original description of this engine, now before us in the hand writing of Mr. Stephenson. "As to the power of this engine, it would take twenty tons without difficulty, but with twelve it will be much better. The small inclination of one in two hundred and twenty five, will affect the motion of the engine very little."

Some experiments will shortly be made in relation to friction and velocity on this road, by some gentlemen connected with the Albany Institute, in connection with the Engineer, which will probably throw some light upon this fruitful subject of calculation.

The stock of this company has stood deservedly high in the market, and will undoubtedly produce to its proprietors, large and increasing dividends.

MISCELLANIES.

(FOREIGN AND DOMESTIC.)

Notices Translated and Extracted by Prof. Griscom.

CHEMISTRY.

1. *Chloride of lime.—Disinfection of the dead bodies collected at the Morgue in Paris, after the revolutionary struggle in July,* 1830.—A letter from A. Chevalier to M. D'Arcet informs the latter, that the writer in passing near the Morgue on the 30th, was forcibly struck with the putrid exhalations which issued from it, and which were very perceptible as far as the pont St. Michel. Fearing unpleasant consequences to the whole neighborhood, he sent one of his pupils immediately to the directors of the Morgue, to offer them gratuitously, the use of as much chloride of lime as might be requisite to arrest the infection, which being accepted, and learning that they were about to remove immediately two hundred dead bodies that were heaped up in the Morgue, he proceeded, though without authority, to the place, prepared a large quantity of liquid chloride, and sprinkled it over the bodies, which, as they were moved, exhaled the most fetid odor. He persuaded the poor men who were employed in the work, though with some difficulty, to wash their hands in the liquid every time they handled the bodies. These, as they were taken to the boat, were well sprinkled, and portions of the dry powdered chloride were scattered in every place where it appeared necessary.

The bodies when heaped in the boat were covered with straw, over which was then spread powdered chloride, on which water was sprinkled. These precautions, notwithstanding the mass of putrefying materials, completely overcame the exhalations, or gave way to those of the chloride.

The Morgue was well washed, first with pure water, then with solution of chloride of lime, and afterwards fumigated. The quantity of chloride of lime used in these operations, was from thirty to thirty five pounds.—*Jour. de Connois. Usuelles, Sept.* 1830.

2. *Cement for uniting fragments of vessels and other objects.*—Add to an ounce of mastich, in tears, well rectified spirit of wine, in sufficient quantity to dissolve it. Steep an ounce of isinglass in water until it is very soft; dissolve it in pure rum or brandy until it forms a strong jelly. Then add a quarter of an ounce of gum ammoniac

well pulverised. Expose the two mixtures together, in an earthen vessel, to a gentle heat: when they are well commingled, pour the whole into a vial, and keep it well corked. When it is to be used, place the vial in hot water, and warm also the vessels of porcelain or glass which are to be mended. It will be better that the broken surfaces, after having been glued together carefully with this cement, remain pressed into close contact during, at least, twelve hours. The broken places will then remain as firm as the other parts.—*Idem, Jan.* 1830.

3. *Method of preventing iron and steel from rusting.*—This easy method consists in heating the steel or iron until it burns the hand; then rub it with virgin or pure white wax. Warm it a second time so as to melt and divide off the wax, and rub it with a piece of cloth or leather until it shines well. This single operation, by filling all the pores of the metal, defends it completely from rust, even though it should be exposed to moisture.—*Ibid.*

4. *To make sealing wax.*—Those who use large quantities of sealing wax may find it economical to make it, which is very easy. Take equal weights of gum lac, vermillion, and pure Venice turpentine. Melt them over a gentle heat, and stir them well together. Take a detached portion of the mass, and roll it with the hand upon a plate of copper slightly heated; or rather it may be cast in a mould made on purpose, of plaster, of horn, or of copper. Instead of vermillion, other colors may be used, according to the tint which it is desired that the wax may have.—*Ibid.*

5. *On the solvent power of hard waters*, by William West, Esq. —The earthy salts exert a great influence in *preventing* the solvent action of water on vegetable substances; the proportion dissolved by pure or soft water, being considerably greater than that by hard water. Thirty six grains of tea were treated with hard and with soft water, by pouring upon that quantity, in similar vessels equal portions of boiling water, hard and soft. After standing for the same time, the infusion in the hard water, left, on evaporation, after deducting the weight of the earthy matter, about four grains of extract. The leaves when again dried weighed thirty two grains, showing the correctness of the estimate. The extract from the soft, or distilled water was pretty exactly eight grains; the leaves, after drying, twenty eight grains. Thus the soft water had extracted from the tea *just twice as*

much as the hard. The author made numerous experiments of this description. The absorbent nature of the leaves renders it difficult to compare, with accuracy, waters differing little from each other.

The effect of pure water, he says, is very near to that of any natural water, containing carbonate of soda, but the soda is supposed a little to increase the quantity taken up, as well as the sensibility of the palate.—*Jour. of Royal Inst. Vol. I. p.* 42.

6. *On the limits of vaporization*, by M. FARADAY, F. R. S.—A series of experiments has been performed by this distinguished chemist to ascertain whether there are actually definite limits to the force of vaporization. Even when water becomes ice, the ice evaporates, and there is no cold either natural or artificial, so intense as entirely to stop the evaporation of water, or in the open air to prevent a wet thing from becoming dry.

The question which the ingenious author sought to determine was whether, as appears to be the opinion of Davy, Dalton, and others, every substance, (even the most solid) has an atmosphere of its own nature about it, and diffused in its own neighborhood. This atmosphere, in the case of fixed substances, as the earths and metals, might, it was thought, be so feeble as to be quite insensible even by extraordinary examination, and yet, rising into the atmosphere, may produce peculiar results.

Some former investigations of the author induced him to suppose that we possess a great number of substances which are perfectly fixed, and no portion of whose substance rises into vapor under any ordinary circumstances of temperature.

In September, 1826, several stoppered bottles were made perfectly clean, and several wide tubes, closed at one extremity, so as to form smaller vessels capable of being placed within the bottles, were prepared. Selected substances were then put into the tubes, and solutions of other selected substances in the bottles; the tubes were placed in the bottles so that nothing could pass from one substance to the other, except by vaporization. The stoppers were introduced, the bottles tied over carefully, and put away in a dark safe cupboard, where they remained undisturbed for four years. The most important results were the following.

No. 1. *Bottle*—clear solution of sulphate of soda with a drop of nitric acid: *tube*—crystals of muriate of baryta. One half the water passed into the tube, and formed a solution of muriate of baryta. No trace of sulphate of baryta in either.

No. 2. *Bottle*—Solution of nitrate of silver: *tube*—fused chloride of sodium. Water passed to the salt, but no chloride of silver in either.

No. 3. *Bottle*—Solution of muriate of lime: *tube*—crystals of oxalic acid. Water remained with the lime. Slight sublimation of oxalic acid in the tube, but rising no higher than the highest part of the original mass. A drop or two of pure ammonia produced, in the solution, a slight precipitate of oxalate of ammonia. Hence oxalic acid is volatile at common temperatures.

No. 6. *Bottle*—Solution of potash: *tube*—white arsenic in pieces and powder. Arsenic unchanged. Solution of potash had acted powerfully on the glass, dissolving the silica, and becoming a soft solid. It contained no arsenic. Hence this substance, though volatile at 600°, had not risen in vapor.

No. 8. *Bottle*—Half sulphuric acid, half water: *tube*—pieces of muriate of ammonia. No change or transference whatever.

No. 9. *Bottle*—Solution of persulphate of iron: *tube*—crystals of ferro-prussiate of potash. Both unchanged.

No. 10. *Bottle*—Solution of potash: *tube*—fragments of calomel; potash acted on the glass. No trace of volatility in the calomel.

No. 11. Same as the last, except corrosive sublimate in lieu of calomel. The corrosive sublimate had sublimed, and formed crystals under the stopper.

No. 14. *Bottle*—Solution of iodide of potash: *tube*—chloride of lead. Both unaltered.

No. 15. *Bottle*—Solution of muriate of lime: *tube*—crystals of carbonate of soda. Part of the water passed to carbonate of soda: neither of the salts volatilized or changed.

No. 16. *Bottle*—Dilute sulphuric acid: *tube*—nitrate of ammonia in fragments. Nitrate became slightly moist, acid found to contain nitric acid.

No. 17. *Bottle*—Solution of persulphate of copper: *tube*—crystals of ferro-prussiate of potash. Crystals had attracted most of the water from the cupreous salt. Neither salt had been volatilized.

From these experiments it would appear that there is no reason to believe that water, or its vapors confer volatility in the slightest degree, upon those substances that alone have their limits of vaporization at temperatures above ordinary occurrence, and consequently that natural evaporation can produce no effect of that kind on the atmosphere.

It appears also that nitrate of ammonia, corrosive sublimate, oxalic acid, and perhaps oxalate of ammonia, evolve vapor at common temperatures.—*Idem.*

7. *On the functions of vegetable life.*—An interesting paper by GILBERT T. BURNETT, Esq. containing an account of various experiments on the transpiration, absorption, and living functions of vegetables, is contained in the first number of the Journal of the Royal Institution. The author arrives, in general, at the following results:

1st. The functions of plants are but *relatively* distinct: many instances occur in which they are intimately blended, and in which, without much care, organs and functions must be, and have been frequently confounded with each other. Organs which have been supposed to be exclusively destined to one function, and incapable of any other, do under certain circumstances perform the functions of other organs.

2d. Air is essential to the roots of plants: the death of large trees in consequence of embankments around them, (as when raised roads have been made through groves or plantations,) has been ascribed to the accumulation of earth around the trunk, and attempts have been made to obviate the evil by forming cylinders of brick around them, but without effect. Death in these cases is caused by a suffocation of the roots. It is well known how favorable the loosening of the soil is to the health of trees, as well as of all other plants.

3d. Absorption takes place, in most plants, both by their roots and leaves; the first course of the sap is upward, and its passage (at least frequently) is through the non-spiral tubes.

4th. The chief current of the sap is *axial*, for it will traverse the whole extent of the trunk before it will enter any of the branches, how near soever to the root they may be situated, and also when it enters the branches, its course is axial with respect to them. Hence the terminal buds are generally the largest and finest, and the first developed.

5th. Several leaves of Potamogeton natans, were wiped quite dry, weighed, the end of the petioles covered with soft wax, and after remaining out of water for two hours, they lost from three grains and a half to five and one fourth each. Being put into water, after the lapse of two hours, they were wiped dry and again weighed. They had gained from three to five grains each, which, of course, could have taken place only by absorption through the cuticle.

6th. The leaves of the plant either deteriorate or ameliorate the air,—increasing or diminishing its oxygen. Both these effects have been too generally ascribed to the same cause, viz. the respiration of plants, which has been supposed sometimes to form, and at others to decompose carbonic acid; but they are, in truth, distinct, and are performed by two separate systems—the one being the result of the digestive, the other of the respiratory function.

7th. Plants do not at one time respire carbonic acid, and convert it into oxygen, and at another respire oxygen, and convert it into carbonic acid,—thus breathing differently at different times, and undoing by night what they had done by day,—but the respiration of plants at every time, by day as well as by night, in the sunshine as in the shade, converts oxygen into carbonic acid.

8th. Light, assisted only by the filamentary forms of lifeless matter, is unable to effect those changes which the living plant so quickly and so certainly induces; nay, experiments show that the decaying leaves of plants, and newly turned up mould deprave the air in which they may be confined.

9th. Unhealthy plants deprave the air, both in the sunshine and in the shade. If the leaves of healthy plants be crushed so as to interfere with the due performance of their functions, they deteriorate the atmosphere. Healthy plants, enclosed in vessels of carbonic acid, are speedily destroyed, whether kept in the light or not.

10th. Experiments show that whenever carbonic acid is produced in excess, the solid substance of the plant is lessened; and, on the contrary, when oxygen is evolved, its solid materials are increased.

11th. Are we not justified in concluding, from these results, that the production of oxygen and its converse, the formation of carbonic acid, are the unvarying results of two different functions: viz. this of respiration, and that of digestion; and that both are vegetative actions, dependent on vitality?

12th. The formation of carbonic acid is constant, both by day and by night, during the life of the vegetable; it is equally carried on, whether in sickness or in health; it is essential to its existence for the sustentation of its irritability; for, if deprived of oxygen and confined in carbonic acid gas, plants like animals quickly die. This function, which is performed chiefly by the leaves and petals, though also in a less degree by the stems and roots, like the respiration of animals, is attended with and marked by the conversion of oxygen into carbonic acid; it is the respiration of plants.

13th. Again, vegetables, under certain circumstances, decompose carbonic acid, and restore oxygen to the atmosphere, but this is dependent not upon the respiratory but the digestive system; it arises in part from the decomposition of water, but chiefly from the decomposition of carbonic acid, absorbed either in the form of gas, or in combination with water either by the roots, or leaves, or both. Its analogy to animal digestion is obvious, for to both plants and animals, carbonic acid, though deleterious when breathed, is invigorating to the digestive system when absorbed as food.—*Idem.*

8. *Ammonia in native oxide of iron.*—(Ann. de Chimie, t. xliii, p. 334.)—In the mine of Cumba, near Marmato, a large vein of hydrated oxide of iron, in syenitic porphyry, is worked as a gold ore. In a part of this mine, called *por a fuera*, where the work proceeds with activity, about a foot of mineral was broken down at the end of the excavation, so as to expose a fresh surface, and then a hole was bored in the very middle of the vein; after being carried eight inches deep, the powder of the ore was collected carefully in a basin, placed under the hole, and touched by nothing but the tool. Four ounces of this ore were then bruised and rubbed in distilled water, the filtered liquor was acidified by muriatic acid and evaporated; it left fifteen grains of residue, which being introduced into a glass tube with a piece of quick lime slightly moistened, and heated, gave ammonia, sensible not only to test papers, but also by its strong odor. Hence it results, as M. Chevalier has stated, that the natural oxides of iron contain ammonia, and this fact, conjoined with that of Austin, that ammonia is formed by the oxidation of iron in contact with air and water, acquires a certain degree of geological importance.—*Idem.*

9. *Salicine.*—(Leroux, Ann. de Chim.)—This substance is in the form of very fine nacreous white crystals, very soluble in water and alcohol, but not in ether; it is very bitter and partakes of the odor of willow bark. In order to obtain it, three pounds of the bark of the willow, (Salix Helix,) dried and pulverized, are to be boiled in fifteen pounds of water, with four ounces of carbonate of potash, for an hour; it is to be filtered, and when cold, two pounds of solution of sub-acetate of lead added: when settled, it is to be filtered, treated with sulphuric acid, the rest of the lead precipitated by sulphuretted hydrogen, the excess of acid neutralized by carbonate of lime, again filtered, the liquid concentrated and saturated by dilute sulphuric acid,

then boiled with animal charcoal to remove color, filtered hot, crystallized repeatedly, and dried without access of light. About one ounce of salicine will be obtained in the large way; probably twice the quantity would result, for great loss is occasioned by the above numerous operations. It may be preserved in well closed bottles, and does not attract moisture.

From the experiments of Miquel, Husson, Bally, Girardin, Cognon, &c. at the hospitals and elsewhere, it is proved that from twenty four to thirty grains of salicine will arrest the return of the fever, whatever may be its kind. This is nearly the same as the dose of sulphate of quinia.—*Idem.*

10. *Malic Acid.*—(Liebeg, Ann. de Chim.)—This curious vegetable acid has been obtained pure and crystallized, by M. Liebeg, and carefully analysed, for the purpose of setting the discordant results of different chemists at rest. It was obtained from the expressed juice of the ripe fruit of the mountain ash, by a complicated chemical process.

The equivalent number of the pure acid and its atomic constitution, were obtained by the decomposition of three of its salts; the malate of zinc, the malate of silver, and the malate of ammonia. Its composition may be considered as follows:

4 atoms of carbon, - - - - -	24
1 do. hydrogen, - - - - -	1
4 do. oxygen, - - - - -	32
Equivalent number, - - - -	57

Idem.

11. *Manufacture of charcoal.*—(Bull. Univ.)—A new process, recommended in the *Journal des Forêts* for this purpose, is to fill all the interstices in the heap of wood to be charred with powdered charcoal. The product obtained is equal, in every respect, to cylinder charcoal; and independently of its quality, the quantity obtained is very much greater than that obtained by the ordinary method. The charcoal used to fill the interstices, is that left on the earth after a previous burning. The effect is produced by preventing much of the access of air which occurs in the ordinary method. The volume of charcoal is increased a tenth, and its weight a fifth.—*Idem.*

12. *Potash obtained from felspar.*—According to M. Fuchs, this important alkali may be extracted from minerals containing it, by the following method;—they are to be calcined with lime, then left for some time in contact with water, and the liquor filtered and evaporated. M. Fuchs says he has thus obtained from nineteen to twenty parts of potash from felspar, and from fifteen to sixteen from mica, per centum.—*Idem.*

13. *Action of the Pile on living animal substances.*—(Ann. de Chim.)—M. Matteuci found that the poles of a Voltaic pile of fifteen pairs, applied to two wounds made on the lateral parts of the abdomen of a rabbit, so as to leave the peritoneum bare, soon occasioned a yellow alkaline liquor, containing many bubbles of air, to collect at the negative pole, while a yellow liquid, with few bubbles and slightly acid, collected at the positive pole. The poles were of gold. The same results were obtained on other parts of the body, as the liver, intestines, &c. The substance obtained at the negative pole, besides alkali, contained much albumen coagulated by heat; the fluid at the positive pole also contained a highly azotated substance.

These experiments are considered by M. Matteuci as supporting the opinion that secretions in the living body are the result of electrical decomposition.—*Ibid.*

14. *Chlorine an antidote to prussic acid.*—By dropping prussic acid upon the eyes of three dogs and dividing the symptoms into three stages, 1. uneasiness, 2. tetanus, 3. interrupted respiration, the experimenters, Persoz and Nonat, found that chlorine applied at these different stages produced, in the first stage, immediate relief; vomiting and alvine discharges occurred, and the animal in half an hour was as lively as at first. Applied at the second stage, the restlessness continued a while, as also the convulsive movements, then vomitings, &c. as before, and at the end of an hour the animal was perfectly well. The same two dogs being treated the next day with the same quantity of prussic acid, without chlorine, died in a few minutes. In the third case, before the chlorine was applied, the respiration had ceased for twenty five seconds, and the animal was rapidly perishing. The chlorine recalled it to life, and ultimately restored it to full vigor.

Afterwards two dogs of equal strength were taken, the crural veins laid bare and separated from the accompanying nervous fibres, and then a drop of prussic acid was put upon each vessel; the effects were instantaneous,—a few drops of a solution of chlorine were let fall on one of the crural veins—the other animal was left alone. The first was as immediately recovered as it was injured; the second died directly. The first felt no inconvenience, after some hours, except from the wound. Endeavors were then made to kill him, by putting prussic acid upon the eye and upon the crural vein of the opposite side; but the animal only felt temporary inconvenience and a few convulsive movements, and was very quickly at ease. Chlorine, then, previously administered, is an effectual antidote to prussic acid. Chlorides of lime and soda were found to possess no corresponding powers, being quite inert as antagonists to the hydro-cyanic acid.—(Ann. de Chimie.)—*Idem.*

15. *Common salt a remedy for animal poison.*—The Rev. J. G. Fischer, formerly a missionary in South America, says he "actually and effectually cured all kinds of very painful and dangerous serpents' bites, after they had been inflicted for many hours," by the application of common salt, moistened with water and bound upon the wound, "without any bad effect ever occurring afterwards."

"I, for my part," says he, "never had an opportunity to meet with a mad dog, or any person who was bitten with a mad dog. I cannot therefore speak from experience, as to hydrophobia, but that I have cured serpents' bites always, without fail, I can declare in truth." He then cites a case from a newspaper, in which a person was bitten by a dog, which in a few hours died raving mad. Salt was immediately rubbed for some time into the wound, and the person never experienced any inconvenience from the bite.

Mr. Fischer was induced to try the above remedy, from a statement made by the late Bishop Loskiell in his history of the Missions of the Moravian Church in N. America, purporting that certain tribes of Indians, had not the least fear of the bite of serpents, relying upon the application of salt as so certain a remedy, that some of them would suffer the bite for the sake of a glass of rum.—*Idem.*

16. *Tenacity of Vegetable Life.*—Mr. Houlton produced a bulbous root to the Medico-Botanical Society, which was discovered in the hand of an Egyptian Mummy, in which it had probably remained for two thousand years. It germinated on exposure to the atmosphere; when placed in earth it grew with great rapidity.—*Idem.*

17. *Precaution in planting Potatoes.*—It would appear from experiments made in Holland, that when potatoes are planted, the germs of which are developed, as happens occasionally in late operations, or after mild winters, that the produce differs in quantity by more than a third to what it would be, if potatoes which had not advanced had been used, and further, that besides this diminished product, the quality is inferior.—*Idem.*

18. *Preservation of trees from Hares.*—According to M. Bus, young fruit trees may be preserved from the bites of hares, by rubbing them with fat, and especially hog's lard. Apple and pear trees thus protected, gave no signs of the attacks of these animals, though their foot marks were abundant on the snow beneath them.—(Bull. Univ.)—*Idem.*

19. *Use of cotton in dressing wounds.*—Dr. Peschier, Secretary of the Medical Society of Geneva, (Switzerland,) in a letter addressed to the Editors of the Bibliotheque Universelle, states that he has proved with entire satisfaction to himself, that the general opinion of the unfitness of cotton for the purpose of dressing wounds, is altogether an unfounded prejudice, and that carded cotton, employed either as lint or as bandages, is in fact preferable to linen. He does not pretend to be the discoverer of this fact, but refers it to an incidental circumstance which occurred in America. A child which had been most severely burned, was laid upon a heap of carded cotton, while the person who first rescued the child went for assistance. On returning, instead of finding it in agony, it was fast asleep; and the wounds, though deep, healed rapidly, with no other application than the soft cotton, which they did not venture to detach. It is, Dr. P. remarks, in the most desperate cases, that cotton is the most useful in burns. When the skin, and even the flesh, has been shrivelled and roasted with the heat, the application of cotton has been found to promote the sloughing and suppuration without too much pain, thus preserving the life of the patient, otherwise so doubtful under circumstances of this nature.

Dr. Peschier cites the following cases, which came under his own notice. Two artillery men, in charging a cannon too hastily, had their hands and faces so severely burned by a sudden deflagration of the cartridge, that the epidermis was separated. The injured parts were immediately covered with cotton, and so successful was the application, that although the hands, and especially the face, were prodigiously swelled, the eyelids tumefied and the nostrils obstructed, the wounds healed so perfectly, that not a trace was left of the accident.

So much for burns. A family of five persons were attacked with typhus, which reduced them to great extremity. They recovered, but one of them, a lad of twelve years of age, became a prey to enormous eschars, on all the parts of his body, which were obliged to sustain any pressure, or even a permanent contact; that on the sacrum was at least six inches in diameter, those of the trochanters were the one five and the other four inches, and on each knee was one of two inches, with smaller ones on the feet. The young man was reduced to the lowest degree of emaciation, and so great was the pain that his cries were almost incessant day and night for nearly a month. After trying in vain the ordinary means, Dr. P. thought of carded cotton, and of this he applied a thick compress on each wound. On the first night after, the patient slept, the pains abated as if by enchantment, the application was continued, and in the month of February, the eschars, which had commenced in September preceding, were reduced to very small simple wounds, and the patient had regained his strength, notwithstanding the enormous suppuration.

The precaution which was observed in this important case, and which Dr. P. considers indispensable to success, was never to change the compress of cotton, except when the amount of suppuration incommoded the patient and almost entirely detached the mass. In dressing also, great care must be taken to cut with good scissors, and never to pull out the fibres of cotton which adhere to the borders of the wound.

Such unexpected success induced the belief that every kind of wound or ulcer might be treated with decided advantage by dry carded cotton. An opportunity of trying it was soon presented. An unfortunate being, with an enormous cancer of the face, was dressed with cotton, without experiencing from it the least pain. The disease being in its nature incurable, Dr. P. did not pretend to heal it by this means, but he rendered the treatment of it far more supportable.

All kinds of wounds, simple and complicated, have been thus kindly and promptly healed. A wound of the head, complicated with much hemorrhage, was by the same means successfully treated. A prejudice exists that cotton is dangerous to the eyes, but Dr. P.

states that he had speedily cured a man who, by falling on some stones, had received a severe contusion of the face, a corner of one of the stones having penetrated and torn the flesh.

Obstinate scrofulous ulcers have been treated in the same manner, with no less success.

"I cite these facts, (observes Dr. Peschier,) only to demonstrate that cotton is applicable, indiscriminately, to all kinds of wounds and ulcers, and that far from being, (as it is unjustly regarded,) *poisonous*, that is to say, *irritating*, it furnishes, on the contrary, a material for dressing wounds, of the softest and most pleasant kind. But, I repeat, it is indispensable to success, that the dressings be rare, and that the threads be never pulled or torn from the wound, a practice which cannot fail to increase either its extent or aggravation. The scissors, lightly handled, must be used to separate from the adhering fibres, the mass, which may be safely detached.

"I would be the first to admit that there is very little scientific merit in substituting cotton for lint; but I deem it to be rendering an important service to the wounded, to their connections, and especially to the attendants at civil and military hospitals, to convince them that they need not be uneasy at the difficulty of procuring lint, a substance nor always easy to preserve,—which becomes easily infected with miasmata, and which cannot be kept in large masses without some danger. Carded cotton is found every where; it is of trifling value, so that the rich will at no time refuse to buy it for the poor, and hospitals can be at all times well provided with it.

"The same remarks apply to cotton cloth. It is of trifling cost, even when of the finest kind; it has precisely the degree of suppleness which fits it for bandages and compresses; it occupies vastly less space in travelling chests than linen or hemp, and it may be any where abundantly obtained."—*Bib. Univ. Mars*, 1831.

NATURAL HISTORY.

1. *To blow eggs for preservation in cabinets.*—A ready method of effecting this purpose, is to take a tube either of glass or metal, one end of which is drawn out, or fashioned to a point, (the tube being large enough to hold the contents of the egg,) and having made a pin hole at the side of the egg, large enough to admit the point of the pipe, (one sixth part of an inch) apply the mouth to the large end, and suck as hard as possible. The contents of the egg will immediately rise into the tube. Having blown them out into a basin, suck a little

clean water into the tube and blow it into the egg; shake the egg for about a minute, and draw out the water again into the tube, and it will leave the egg perfectly clean. The common dropping tube of the chemist, which has a ball in the middle of it, answers this purpose extremely well.—*Loudon's Mag. of Nat. Hist., March*, 1831.

2. *Killing large insects.*—As many of your young entomological readers may have found equal difficulty with myself in ascertaining the readiest method of killing the larger moths when captured, I trust you will excuse my troubling you with the following remarks. In the *Journal of a Naturalist*, prussic acid is suggested; but that is not only very expensive, but a most dangerous thing to have any dealing with. I have tried hot water, steam, hot needles, ether, sulphur, aqua fortis, &c. but found none so decidedly effective as *oxalic acid*, which I thus apply:—First, shape a nice small quill into the form of a very sharp pointed blind pen, (i. e. a pen without a slit) then seize your moth, with the finger and thumb between the wings on the under side, holding it with its head towards you, firmly, but with as little pressure as possible. Then dip your pen-shaped quill into the acid and run it into its thorax, just below the head, or between the first pair of legs; and after two or three quick applications, the moth will be found perfectly dead. This is not only the most humane and expeditious, but very economical, as two pence worth of acid would be sufficient to destroy subjects to fill a whole cabinet. As I am writing for the information of your young friends, I may be excused for adding that oxalic acid is in the form of crystals, which must be reduced to a liquid by a little water.—*An Entomological Amateur.*—*Idem.*

3. *Improvement in Ornithological terms.*—Having observed in the *Gentleman's Magazine* the amendments proposed by Mr. Vigors, in substituting names which should express the actions of the different kinds of birds, for those of Linnæus, and admiring the happy selection of terms by which he has designated each class, it may appear presumption to recommend any change. It is, therefore, with great diffidence that I offer the following, having a reference to the structure and habits of the birds.

The second class, named by Mr. Vigors Insessòres or Perchers, might, perhaps, with more propriety be called Perticatòres, from *pertica*, a perch; the expression *insidere perticæ*, to sit on a perch, being well authenticated. With respect to the fourth class, the Grallatòres of Mr. Vigors, and Grállæ of Linnæus, expressive of the long legs of the birds, I would denominate them Vadatòres, a much nearer approach to the English name, waders; and in order to maintain the same number of classes as used by Linnæus, which are reduced to five by Mr. Vigors, I would suggest the combining of all the birds whose feet are formed for climbing into one class, to which the name of Scansòres, or climbers, might be applied, and would consist of the parrots, toucans, woodpeckers, &c. birds which cannot well be ranked with any of the other classes. The table of classes would then be;—1. Raptòres or snatchers, 2. Perticatòres, or perchers, 3. Natatòres, or swimmers, 4. Vadatòres, or waders, 5. Rasòres, or scratchers, 6. Scansòres, or climbers.—*Juvenis.*—*Idem.*

Edmonton, Oct. 9, 1830.

4. *Touchwood.*—The wood which forms this substance has undergone, in the progress of decay, a remarkable change. Its solid texture has disappeared; it is light and friable; it easily takes fire, and is consequently used for tinder. When once kindled it burns for hours, until the whole is consumed without ever bursting into flame, and however small the part to which the spark of fire has been communicated; and, what is still more remarkable, the whole mass of wood, even when not ignited, gives a bright light in the dark equal in intensity, and similar in color, to that given out by phosphorus. On examining a piece of it, it contained neither phosphorus nor nitre. It is now pretty well ascertained that the glow worm, and other insects of the kind, do not produce their light by means of phosphorus. The writer finds no information in the books respecting touchwood.—*Idem.*

5. *Habits of the crocodile.*—A remarkable peculiarity in the pulmonic structure and functions of this animal is described by Geoffroy Saint-Hilaire, in the lectures, delivered by him at the Garden of Plants in 1828, on the natural history of mammiferous animals. It is thus described by a correspondent in Loudon's Magazine of Natural History.

The crocodile, although furnished with a lung more perfect than that of any other reptile, is little excited by the use of that organ. On the land, where it breathes by the lungs only, it is timid, and has no confidence in itself, seizes its prey at unawares or by stratagem, provides previously for security in case of resistance, and on any alarm hastens to throw itself into the water. Here it is quite another animal; its energy is extreme; its swimming rapid; and, rash even to excess, there is no enemy which it fears openly to attack, and "none is so fierce that dare stir him up." But all vitality, all muscular energy, depends on the act and effects of respiration; and how are these habits of the crocodile to be reconciled with this law? On land, when breathing the atmosphere at full, he is sluggish and fearful; it is only when immersed in water, and when respiration is liable to be impeded, that he acquires strength, activity, and courage. There is here an exception to the law, but it is only in appearance; and it is curious to remark how simply nature in this case enlarges the respiratory organ and function, and gives the aquatic creature its corresponding power, without deviating in any thing from the one model of organization. By means of two canals which take their origin in the cloacum, and which open into the cavity of the peritoneum, water is conveyed within the abdomen to act upon the blood in its vessels; and through the abdominal vessels thus called upon to aid the lungs in oxygenating the blood, the additional vigor to the muscular system is imparted. The crocodile has an abdominal sternum independently of its pectoral sternum: each sternum and its muscles regulate the effects of their proper and respective respiration. When the animal is on land, it is the thorax and its sternum which are only in action; when in the water, the abdomen and its sternal apparatus are likewise called into play. Isidore Geoffroy Saint-Hilaire and Joseph Martin were the discoverers of the canals which open into the peritoneum; a discovery of great interest, as previously to it the habits of the crocodile were inexplicable.—*Mag. of Nat. Hist. Sept.* 1830.

6. *Are the songs of birds innate or acquired?*—This question has occasioned some controversy among the contributors to Loudon's valuable Magazine of Natural History. One writer (R. Sweet, Pomona Place) maintains that blackbirds or thrushes, brought up in a city, will have no variety in their notes, and will only imitate the tones of people who whistle to them, or the discordant noises of the streets. A nightingale, caught when young, and which he had kept for three years, only sang two or three notes. It was turned out in the summer, migrated in autumn with other birds, but returned in the spring, and was recognized by its imperfect notes. Another bird (Saxicola Rubetra, or Whinchat) bred from the nest, turned out to be a very fine singing bird, but its notes were all acquired by mocking other birds, and had scarcely any thing in them of the natural song of the species. Other birds, which had acquired their own wild notes when taken, learned also to imitate the cage birds around them. Even in

a wild state, he observes, some birds of the same species have a much greater variety of notes than others, and are much better songsters.

Another correspondent maintains that the well known habits of the cuckoo, prove that the songs of birds are innate, and not acquired. He saw one of these birds, (which had been found half fledged in a field,) in a house, in a narrow street, where it had probably never seen or heard one of its own species, but which at the sight of its protectress, or when hungry, would cry cuckoo! cuckoo! in the natural tone.

Perhaps some of our readers, from their own observations or experiments, may be able to throw light on this question, which, in a physiological point of view, possesses some interest.

MECHANICAL PHILOSOPHY.

1. *To prevent the cracking of lamp glasses*, by the sudden expansion produced by the heat; an effectual remedy is found in running a point of a diamond along the base of the tube. By this solution of continuity, it is relieved from the violence produced by the sudden effects of the heat. A glazier can best perform the operation with the diamond.—*Jour. des Connois. Usuelles, Jan.* 1830.

2. *On giving a fine edge to razors, lancets, and other cutting instruments.*—In a paper on this subject by Thomas And. Knight, Esq. F. R. S. the following method is recommended as preferable to any other which the author has tried.

A cylindrical bar of cast steel is provided, three inches long without its handle, and about one third of an inch in diameter. It is rendered as smooth as it can be made with sand, or, more properly, glass paper, applied longitudinally; and it is then made perfectly hard. Before it is used it must be well cleaned, not brightly polished, and its surface must be smeared over with a mixture of oil and the charcoal of wheat straw, which necessarily contains much siliceous earth in a very finely reduced state. Charcoal of the leaves of some of the marsh grasses the author thinks, may perhaps answer as well or better.

In setting a razor, its edge (which must not have been rounded by a strap) is brought into contact with the surface of the bar, at a very acute angle, proportionate to the strength intended to be given to the edge, and the razor is to be moved in a succession of small circles from heel to point, and back again without any more pressure than the weight the blade gives, till the object is attained. If the razor have been properly ground and prepared, a very fine edge will be given in a few seconds, and it may be renewed again during a very long period, wholly by the same means.

The author has had a razor in constant use during more than two years and a half, and no visible portion of its metal has been worn away, though the edge has remained as fine as possible, and he has never at any one time spent a quarter of a minute in setting it. He thinks it operates best when the temperature of the blade has been raised by the aid of warm water.

Although a cylindrical bar is much superior to a plane surface for for giving an edge to a razor or pen knife, it is ill calculated to give a fine point to a lancet. For this purpose a plane surface is made a quarter of an inch wide on one side of the bar, and this form is found to be extensively useful.

The author finds that the material which appeared to receive the most eager edge (and very durable) was wootz, and that which received the smoothest edge and best adapted to surgical purposes, was a mixture of rhodium and steel; the powers of pure steel appeared to be intermediate.—*Journal of the Royal Institution, Vol. I, p.* 13.

3. *Interesting optical experiments.*—If, without closing the lids, the left eye be covered with the hand, or some other obstacle, and a candle or lamp be held in the right hand within two or three inches of the right eye but rather below it, (keeping the eye directed straight forward,) on moving the candle slowly backward and forward, i. e. from right to left, (or if the candle be held on the right side of the eye it may be moved up and down,) a spectrum appears after a short time in which the blood vessels of the retina, with all their ramifications, are distinctly seen projected, as it were, on a plane without the eye, and greatly magnified. They seem to proceed from the optic nerve, and consist of two upper and two lower principal branches, which are variously ramified towards the field of vision, where a dark point is seen, which sometimes appears concave. A similar but inverted figure, and less distinct, appears in the left eye. The origin of the vessels is a dark oval spot, with a light areola; the figure itself, or rather fragments of it, are seen under various other circumstances. There can be no doubt that it is formed by the central vessels of the retina. A remarkable circumstance of this phenomenon is, that at the point corresponding to the projection of the foramen

centrale, a crescent-formed image is occasionally observed; its appearance depends on the position of the light with respect to the axis of the eye; for instance, when the light is placed below the eye, the image appears on looking downwards, and in general it appears on looking towards the light and disappears on looking from it.

The following is the probable explanation of this beautiful phenomenon: Were the blood vessels which are spread on the anterior surface of the retina entirely opaque, they would prevent the transmission of light to the nervous matter beneath them, and their distribution would be constantly visible; but they are transparent, and in ordinary cases the intensity of the light which passes through them does not materially differ from that which falls directly on the retina. When however the retina is fatigued by a strong light, the veins become visible, because the retina is rendered insusceptible to a portion of the light they transmit; but this effect is only momentary, for those parts which are thus shaded from the more intense light promptly recover their usual susceptibility and the images vanish; but they may again be made perceptible by displacing them on the retina; and by making them constantly change their places, the images may be rendered permanent. The momentary appearance of these images may be frequently observed on looking at a strong light immediately after waking in the morning, and may be reproduced several times by successively shutting and opening the eyes.

The foregoing beautiful experiment of exhibiting to its own vision the blood vessels of the eye, was first described, it appears, by Steinbuch, in his Physiolie der Sinne, 1811. It has since been brought into notice by Dr. J. Purkinje, Professor of Physiology at the University of Breslau, 1823.—*Idem.*

4. *Hardness of Lead.*—It results from the experiments of M. Coriolis, that lead fused and cast in the open air is of variable hardness, and that to obtain it with a true and constant power of resistance, it must be cast out of contact of air, and drawn off from the bottom of the mass.—*Idem.*

5. *On the power of horses; by* B. Bevan.—(Phil. Mag.)—"The mean force exerted by one hundred and forty four horses at various ploughing matches at Woburn and Ashbridge, was one hundred and sixty three pounds each horse, and although the speed was not particularly noted, it could not be less than two miles and a half per hour.

"As these experiments were fairly made, and by horses of the common breed used by farmers, and upon ploughs from various counties, these numbers may be considered as a pretty accurate measure of the force actually exerted by horses at plough, and which they are able to do without injury, for many weeks; but it should be remembered that if these horses had been put out of their usual walking pace, the result would have been very different."—*Idem.*

6. *Composition of Size for Illuminators, Artists, &c.*—(Bull. Univ.)—Four ounces of Flanders Glue, and four ounces of white soap, are to be dissolved on the fire in a pint of water, two ounces of powdered alum added, the whole stirred and left to cool. It is to be spread cold with a sponge or pencil on the paper to be prepared, and is much used by those who have to color unsized paper, as artists, topographers, &c.—*Idem.*

STATISTICS.

1. *Yorkshire Philosophical Society.*—This society, in the ancient and venerable city of York, was established in December, 1822, by the voluntary association of gentlemen of the city and county, for the purpose of encouraging scientific and literary pursuits. The annual report of the council in 1824, two years after the institution of the society, states that the donations to the geological collection had then amounted to nearly *two thousand five hundred*, independent of more than *two hundred* specimens added to the mineralogical cases. A collection of zoology and comparative anatomy had been deposited in the museum, and the library was beginning to assume a respectable appearance. In 1827 a grant was made to the institution, by the late king, of about three acres of ground, part of the site of the once rich and powerful abbey of St. Mary. The venerable ruins of the abbey occupy the north western side of the enclosure; the Roman multangular tower and ancient city walls separate it from the city to the south east.

In this enclosure the society has erected a museum for its collections, its meetings, and for the lectures which are given under its auspices. On an eminence in the centre, the museum rears its noble front, looking down upon the river, and to the extensive landscape beyond. The entrance to the grounds from the city, is by a Doric gateway, or propylæum, opening out of Lendal street. On each side of the walk leading thence to the museum, the ground is appropriated to a botanic garden, which is designed to combine ornament with scientific utility. The remainder of the enclosure is laid out and planted with a view to picturesque embellishment, and with particular reference to the favorable display of the venerable remains of antiquity which adorn and consecrate the ground.

The front of the museum extends one hundred and two feet, and was designed by Wm. Wilkins, Esq. R. A. In the centre is a portico of four Grecian Doric columns, (three feet six inches in diameter and twenty one feet six inches high,) extending thirty five feet and projecting ten feet, with bold steps all round it. The space on each side of the portico, which is terminated by an antae pilaster, has three windows, ornamented by suitable architraves. A bold massive Grecian pediment is supported by the columns, and the entablature continues the whole length of the front, and returns round the ends of this building, which is about twenty four feet wide. These ends have an antae pilaster at each angle, supporting a massive architectural screen to the roof, imitated from the choragic monument of Thrasyllus at Athens. The whole of this building is faced with Hackness stone, from the quarries of Sir J. V. B. Johnstone, Bart., the gift of the munificent proprietor, and also the sides of the back buildings which are lower than the front.

From the portico, the entrance into the building is by spacious folding doors, with a light over them, resembling that over the door of the Pantheon at Rome.

The internal arrangements were principally founded on a design made by Mr. Sharp in 1825, and subsequently much enlarged and improved. The hall is twenty nine feet six inches by eighteen feet six inches. The floor is formed of scagliola plaster, by Mr. Ellison, in imitation of porphyry. The walls resemble stone; and the ceiling being divided into bold panels, gives the whole a very massive and suitable effect. On the right of the hall is the library, thirty one feet nine inches by eighteen feet six inches: here the books and miscellaneous antiquities belonging to the society are deposited. A door on the left of the library leads to the staircase and council-room. Directly opposite the front door, corresponding folding doors lead into the theatre or lecture-room, thirty five feet by forty four feet. This beautiful room is ornamented by six Corinthian columns and four pilasters, supporting beams enriched by guilloche ornaments, dividing the ceiling into four principal compartments, in each of which are two rows of deep caisons: those of the two middle divisions are filled with ground glass, through which the room is lighted. By a simple but ingenious contrivance, these lights can be instantly obscured by shutters, at the command of the lecturer, whenever any experiments require to be performed in the dark. The seats for the spectators, which are equally handsome and commodious, gradually descend from the level of the entrance hall towards the table of the lecturer, situated opposite the entrance and nearly on a level with the basement floor. The lower part of the lecture-room is rusticated, and the whole of the walls and part of the floor are in imitation of stone. On the right and left of the lecture-room, and communicating with it, are spacious apartments, fifty one feet six inches long by eighteen feet six inches wide, for the collections in geology and mineralogy; the former containing a suite of nearly ten thousand specimens of British rocks and fossils, arranged in the order of their position in the earth; the latter exhibiting above two thousand minerals, classed according to their chemical relations. At the back of the lecture-room and connecting the two lateral rooms, is the museum for zoology, forty four feet by twenty two feet, in which the foreign and British quadrupeds, birds, reptiles, fishes, shells, insects and corallines, which the society possesses, are systematically displayed. These three rooms are lighted by plate glass sky-lights, and are admirably suited to their purpose: they are at present only partially fitted up, as the funds of the society do not allow of more being done.

The front building has an upper story, containing three spacious rooms, one of which is allotted to the use of the keeper of the museum, and another to the valuable collection of comparative anatomy, the property of the curator of that department, James Atkinson, Esq. The whole of the building, except the basement, is peeled by stones erected by Mr. Haden of Trowbridge, and by Mr. Pickersgill of York. Preparations are making for lighting the whole with gas. A considerable part of the internal finishings have been executed under the gratuitous direction of Mr. Pritchett. The basement story contains a laboratory; accommodations for the lecturer, immediately communicating with the lecture-room; a dwelling house for the subcurator; and a long gallery, containing the architectural fragments of the abbey, discovered in the late excavations. A curious old fireplace, belonging to the abbey, is preserved in its original position in one of the basement rooms, and forms a very interesting object to the antiquary. The room being necessarily nearly dark, a gas light is fixed to throw a feeble light upon this relic, and adds not a little to the interest it excites.

A great scientific meeting was held at York, in the month of July, 1831. The object was similar to that of the German society held last year at Hamburgh. The sittings were continued for a week. The Lord Mayor and the authorities of York entered heartily into the plan.

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Observations requested concerning the Fructification of the Mosses. Extracted from a letter of M. Durieu de Maisonneuve, Corresponding Member of the Linnean Society of Bordeaux, to M. Charles des Moulins, Vice-President. *Translated from the first volume of the Bulletin d'Histoire Naturelle de la Société Linnéenne de Bordeaux, by* Jacob Porter.

Paris, 1826.

You were very fortunate in discovering the *Hypnum cuspidatum* in fruit, in Perigord. It commonly bears fruit in the Pyrenees, but in the interior of France, I have never found it in fruit, except once, at Nantes. I take this opportunity of laying before you some reflections concerning the fructification of the mosses. A person of my acquaintance has been endeavoring to ascertain why such a species of moss bears fruit in one country rather than in another, where the temperature or the climate would seem to have no different influence upon the development of the capsules. I might cite a great number of species, that are in point, such as the *Hypnum splendens, Schreberi* and others. The *Hypnum triquetrum,* which, in certain countries, generally bears fruit, is barren in Britain and at Bordeaux. It is very probable that all the mosses present the like phenomenon; and, in support of this opinion, I would cite the *Hypnum cupressiforme,* a very common moss, which bears fruit abundantly throughout France; but I have constantly found it barren at Madrid and in its environs, which proves that there it is, at least, rare in fruit.

The development and the want of the fructification certainly depend on causes, of which we are ignorant, and which it appears to me very difficult to conjecture. An observation, which I would state to you, (and such observations might, without doubt, be multiplied indefinitely, were one's attention directed closely to the subject,) will show that the physical causes, by which we might hope to explain this phenomenon, have really no part in it, or, at most, contribute to it only in a very subordinate degree. The last winter I noticed two large and aged oaks of equal size, standing by the side of each other. The trunks of both, on the side facing the west, were entirely hung over, from the base to a considerable height, with the *Leucodon sciuroides.* On one of them, this moss was covered with fruit; on the other I could not observe a single capsule, notwithstanding the scrupulous attention with which I used to visit it. The same climate, the same temperature, the same exposure, the same humidity, the same vigor in the two coverings of moss, the same nourishing principles, since they are both growing on trees of the same species, which are themselves so near that their roots are doubtless interlaced, and derive the same elements from the same soil. Were we not acquainted with the admirable order of the laws of nature, we might be tempted to believe that the mosses fructify only by caprice.

Before making any researches on this subject, it would be well, I believe, to know precisely in what countries and under what circumstances this or that moss flowers in preference. For this purpose, it is necessary that the authors of local Floras should take the trouble of pointing out, at the close of each species, the greater or less rarity of its fructification in the countries which they explore. M. Mérat, to whom I communicated my idea, approved of it, and assured me that, in the new edition of his Flore des Environs de Paris, he would annex this indication to the description of each species.

I would, therefore, request that the Linnean Society express, in its Bulletin, the desire of seeing the authors of local Floras give likewise these indications at the close of each species of the mosses, hepatic mosses and lichens, which they describe.

The knowledge of the causes, that determine the fructification in these families, would be a very important discovery in natural history, and would probably be a great advance in the cryptogamic department of botany.

NOTICE OF JOURNALS, MEMOIRS, AND OCCASIONAL DISCOURSES.

It is our intention, to introduce, when it may be convenient, among the divisions of this journal, notices of periodical and other works of science, and sometimes of interesting occasional productions.

As coadjutors, however humble, with those who are earnestly engaged in extending the boundaries of useful knowledge, we are happy to manifest a decent respect for our fellow laborers;—not by unmerited or indiscriminate eulogy, or censure, but, by presenting such a view of their labors and merits, as may comport with the limited space and means which we may have to devote to such an object.

Without intending to convert this Journal into a review, or to depart from that simplicity, and matter of fact character, which it has been our desire to sustain, we may sometimes advert to what others are doing, but always, we trust, with that comity which should ever prevail among those who, with enlightened aims and motives of beneficence, are travelling the same road.

This purpose is consistent with our original design, for, the score of volumes by which we are now known to the world, contain numerous analyses of scientific publications. We have performed this duty, however, rather incidentally, and it may be that this will be all which we can, consistently with other duties, perform in future. It would doubtless be interesting and instructive to most readers, to have presented to them a panoramic view of the state and progress of scientific literature, and were it in our power to accomplish such a review with distinctness and discrimination, we should no more doubt of its utility than that it is compatible with the primary objects of the American Journal. Our pages must still be devoted, mainly, to original communications. Our ambition has ever been to render the journal eminently national;—and we are aware that to sustain this character, every facility must be afforded for the cultivation of native talent, and for the exhibition of the results of native research.

1. *Journal of the Philadelphia College of Pharmacy.—Edited by Benjamin Ellis, M. D. Prof. of Mat. Med. and Phar. in the College, assisted by a publishing committee consisting of Daniel B. Smith, Charles Ellis, S. P. Griffitts, Jr., and George B. Wood, M. D. Prof. of Chemistry in the College, &c. Published by the College.*—This is a quarterly periodical, commenced in the month of December, 1825, under the auspices of the Philadelphia College of Pharmacy, an institution which was incorporated in 1822, and which was the first association of the kind in the United States. It originally comprehended sixty eight druggists and apothecaries, then about half the number in Philadelphia. Its influence over the habits of apothecaries, and of physicians themselves, within the first ten years of its existence, we are induced to believe, has been decidedly advantageous. It has been followed by a similar incorporation in the city of New York. An institution of this kind in such a place as

either Philadelphia or New York, must produce a favorable effect throughout the country. There is perhaps no profession more liable to abuse than that of the Pharmaceutist;—none in which the deceptions that may be, and that have been practiced, are more gross and deleterious,—none in which ignorance and negligence have produced, and are producing more fatal agencies. The compounds of pharmacy are held together by chemical affinities which, in numerous instances are so easily subverted;—the value, the absolute qualities of these compounds depends so entirely upon the accurate predominance of these atomic affinities;—and the inertness or the activity of medicine is consequently so dependent on the skill and honesty of the manufacturer and compounder, there is surely no earthly reason why the members of this profession ought not to enjoy all the advantages, and be subject to all the restrictions, which can and do arise from incorporated associations. It is unnecessary for us here to define the nature, or urge the importance of these advantages. They are so well set forth in an address delivered before the Philadelphia college, by its president, Daniel B. Smith, published in the first volume of the Journal of Pharmacy; that we cannot do better than to recommend to every one who is interested in the quality of the medicine, which is administered to himself, or his family, (and what rational being in the country is not so interested,) to peruse this valuable discourse.

In the commencement of its Journal of Pharmacy, it was the intention of the Philadelphia college to rely chiefly on original contributions, and to publish their numbers only as often as their materials would warrant. Upon this scheme they issued four numbers,—the first in December 1825, and the last in 1827. From this time there was a suspension until April 1829, when the publication was resumed under a resolution to continue the journal as a quarterly periodical; and to supply any deficiencies of original matter by selections, adapted to the sciences, which it is the main object of the members of the college to promote, by their associated efforts. These sciences are stated to be those strictly connected with pharmacy, viz. chemistry, (general and pharmaceutic) materia medica, zoology, botany and mineralogy. Thus renovated, and placed under the able direction of the gentlemen, whose names appear in the title, the Journal of Pharmacy has regularly fulfilled the conditions of its prospectus, and has, within the two or three years of its existence, presented, to the members of this important and responsible profession, a body of memoirs, and of facts, original and selected, well worthy of their serious attention.

Our space will enable us, at present, to take only a hasty view of some of the most important of the original articles.

The first is a short paper "on the preparation of glauber and epsom salt, and magnesia from sea water;" by Daniel B. Smith. After stating the manipulations practiced in the large salt works of Massachusetts, and giving the composition of sea water, as obtained by Dr. Marcet, the author remarks that "The state in which these elements exist in sea water, is involved in much obscurity. According to the temperature employed in the evaporation, we procure from it either sulphate of lime, sulphate of magnesia, or sulphate of soda. It is therefore evident that a change of temperature is sufficient to disarrange the combinations that usually obtain.

"If we suppose the sulphuric acid to exist in combination with soda, the following may be considered as the composition of one thousand grains of sea water.

Sulphate of soda, - - -	4.698 grains.
Hydrochlorate of magnesia, - -	6.4125
lime, - -	1.625
Chloride of sodium, - - -	26.27

"If it be combined with magnesia, the following arrangement may be considered as obtaining:

Sulphate of magnesia, - -	3.915 grains
Hydrochlorate of magnesia, - -	2.69325
lime, - -	1.625
Chloride of sodium, - -	30.185

"The latter formula agrees better than the former with the medium proportion of salt, (which is about 3 per cent.) in sea water."

"The formation of Glauber's salt (it is added) cannot be advantageous to the manufacturer. It lessens the production of common salt about 13 per cent. and though the same quantity of magnesia can be obtained from the bitterns, it will not yield Epsom salt."

The next article is by the same author, and is entitled "*Remarks on the common Hydrometer, with a description of a new method of graduating that instrument.*" The author objects to the common instruments, that in all of them the scales are altogether arbitrary, and will not compare with each other, and are not intelligible to the general student; and that the mode of graduation is very defective, as in taking as starting points so small a part of the scale, the error of observation, if any, is multiplied in the higher numbers. He proposes to construct an instrument, of which one hundred degrees shall represent an increase or decrease of two tenths of specific gravity, water being zero, and the scale equally divided.

After adverting to the limitation of the use of the hydrometer by the unequal expansion of different fluids by heat, a copious table is inserted, calculated from the very copious tables, prepared by direction of the British Excise, exhibiting the per centage of alcohol of .825 specific gravity, indicated by each degree of the hydrometer for every five degrees of temperature, from 30° to 80° of Fahrenheit.

The second number contains an article on James's Fever Powders by Dr. Samuel Jackson, who infers, as well from the various analyses of this substance, as from a trial of it in the alms house, Philadelphia, that it is an inert and wholly useless preparation, and should be expunged from the Pharmacopœia.

In the same number we find a very judicious article on the Black Drop, by Thomas Evans, in which the writer shows plainly enough, we think, that this celebrated preparation is very improperly called in the most noted pharmacopœias, *the vinegar of opium*,—that it is in fact a *compound syrup of opium*, exceedingly clumsy and unscientific in its preparation, and that administering such a mixture, the practitioner can never know what quantity of opium he is giving. The writer however, who is an experienced pharmacien, admits the advantage of acetic acid as a solvent of opium. "Some years ago (he observes) Dr. Joseph Hartshorne directed the preparation of such a tincture, according to the following recipe, viz.

Turkey opium, - - - -	℥ ii
Strong vinegar, - - - -	℥ f. xiii.
Alcohol, - - - - -	℥ f. viii.

Triturate the opium with the vinegar; add the alcohol, and digest with gentle heat for ten days; then filter through paper for use. This has been extensively used, and found to possess all the virtue of the black drop. As a substitute for common strong vinegar, which is often impure, and of uncertain strength, the writer proposes pure pyroligneous acid ℥ f. v, with water ℥ f. vii, and the same proportions as before stated of alcohol and opium.

The fourth number of the new series of the Journal, contains the excellent discourse of the President, to which we have alluded, and in which the young apothecary will find an interesting account of the progress and condition of the pharmaceutic art, in the most civilized countries of Europe, with some strictures upon the manner in which it is conducted in this country. This and each of the three succeeding numbers, contains a colored plate of some medicinal plant, with a botanical and pharmaceutical account of it by D. B. Smith. These "very faithful and spirited engravings" were executed from drawings by Dr. W. P. C. Barton, for his Medical Flora of the United States, and it is intended to publish one of these in every future number of the Journal.

In the fourth number of the second volume, however, in lieu of a plant, we have a colored engraving of certain indigenous species of the genus Cantharis of Latreille, as fit substitutes for the blistering fly of the shops, with an elaborate description of the insect by Elias B. Durand. To this gentleman the Journal is indebted for various other communications, indicative of taste and science.

In the same concluding number of the second volume, is an address delivered to the graduates of the college, in October last, by Henry Troth, Esq. one of the vice presidents. This is a spirited and sensible address, urging upon the young members of the profession of pharmacy, those dispositions and habits that cannot fail, if properly cherished, to rescue the trade from various existing blemishes, and render the dispensers of physic, in *all* its departments, more enlightened and respectable.

But of all the original articles in the two published volumes of this Journal, that which displays the most learning is a "Review of the Pharmacopœia of the United States of America, by the authority of the General Convention for the formation of the American Pharmacopœia, held in 1830. Second edition, (from the first edition, published in 1820,) with additions and corrections. New York; published by S. Converse. November, 1830."

This review bears upon the face of it, the ability of an experienced pharmacien; and we shall probably not miss the mark very widely, in ascribing it, as we do at a venture, to the pen of the president of the college.

The reviewer observes in the outset, with no less truth than pungency, that in the examination of such a work as a pharmacopœia, (especially, we may add, when it claims the authority of a national code,) a spirit of severe criticism may be laudably indulged. We cannot follow him through the twenty pages which he has devoted to this interesting examination. He *has* indulged a spirit of wholesome severity; and although a book which requires such rigid exactness of detail and such a "lynx-eyed revision of the press" as a pharmacopœia, could scarcely be expected to escape without faults, if left to a *committee* for revision, yet we must confess, after reading this review, that the conclusion is forced upon us, either that this intended national work was committed to very incompetent hands, or that both the compilers and revisers were extremely remiss in their duties. The inference to us appears inevitable, that "with all these imperfections the work could not, under any circumstances, gain the confidence of the profession, nor be received as the general standard."

But to this impression, so unfavorable to the state of chemical and pharmaceutical science in the United States, we find a relief in a review, evidently by the same writer, in the next number of the Journal, (April, 1831,) of "The Pharmacopœia of the United States of America. By authority of the National Medical Convention, held at Washington, 1830. Philadelphia: 1831." This convention was held in conformity to the provisions made by the Convention of 1820, for a decennial meeting of delegates at Washington, for the special purpose of revising the Pharmacopœia. It appears from the statement of the reviewer, that from certain difficulties and misapprehensions, (which we need not take time to explain,) two conventions were held, one at New York and one at Washington. To the former we are indebted for the New York edition of 1830; to the latter for the Philadelphia edition of 1831.

We know not how much influence, (or whether any at all,) sectional prejudices, or the rivalship of schools, may have had in the production of these two rival editions of the National Pharmacopœia. But unless the objections made by this able reviewer to the former of these editions, and the general eulogium bestowed on the latter, can be proved to be exaggerations, (and we must say that on the face of his shewing, it would be difficult, we conceive, to substantiate a charge of incorrectness, or of improper bias,) there can be no hesitation, in respect to these two editions, which of them ought to be recommended to the medical student.

The ninth and last published number of the Journal of Pharmacy, contains an account of *Liriodendrine*, or the bitter principle of the Liriodendron Tulipifera; by Professor Emmet of the University of Virginia. The chemical characters of this substance are well stated in the memoir. It has hitherto passed for a resin, which, when not crystallized, it much resembles, but its volatility and other characters seem to place it, as the writer observes, with camphor, as a connecting link between the resins and volatile oils.

This article of Dr. Emmet is followed by a description, botanical and medical, of the Liriodendron Tulipifera or American poplar, by Dr. Benjamin Ellis, and is accompanied with a fine engraving;—to this succeeds an account of *Ichthyocolla*, by D. B. Smith;—and the fourth and last original article is a dissertation on Peruvian Bark, by Dr. Geo. B. Wood. These are followed by a number of well selected articles, from foreign and other journals, and by the Review of the Philadelphia edition of the Pharmacopœia before mentioned.

From the foregoing account of the Journal of the Philadelphia College of Pharmacy, our readers we trust will unite in the opinion that such an attempt to sustain and enlarge the science of a profession so intimately connected with the welfare of society, ought to be amply encouraged by the extension of its subscription list to every part of the United States, where drugs are compounded and the quality of them is a matter of interest to the buyer and the seller.

We have heard with much regret of the death of Dr. Benjamin Ellis, the principal editor of the Journal. He has left we understand, from his many amiable qualities, a painful blank in the circle of his acquaintance. From the able support which he received from the committee, we do not anticipate any diminution of interest in the Journal.

2. *American Conchology, or descriptions of the shells of North America. Illustrated by colored figures from original drawings, executed from nature; by* Thomas Say, F. M. L. S. &c. Vol I. Nos. 1 and 2. New Harmony, Indiana.

Since the notice, in our last volume, of Mr. Conrad's first No. of American Marine Conchology, we have received Mr. Say's two numbers of a work intending to embrace the whole of American Conchology. It gives us pleasure at all times to see any thing in the way of Natural History, from the pen of so distinguished and so industrious a naturalist. Wishing success to every undertaking intended to illustrate our *Fauna*, we would call public attention to this undertaking which will require the assistance of students of this branch of Natural Science.

In his prospectus, the author says, "the object of this work is to fix the species of our Molluscous animals, by accurate delineation in their appropriate colors, so that they may be easily recognized even by those who have not extensive cabinets for comparison."

Although it is intended to elucidate the Molluscous animals, of *all* North America, yet it is proposed to introduce those of the United States chiefly, into the first part of the work, so that those subscribers who may wish to limit their inquiries or expenditures to the shells of this union may be accommodated.

We have no doubt the able author will redeem his pledges, if sustained by an adequate subscription on the part of the public, and we sincerely hope that a scientific work, so likely to prove creditable to the country, will not be suffered to languish or die, for want of the required assistance.

We regret that Mr. Say has not thought it better to publish the species of each genus together. When the work shall be finished, it will not present any systematic order, unless the whole be taken to pieces and rearranged. For the sake of making the rarer and more doubtful species known, we should have preferred that those should have been described in the early numbers, and such species as *Oliva literata*, *Paludina decisa*, &c. well known, and in most of our cabinets, left until towards the conclusion of the work. The plates are executed with great accuracy, and we must not withhold our praise from the fair artist who has so happily delineated the illustrations. Were we disposed to censure any part of the work, it would fall on the compositor and pressman, who might be a little more careful, and free the work from inaccuracies and blemishes, which are not creditable to the present state of the American press.

3. *Prof. Griscom's address to the Newark Mechanics Association.*—This discourse, delivered in January, 1831, is replete with sound sense, with exact and valuable knowledge, and with the most important moral and practical views. It is lucid and attractive, and must have given much satisfaction to the very respectable association to which it was delivered. That association, situated in a flourishing and beautiful town, appears from the report, appended to the published discourse, to be in a prosperous and efficient condition, and, we trust, will prove eminently beneficial to the members of the institution, and to the spread of useful knowledge in our country.

4. *Gen. Cass's address before the Alumni of Hamilton College, August*, 1830.—A chaste, eloquent and beautiful production, rich in valuable thoughts and facts, and in sound views of classical learning. Gen. Cass is a fine example of the union of literature, with active habits both in the field and in civil life.

5. *Discourse on classical learning before the Alumni of Columbia College, New York, May*, 1830, *by John T. Irving.*—This production is not unlike the preceding, both in its literary character, and in the views which it propounds on the subject of classical education. It is both illustrated, and recommended by a biographical notice of the late eminent Dr. William Samuel Johnson of Connecticut, one of the most splendid ornaments of literature and jurisprudence which this country has produced. When he was more than ninety years of age he was still eloquent, and interesting; and not more venerable than attractive; for, his manners were still those of finished courtesy, and the native vivacity his mind was scarcely repressed by his years.

6. *Address at the opening of the Classical Hall at Brooklyn, by Theodore Eames. Discourse on Education, before the Wayne County Education Society,* (*N. Y.*) *by Myron Holley.*—Both these discourses display in an advantageous manner, the great object and importance of education, and it is very gratifying to observe men of decided talent and knowledge, giving the power of their minds, to this, the highest interest of the community. Mr. Holley has displayed in a glowing manner, the advantages of our free institutions. In all the addresses which we have thus concisely mentioned, it is not knowledge alone that is recommended; a high moral standard is also exhibited, and the pupil is forcibly reminded, that knowledge, without virtue, is only the power, to do harm more effectually and extensively.

7. *Address at the opening of a new edifice, for the New York Dispensary, by the Rev. J. F. Schroeder*, A. M. 1830.—This is a powerful appeal to the better feelings of men, in behalf of the victims of poverty, disease and suffering, and it is supported by many very interesting facts.

Mr. Schroeder is prone to give his influence in favor of good and liberal things, and there can be no doubt that such discourses, by enlightened christian orators, produce an extensive, lasting, and happy influence on society.

8. *Method of acquiring a full knowledge of the English language, by A. B. Johnson, before the New York State Lyceum, at Utica.*—An arrangement upon the plan recommended by Mr. Johnson, would facilitate the just and full comprehension of the English language, and had the alphabetical arrangement, (which he does not propose

to relinquish, and which must ever be retained,) corresponded with the full exhibition of all the cognate meanings of the different parts of the same elementary idea, it would have been a happy coincidence.

9. *Southern Agriculturalist for July*, 1831.—This useful work is continued as heretofore. It abounds with that practical information, which, although avowedly local in its principal features, is very properly so, because the peculiarities of southern soil, vegetation and culture, cause some interests to be prominent, and of paramount importance in those parts of the continent. Still there is valuable information, which is useful to every part of the Union.

10. *Analysis of the mineral water of Saratoga, and Ballston, with an account of their medicinal properties, &c. by John Steel*, M. D.—Dr. Steel has compressed in this little volume, all the information that is most interesting to the multitudes who visit the very remarkable waters of which he treats. He has prefixed a history of the springs, and a geological description of the county of Saratoga, in which they are situated.

The description of the springs, and the account of the analysis of the waters, especially of the Congress fountain, is full and satisfactory.

There is no reasonable ground to doubt, that the composition of the springs is substantially what Dr. Steel has indicated, and the quantity of mineral ingredients is remarkably great, compared with those of other celebrated mineral waters.

The Congress water appears by Dr. Steel's analysis, to contain in one gallon, or two hundred and thirty one cubic inches:

Marine Salt (chloride of sodium) - -	385.0
Hydriodate of soda, - - -	3.5
Bi-carbonate of soda, - - - -	8.982
Bi-carbonate of magnesia, - -	95.788
Carbonate of lime, - - - -	98.098
Carbonate of iron,	5.075
Silica, - - - - - -	1.5
	597.943 grs.

Carbonic acid gas - -	311
Atmospheric air, - -	7
Gaseous contents, - -	318 cubic inches.

The large quantity of saline ingredients, both cathartic, (or what may become such,) and antacid—the iron,—the great proportion of redundant carbonic acid gas, and even the small quantities of iodine and bromine, give these waters a rare combination of powers;—deobstruent, cathartic, diuretic, solvent and tonic, and their important effects on glandular complaints are now satisfactorily explained by the new bodies whose existence has been happily discovered in the waters.

Their effect is no doubt promoted by air, and exercise, by abstinence from other drinks especially alcohol, and by the mental excitement, and the cheering hope which such visits usually inspire; but still the properties of these springs must forever (while the waters flow the same) remain intrinsically important.

It is not necessary to advert, particularly, to the numerous springs which Dr. Steel has described in this valley of health, but it is proper to say that his cautions as to the use of the waters, are highly judicious and that they should be carefully read by every invalid, before he begins his course of drinking. It is madness to drink these or any other waters, as many people do, unless they had the capacity of the camel of the African desert, and expected, like that animal, to drink only at long intervals.

Dr. Steel's account of the springs of the sister village of Ballston is candid, which is the more desirable, as some rivalry exists between the two places; we trust, however, that this rivalry will be hereafter only a friendly one; for both places are sufficiently attractive, on account of the abundance and excellence of their waters; there are visitors enough for both, and their enjoyments are increased by the sociable calls that are made from the one place to the other.

The mineral impregnation of the waters, in the two places, is substantially the same, differing only in the proportions. If the saline ingredients are in less quantity at Ballston than at Saratoga, there is a greater predominance of iron, and the carbonic acid gas being abundant, very delightful acidulous chalybeate waters are thus afforded. Saratoga and Ballston must be regarded as one grand system of springs, depending upon the same general causes; and the variety that exists between the different springs is altogether desirable, and adds much to their utility. The repeated eruption of new springs, especially at Ballston, (either by accident or in consequence of boring,) is an interesting geological circumstance, and the expulsion of the water in copious jets, above the surface of the ground, and boiling with carbonic acid gas, evinces that there is much power condensed below, and renders it not improbable that the elevating agent is carbonic acid gas itself.* We are glad to observe that genuine sulphureous waters have been discovered in this region of Saratoga and Ballston. The indications of sulpureous waters stated by Dr. Steel are unequivocal, and very different from those which are often ignorantly assumed to establish the same point. A fetid impregnation, arising from decomposing organic matter, may produce an offensive water, but will not give a true impregnation of sulphuretted hydrogen. We have tried some of these, so called, sulphureous waters, and while they were somewhat fetid, they produced no tarnish in the most delicate metallic solutions, such as those of bismuth, silver and lead. We can with pleasure recommed Dr. Steel's little volume, as a valuable acquisition to this department of local knowledge. There can be no doubt it must speedily pass to another edition, and although we have a great distaste for petty criticism, were we at the Doctor's elbow, when he blots a copy of this edition that it may appear improved in another, we should venture to suggest a few hints, especially in the literary department of the work.

11. *Essays on some of the most important articles of the Materia Medica,—with an account of the new proximate principles, &c. &c.; by George W. Carpenter.*—Mr. Carpenter has been, for some years, well known as an active, ingenious, and successful pharmaceutist; and the public have been not a little indebted to him for his zeal and tact in bringing forward discoveries and improvements, (not unfrequently his own) in the materia medica. Many of his valuable papers have appeared in this journal; and in its pages, and in those of the medical journals of Philadelphia, some prominent parts of the present work may be found. There is however an important advantage in bringing these papers, (embodied also with the important additions which in relation to other subjects, have been made, in the present volume,) into a portable, compact and cheap form, that they may be easily accessible to the practitioner. We can say, with the editor of the National Gazette, "that we closed this volume with the impression that it must be serviceable in every family, and may fix and reward the attention of any inquirer. The improvements which have been made in the preparation and exhibition of many of

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* The explosion of a sulphureous water at Ballston, by which the peculiarity of the water was destroyed and a sulphureous smell diffused to a considerable distance around, would seem to imply that some of the gases of sulphur are occasionally concerned in generating the power.

the most important articles of the Materia Medica, are scarcely less curious than satisfactory, and are clearly described by Mr. Carpenter—for instance, opium, bark, sarsaparilla, and the oil of cantharidin. This oil supersedes, most mercifully, the common mode of blistering. It is produced by separating in a crystallized state the vesicating principle of the Spanish flies, and dissolving that in oil. This preparation seems to possess remarkable advantages over the ordinary epispastics. A few drops of it, applied to any part of the body, effectually draws, in six or eight hours, a complete blister, and with a degree of pain and inconvenience comparatively slight for the patient: or a piece of paper, made to imbibe a portion of it, forms an excellent blister, which may be adapted to any part however irregular, and the consequent verification is circumscribed and defined exactly with the paper."*

As. Mr. Carpenter's valuable manual must soon require a reprint, we will beg leave to suggest, that an attentive *literary revision* of the work, will add new attractions to the great intrinsic value which it certainly possesses; and if we were to add another remark, it would be, that the less of the spirit of trade appears in a work of science the better.

12. *Franklin Institution of New Haven.*—A patriotic and enterprising citizen of New Haven, Mr. James Brewster, a practical mechanic, and long well known for his extensive manufactory of excellent carriages, has recently erected, at his own expense, an establishment for popular lectures. Mr. Brewster has devoted two stories of a large and handsome building to this purpose. One of them is occupied by the lecture room and laboratory, and the other by a cabinet of natural history, and apartments for those who may be connected with the institution.† The lecture room will contain three hundred persons; it is airy, well lighted, and finished in good taste. It is equally well adapted to lectures, of an intellectual character only, as to those of experiment and illustration by machines and models, and by specimens in natural history. An apparatus is already collected, and will be, from time to time, enlarged, and the cabinet of natural history, of three or four thousand specimens, is rich in minerals, rocks and shells.

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* See the more detailed account of the preparation and properties of cantharidin at p. 69 of this No.

† With apartment also for lodging rooms.

Gentlemen, accustomed to such duties, are engaged to give short courses of lectures in different departments of science, arts and literature, and it is expected that a mental entertainment will thus be afforded during nearly every week in the year. The lectures are open to strangers as well as to citizens; the charges will be only sufficient to pay the expenses, and should there be any thing remaining, it will be devoted by Mr. Brewster to the formation of a library for the institution. At the head of it, is placed Mr. C. U. Shepard, a gentlemen already advantageously known as a zealous and successful cultivator of natural knowledge, especially of chemistry and natural history,* and more especially of mineralogy and botany. Mr. Shepard will be responsible to give system and effect to the lectures; and at three preliminary meetings the design of the institution has been already explained to different divisions of citizens and strangers. We need scarcely say that Mr. Brewster's example is worthy of all praise and imitation, especially when we add, that his exertions and contributions are equally conspicuous in the promotion of every other important interest of the community.

We hope to announce, at no distant day, another example,—not of a mechanic, as in this instance, but of a practical farmer, who, earning his money at the plow, and willing to see good done while he is yet in vigorous, middle life, bestows his earnings, by thousands, for the promotion of liberal knowledge.

13. *Addresses of the Rev. Adam Sedgwick at the aniversary meetings of the Geological Society of London.*—The last of these very able addresses was delivered Feb. 18, 1831. Like those that have preceded it, from the same source, it is characterized by great learning, vigor and discrimination. Professor Sedgwick's masterly summaries of the progress of geological discovery and induction, form the best history of the science, during the period which they cover; and there is no conclusion which they tend more fully to establish than the necessity of great caution in drawing general inferences from a limited view of facts. To be justly appreciated, these discourses must be studied with attention, and it is to be hoped that the learned author will, in some other form if not in the present, (since he has ceased to preside over the geological society,) continue his reviews of the progress of geology with unsparing although courteous criticism.

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* See his papers in this Journal, passim.

14. *American Botanical Register.*—The nature and object of this work, were announced at p. 160, of our last volume, to which notice, we refer our readers.

We have now to state, that in accordance with the plan, No. 1 of the work has appeared, and the numerous colored engravings beautifully executed, have fully redeemed the engagements of the editors on that head. We trust that the work will prove useful to the advancement of botanical knowledge.

15. *Encyclopedia Americana.*—The seventh volume of this valuable work has been published, and is occupied by parts of the letters I and L. It is pleasing to see it appear with such punctuality, and to observe the rich additions that are made on American topics which cannot fail to render it both more useful and more interesting to American readers. In the account of the New Haven and Farmington Canal some slight errors have crept in; Colebrook is remote from the line of the canal, which, instead of being merely under contract to Southwick, has been, for several years, navigable to that place, and beyond it to Westfield, in Massachusetts.

Messrs. Carey and Lea have republished a series of articles from the Encyclopedia, relating chiefly to France; thus a valuable mass of information respecting that fine country, now so peculiarly interesting to the world, has acquired a wide diffusion.

16. *Tables for determining the latitude at sea by an altitude of the polar star, observed at any distance from the meridian.*—The naval profession is indebted to Mr. J. P. Rodriguez of the U. S. Navy Yard at Gosport, for the very useful tables named above; from their source we cannot doubt of their accuracy, and every thing of this kind is particularly interesting, in a country which is eminently the land of ships and seamen.

17. *Science in the West.*—Useful knowledge is advancing in these favored regions with the general progress of society. We have already mentioned the Detroit Lyceum, and, in a large, handsome, and well arranged newspaper,—The Detroit Journal and Michigan Advertiser,—we observe a discourse or lecture, pronounced in May last before that institution, by Mr. Schoolcraft; it is interesting and instructive, and replete with the personal knowledge, acquired by that gentleman in his extensive travels, in the interior of this conti-

nent. He is one of a considerable number of gentlemen to whom the country is much indebted for this species of information, gained by no small share of toil, privation and danger, in adventures of observation and discovery in the less explored parts of North America.

18. *Science in the South.*—Among the literary institutions that have been established in the Southern States, the university of Tuscaloosa appears to be one of the best endowed and one of the most promising. Its president, the Rev. Alva Woods, pronounced, in June, a valuable discourse before the lyceum of Tuscaloosa, an institution designed, like others of its name, to diffuse useful knowledge as extensively as possible among the people.

OTHER NOTICES AND COMMUNICATIONS.

1. *Remarks on the American Locust,* (Cicada Septendecem,) *by* David Thomas.—The locusts have appeared in great numbers this season, along the shores of the Cayuga lake; but I have not yet ascertained the boundaries of their district. To the east, they were found at Onondaga, and as far to the west as Genesee river. It is probable, however, that they extended farther in both directions.

One remarkable fact in the history of this insect, I have not seen noticed in the course of my reading, viz. *in different parts of our country, it comes forth in different years.* Thus, it appeared in the western states in 1829;* in the western part of New York in 1831; and in the eastern part of Pennsylvania in 1800, corresponding with 1817 and 1834. Another *district* has been mentioned to me by different persons, but *the year* has not been ascertained.

A *map* of the United States, shewing the boundaries of such *districts*, and marked with *the years* in which these insects come forth, would be an interesting present to entomologists; and if each friend of science who subscribes for this Journal would contribute his mite, it might speedily be completed.

Oak lands seem the favorite residence of this insect. It is doubtful if it ever inhabits beech and maple lands in a state of nature, but since the forests have been partially removed, it is evidently extending its limits.

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* See Dr. S. P. Hildreth's account, Vol. XVIII, p. 47, of this Journal.

What is the food of this insect in its *larva* state?

From what depths in the earth has it been taken?

What has caused the locusts of one district to differ in regard to *time* from the locusts of another district?

Do not these insects extend the boundaries of their districts? and if so, do not those districts, in some places, overlap or interfere?

Agreeably to this view, may not the same district be inhabited by locusts that observe different *years?*

May not their appearance in some places, therefore, seem anomalous, when in fact they observe, with exactness, the period of seventeen years?

Greatfield, Cayuga county, N. Y. 7th Mo. 8, 1831.

2. *Notice of a halo;* by J. W. Tyler, Acting Principal and Lecturer on Natural Sciences in the seminary of "Oneida Conference, Cazenovia, N. Y."—A rare and curious phenomenon was observed at this place (Lat. 42° 55′) on the 11th of January last. The weather had been mild for a number of days previous, and on that day the thermometer ranged from 23° to 30°. The atmosphere was so hazy that a shadow was but faintly visible, the haziness being most dense near the south horizon, but growing rarer and finally disappearing a little north of the zenith. The phenomenon was observed at about 8 o'clock 45 min., morning. The azimuth of the sun was about 45° 20′ south east, and altitude about 11° 16′.

The first appearance was a brilliant parhelion, about 25° west of the sun, and at about the same altitude. Its form at first was nearly circular, and its apparent diameter a little greater than that of the true sun. Its light, which was of a brilliant white, was so intense as to pain the eyes. In a few moments another parhelion of equal brightness appeared at the same distance, on the east side of the sun, and at the same altitude. When first seen, it appeared a little elongated vertically, and slightly colored. Both these parhelia retained their size and appearance for a few moments, and then began to lengthen in a vertical direction, and to show the prismatic colors with considerable brilliancy. Their greatest length in a vertical direction was about 10°, and the resemblance between them complete.

Directly above the sun appeared, at the same time with the parhelia a colored arc, containing 45° or 50° of a circle, described to a radius of about 25°, having its center in the zenith and its convexity towards the sun. The exterior of the arc was red, and this was the only color that was distinctly defined. The other colors were merged into each other, but the blue and green appeared predominant though faint. The arc was seen for nearly a quarter of an hour, and then disappeared but an instant before the parhelia.

During the succeeding night and day there was a heavy fall of snow and the thermometer fell to 0. During the succeeding week, the mean temperature was 4.97°, the highest being 15° and the lowest —11°; affording, in my view, a confirmation of the theory of halos, parhelia, &c. given in the Library of Useful knowledge, No. 19.

3. *On the supposed collapse of steam boilers, and the means of preventing explosions; by* W. C. Redfield.

TO THE EDITOR.

Dear Sir—The review of Professor Renwick's Treatise on the Steam Engine, which appeared in the last number of your valuable Journal, contains the following passage.

"A great proportion of the fatal accidents which have occurred in steam boats, have arisen from a *collapsing of the boilers;* that is, in consequence of the sudden formation of a vacuum in the boiler, by which means the sides of the boiler have been crushed together by external pressure, and the hot water and steam forced out with great violence. It seems a very easy matter to provide against this source of danger, by attaching to the upper parts of the boiler an air valve opening inwards. Whenever the tension of the steam becomes less than the pressure of the atmosphere, the valve will open and restore the equilibrium."

As a just apprehension and estimate of the facts, is of great importance in guiding our enquiries on this interesting subject, I am induced to state my impression that no fatal accident has occurred to any steam boat in the American waters, which can justly be ascribed to the cause mentioned in the foregoing paragraph. In all the accidents which have happened in this quarter, the boilers have been crushed or broken through *in the direction which is opposite or contrary to the pressure of the atmosphere.* It appears also, from the best evidence which we can obtain, that the pressure of steam at the time of these accidents, as well as on ordinary occasions, has *exceeded that of the atmosphere* by a pressure of from seven to seventeen pounds to each square inch of surface, and in some instances by a much greater force. It deserves also to be mentioned, that most of these boilers were furnished with "an air valve opening inwards," for the special purpose of obviating any danger which might be supposed to arise from such a source.

The indeterminate use of the word *collapse* by persons attached to steam boats, and by those who have given accounts of these accidents, has probably occasioned most of the misconception which appears to prevail on this subject. Most of the boilers which have failed in this vicinity, were so constructed as to contain large internal flues, which were broken in by the external pressure of the steam upon them, and the term *collapse* has been used merely to designate the direction in which the disruption has taken place, or rather to indicate the portion of the boiler which sustained the injury.

To illustrate clearly the causes of failure in those boilers which have come under my own observation, would require a prolixity of detail which is not suited to the object of this communication.

The statement of Professor Renwick, that in our American steam boats "there is never but one safety valve," and that "plates of fusible metal are unknown," is somewhat too broad, and is calculated to mislead the public, in regard to the actual state of what may be called practical science, in this country. Fusible metal was several years ago applied to boilers, as an additional means of safety, under the directions of the writer, and was also used in other boats navigating from this city.

Although the strictest attention to the means of safety in steam boats cannot be too often or too strongly urged upon those who construct or navigate them, still it is true that much unmerited censure has been dealt out to this class of persons, not only by the ordinary periodical press, but sometimes through the medium of scientific works of a more permanent character. It should always be recollected, that an undivided and careful attention to one or two safeguards of known and acknowledged efficacy, will, in ordinary hands, afford a much greater degree of safety than can be secured by the adoption of all the contrivances with which curious or learned men have from time to time become interested. A due regard to *strength* in the form and structure of boilers, will remove all reasonable grounds of apprehension, in regard to a mode of travelling which is already the safest, on the whole, of any with which we are acquainted.

New York, September 24, 1831.

4. *Hurricane of August*, 1831.—In an article which was published in the April number of the *American Journal of Science*, I attempted to show that *storms and hurricanes consist in the regular gyratory motion or action of a progressive body of atmosphere;*

which action is the sole cause of the violence which they may exhibit; and that the storms of the Atlantic Ocean are *drifted* in a determinate direction, conforming to that of the general atmospheric current of the region in which they occur. The late hurricane in the West Indies, having from its peculiar violence attracted considerable attention, I am induced to offer you the following notices of its appearance and progress, which have been obtained from various sources.

The earliest accounts are from the Island of Barbadoes, where the hurricane raged with great violence, on the night of the 10th of August. On the 11th it passed over the islands of St. Vincent, and St. Lucia, extending its influence to Martinico and the neighboring islands on the north, and to Grenada on the south, but exhibiting its chief violence between 12° 30′ and 14° 30′ of north latitude. On the 12th it arrived on the southern coast of the Island of Porto Rico. From the 12th to the 13th it swept over the island of Hayti or St. Domingo, and extended its influence as far southward as Jamaica. On the 13th it raged on the eastern portion of Cuba, sweeping in its course over large districts, if not the whole of that extensive island. On the 14th it was at Havanna, towards the West end of the same island. Of its progress on the 15th we have no distinct accounts; but on the 16th and 17th it arrived on the northern shores of the Gulf of Mexico, in about the 30° north latitude, raging simultaneously at Pensacola, Mobile, and New-Orleans, where its effects were continued till the 18th, thus having occupied a period of six days in its passage from Barbadoes to New Orleans.

From the coast of the gulf of Mexico the storm entered upon the territories of the adjoining States, where it appears to have spent itself in heavy rains. If its peculiar action was longer continued, it must have been only in the higher atmosphere, as we have no account of any violent effects at the surface nearer than the Southern States.

When accounts of huricanes were formerly received, as occurring at different islands, on various dates, with marked differences also in the direction of the wind, it was taken for granted that those violent winds were *rectilinear* in their course, and that such accounts, in most cases, related to different storms. We now discover, however, that there is no difficulty in tracing these storms successively from one island or locality to another, and the direction of the wind at any one point or place is found to have no connection with the general progress or direction of the storm.

At most of the Islands, during the late hurricane, the winds in the earlier part of the storm were from a Northern quarter, and in its later periods from a Southern quarter of the horizon; from which it results that the gyratory action was from *right to left*, as in the storms which pass to the northward of the great islands and along our Atlantic coast. The distance passed over by the storm in its passage from Barbadoes to N. Orleans, is equal to *twenty-three hundred statute miles*. The time of passage being six days, gives an average rate of about sixteen miles an hour, which accords with the rate of progress which I had previously ascribed to the storms of that region.

This hurricane appeared in a more Southern latitude than those which are described in my article before mentioned, but pursued the same general direction as that which occurred at the same season in 1830, passing over or to the Southward of the great Islands, and across the gulph of Mexico, with a course curving Northwardly as it approached the American coast.—Hence it follows that its atmosphere must have subsequently passed over a considerable portion, if not the whole of the Atlantic States, according to the prevailing tendency of the general atmospheric current in this part of the globe. In its progress from Barbadoes to New Orleans the storm was constantly enlarging in its dimensions and sphere of action, which is shown by its increasing duration as it proceeded Westward, as well as by other evidence.

It is perhaps worthy of notice that the peculiar aspect of our atmosphere, together with the unusual color and appearance of the sun, which excited so much attention a few weeks ago, was exhibited a few days after the occurrence of the hurricane at Barbadoes, and at Mobile and New Orleans was the immediate precursor of the storm. W. C. Redfield.

New York, September 27th, 1831.

N. B. To the list of localities in which the *second* hurricane of August, 1830, exhibited its violence, as published in the Journal of Science, that of Martinico may be prefixed; at which island the Southern margin of that storm shewed itself on the night of 19—20th of that month.—*N. Y. Journal of Commerce.*

5. *Agriculture and Horticulture in the West.*—There are numerous indications, of thrift in the Western States, and we observe with satisfaction, the increase of useful periodical publications; among

them the Western Tiller deserves to be mentioned. It is a weekly quarto, devoted mainly to horticulture and agriculture, but embraces other useful arts and valuable miscellaneous imformation. We trust it meets with support proportioned to the importance of the objects which it sustains.

6. *Population of Philadelphia.*—In Hazard's Register of Pennsylvania for July 30, 1831, there is a valuable paper on the statistics of the population of Philadelphia. It scarcely admits of abridgement or analysis, but will be found to exhibit, in a lucid manner, the leading facts on this important subject with ample elucidations of the points that are chiefly interesting to a political economist.

7. *Temperance.*—This subject is sufficiently physical to be entitled to a place in our pages, even although we were precluded from touching the moral interests of man. These interests cannot indeed occupy a principal place in such a journal as this; but who can be indifferent to the moral bearing of his own pursuits, or to those of his fellow men! The annual report of the Louisville temperance* society, lies before us, and it is replete with interesting and important facts; especially in the appended documents from judicial, medical, and other public men. Among these most respectable witnesses, there is but one voice, and that is, that nearly all the crimes, most of the poverty, and a large part of the diseases and casualties, and we may add, of the cases of insanity are due to this cause. There is but one remedy, and that is the total abandonment of the use of ardent spirits as a drink. This course is effectual, as half a million of persons who are now supposed to be associated in the United States for this purpose, can testify; and doubtless, half a million more can echo the same report, because, although not avowedly associated for this purpose, they act upon the same principle. We would by no means insinuate, that a large proportion of the remainder are intemperate, but too many fail to give the world the influence of their decided opinion and example. We find it difficult to refrain from enlarging on a topic of such momentous import, and which has been rendered familiar to us by much contemplation and examination. There remains

* The addresses of Dr. Sewall, of Dr. Mussey, and of many others, besides many reports of societies, as those of the state of South Carolina, of New York, &c. are in our hands, but we have not room to advert particularly to their interesting contents.

no doubt, that were the use of ardent spirit entirely abandoned to the arts, to science, and, in some few cases perhaps, to medicine, society would, in a few years, wear an entirely new aspect. We are certain that this would be the result upon the largest scale, because the experiment is already completely successful on the smaller scale, upon which it has been made. We have not merely heard the fact—we have seen it; we know it; and no evidence can weaken the conviction resting upon our minds. In physics, experiments, although successful on a small scale, sometimes fail on the large; but, not so in morals; the virtue of a good man repeated in every other man, would make the whole community good, and the same is strictly true of temperance, and of every thing that depends upon it. There is not one reason, nor the shadow of a reason, for the habitual use of ardent spirit; it does only harm; it is both physically and morally noxious, and if persevered in, it is fatal to every interest, and to every hope.

8. *Notice of Cobalt, Nickel, &c. of the Chatham mine, Connecticut, in a letter from Mr. A. A. Hayes to the Editor, dated Roxbury Laboratory, Aug.* 29, 1831.—I have done nothing in experimental chemistry for some time, except making an examination of a specimen of the produce of the Chatham mine. The operations, it seems, were unskilfully conducted, and the whole produce of metal, seven or eight hundred pounds, is now in the market. Its value as a coloring material in the pottery manufacture, was the object; but having detected *antimony* in an assay with the blowpipe, I was lead to make a careful analysis of it. It is a black powder containing, in one hundred parts

Unexamined insoluble matter,	3.00	Oxide of	Iron,	6.15
Sulphur,	8.92	"	Cobalt,	17.30
Arsenic,	16.25	"	Nickel,	43.85
Antimony,	4.50			——
				99.97

exclusive of hygrometic water. The numbers approach nearer the original quantity than we should expect from the circumstance that the "oxide of nickel" may be in the specimen, in part metallic nickel. The antimony was separated from the yellow sulphuret of arsenic, in a current of hydrogen, as pointed out by Rose.

I thought it might be interesting as a discovery, as it may lead mineralogists to look for nickeliferous antimony, among their specimens of arsenical nickel from this locality; and we shall probably mention it in an account of an examination, of another arsenical compound, which has been the subject of many experiments. It is the arseniuret of iron with sulphuret of cobalt, described by Prof. Dana, and which you noticed in your late work.* I was engaged in the examination, so long ago, as when its containing cobalt was the subject of your correspondence with him, and it has been occasionally the subject of experiment since. It is a refractory compound, and while a pupil with Prof. D. I subjected it to all the processes which had been published, with a determination to finish its examination. Finding the characters of the constituent metals erroneously described, a partial examination of them became necessary; want of sufficient leisure afterwards, prevented my completing what was begun. Some months since I prevented a friend from publishing his opinion, that it contained no cobalt, *by actual experiment.* Prof. D. was however led into an error, in relation to the quantity of cobalt which can be detected by the blowpipe, from his trusting to the purity of a specimen from Frederick Accum; it was merely a *fused ore of cobalt*: a ten thousandth of cobalt, can be detected by a practised eye.

The value of the blowpipe as an instrument of research, has not been duly appreciated in this country; few I believe use it with skill, even in mineralogical inquiries.

9. *Manufacture of lead pots, &c. by Messrs. Dixon.*—We have pleasure in stating to the public, that there has lately been established in Salem, Massachusetts, a Manufactory of black lead pots, by a process, the discovery of Messrs. J. and F. Dixon. These pots, as we learn from the artists who have used them, prove on trial to possess great advantages over other pots. 1st. They resist sudden change of temperature better. 2d. They are not liable to change their form, on pressure of the tongs in a great heat. 3d. They are found to be far more durable. But their high estimation with those who have used them, is, perhaps, best proved by the fact, that the orders for them, have been so frequent, that the manufacturers have not been, and are not now able to make them so fast as they are called for.

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We are informed also that one of the Messrs. Dixon has ground and polished a concave lens for the venerable and ingenious Dr. B. Lynde Oliver, of Salem, who has been constructing an achromatic

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* Elements of Chemistry, Vol. II, p. 200.

telescope on the principle of Rogers, mentioned in Dr. Brewster's journal; this telescope proved to be a very good one for a small power, although it is not completed: its length is five feet, and aperture three inches and three fourths. Mr. Dixon, has made a machine for grinding and polishing mirrors and lenses, on the plan of Lord Oxmanton's, mentioned by Dr. Brewster. Mr. Dixon has also established a manufactory of prussian alkali for dyers.

10. *Skulls*—Dr. Samuel G. Morton of Philadelphia, has recently deposited in the Academy of Natural Sciences of that city, an extensive series of *skulls*, embracing those of the different races of men and the various classes of inferior animals. A principal object in forming this collection, is to investigate the peculiarities of the aboriginal inhabitants of the American continent; and persons who are in possession of Indian crania, are respectfully invited to communicate with Dr. M. in reference to them.

11. *Notices of scenery, &c. in Pennsylvania; in a letter to the Editor from Mr. W. B. Weed, dated Chilicothe, Aug.* 13, 1831.—From Harrisburg westward, to the distance of sixty or seventy miles, the country presents one continued scene of beauty and sublimity. The road is cut along the side of a ridge that rises above you, in rugged bluffs, to the height of two or three hundred feet, and descends as far below, to the bank of the Juniata, whose gentle current and waveless surface formed a striking contrast with the rude surrounding scenery. Here too is the Pennsylvania Canal, running parallel with the river, with nothing but the tow-path between, and producing a most beautiful effect. On the other side of the river ascends a ridge to the height of four hundred feet, crowned with thick forests to its very summit, which, seen through the thin veil of vapor which is continually ascending from the water, presented (though not half a mile distant) the exact appearance of the densest thunder cloud. The summit of this ridge, for fifty miles, is perfectly uniform, as if levelled by art. Pittsburg too has an abundance of fine scenery, both within and around it. The only trace which remains of Fort Pitt, which you know was built on the ruins of Fort Du Quesne, is the magazine. Built as it is of massive rock, it will probably remain for centuries, to indicate the origin of this flourishing city. You know Pittsburg is situated at the confluence of the two rivers which form the Ohio. From the top of "Coal hill," you have a fine view of all three. The Allegha-

ny comes down like a race-horse, turning the current of the Monongahela and marking its way entirely across its mouth, by the yellow color which its waters receive from the soil that is mingled with it. The Monongahela, on the other hand, flows slowly and sullenly, as if unwilling to approach the point where it must yield up its tribute; while the Ohio, far from imitating the stupid sluggishness of the one or the headlong impetuosity of the other, rolls on its waters with a calm and amazing grandeur.

The valley of the Scioto, in which you know the town of Chilicothe stands, affords a subject of interesting speculation to the geologist. In digging the canal which is now in progress, the workmen, after descending four or five feet, invariably come to a band of sand, such as is found upon the sea-shore. This sand is filled with pebbles of every size, rounded as if by long and constant attrition. What is the conclusion? Is it not, that the waters of the Scioto were once confined to this valley and formed a lake extending through the whole of it, and that the river has at length broken through its bounds and drained the country? I can account for the above appearances in no other way.

12. *Singular Phenomenon.*—On Saturday last, between five and six o'clock P. M., the attention of our citizens was attracted by the extraordinary appearance of the sun. The predominating color of the rays of light which it transmitted, was a pale blue or violet, varying occasionally from that to a sea green. A large spot, apparently of the size of a dollar, was also visible to the naked eye on its lower limb. On Sunday morning it exhibited the same unusual appearance, casting a bluish shade over the objects on which it shone; and at 6 o'clock on Monday evening its whole face was of a pale green color. It was not seen yesterday. The sky was thickly overcast with clouds, and a violent storm set in last evening from the southeast. The winds were very high during the night, and this morning at six o'clock, the water of the bay was on a level with most of the wharves. Commerce street, from Barney's new building, north, and from Conti Street south, is now under water, as is also the north end of Water-street. There is every appearance of the continuance of the storm, and should the water rise much higher, great damage will inevitably ensue.—*Mobile Register, Aug.* 17.

APPENDIX.

Four Cardinal Points in Stratiographical Geology, established by Organic Remains; by A. Eaton.

If the identity of the *Granular*, the *Metalliferous*, and the *Oolitic, calcareous rocks*, and of the *Tertiary Marls*, are established on both continents, all intervening strata may be ascertained with great facility. I think, that a reference to the following facts will be sufficient to establish their equivalent characters, at least.

First Cardinal Point.

GRANULAR LIMEROCK.

The only limerock, which is always destitute of organic remains.

Second Cardinal Point.

METALLIFEROUS, MOUNTAIN OR CARBONIFEROUS LIMEROCK.

Shelly kind.—This rock contains Fungia discoidea, F. polymorpha, Columnaria sulcata, Productus hemisphericus, Calamena Blumenbachii, Asaphus caudatus, Orthocera annulata, O. striata, O. undulata, Spirifer ambiguus, Turbinola mitrata, Lithodendron dichotomum and L. plicatum. These I have before me, which were collected chiefly at Glenn's and Trenton Falls, and all of them have been collected in Germany, France and England, and well figured and described by Sowerby, Brongniart, Goldfuss, Parkinson and others.

Cornitiferous or Cherty kind.—Cyathophyllum ceratites, C. vermiculosum, C. flexuosum, C. vesiculosum, C. helianthoides, C. quadrigeminum, C. hexagonum. These seven species of the *stone horns*, are found at and near Bethlehem Caverns, in the county of Albany; also in Germany, Great Britain, &c. in the same rock. At Bethlehem, Catskill, Esopus strand, and on the Rondout, we find, in the same rock, the Sarcinula auleticon, S. microphthalma, Orthocera paradoxica, Conularia quadrisulcata, C. teres, Productus depressus and Gorgonia ripesteria.

Third Cardinal Point.

OOLITIC SERIES OF CALCAREOUS ROCKS.

Coral Rag, or the Pyritiferous kind.—Astrea stylophora, A. porosa, Asaphus Hausmannii. These three species are found in Europe, in this rock; and I found the same on the south shore of Lake Erie. I found the four following species, (all of which have been found in Germany,) in the coral rag, over the cavern two miles north of a little village on the Helderberg, twenty three miles south west of Albany. Diploctenium pluma, Lithodendron cespitosum, Columnaria alveolata, Gorgonia infundibiliformis.

Fourth Cardinal Point.

TERTIARY MARLS.

Marly clay, London clay kind.—Placatula pectinoides, Nautilus imperialis. These I found in New Jersey, south of Amboy bay, in Middletown.

Shell marl, or fresh water marl.—Planorbis obtusa, Limnea longiscata, L. minima. These I found in the stratified shell marl in the bank of Erie canal, ten miles west of Onondaga Salt-works.

All the organic remains, quoted above, are found on both continents in similar strata, known to all correct geologists by the name here given. Though I have ascertained numerous other relics in each stratum, I have introduced none but those which are well authenticated, both in regard to their names, and the strata with which they are respectively associated.

Important inferences may be deduced from the establishment of these four starting points. The argillite being between the granular and carboniferous limerocks, the carbonaceous beds contained in it, are, of course, made up of the genuine anthracite. The carboniferous limerocks of Bethlehem Caverns, Catskill, Esopus, &c. actually extend into Pennsylvania, and appear in view of the Hudson and Delaware canal, until they pass under the rocks embracing the coal beds of Carbondale, Lehigh, &c. We are enabled to identify these beds with those of the great coal measures of Europe. The absurdity of treating them as beds of anthracite becomes manifest on taking this view of the subject. The coal of these beds is the Culm coal, or Kilkenny coal of Europe. It might be called Anasphaltic coal, or coal destitute of bitumen, like some varieties of the great coal beds of Europe.

The relations which our deposits of gypsum, &c. bear to those of Europe, may be shown by a reference to those established strata; and the practical mineralogist may be directed by them in all his researches. A. E.

Troy, N. Y. October 2, 1831.

Scull. N.Y.

Eli Whitney

THE

AMERICAN

JOURNAL OF SCIENCE, &c.

Art. I.—*Memoir of the Life of* Eli Whitney, Esq.*

The memory of the late Mr. Whitney is so fondly cherished by his fellow citizens, out of respect to his distinguished talents, his private virtues, and his public spirit, and his name holds so honorable a place among the benefactors of our country, that the wish has often been intimated to us of seeing a more extended biography of him, than has hitherto been given to the public.

We now enter with pleasure upon such a task; and to enable us to do the better justice to the subject, we have been favored with access to his extensive correspondence, and all his other writings, and have conferred freely with various persons, who were long and intimately acquainted with him.

Eli Whitney was born at Westborough, Worcester County, Massachusetts, December 8, 1765. His parents belonged to the middle class in society, who, by the labors of husbandry, managed, by uniform industry and strict frugality, to provide well for a rising family. From the same class have arisen most of those who, in New England, have attained to high eminence and usefulness; nor is any other situation in society so favorable to the early formation of those habits of economy, both of time and money, which, when carried forward into the study of the scholar, or the field of active enterprise, afford the surest pledge of success.

The paternal ancestors of Mr. Whitney, emigrated from England among the early settlers of Massachusetts, and their descendants were among the most respectable farmers of Worcester County. His maternal ancestors, of the name of Fay, were also English emigrants, and ranked among the substantial yeomanry of Massachusetts. A

* The editor is indebted exclusively to Prof. Olmsted, for this article.

family tradition respecting the occasion of their coming to this country, may serve to illustrate the history of the times. The story is, that, about two hundred years ago, the father of the family, who resided in England, a man of large property and great respectability, called together his five sons and addressed them thus: "America is to be a great country; I am too old to emigrate to it myself; but if any one of you will go, I will give him a double share of my property." The youngest son instantly declared his willingness to go, and his brothers gave their consent. He soon set off for the New World, and landed at Boston, in the neighborhood of which place he purchased a large tract of land, where he enjoyed the satisfaction of receiving two visits from his venerable father. His son, *John Fay*, from whom the subject of this memoir is immediately descended, removed from Boston to Westborough, where he became the proprietor of a large tract of land, since known by the name of the *Fay-Farm.*

From Mrs. B. the sister of Mr. Whitney, we have derived some particulars respecting his childhood and youth, and we shall present the anecdotes to our readers in the artless style in which they are related by our correspondent, believing that they would be more acceptable in this simple dress than if, according to the modest suggestion of the writer, they should be invested with a more labored diction. The following incident, though trivial in itself, will serve to show at how early a period certain qualities, of strong feelling tempered by prudence, for which Mr. Whitney afterwards became distinguished, began to display themselves. When he was six or seven years old, he had overheard the kitchen maid, in a fit of passion, calling his mother, who was in a delicate state of health, hard names, at which he expressed great displeasure to his sister. "She thought (said he) that I was not big enough to know any thing; but I can tell her, I am too big to hear her talk so about my mother. I think she ought to have a flogging, and if I knew how to bring it about, she should have one." His sister advised him to tell their father. "No (he replied,) that will not do; it will hurt his feelings and mother's too; and besides, it is likely the girl will say she never said so, and that would make a quarrel. It is best to say nothing about it."

Indications of his mechanical genius were likewise developed at a very early age. Of his early passion for such employments, his sister gives the following account. "Our father had a workshop, and sometimes made wheels, of different kinds, and chairs. He had a variety of tools, and a lathe for turning chair posts. This gave my brother an opportunity of learning the use of tools when very young. He lost no time, but as soon as he could handle tools he was always making something in the shop, and seemed not to like working on the farm. On a time, after the death of our mother, when our father had been absent from home two or three days, on his return, he inquired of the housekeeper, what the boys had been doing? She told him what B. and J. had been about. But what has Eli been doing, said he. She replied, he had been making a fiddle. 'Ah! (added he despondingly) I fear Eli will have to take his portion in fiddles.' He was at this time about twelve years old. His sister adds, that this fiddle was finished throughout, like a common violin, and made tolerably good music. It was examined by many persons, and all pronounced it to be a remarkable piece of work for such a boy to perform. From this time he was employed to repair violins, and had many nice jobs, which were always excuted to the entire satisfaction, and often to the astonishment, of his customers. His father's watch being the greatest piece of mechanism that had yet presented itself to his observation, he was extremely desirous of examining its interior construction, but was not permitted to do so. One Sunday morning, observing that his father was going to meeting, and would leave at home the wonderful little machine, he immediately feigned illness as an apology for not going to church. As soon as the family were out of sight, he flew to the room where the watch hung, and taking it down, he was so delighted with its motions, that he took it all in pieces before he thought of the consequences of his rash deed; for his father was a stern parent, and punishment would have been the reward of his idle curiosity, had the mischief been detected. He, however, put the work all so neatly together, that his father never discovered his audacity until he himself told him, many years afterwards."

Whitney lost his mother at an early age, and when he was thirteen years old, his father married a second time. His step mother, among her articles of furniture, had a handsome set of table knives, that she valued very highly; which our young mechanic observing, said to her, 'I could make as good ones if I had tools, and I could make the necessary tools if I had a few common tools to make them with.' His step mother thought he was deriding her, and was much displeased; but it so happened, not long afterwards, that one of the knives got broken, and he made one exactly like it in every respect, except the stamp on the blade. This he would likewise have executed, had not the tools required been too expensive for his slender resources.

When Whitney was fifteen or sixteen years of age, he suggested to his father an enterprise, which was an earnest of the similar undertakings in which he engaged on a far greater scale in later life. This being the time of the Revolutionary War, nails were in great demand, and bore a high price. At that period, nails were made chiefly by hand, with little aid from machinery. Young Whitney proposed to his father to procure him a few tools, and to permit him to set up the manufacture. His father consented, and he went steadily to work, and suffered nothing to divert him from his task, until his day's work was completed. By extraordinary diligence, he gained time to make tools for his own use, and to put in knife blades, and to perform many other curious little jobs, which exceeded the skill of the country artisans. At this laborious occupation, the enterprising boy wrought alone, with great success, and with much profit to his father, for two winters, pursuing the ordinary labors of the farm during the summers. At this time he devised a plan for enlarging his business and increasing his profits. He whispered his scheme to his sister, with strong injunctions of secrecy; and requesting leave of his father to go to a neighboring town, without specifying his object, he set out on horseback in quest of a fellow laborer. Not finding one so easily as he had anticipated, he proceeded from town to town, with a perseverance, which was always a strong trait of his character, until at the distance of forty miles from home, he found such a workman as he desired. He also made his journey subservient to his improvement in mechanical skill, for he called at every work shop on his way, and gleaned all the information he could respecting the mechanic arts.

At the close of the war, the business of making nails was no longer profitable; but a fashion prevailing among the ladies of fastening on their bonnets with long pins, he contrived to make those with such skill and dexterity, that he nearly monopolized the business, although he devoted to it only such seasons of leisure as he could redeem from the occupations of the farm, to which he now principally betook himself. He added to this article, the manufacture of walking canes, which he made with peculiar neatness.

In respect to his proficiency in learning, while young, we are informed that he early manifested a fondness for figures, and an uncommon aptitude for arithmetical calculations, though in the other rudiments of education, he was not particularly distinguished. Yet at the age of fourteen, he had acquired so much general information, as to be regarded on this account, as well as on account of his mechanical skill, as a very remarkable boy.

From the age of nineteen, young Whitney, conceived the idea of obtaining a liberal education; but being warmly opposed by his step-mother, he was unable to procure the decided consent of his father, until he had reached the age of twenty three years. But, partly by the avails of his manual labor, and partly by teaching a village school, he had been so far able to surmount the obstacles thrown in his way, that he had prepared himself for the Freshman class in Yale College, which he entered in May, 1789. An intelligent friend and neighbor of the family helped to dissuade his father from sending him to college, observing, that "it was a pity such a fine mechanical genius as his should be wasted;" but he was unable to comprehend how a liberal education, by enlarging his intellectual powers and expanding his genius, would so much exalt those powers, and perfect that genius, as to place their possessor among the Arkwrights of the age, while without such means of cultivation, he might have been only an ingenious mill-wright or blacksmith. While a schoolmaster, the mechanic would often usurp the place of the teacher; and the mind, too aspiring for such a sphere, was wandering off in pursuit of perpetual motion. While at home in the month of July, 1788, making arrangements to go to New Haven, for the purpose of entering college, he was seized with a violent fever attended by a severe cough, which threatened to terminate his life. At length the disease centered in one of his limbs. A painful swelling, extending to the bone, ensued, which was finally relieved by a surgical operation. After his recovery he went to Durham, in Connecticut, and finished his preparation for college under the care of that eminent scholar Doctor Goodrich. As we are soon to accompany Mr. Whitney, beyond the sphere of his domestic relations, we may mention here, that he finished his collegiate education with little expense to his father. His last college bills were indeed paid by him, but the money was considered as a loan, and for it the son gave his note, which he afterwards duly cancelled. After the decease of his father, he took an active part in the settlement of his estate, but generously relinquished all his patrimony for the benefit of the other members of the family.

We have already mentioned, that Mr. Whitney entered Yale College, at the mature age of twenty three years. He had enjoyed but little intercourse with men of learning, and the state of elementary education, in the part of the country where he passed his minority, was unfavorable to his acquiring a knowledge of polite literature; and while a member of college he seems to have devoted more attention to the mathematics, and especially to mechanics, theoretical as well as practical, than to the ancient classics. Among his files are found most or all of the compositions and disputions which he wrote during this period, commencing with 1789. The compositions are frequently characterized by great vividness of imagination, and the disputations by sound and correct reasoning. At this time of life, indeed Mr. Whitney exhibited an imagination somewhat poetical; his prose compositions had something of this vein, and he occasionally wrote verses. The written disputations found among his papers, are more than twenty in number. Some of them were read before the President, (the late Dr. Stiles,) and others were exhibited in the literary society to which he belonged. Their titles indicate the topics that were agitated by the students of that day. The subjects discussed were oftener political than literary. The writers partook largely of the enthusiasm which pervaded all ranks of our countrymen. They exulted in their release from a foreign yoke, and boasted of the victory they had achieved over British arms. They extolled the matchless wisdom of the new government, and contrasted its free spirit with the tyranny of most of the governments of the old world, and its youthful vigor with those moldering fabrics. With a spirit somewhat prophetical, they anticipated the decline and overthrow of all arbitrary governments, and the substitution in their place, of a purely representative system like our own, and thus maintained, (what is now even more probable than it was then,) that this government was set up to be a model to all the nations of the earth.

The propensity of Mr. Whitney to mechanical inventions and occupations, was frequently apparent during his residence at College. On a particular occasion, one of the tutors happening to mention some interesting philosophical experiment, regretted that he could not exhibit it to his pupils, because the apparatus was out of order, and must be sent abroad to be repaired. Mr. Whitney proposed to undertake this task, and performed it greatly to the satisfaction of the Faculty of the College.

A carpenter being at work upon one of the buildings of the gentleman with whom Mr. Whitney boarded, the latter begged permission to use his tools during the intervals of study; but the mechanic being a man of careful habits, was unwilling to trust them with a student, and it was only after the gentleman of the house had become responsible for all damages, that he would grant the permission. But Mr. Whitney had no sooner commenced his operations, than the carpenter was surprised at his dexterity, and exclaimed, "there was one good mechanic spoiled when you went to college."

Soon after Mr. Whitney took his degree, in the autumn of 1792, he entered into an engagement with a Mr. B. of Georgia, to reside in his family as a private teacher. On his way thither, he was so fortunate as to have the company of Mrs. Greene, the widow of Gen. Greene, who, with her family were returning to Savannah, after spending the summer at the north. At that time it was deemed unsafe to travel through our country without having had the small pox, and accordingly Mr. W. prepared himself for the excursion, by procuring inoculation while in New York. As soon as he was sufficiently recovered, the party set sail for Savannah. As his health was not fully re-established, Mrs. Greene kindly invited him to go with the family to her residence at Mulberry Grove, near Savannah, and remain until he was recruited. The invitation was accepted; but lest he should not yet have lost all power of communicating that dreadful disease, Mrs. Greene had white flags (the meaning of which was well understood) hoisted at the landing, and at all the avenues leading to the house. As a requital for her hospitality, her guest procured the virus, and inoculated all the servants of the household, more than fifty in number, and carried them safely through the disorder.

Mr. Whitney had scarcely set his foot in Georgia, before he was met by a disappointment which was an earnest of that long series of adverse events which, with scarcely an exception, attended all his future negotiations in the same State.* On his arrival, he was informed that Mr. B. had employed another teacher, leaving Whitney, entirely without resources or friends except those whom he had made in the family of Gen. Greene. In these benevolent people however, his case excited much interest, and Mrs. Greene kindly said to him,

* In a letter to his friend, Josiah Stebbins, Esq. (the late Judge Stebbins of Maine) dated Geo. April 11, 1793, Mr. Whitney says, "Fortune has stood with her back towards me ever since I have been here."—It does not appear that, so far as related to Georgia, he ever found her position reversed.

my young friend, you propose studying the law; make my house your home—your room your castle, and there pursue what studies you please. He accordingly commenced the study of the law under that hospitable roof.

Mrs. Greene was engaged in a piece of embroidery in which she employed a peculiar kind of frame called a *tambour*. She complained that it was badly constructed, and that it tore the delicate threads of her work. Mr. Whitney, eager for an opportunity to oblige his hostess, set himself at work and speedily produced a tambour frame made on a plan entirely new, which he presented to her. Mrs. Greene and her family were greatly delighted with it, and thought it a wonderful proof of ingenuity.*

Not long afterwards, a large party of gentlemen came from Augusta and the Upper country, to visit the family of Gen. Greene, consisting principally of officers who had served under the General in the Revolutionary army. Among the number were Major Bremen, Major Forsyth, and Major Pendleton. They fell into conversation upon the state of agriculture among them, and expressed great regret that there was no means of cleaning the green seed cotton, or separating it from its seed, since all the lands which were unsuitable for the cultivation of rice, would yield large crops of cotton. But until ingenuity could devise some machine which would greatly facilitate the process of cleaning, it was in vain to think of raising cotton for market. Separating one pound of the clean staple from the seed was a day's work for a woman; but the time usually devoted to picking cotton was the evening, after the labor of the field was over. Then the slaves, men, women and children, were collected in circles with one, whose duty it was to rouse the dozing and quicken the indolent. While the company were engaged in this conversation, "gentlemen (said Mrs. Greene,) apply to my young friend Mr. Whitney—he can make any thing." Upon which she conducted them into a neighboring room, and showed them her tambour frame, and a number of toys which Mr. W. had made, or repaired for the children. She then introduced the gentlemen to Whitney himself, ex-

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* Several years afterwards, his partner, Mr. Miller, writes to Mr. Whitney, "I presume your skill in mechanics is likely to give you employment enough with the ladies; for your name is often coupled with work frames, needles, &c. &c.; so that I apprehend you will ultimately be compelled to become ignorant and unskillful in these things, in your own defence."

tolling his genius, and commending him to their notice and friendship. He modestly disclaimed all pretensions to mechanical genius; and when they named their object, he replied that he had never seen either cotton or cotton seed in his life. Mrs. G. said to one of the gentlemen, "I have accomplished my aim. Mr. Whitney is a very deserving young man, and to bring him into notice was my object. The interest which our friends now feel for him, will, I hope, lead to his getting some employment to enable him to prosecute the study of the law."

But a new turn that no one of the company dreamed of, had been given to Mr. Whitney's views. It being out of season for cotton in the seed, he went to Savannah and searched among the ware houses and boats, until he found a small parcel of it. This he carried home, and communicated his intentions to Mr. Miller, who warmly encouraged him, and assigned him a room in the basement of the house, where he set himself at work with such rude materials and instruments as a Georgia plantation afforded. With these resources however, he made tools better suited to his purpose, and drew his own wire, (of which the teeth of the earliest gins were made,) an article which was not at that time to be found in the market of Savannah. Mrs. Greene and Mr. Miller were the only persons ever admitted to his workshop, and the only persons who knew in what way he was employing himself. The many hours he spent in his mysterious pursuits, afforded matter of great curiosity and often of raillery to the younger members of the family. Near the close of the winter, the machine was so nearly completed as to leave no doubt of its success.

Mrs. Greene was eager to communicate to her numerous friends the knowledge of this important invention, peculiarly important at that time, because then the market was glutted with all those articles which were suited to the climate and soil of Georgia, and nothing could be found to give occupation to the negroes, and support to the white inhabitants. This opened suddenly to the planters boundless resources of wealth, and rendered the occupations of the slaves less unhealthy and laborious than they had been before.

Mrs. Greene, therefore, invited to her house gentlemen from different parts of the State, and on the first day after they had assembled, she conducted them to a temporary building, which had been erected for the machine, and they saw with astonishment and delight, that more cotton could be separated from the seed in one day, by the labor of a single hand, than could be done in the usual manner in the space of many months.

Mr. Whitney might now have indulged in bright reveries of fortune and of fame; but we shall have various opportunities of seeing, that he tempered his inventive genius with an unusual share of the calm, considerate qualities of the financier. Although urged by his friends to secure a patent, and devote himself to the manufacture and introduction of his machines, he coolly replied, that on account of the great expenses and trouble which always attend the introduction of a new invention, and the difficulty of enforcing a law in favor of patentees, in opposition to the individual interests of so large a number of persons as would be concerned in the culture of this article, it was with great reluctance that he should consent to relinquish the hopes of a lucrative profession, for which he had been destined, with an expectation of indemnity either from the justice, or the gratitude of his countrymen, even should the invention answer the most sanguine anticipations of his friends.

The individual who contributed most to incite him to persevere in the undertaking, was *Phineas Miller*, Esq. Mr. Miller was a native of Connecticut, and a graduate of Yale College. Like Mr. Whitney, soon after he had completed his education at college, he came to Georgia as a private teacher, in the family of General Greene, and after the decease of the General, he became the husband of Mrs. Greene. He had qualified himself for the profession of law, and was a gentleman of cultivated mind and superior talents; but he was of an ardent temperament, and therefore well fitted to enter with zeal into the views which the genius of his friend had laid open to him. He had also considerable funds at command, and proposed to Mr. Whitney to become his joint adventurer, and to be at the whole expense of maturing the invention until it should be patented. If the machine should succeed in its intended operation, the parties agreed, under legal formalities, "that the profits and advantages arising therefrom, as well as all privileges and emoluments to be derived from patenting, making, vending, and working the same, should be mutually and equally shared between them." This instrument bears date May 27, 1793, and immediately afterwards they commenced business under the firm of *Miller & Whitney.*

An invention so important to the agricultural interest (and, as it has proved, to every department of human industry,) could not long remain a secret. The knowledge of it soon spread through the

State, and so great was the excitement on the subject, that multitudes of persons came from all quarters of the State to see the machine; but it was not deemed safe to gratify their curiosity until the patent right had been secured. But so determined were some of the populace to possess this treasure, that neither law nor justice could restrain them; they broke open the building by night, and carried off the machine. In this way the public became possessed of the invention; and before Mr. Whitney could complete his model and secure his patent, a number of machines were in successful operation, constructed with some slight deviation from the original, with the hope of evading the penalty for violating the patent right.

As soon as the copartnership of Miller & Whitney was formed, Mr. Whitney repaired to Connecticut, where as far as possible, he was to perfect the machine, obtain a patent, and manufacture and ship for Georgia, such a number of machines as would supply the demand.

Within three days after the conclusion of the copartnership, Mr. Whitney having set out for the north, Mr. Miller commenced his long correspondence relative to the Cotton Gin.* The first letter announces that encroachments upon their rights had already commenced. "It will be necessary (says Mr. Miller) to have a considerable number of gins made, to be in readiness to send out as soon as the patent is obtained, in order to satisfy the absolute demands, and make people's heads easy on the subject; *for I am informed of two other claimants for the honor of the invention of cotton gins, in addition to those we knew before.*

On the 20th of June 1793, Mr. Whitney presented his petition for a patent to Mr. Jefferson, then Secretary of State; but the prevalence of the yellow fever in Philadelphia, (which was then the seat of government,) prevented his concluding the business relative to the patent until several months afterwards. To prevent being anticipated, he took however the precaution to make oath to the invention before the Notary Public of the city of New Haven, which he did on the 28th of October, of the same year.

Mr. Jefferson, who had much curiosity in regard to mechanical inventions, took a peculiar interest in this machine, and addressed to the inventor an obliging letter, desiring farther particulars respecting it, and expressing a wish to procure one for his own use. Mr. Whitney accordingly sketched the history of the invention, and of the con-

* This name was not applied by the inventor, but became such by popular ues.

struction and performances of the machine. "It is about a year (says he) since* I first turned my attention to constructing this machine, at which time I was in the State of Georgia. Within about ten days after my first conception of the plan, I made a small though imperfect model. Experiments with this, encouraged me to make one on a larger scale; but the extreme difficulty of procuring workmen and proper materials in Georgia, prevented my completing the larger one until some time in April last. This, though much larger than my first attempt, is not above one third as large as the machines may be made with convenience.—The cylinder is only two feet two inches in length, and six inches diameter. It is turned *by hand*, and requires the strength of one man to keep it in constant motion. It is the stated task of one negro to clean fifty weight, (I mean fifty pounds after it is separated from the seed,) of the green seed cotton per day.—In the same letter Mr. Jefferson assured Mr. Whitney, that a patent would be granted as soon as the model was lodged in the Patent Office. In mentioning the favorable notice of Mr. Jefferson to his friend Stebbins, he adds, with characteristic moderation, *I hope, by perseverance, I shall make something of it yet.*

At the close of this year, (1793) Mr. Whitney was to return to Georgia with his Cotton Gins, and Mr. Miller had made arrangements for commencing business immediately after his arrival. The plan was to erect machines in every part of the cotton district, and engross the entire business themselves. This was evidently an unfortunate scheme. It rendered the business very extensive and complicated, and as it did not at once supply the demands of the cotton growers, it multiplied the inducements to make the machines in violation of the Patent. Had the proprietors confined their views to the manufacture of the machines, and to the sale of patent rights, it is probable they would have avoided some of the difficulties with which they afterwards had to contend. The prospect of making suddenly an immense fortune by the business of ginning, where every third pound of cotton (worth at that time from twenty five to thirty three cents,) was their own, presented great and peculiar attractions. Mr. Whitney's return to Georgia was delayed until the following April. The importunity of Mr. Miller's letters written during the preceding period, urging him to come on, evinces how eager the Georgia planters were to enter the new field of enterprise, which the genius of Whitney

* This letter is dated Nov. 24, 1793.

had laid open to them. Nor did they at first, *in general*, contemplate availing themselves of the invention unlawfully. But the minds of the more honorable class of planters were afterwards deluded by various artifices, set on foot by designing men, with the view of robbing Mr. Whitney of his just right. To these we shall advert more particularly hereafter.

One of the greatest difficulties experienced by men of enterprise, at the period under review, was the extreme scarcity of money. In order to carry on the manufacture of cotton gins, and to make advances in the purchase of cotton, and establishments for ginning, to an extent in any degree proportioned to their wishes, Miller & Whitney required a much greater capital than they could command; and the sanguine temperament of Mr. Miller, was constantly prompting him to advance in hazards, much farther than the more cautious spirit of Mr. Whitney would follow. But even the latter found it necessary sometimes to borrow money at an enormous interest. The first loan (for two thousand dollars) was made on terms, which were deemed at that time peculiarly favorable; yet the company were to pay five per cent. premium in addition to the lawful interest. This was in 1794. In consequence of the numerous speculations in new lands into which so many of our countrymen were deluded, and the want of confidence created by the very application for a loan, the pressure for money was continually increasing. In 1796, Mr. Whitney applied to a friend in Boston to raise money for him on a loan, and received the following reply. "I applied to one of those vultures called brokers, who are preying on the purse strings of the industrious, and was informed, that he can procure the sum you wish at a premium of twenty per cent. on the following conditions, viz.—You must make over and deposit with him public securities, such as funded stock, bank stock, or any kind of State notes, or Connecticut reservation land certificates, sufficient, at the going prices, fully to secure the debt and premium." In a more embarrassed state of Mr. Miller's private affairs, several years afterwards, he paid the enormous interest of five, six, and even seven per cent. *per month.*

We have said that the loan contracted by Mr. Whitney in 1794, at a premium of five per cent. in addition to the lawful interest, was regarded as peculiarly favorable; this is evident from the fact that, during the same year, Mr. Miller urges him to contract a new loan, if possible, for three thousand dollars at twelve or fourteen per cent. provided it could be extended over a year.

In July 1794, Mr. Whitney was confined by a severe illness, from which he recovered slowly; but his business received a still farther interruption from a very fatal sickness, (the scarlet fever) which prevailed in New Haven during this year, and which attacked a number of his workmen.

Under all these discouragements, Mr. Miller was constantly writing the most urgent letters from Georgia, to press forward the manufacture of machines. "Do not let a deficiency of money, do not let any thing (says Mr. Miller) hinder the speedy construction of the Gins. The people of the country are almost running mad for them, and much can be said to justify their importunity. When the present crop is harvested, there will be a real property of at least fifty thousand, yes of a hundred thousand dollars, lying useless, unless we can enable the holders to bring it to market. Pray remember that we must have from fifty to one hundred gins between this and another fall,* if there are any workmen in New England, or in the Middle States, to make them. In two years we will begin to take long steps up hill, in the business of patent ginning, fortune favoring."

The general resort of the planters to the cultivation of cotton, and its consequent production in vast quantities, the value of which depended entirely upon the chance of getting it cleaned by the gin, created great uneasiness, which first displayed itself in this pressure upon Miller & Whitney, and afterwards afforded great encouragement to the marauders upon the patent right, who were now becoming numerous and audacious.

The *roller gin*, was at first the most formidable competitor, with Whitney's Machine. It extricated the seeds by means of rollers, crushing them between revolving cylinders, instead of disengaging them by means of teeth. The fragments of seeds which remained in the cotton, rendered its execution much inferior in this respect to Whitney's Gin, and it was also much slower in its operation. Great efforts were made, however, to create an impression in favor of its superiority in other respects, to which we shall advert by and by.

But a still more formidable rival appeared early in the year 1795, under the name of the *Saw Gin*. It was Whitney's gin, except that the teeth were cut in circular rims of iron, instead of being made of wires, as was the case in the earlier forms of the patent gin. The

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* This letter is dated Oct. 26, 1794.

idea of such teeth had early occurred to Mr. Whitney, as he afterwards established by legal proof. But they would have been of no use except in connection with the other parts of his machine; and, therefore, this was a palpable attempt to evade the patent right, and it was principally in reference to this, that the lawsuits were afterwards held.

In March 1795, in the midst of these perplexities and discouragements, Mr. Whitney went to New York, on business, and was detained there three weeks by an attack of fever and ague, the seeds of which had been sown the previous season in Georgia. As soon as he was able to leave the house, he embarked on board a packet for New Haven. On his arrival at this place, he was suffering under one of those chills which precede the fever. As was usual on the arrival of the packet, people came on board to welcome their friends, and to exchange salutations, when Mr. Whitney was informed that on the preceding day, *his shop, with all his machines and papers, had been consumed by fire!* Thus suddenly, was he reduced to absolute bankruptcy, having debts to the amount of four thousand dollars, without any means of making payment. Mr. Whitney, however, had not a spirit to despond under difficulties and disappointments, but was aroused by them to still more vigorous efforts.

Mr. Miller also, on hearing of this catastrophe, manifested a kindred spirit. The letters written by Mr. Whitney on the occasion, we have not been able to obtain; but the reply of Mr. Miller indicates what were the feelings of both parties. It may be of service to enterprising young men, who meet with misfortunes, to read an extract or two.

"I think with you, (says Mr. M.) that we ought to meet such events with equanimity. We have been pursuing a valuable object by honorable means; and I trust that all our measures have been such as reason and virtue must justify. It has pleased Providence to postpone the attainment of this object. In the midst of the reflections which your story has suggested, and with feelings keenly awake to the heavy, the extensive injury we have sustained, I feel a secret joy and satisfaction, that you possess a mind in this respect similar to my own—that you are not disheartened—that you do not relinquish the pursuit—and that you will persevere and endeavor at all events, to attain the main object. This is exactly consonant to my own determinations. I will devote all my time, all my thoughts, all my exertions, and all the money I can earn or borrow, to encompass and complete the business we have undertaken; and if fortune should by any future disaster, deny us the boon we ask, we will at least deserve it. It shall never be said that we have lost an object which a little perseverance could have attained. I think, indeed, it will be very extraordinary, if two young men in the prime of life, with some share of ingenuity, with a little knowledge of the world, a great deal of industry, and a considerable command of property, should not be able to sustain such a stroke of misfortune as this, heavy as it is."

After this disaster the company began to feel much straightened for want of funds. Mr. Miller expresses a confidence that they should be able to raise money *in some way or other*, though he knows not how. He recommends to Mr. Whitney to proceed forthwith to erect a new shop, and to recommence his business, and requests him to tell the people of New Haven, who might be disposed to render them any service, that they required nothing but a little time to get their machinery in motion before they could make payment, and that the loan of money at *twelve per cent.* per annum would be as great a favor as they could ask. But, he adds, "in doing this, use great care to avoid giving an idea that we are in a *desperate situation*, to induce us to borrow money. To people who are deficient in understanding, this precaution will be extremely necessary: men of sense can easily distinguish between the prospect of large gains, and the approaches to bankruptcy. Such is the disposition of man (he observes on another occasion,) that while we keep afloat, there will not be wanting those who will appear willing to assist us; but let us once be given over, and they will immediately desert us." While struggling with these multiplied misfortunes, intelligence was received from England, which threatened to give a final blow to all their hopes. It was, that the English manufacturers condemned the cotton cleaned by their machines, on the ground that *the staple was greatly injured.*

On the receipt of this intelligence, Mr. Miller writes as follows. "This stroke of misfortune is much heavier than that of the fire, unless the impression is immediately removed. For, with that which now governs the public mind on this subject, our patent would be worth extremely little. Every one is afraid of the cotton. Not a purchaser in Savannah will pay full price for it. Even the merchants with whom I have made a contract for purchasing, begin to part with their money reluctantly. The trespassers on our right only laugh at our suits, and several of the most active men are now putting up the

Roller Gins; and, what is to the last degree vexing, many prefer their cotton to ours."

At this time (1796) Miller & Whitney had thirty gins at eight different places in the state of Georgia, some of which were carried by horses or oxen, and some by water. A number of these were standing still for want of the means of supplying them. The company had also invested about $10,000 in real estate, which was suited only to the purposes of ginning cotton. All things now conspired to threaten them with deep insolvency. Under date of April 27th, Mr. Miller writes thus: "A few moments only are allowed me to tell you, that the industry of our opponents is daily increasing, and that prejudices appear to be rapidly extending themselves in London against our cotton. Hasten to London if you return immediately—our fortune, our fate depends on it. The process of patent ginning is now quite at a stand. I hear nothing of it except the condolence of a few real friends, who express their regret that so promising an invention has entirely failed."

Through nearly the whole of the year 1796, Mr. Whitney was on the eve of departing for England, whither he was going with the view of learning the certainty of the prejudices, which were so currently reported to be entertained by the English manufacturers against the cotton cleaned by the Patent Gin, and the fame of which was so industriously circulated throughout the southern papers; and should he find these prejudices to exist, firmly believing, as the event has shown, that they were utterly unfounded, he hoped to be able to remove them by challenging the most rigorous trials. He had several times fixed on the day of his departure, and on one occasion had actually engaged his passage, and taken leave of some of his friends. But he was in each case thwarted by an unexpected disappointment in regard to the funds necessary to defray the expenses of the journey.

Mr. Whitney had counted on obtaining one thousand dollars for this purpose through the aid of Mr. John C. Nightingale, who, having married a daughter of Mrs. Miller, had become interested in their concerns. Mr. Nightingale had inherited a considerable fortune, but had become greatly embarrassed by speculations in the Yazoo lands. He had however some credit left, while neither Miller nor Whitney, nor both together, had credit enough to borrow a thousand dollars. The plan was, therefore, for Nightingale to borrow the money and lend it to them; and Miller urges this even at the rate of *thirty per cent.* per annum. After various ineffectual trials, Nightingale abandoned all hope of affording the promised succor, and thus Whitney was compelled to forego the great advantages he confidently anticipated from the voyage to England.

We regret that we have not been able to obtain the letters written at this period by Mr. Whitney to his partner, but the nature of their contents will be easily gathered from those of Mr. Miller.

In March 1797, Mr. Miller says, "Unless Nightingale should have the power to assist you with some supplies, which your letter furnishes little ground to hope, I foresee that our money engagements cannot be complied with; and we can only regret as a misfortune what we cannot remedy. In the event of this failure, I can only take to myself the one half of the blame which may attach itself to our misplaced confidence in the public opinion. I confess myself to have been entirely deceived in supposing that an *egregious error*, and a general deception with regard to the quality of our cotton, could not long continue to influence the whole of the manufacturing, the mercantile, and the planting interests, against us. But the reverse of this fact, allowing the staple of our cotton to be uninjured, has to our sorrow proved true, and I have long apprehended that our ruin would be the inevitable consequence.

"I am now devoting my time and attention, to prepare, in the best manner in my power, the suits which are to be tried in April; and am determined that all the dark clouds of adversity, which at present overshadow our affairs, shall not abate my ardor in laboring to burst through them, in order to reach the dawn of prosperity, that has so long been withheld from our view."

Notwithstanding the disastrous condition of the affairs of Miller & Whitney, Mr. Nightingale, who was of an adventurous spirit, having partially extricated himself from his own embarrassments, was ready to purchase a part of their concern, and offered upon certain condition to advance five thousand dollars to the company.

We have before us a letter written by Mr. Whitney, dated Oct. 7th, 1797, from which it will be seen what was the state of his affairs and of his feelings, at this period. "The extreme embarrassments (says he) which have been for a long time accumulating upon me, are now become so great, that it will be impossible for me to struggle against them many days longer. It has required my utmost exertions *to exist*, without making the least progress in our business. I have labored hard against the strong current of disappointment, which has been threatening to carry us down the cataract, but I have labored with a shattered oar, and struggled in vain unless some speedy relief is obtained. I am now quite far enough advanced in life to think seriously of marrying. I have ever looked forward with pleasure to an alliance with an amiable and virtuous companion, as a source from whence I have expected one day to derive the greatest happiness. But the accomplishment of my tour to Europe, and the acquisition of something which I can call my own, appears to be absolutely necessary, before it will be admissible for me even *to think* of family engagements. Probably a year and a half, at least, will be required to perform that tour, after it is entered upon. Life is but short at best, and six or seven years out of the midst of it, is, to him who makes it, an immense sacrifice. My most unremitted attention has been devoted to our business. I have sacrificed to it other objects from which, before this time, I might certainly have gained twenty or thirty thousand dollars. My whole prospects have been embarked in it, with the expectation that I should, before this time, have realized something from it."

These observations are made with reference to a proposition which he had brought forward, to be allowed to retain a certain portion of the proceeds of the receipts from Mr. Nightingale as his private property; or, at least, to be permitted to adopt such arrangements as would secure it to him after a limited period. But the involved state of the company concerns was such that Mr. Miller would not consent to such an arrangement, nor does it appear to have ever been made. However, brighter prospects seemed now to be opening upon them, from the more favorable reports that were made respecting the quality of their cotton. Respectable manufacturers, both at home and abroad, gave favorable certificates, and retailing merchants sought for the cotton cleaned by Whitney's Gin, because it was greatly preferred by their customers to any other in the market. This favorable turn in public opinion, would have restored prosperity to the company, had not the encroachments on their patent right become so extensive as almost to annihilate its value.

The issue of the first trial they were able to obtain, is announced in the following letter from Mr. Miller, dated May 11, 1797.

"The event of the first patent suit, after all our exertions made in such a variety of ways, has gone against us. The preposterous custom of trying civil causes of this intricacy and magnitude, by a common jury, together with the imperfection of the Patent law, frustrated all our views, and disappointed expectations, which had become very sanguine. The tide of popular opinion was running in our favor, the Judge was well disposed towards us, and many decided friends were with us, who adhered firmly to our cause and interests. The Judge gave a charge to the jury pointedly in our favor; after which the defendant himself told an acquaintance of his, that he would give two thousand dollars to be free from the verdict; and yet the jury gave it against us after a consultation of about an hour. And having made the verdict general, no appeal would lie.

"On Monday morning, when the verdict was rendered, we applied for a new trial; but the Judge refused it to us on the ground that the Jury might have made up their opinion on the defect of the law, which makes an aggression, consist of *making, devising and using, or selling;* whereas we could only charge the defendant with *using.*

"Thus after four years of assiduous labor, fatigue, and difficulty, are we again set afloat by a new and most unexpected obstacle. Our hopes of success are now removed to a period still more distant than before, while our expenses are realized beyond all controversy."

Great efforts were made to obtain trial in a second suit, at the session of the Court in Savannah, in May 1798. A great number of witnesses were collected from various parts of the country, to the distance of a hundred miles from Savannah, when, behold, no Judge appeared, and of course no court was held. In consequence of the failure of the first suit, and so great a procrastination of the second, the encroachments on the patent right had been prodigiously multiplied, so as almost entirely to destroy the business of the patentees.

In April 1799, Mr. Miller writes as follows. "The prospect of making any thing by ginning in this State, is at an end. Surreptitious Gins, are erected in every part of the country; and the jurymen at Augusta, have come to an understanding among themselves, that they will never give a cause in our favor, let the merits of the case be as they may."

The company would now have gladly relinquished the plan of working their own machines, and confined their operations to the sale of patent rights; but few would buy a patent right which they could use with impunity without purchasing, and those few, hardly in a single instance, paid cash, but gave their notes, which they afterwards to a great extent avoided paying, either by obtaining a verdict from the juries declaring them void, or by contriving to postpone the collection until they were barred by the statute of limitations, a period of only four years. When thus barred, the agent of Miller & Whitney, who was dispatched on a collecting tour through the State of Georgia, informed them, that such obstacles were thrown in his way from one or the other of the foregoing causes, he was unable to collect money enough from all these claims to bear his expenses, but was compelled to draw for nearly the whole amount of these upon his employers.

The agent here referred to was Russel Goodrich, Esq. who had engaged in the service of Miller & Whitney, as early as the year 1798. He was educated at Yale College, in the same class with Mr. Miller, and was for many years an able and zealous agent in the affairs, first of the company, and after the decease of Mr. Miller, of Mr. Whitney.

In a letter addressed to Mr. Whitney, dated Georgia, September 3d, 1801, Mr. Goodrich writes thus: "I have spent a part of this summer in South Carolina, upon the business of Miller & Whitney. Many of the planters of that region, expressed an opinion that if an application were made to their legislature by the citizens, to purchase the right of the patentees for that State, there was no doubt that it would be done to the satisfaction of all parties. Accordingly, they had petitions circulated among the people, which appeared to be generally approved of, and were very generally signed." Mr. Goodrich further urges the importance of Mr. Whitney's coming on to South Carolina, to attend at the approaching session of the legislature, in order to make the proposed contract.

Accordingly, Mr. Whitney repaired to Columbia, taking the city of Washington in his way, where he was furnished with very obliging letters from President Jefferson, and Mr. Madison, then Secretary of State, testimonials which no doubt were of great service to him in his subsequent negociations. Soon after the opening of the session of the legislature in the month of Dec. 1801, the business was regularly brought before the legislature, and a joint committee of both Houses appointed to treat with the patentees. To this committee Messrs. Miller & Whitney submitted the following proposals—

"*To the Joint Committee of both Houses of the Legislature of South Carolina.*

"Gentlemen,

"The subscribers in estimating the value of their property in the Patent Machine for cleaning cotton, commonly called the Saw Gin, are influenced by the following considerations, viz.

"That no right of property is so well founded in nature, as that of one's own invention: that their fellow citizens by their representatives in the national Government, from considerations both of policy and justice, have declared that individuals who will use their exertions to acquire this species of property, shall enjoy an exclusive right in the same for fourteen years: That influenced by, and relying on, these declarations of their country, they have spent a number of years, and exhausted their funds, in inventing and bringing into use, their Saw Gin: That notwithstanding the innumerable misrepresentations and prejudices which have gone forth respecting this concern, they have firm reliance on the laws of their country, and feel a conscious rectitude in the justice of their cause.

"When we look around and see many of our fellow citizens, who are engaged in pursuits exclusively for their *own* benefit, guarded and protected, in those pursuits, by the laws of their country, we cannot believe that those who have contributed, in any degree, to benefit their *fellow citizens* and the public, will be deprived of the same protection, and abandoned to poverty.

"We will not go into any detailed calculations as to the value of this invention, but only observe, that the citizens of South Carolina have gained, and will gain many millions of dollars by the use of this machine, which they never could have acquired without it. Being under embarrassments in consequence of debts incurred in prosecuting this undertaking, and desirous of obtaining some compensation for our labors, we will not measure our demand by the value of the property, but are willing to dispose of it to the State of South Carolina for a sum far below its real value; and therefore we submit to the committee the following Proposals:

"The subscribers will relinquish and transfer to the legislature of South Carolina, so much of their patent right, of the machine for separating cotton from its seeds, commonly called the Saw Gin, as appertains to said State, for the sum of one hundred thousand dollars, the one half of the said sum to be paid on the transfer of said right, the other by installments as shall be hereafter agreed upon.

Miller & Whitney."

After some discussion, it was agreed by the legislature to offer to the patentees the sum of *fifty thousand dollars*. We subjoin a letter addressed at this time by Mr. Whitney to his friend Stebbins, both as a statement of the particulars relating to the contract, and as evincive of the feelings of the writer.

"Columbia, South Carolina, Dec. 20, 1801.

"*Dear Stebbins,*

"I have been at this place a little more than two weeks, attending the Legislature. They closed their session at 10 o'clock last evening. A few hours previous to their adjournment, they voted to purchase, for the State of South Carolina, my patent right to the machine for cleaning cotton, at fifty thousand dollars, of which sum, *twenty thousand is to be paid in hand, and the remainder in three annual payments, of ten thousand dollars each.*

"This is selling the right at a great sacrifice. If a regular course of law had been pursued, from two to three hundred thousand dollars would undoubtedly have been recovered. The use of the machine here is amazingly extensive, and the value of it beyond all calculation. It may, without exaggeration, be said to have raised the value of seven eighths of all the three Southern States from fifty to one hundred per cent. We get but a song for it in comparison with the worth of the thing; but it is *securing* something. It will enable Miller & Whitney to pay all their debts, and divide something between them. It establishes a precedent which will be valuable as it respects our collections in other States, and I think there is now a fair prospect that I shall in the event realize property enough to render me comfortable, and in some measure independent.

"Though my stay here has been short, I have become acquainted with a considerable part of the members of the Legislature, and of the most distinguished characters in the State. My old classmate, H. D. W., is one of the Senate. He ranks among the first of his age in point of talents and respectibility. He has shown me much polite attention, as have also many others of the citizens.

Truly your friend,

J. Stebbins, Esq. ELI WHITNEY."

In December 1802, Mr. Whitney negociated a sale of his patent right with the State of North Carolina. The legislature laid a tax of two shillings and sixpence upon *every saw** employed in ginning cotton, to be continued for five years, which sum was to be collected by the sheriffs in the same manner as the public taxes; and after deducting the expenses of collection, the avails were faithfully paid over to the patentee. At that time, the culture of cotton had made comparatively little progress in the State of North Carolina; but, in proportion to the amount of interest concerned, this compensation was

* Some of the gins had forty saws.

regarded by Mr. Whitney as more liberal, than that received from any other source.

While these encouraging prospects were rising in North Carolina, Mr. Goodrich, the agent of the company, was entering into a similar negociation with the State of Tennessee. The importance of the machine began to be universally acknowledged in that State, and various public meetings of the citizens were held, in which were adopted resolutions strongly in favor of a public contract with Miller & Whitney.* Accordingly, the legislature of Tennessee at their session in 1803, passed an act laying a tax of thirty seven cents and a half per annum on every saw for the period of four years.

But while a fairer day seemed dawning upon the company in this quarter, an unexpected and threatening cloud was rising in another. It was during Mr. Whitney's negociation with the legislature of North Carolina, that he received intelligence that the legislature of South Carolina had annulled the contract made with Miller & Whitney the preceding year, had suspended payment of the balance (thirty thousand dollars) due them, and instituted a suit for the recovery of what had already been paid to them.

The ostensible causes of this extraordinary measure, adopted by the legislature of South Carolina, were a distrust of the validity of the patent right, and failure on the part of the patentees to perform certain conditions agreed on in the contract. Great exertions had constantly been made in Georgia to impress the public with the notion, that Mr. Whitney was not the original inventor of the cotton gin, somebody in Switzerland having conceived the idea of it before him, and, especially, that he was not entitled to the credit of the invention in its improved form, in which saws were used instead of wire teeth, inasmuch as his partticular form of the machine was introduced by one Hodgin Holmes. It was on these grounds, that the Governor of Georgia, in his message to the legislature of that State in 1803, urged the inexpediency of granting any thing to Miller & Whitney. We have before us a copy of the report of the committee appointed on that part of the Governor's message, and since it will serve to show both the grounds and the character of the opposition, we will subjoin a few extracts from it.†

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* Of one of these meetings, General Jackson, now President of the United States, was chairman.

† In adverting to these transactions of former times, it is no part of our purpose to revive unpleasant recollections, or to throw discredit on the history of the very respectable States above named; but without the recital of these facts the life of Whitney could not have been written.

"The Committee to whom was referred, &c. Report:—

"That they have carefully attended to that part of the communication which relates to the Cotton Gin, and cordially agree with the Governor in his observations, that monopolies are at all times odious, particularly in free governments, and that some remedy ought to be applied to the wound which the cotton gin monopoly has given, and will otherwise continue to give, to the culture and cleaning of that precious and increasing staple. They have examined the Reverend James Hutchinson, who declares that Edward Lyon, at least twelve months before Miller & Whitney's machine was brought into view, had in possession a saw or cotton gin, in miniature, of the same construction; and it further appears to them, from the information of Doctor Cortes Pedro Dampiere, an old and respectable citizen of Columbia County, that a machine of a construction similar to that of Miller & Whitney, was used in Switzerland, at least forty years ago, for the purpose of picking rags to make lint and paper.

"That, however, as Congress has the constitutional power to establish patents of the nature of Miller & Whitney's, the committee uniting with the Governor in opinion that no Legislative power but Congress can interfere, and also convinced that in the passage of the law, Congress could have had no idea of laying the two Southern States, and in all probability North Carolina and Tennessee, under contribution to two individuals, (the article at the passing of the first act not being thought of, as about to become the principal staple of export from those States,) do recommend the following resolutions:—

"*Resolved*, That the Senators and Representatives of this State in Congress be, and they hereby are, instructed to use their utmost endeavors to obtain a modification of the act, entitled an act to extend the privilege of obtaining Patents for useful discoveries and inventions, to certain persons therein mentioned, and to enlarge and define the penalties for violating the rights of patentees, so as to prevent the operation of it, to the injury of that most valuable staple cotton, and the cramping of genius in improvements, in Miller & Whitney's patent Gin, as well as to limit the price of obtaining a right of using it, the price at present being unbounded, and the planter and poor artificer altogether at the mercy of the patentees, who may raise the price to any sum they please.

"And in case the said Senators and Representatives of this State shall find such modification impracticable, that they do then use their best endeavors to induce Congress, from the example of other nations, to make compensation to Miller & Whitney for their discovery, take up the patent right, and release the Southern States from so burthensome a grievance.

"*Resolved*, that his Excellency the Governor, be requested to transmit copies of the foregoing report and resolutions, to the Executives of the States of South Carolina, North Carolina, and Tennessee, to be laid before their respective Legislatures, with a request of coöperation, through their Senators and Representatives in Congress."

Popular feeling, stimulated by the most sordid motives, was now awakened throughout all the cotton-growing States. Tennessee followed the example of South Carolina, in suspending the payment of the tax laid upon cotton gins, and a similar attempt was made at a subsequent session of the Legislature of North Carolina, but it wholly failed, and the report of a committee, offering a resolution, that "the contract ought to be fulfilled with punctuality and good faith," was adopted by both branches of the Legislature.

There were also high minded men in South Carolina, who were indignant at the dishonorable measures adopted by their Legislature of 1803, and their sentiments had impressed the community so favorably with regard to Mr. Whitney, that at the session of 1804, the Legislature not only rescinded what the previous Legislature had done, but signified their respect for Mr. Whitney, by marked commendations.

Nor ought it to be forgotten, that there were in Georgia too, those who viewed with scorn and indignation, the base attempts of men led by unprincipled demagogues, to defraud Mr. Whitney. The Augusta Herald of January 10, 1805, mentions the transactions in South Carolina in the following manner.

"Our readers will no doubt recollect that the Legislature of South Carolina a year or two past, purchased of Messrs. Miller & Whitney, the patent right of using the Saw Gin in that state, for the sum of fifty thousand dollars. In this contract, Mr. Whitney was obligated within a stipulated time, to furnish the state with two models for the Saw Gin, of the best size and make according to his opinion, for separating cotton from its seed. From some unexpected circumstances, the models were not furnished in due time; and some gross misrepresentations having been made to a subsequent Legislature of that state, and considerable improper exertion having been made to persuade them that Mr. Whitney was not the original *inventor* of the Saw Gin, they rather precipitately passed an act for a resolution, *suspending* the execution of their contract, and directing a suit to be brought against Messrs. Miller & Whitney, for the recovery of twenty thousand dollars which as part of the contract, had been paid them. At the last session of the Legislature, Mr. Whitney was enabled not only to furnish satisfactory evidence of his being the original inventor of the gin, but to explain away all former misrepresentations, and to show that the very Patent of the person who had attempted to wrest from him his right, had been repealed in a court of justice. Two models of a gin were also furnished by Mr. Whitney, executed we are told in a most superior and masterly manner, and far surpassing in excellence, any machinery of *the kind* ever before seen—they were of metal, and so nicely, and substantially made, that it was hardly possible for them to get out of order; and they worked with such ease, that when the hopper of a forty Saw Gin was filled with cotton, the labor of turning it was not greater than that of turning a common grindstone. The models were highly approved, and the Legislature did not hesitate to do justice to the ingenious inventor, according to their original agreement; and we are pleased to see that they disclaimed the *monstrous* doctrine, of a Legislature's having authority to rescind a solemn contract made with an individual, and of their being justified in refusing to do right, because they have the *power* to do wrong.

"Our sister State of South Carolina, has usually been very far from discovering any disposition to do injustice to individuals, and their proceedings against Mr. Whitney, were predicated upon imposition practised on them, and their recent conduct evidences that they were satisfied thereof.

"The following is the report of the committee.

"*The joint Committee of both branches of the Legislature, to whom was referred the memorial of Eli Whitney,*

"Report, that on the most mature deliberation, they are of opinion that Miller & Whitney, from whom the State of South Carolina purchased the patent right for using the Saw Gin within this State, have used due and proper diligence to refund the money and notes received by them from divers citizens; and as from several unforeseen occurrences the said Miller & Whitney have heretofore been prevented from refunding the same; they therefore recommend that the money and notes aforesaid, be deposited with the Comptroller General, to be paid over on demand, to the several persons from whom the same have been received, upon their delivering up the licences for which the said notes of hand were given, and said monies paid to the Comptroller General, and that he be directed to hold the said licences subject to the order of said Whitney.

"That the excellent and highly improved models now offered by the said Whitney, be received in full satisfaction of the stipulations of the contract between the State and Miller & Whitney, relative to the same; and that the suit commenced by the State against said Miller & Whitney, be discontinued.

"The joint committee taking every circumstance alleged in the memorial into their serious consideration, further recommend that (as the good faith of this State, is pledged for the payment of the purchase of the said patent right) the contract be now fufilled, as in their opinion it ought to be, according to the most strict justice and equity.

"And although from the documents exhibited by said Whitney, to the committee, they are of opinion that the said Whitney is the true, original inventor of the Saw Gin, yet in order to guard the citizens, from any injury hereafter, the committee recommend, that before the remaining balance is paid, the said Whitney be required to give bond and security, to the Comptroller General, to indemnify each, and every citizen of South Carolina, against the legal claims of all persons whatsoever, other than the said Miller & Whitney, to any patent or exclusive right, to the invention or improvement of the machine, for separating cotton from its seeds, commonly called the Saw Gin, in the form, and upon the principles which it is now, and has heretofore been used in this State.

"The preceding report was adopted by both branches of the Legislature."

When Mr. Whitney first heard of the transactions of the South Carolina Legislature annulling their contract, he was at Raleigh, where he had just concluded his negociation with the Legislature of North Carolina. In a letter written to Mr. Miller at this time he remarks: "I am for my own part, more vexed than alarmed by their extraordinary proceedings. I think it behoves us to be very cautious and circumspect in our measures and even in our remarks with regard to it. Be cautious what you say or publish till we meet our enemies in a court of justice, when, if they have any sensibility left, we will make them very much ashamed of their childish conduct."

But that Mr. Whitney felt very keenly in regard to the severities afterwards practised towards him, is evident from the tenor of the remonstrance which he presented to the Legislature. "The subscriber (says he) respectfully solicits permission to represent to the

Legislature of South Carolina, that he conceives himself to have been treated with unreasonable severity in the measures recently taken against him by and under their immediate direction.—He holds that, to be seized and dragged to prison without being allowed to be heard in answer to the charge alleged against him, and indeed without the exhibition of any specific charge, is a direct violation of the common right of every citizen of a free government; that the power, in this case, is all on one side, that whatever may be the issue of the process now instituted against him, he must, in any case, be subjected to great expense and extreme hardships; and that he considers the tribunal before which he is holden to appear, to be wholly incompetent to decide, definitively, existing disputes between the State and Miller & Whitney.

"The subscriber avers that he has manifested no other than a disposition to fulfil all the stipulations, entered into with the State of South Carolina, with punctuality and good faith; and he begs leave to observe farther, that to have industriously, laboriously, and exclusively, devoted many years of the prime of his life, to the invention and the improvement of a machine, from which the citizens of South Carolina have already realized immense profits,—which is worth to them millions, and from which their posterity, to the latest generations must continue to derive the most important benefits, and in return to be treated as a felon, a swindler, and a villain, has stung him to the very soul. And when he considers that this cruel persecution is inflicted by the very persons who are enjoying these great benefits, and expressly for the purpose of preventing his ever deriving the least advantage from his own labors, the acuteness of his feelings is altogether inexpressible."

At this time, a new and unexpected responsibility devolved on Mr. Whitney, in consequence of the death of his partner, Mr. Miller, who died on the 7th of December, 1803. Mr. Miller had, in the early stages of the enterprise, indulged very high hopes of a sudden fortune; but perpetual disappointments appear to have attended him throughout the remainder of his life. The history of them, as detailed in his voluminous correspondence, which is now before us, affords an instructive exemplification of the anxiety, toil, and uncertainty, that frequently accompany too eager a pursuit of wealth, and the pain and disappointments that follow in the train of expectations too highly elated. If Mr. Miller anticipated a great bargain from an approaching auction of cotton, some sly adventurer was sure to step in before him, and bid it out of his hands. If he looked to his extensive rice crops, cultivated on the estate of General Greene, as the means of raising money to extricate himself from the numerous embarrassments into which he had fallen, a severe drought came on and shrivelled the crop, or floods of rain suddenly destroyed it. The markets unexpectedly changed at the very moment of selling, and always to his disadvantage. Heavy rains likewise destroyed the cotton crops on which he had counted for thousands; and more than all, wicked and dishonest men, contrived to cheat him of his just rights, and thus his airy hopes were often frustrated, until at length, the speculations in Yazoo lands beguiled him into inextricable difficulties, and in the midst of all, and on the dawn of a brighter day, death stepped in and dissolved the pageant that had so long been dancing before his eyes.

Mr. Whitney was now left alone, to contend singly against those difficulties which had for a series of years almost broken down the spirits of both the partners. The light moreover which seemed to be rising upon them from the favorable occurrences of the preceding year, proved but the twilight of prosperity, and a darker night seemed about to supervene.

But the favorable issue of the affairs of Mr. Whitney, in South Carolina during the subsequent year, and the generous receipts that he obtained from the avails of his contracts with North Carolina, relieved him from the embarrassments under which he had so long groaned, and made him in some degree independent. Still, no small portion of the funds thus collected in North and South Carolina, was expended in carrying on the fruitless, endless law suits in Georgia.

In the United States court, held in Georgia in December, 1807, Mr. Whitney obtained a most important decision, in a suit brought against a trespasser of the name of Fort. It was on this trial that Judge Johnson gave his celebrated decision. It was in the following words.

"*Whitney*, survivor of *Miller & Whitney*, vs. *Arthur Fort.* } In equity.

"The complainants, in this case, are proprietors of the machine called the saw gin. The use of which, is to detach the short staple cotton from its seed.

"The defendant, in violation of their patent right, has constructed, and continues to use this machine; and the object of this suit is to obtain a perpetual injunction to prevent a continuance of this infraction of complainant's right.

"Defendant admits most of the facts in the bill set forth, but contends that the complainants are not entitled to the benefits of the act of Congress on this subject, because—

1st. The invention is not original.

2d. Is not useful.

3d. That the machine which he uses is materially different from their invention, in the application of an improvement, the invention of another person.

"The court will proceed to make a few remarks upon the several points as they have been presented to their view: whether the defendant was now at liberty to set up this defence whilst the patent right of complainants remains unrepealed, has not been made a question, and they will therefore not consider it.

"To support the originality of the invention the complainants have produced a variety of depositions of witnesses, examined under commission, whose examination expressly proves the origin, progress, and completion of the machine by Whitney, one of the copartners. Persons who were made privy to his first discovery, testify to the several experiments which he made in their presence before he ventured to expose his invention to the scrutiny of the public eye. But it is not necessary to resort to such testimony to maintain this point. The jealousy of the artist to maintain that reputation which his ingenuity has justly acquired, has urged him to unnecessary pains on this subject. There are circumstances in the knowledge of all mankind which prove the originality of this invention more satisfactorily to the mind, than the direct testimony of a host of witnesses. The cotton plant furnished clothing to mankind before the age of Herodotus. The green seed is a species much more productive than the black, and by nature adapted to a much greater variety of climate. But by reason of the strong adherence of the fibre to the seed, without the aid of some more powerful machine for separating it, than any formerly known among us, the cultivation of it would never have been made an object. The machine of which Mr. Whitney claims the invention, so facilitates the preparation of this species for use, that the cultivation of it has suddenly become an object of infinitely greater national importance than that of the other species ever can be. Is it then to be imagined that if this machine had been before discovered, the use of it would ever have been lost, or could have been confined to any tract or country left unexplored by commercial enterprize? but it is unnecessary to remark further upon this subject. A number of years have elapsed since Mr. Whitney took out his patent, and no one has produced or pretended to prove the existence of a machine of similar construction or use.

"2d. With regard to the utility of this discovery, the court would deem it a waste of time to dwell long upon this topic. Is there a man who hears us, who has not experienced its utility? the whole interior of the Southern States was languishing, and its inhabitants emigrating for want of some object to engage their attention, and employ their industry, when the invention of this machine at once opened views to them which set the whole country in active motion. From childhood to age it has presented to us a lucrative employment. Individuals who were depressed with poverty and sunk in idleness, have suddenly risen to wealth and respectability. Our debts have been paid off. Our capitals have increased, and our lands trebled themselves in value. We cannot express the weight of the obligation which the country owes to this invention. The extent of it cannot now be seen. Some faint presentiment may be formed from the reflection that cotton is rapidly supplanting wool, flax, silk, and even furs in manufactures, and may one day profitably supply the use of specie in our East India trade. Our sister States, also, participate in the benefits of this invention; for, besides affording the raw material for their manufacturers, the bulkiness and quantity of the article afford a valuable employment for their shipping.

"3d. The third and last ground taken by defendant, appears to be that on which he mostly relies. In the specification, the teeth made use of are of strong wire inserted into the cylinder. A Mr. Holmes has cut teeth in plates of iron, and passed them over the cylinder. This is certainly a meritorious improvement in the mechanical process of constructing this machine. But at last what does it amount to, except a more convenient mode of making the same thing. Every characteristic of Mr. Whitney's machine is preserved. The cylinder, the iron tooth, the rotary motion of the tooth, the breast work and brush, and all the merit that this discovery can assume, is that of a more expeditious mode of attaching the tooth to the cylinder. After being attached, in operation and effect they are entirely the same. Mr. Whitney may not be at liberty to use Mr.

Holmes's iron plate. But certainly Mr. Holmes's improvement does not destroy Mr. Whitney's patent right. Let the decree for a perpetual injunction be entered."

This favorable decision, however, did not put a final stop to aggression. At the next session of the United States court, two other actions were brought, and verdicts for damages gained of two thousand dollars in one case, and one thousand and five hundred dollars in the other. The history of these suits, as reported for one of the journals of the day, appears to us to be a document worth preserving, on account of the light it throws on the subject of patent rights in general, as well as in relation to the subject before us.

Law case.—At a circuit court of the United States, for the district of Georgia, lately holden in this city, [Savannah] was tried the case of Eli Whitney *vs.* Isaiah Carter, for infringing a right vested by patent, "for a new and useful improvement in the mode of ginning cotton." The plaintiff supported his declaration by proving the patent, model, and specification, and proving the use of the machine in question by the defendant. He also introduced the testimony of several witnesses residing in New Haven, to prove the origin and progress of his invention.

The defendant rested his defence on two grounds—First: That the machine was not originally invented by Whitney.—Second: That the specification does not contain the whole truth, relative to the discovery.

General Mitchell of counsel for the defendant, produced a model which was intended to represent a machine used in Great Britain for cleaning cotton, denominated the "*Teazer or Devil.*"—A witness was produced, who testified that he had seen in England, about seventeen years ago, a machine for separating cotton from the seed, which resembled in principle the model now exhibited by defendant.

Another witness testified, that he had seen a machine in Ireland, upon the same principle, which was used for separating the motes from the cotton before going to the carding machine.

By the machine, of which a model was exhibited, the cotton is applied in the first instance to rollers made of iron, revolving conversely. By these rollers, the fibres are separated from the seeds and protruded within the sweep of certain straight pieces of wire, revolving on a cylinder, which tear and loosen the cotton as they revolve. It was contended by the defendant's counsel, that this model conforms in principle to Mr. Whitney's machine, and that the evidence given in support of it, establishes a presumption, that he must have derived the plan of his machine from a similar one used in the cotton manufactories in Great Britain.

In support of the second ground of defence, evidence was produced to show that Mr. Whitney now uses, and that the defendant also uses, teeth, formed of circular iron plates, instead of teeth made of wire. And it was contended that this is a departure from the specification, and an improvement on the original discovery, which destroys the merit of that discovery, and the validity of plaintiff's patent. It was also insisted that the plaintiff had concealed the best means of producing the effect contemplated.

Mr. Noel of counsel for the plaintiff, in opposition to the first ground of defence, stated two points—First: That if the principle be the same, yet the plaintiff's application of that principle being new, and for a distinct purpose, has all the merit of an original invention. Second: That the principle of Mr. Whitney's machine is entirely different from that exhibited by defendant.

He defined the term principle, as applied to mechanic arts, to mean the elements and rudiments of those arts, or in other words, the first ground and rule for them. That for a mere principle, a patent cannot be obtained. That neither the elements, nor the manner of combining them, nor even the effect produced, can be the subject of a patent, and that it can only be obtained for the application of this effect to some new and useful purpose.

To prove this position, several examples were stated of important inventions, for which patents had been obtained, which had resulted from principles previously in common use, and an argument of a celebrated Judge, at Westminster Hall, was cited, in which it is asserted "that two thirds, or three fourths of all patents granted since the statute passed, are for methods of operating and manufacturing, producing no new substances, and employing no new machinery;" and he adds, in the significant words of Lord Mansfield, "a patent must be for method, detached from all physical existence whatever."

The second point was principally relied on, to wit: That the principle of Mr. Whitney's machine is distinct from that produced by defendant, and new in its origin.

It consists of teeth, or sharp metallic points, of a particular form and shape, and its application is to separate cotton from the seed; whereas the principle of the model exhibited by the defendant, and of every other machine before invented, and used for the same, or any similar purpose, consists of two small rollers made of wood or iron. In illustration of this point, plaintiff's counsel cited the opinion of this court, delivered by Judge Johnson, in December term, 1807, in the case of Whitney and others *vs.* Fort, upon a bill for injunction.

The second objection relied on by the defendant, was "that the specification does not contain the whole truth respecting the discovery." To this it was answered, that by the testimony it appears Mr. Whitney in the original construction of his machine, contemplated each mode of making the teeth, and doubted which mode was best adapted to the purpose. If the alteration which forms the basis of this objection has the merit of an improvement, how far does it extend? An improvement, not in the principle, nor in the operation of the machine, but in making one of its component parts; merely in forming the same thing, to produce the same effect, by means somewhat different. In the case above cited, Judge Johnson remarked on this point, as follows:

"A Mr. Holmes has cut teeth in plates of iron, and passed them over the cylinder. This is certainly a meritorious improvement in the mechanical process of constructing this machine—But at last, what does it amount to, except a more convenient mode of making the same thing? Every characteristic of Mr. Whitney's machine is preserved—The cylinder, the iron tooth, rotatory motion of the tooth, the breast work and brush; and all the merit that this discovery can assume, is that of a more expeditious mode of attaching the tooth to the cylinder."

The counsel for Whitney, admitted that an improvement in a particular part of the machine, would entitle the inventor to a patent for a new and better mode of making that specific part, but not for the whole machine, as in the case Boulton *vs.* Bull, where a patent was granted for an invention to lessen the quantity of fuel in the use of a certain Steam Engine: It was decided "that the patent was valid, for this improvement; but that it gave no title to the engine itself."

It was also stated, that by experiments made on plaintiffs model in the face of the court and jury, and by testimony produced, it was apparent, no improvement had resulted from this alteration; that no beneficial change, or amendment in the principle had taken place; nor had the effect been aided or facilitated. In the charge of the court to the jury, Judge Stephens remarked, that, the case cited, *Whitney and others vs. Fort*, was decided without any evidence on the part of the defendant:—That from the testimony now produced, his opinion is, that the plaintiff must have received his first impressions from a machine previously in use, on a similar principle; and that an improvement had been made as to the teeth, by which the merit of Mr. Whitney's original invention was diminished. For these reasons Judge Stephens had some doubts whether the Plaintiff ought to recover.

Judge Johnson remarked to the jury, that after hearing the evidence, which had been relied on by the defendant, he remained content with the opinion which he had given in the case of Whitney, against Fort, and that he was also as fully satisfied with the charge he was about to give, as any he had delivered. That as to the origin of this invention, the plaintiff's title remained unimpeached by any evidence which has been adduced in this cause. He agreed with the plaintiff's council, that the legal title to a patent consists not in a principle merely, but in an application of a principle, whether previously in existence or not, to some new and useful purpose. And he was also of opinion, that the principle of Mr. Whitney's machine was entirely new, that it originated with himself, and that it had no resemblance to that of the model exhibited by the defendant.

He considered the defendant's second objection equally unsupported, and referred to the sixth section of the Patent Law of the United States, by which it is required that the concealment alleged (in order to defeat the Patentee's recovery,) must appear to have been made for the purpose of deceiving the public. That Mr. Whitney in the original formation of this machine, could have no motive for such concealment, and that in making use of wire, in preference to the other mode, he appears to have acted according to the dictates of his judgment. If in this instance he erred, the error related to a point, not affecting the merit of his invention, or the validity of his patent.—Verdict for plaintiff—Damages two thousand dollars.

Same Term, Whitney against Gachet, same cause of action.—Verdict for Plaintiff—Damages one thousand five hundred dollars.

The influence of these decisions, however, availed Mr. Whitney very little, for now the term of his patent right was nearly expired. More than sixty suits had been instituted in Georgia before a single decision on the *merits* of his claim was obtained, and at the period of this decision, thirteen years of his patent had expired. In prosecution of this troublesome business, Mr. Whitney had made six different journeys to Georgia, several of which were accomplished by land at a time when, compared with the present, the difficulties of such journeys were exceedingly great, and exposed him to excessive fatigues and privations, which at times seriously affected his health, and even jeopardized his life. A gentleman* of much experience in the profession of law, who was well acquainted with Mr. Whitney's affairs in the South, and sometimes acted as his legal adviser, observes, in a letter obligingly communicated to the writer of this memoir, that, "in all his experience in the thorny profession of the law, he has never seen a case of such perseverance, under such persecution; nor (he adds) do I believe that I ever knew any other man who would have met them with equal coolness and firmness, or who would finally have obtained even the partial success which he had. He always called on me in New York, on his way South, when going to attend his endless trials, and to meet the mischievous contrivances of men who seemed inexhaustible in their resources of evil. Even now after thirty years, my head aches to recollect his narratives of new trials, fresh disappointments, and accumulated wrongs."

We have thought the Cotton Gin, sufficiently instructive in its history, and important in its consequences, to merit the attention we have bestowed upon it. After a more cursory notice of the other chief enterprise which occupied the life of Mr. Whitney, we shall hasten to the conclusion of this memoir.

In 1798, Mr. Whitney became deeply impressed with the uncertainty of all his hopes founded upon the Cotton Gin, notwithstanding their high promise, and he began to think seriously of devoting himself to some business in which superior ingenuity, seconded by uncommon industry, qualifications which he must have been conscious of possessing in no ordinary degree, would conduct him by a slow but sure route to a competent fortune; and we have always considered it indicative of a solid judgment, and a well balanced mind, that he did not, as is frequently the case with men of inventive genius, become so poisoned with the hopes of vast and sudden wealth, as to be disqualified for making a reasonable provision for life, by the sober earnings of frugal industry.

The enterprise which he selected in accordance with these views; was the *Manufacture of Arms for the United States*. He accordingly addressed a letter to the Hon. Oliver Wolcott, Secretary of the

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* Hon. S. M. Hopkins.

Treasury, and through his influence obtained a contract for ten thousand stand of arms, amounting (as the price of each musket was to be thirteen dollars and forty cents) to *one hundred and thirty four thousand dollars*,—an undertaking of great responsibility, considering the limited pecuniary resources of the undertaker. This contract was concluded on the 14th of January, 1798, and four thousand were to be delivered on or before the last day of September of the ensuing year, and the remaining six thousand within one year from that time; so that the whole countract was to be fulfilled within a little more than the period of two years; and for the due fulfilment of it, Mr. Whitney entered into bonds to the amount of thirty thousand dollars. He must have engaged in this undertaking resolved "to attempt great things," without stopping to weigh all the chances against him; for as yet, the works were all to be erected, the machinery to be made, and much of it to be invented; the raw materials were to be collected from different quarters, and the workmen themselves, almost without exception, were yet to learn the trade. Nor was it a business with which Mr. Whitney himself was particularly conversant. Mechanical invention, a sound judgment, and persevering industry, were all that he possessed, at first, for the accomplishment of an enterprise, which was at that time probably greater than any man had ever undertaken, in the State of Connecticut.

The low state of the Mechanic Arts, moreover, increased his difficulties. There were in operation near him no kindred mechanical establishments, upon which some branches of his own business might lean: even his very tools required to be to a great extent fabricated by himself. If it is recollected also, in what a depressed state the cotton ginning business was at this period, it will appear still more evincive of the bold spirit of enterprise which Mr. Whitney possessed, as it will be seen that he could not avail himself of any resources from that quarter, nor could he reasonably hope to derive from the same source any future succor. But Mr. Whitney had strong friends among the most substantial citizens of New Haven, who had been witnesses alike of the fertility of his genius, and the extent of his industry. Ten of these came forward as his security to the bank of New Haven, for a loan of ten thousand dollars. Mr. Wolcott, on the part of the United States, advanced five thousand more at the time of contract, with the promise of a similar sum, as soon as the preparatory arrangements for the manufacture of arms were completed. No farther advances were to be demanded, until one thousand stand of arms were ready for delivery; at which time, the additional sum of five thousand dollars was to be advanced. Full payment was to be made on the delivery of each successive thousand, with occasional advances at the discretion of the Secretary.

The expenses incurred in getting the establishment fully into operation, must have greatly exceeded the expectation of the parties, for advances of ten and fifteen thousand dollars were successively made by the government, above what was originally contemplated; but the confidence of the government seems never to have been impaired; for the Secretary, after having examined Mr. Whitney's works in person, declared to him, in the presence of witnesses, that the advances which he had made had been laid out with great prudence and economy, and that the undertaker had done more, than he should have supposed possible with the sum advanced.

The site which Mr. Whitney had purchased for his works, was at the foot of the celebrated precipice called East Rock, within two miles of New Haven. This spot (which is now called Whitneyville) is justly admired for the romantic beauty of its scenery. A waterfall of moderate extent, afforded here the necessary power for propelling the machinery. In this pleasant retreat, Mr. Whitney commenced his operations with the greatest zeal; but he soon became sensible of the multiplied difficulties which he had to contend with. A winter of uncommon severity set in early, and suspended his labors; and when the spring returned, he found himself so little advanced, that he foresaw that he should be utterly unable to deliver the four thousand muskets according to contract. In this predicaament, he resolved to throw himself on the indulgence of the enlightened Secretary of the treasury, to whom he explained at length the various causes which had conspired to retard his operations.

"I find, says he, that my personal attention and oversight, are more constantly and essentially necessary to every branch of the work, than I apprehended. Mankind, generally, are not to be depended on, and the best workmen I can find are incapable of directing. Indeed there is no branch of the work that can proceed well, scarcely for a single hour, unless I am present."

At the end of the first year after the contract was made, instead of four thousand muskets, only five hundred were delivered, and it was eight years, instead of two, before the whole ten thousand were completed. The entire business relating to the contract was not closed until January, 1809, when, (so liberally had the government made advances to the contractor,) the final balance due Mr. Whitney, was only two thousand four hundred and fifty dollars.

During the ten years Mr. Whitney was occupied in performing this engagement, he applied himself to business with the most exemplary diligence, rising every morning as soon as it was day, and at night, setting every thing in order appertaining to all parts of the establishment, before he retired to rest. His genius impressed itself on every part of the manufactory, extending even to the most common tools, all of which received some peculiar modification which improved them in accuracy, or efficacy, or beauty. His machinery for making the several parts of a musket, was made to operate with the greatest possible degree of uniformity and precision. The object at which he aimed, and which he fully accomplished, was to make the same parts of different guns, as the locks for example, as much like each other as the successive impressions of a copper plate engraving. It has generally been conceded that Mr. Whitney greatly improved the art of manufacturing arms, and laid his country under permanent obligations by augmenting her facilities for national defence. So rapid has been the improvement in the arts and manufactures in this country, that it is difficult to conceive of the low state in which they were thirty years ago. To this advancement the genius and industry of Mr. Whitney most essentially contributed, for while he was clearing off the numerous impediments, which were thrown in his way, he was at the same time performing the office of a pioneer to the succeding generation.

In the year 1812, he entered into a new contract with the United States to manufacture for them fifteen thousand stand of arms; and in the mean time he executed a similar engagement (we know not how extensive) for the State of New York. Although his resources enabled him now to proceed with much greater despatch, and with far less embarrassment, than in his first enterprise, yet some misunderstanding arose with one of the agents of the government, which made it necessary for him to bring his case before the Secretary of war. The following testimonials, which he obtained on this occasion from the late Governor Tompkins, and from Governor Wolcott, will serve to show in what estimation he was held by those who knew him best, and who were most competent to judge of his merits. The letters, dated May, 1814, are both addressed to General Armstrong the existing Secretary of war. Governor Tompkins observes as follows: "I have visited Mr. Whitney's establishment at

New Haven, and have no hesitation in saying that I consider it the most perfect I have ever seen; and I believe it is well understood, that few persons in this country surpass Mr. Whitney in talents as a mechanic or in experience as a manufacturer of muskets. Those which he has made for us, are generally supposed to exceed, in form and quality, all the muskets either of foreign or domestic fabrication belonging to the State, and are universally preferred and selected by the most competent judges.

It is perhaps proper for me to observe further that all Mr. Whitney's contracts with the State of New York, have been performed with integrity, and to the entire satisfaction of the several military commissaries of the state." Governor Wolcott's testimony is still more full, as his opportunities for acquaintance with Mr. Whitney had been more extensive. We insert the letter entire, as not only indicating the high reputation of the individual to whom it relates, but as exemplifying the liberality with which the writer is known always to have fostered and encouraged genius and merit.

"New York, May 7, 1814.

"*Sir*—I have the honor to address you on behalf of my friend, Eli Whitney, Esq. of New Haven, who is a manufacturer of arms, under a contract with your department. Mr. Whitney first engaged in this business under a contract with me, as Secretary of the Treasury; when, according to existing laws, all contracts for military supplies were formed under my superintendence. I have since been constantly acquainted with him, and venture to assure you that the present improved state of our manufactures is greatly indebted to his skill and exertions; that though a practical mechanic, he is also a gentleman of liberal education, a man of science, industry and integrity, and that his inventions and labors have been as useful to this country as those of any other individual. Moreover, that if any further alterations or improvements in the construction of military machines are proposed, Mr. Whitney is one of the few men who can safely and advantageously be consulted, respecting the best mode of giving them effect.

I make these declarations to you, with a perfect conviction that they express nothing more than Mr. Whitney has a right to demand from every man, who is acquainted with his merits and capable of estimating their value; and understanding that he experiences some difficulties in regard to his contract, I venture respectfully to request that you would so far extend to him your favor, as to inform yourself particularly of the merits of his case and the services he can perform; in which case, I am certain he will receive all the patronage and protection to which he is entitled.

I have the honor to remain, with the highest respect Sir, your obedient servant, (Signed) OLIVER WOLCOTT.

The Hon. Secretary Armstrong.

*Several other persons made contracts with the government at about the same time, and attempted the manufacture of muskets, following, substantially, so far as they understood it, the method pursued in England.—The result of their efforts was a complete failure to manufacture muskets of the quality required, at the price agreed to be paid by the government: and in some instances they expended in the execution of their contracts, a considerable fortune in addition to the whole amount received for their work.

The low state to which the arts had been depressed in this country by the policy of England, under the colonial system, and from which they had then scarcely begun to recover, together with the high price of labor, and other causes, conspired to render it impracticable at that time even for those most competent to the undertaking, to manufacture muskets here in the English method. And doubtless Mr. Whitney would have shared the fate of his enterprising but unsuccessful competitors, had he adopted the course which they pursued; but his genius struck out for him a course entirely new.

In maturing his system he had many obstacles to combat, and a much longer time was occupied, than he had anticipated; but with his characteristic firmness he pursued his object, in the face of the obloquy and ridicule of his competitors, the evil predictions of his enemies, and the still more discouraging and disheartening misgivings, doubts, and apprehensions of his friends. His efforts were at length crowned with success, and he had the satisfaction to find, that the business which had proved so ruinous to others, was likely to prove not altogether unprofitable to himself.

Our limits do not permit us to give a minute and detailed account of this system; and we shall only glance at two or three of its more

* For the following remarks on the manufacture of arms, the writer of this article is indebted to a gentleman who is personally and intimately acquainted with the subject.

prominent features, for the purpose of illustrating its general character.

The several parts of the musket were, under this system, carried along through the various processes of manufacture, in lots of some hundreds or thousands of each. In their various stages of progress, they were made to undergo successive operations by machinery, which not only vastly abridged the labor, but at the same time so fixed and determined their form and dimensions, as to make comparatively little skill necessary in the manual operations. Such was the construction and arrangement of this machinery, that it could be worked by persons of little or no experience; and yet it performed the work with so much precision, that when, in the later stages of the process, the several parts of the musket came to be put together, they were as readily adapted to each other, as if each had been made for its respective fellow. A lot of these parts passed through the hands of several different workmen successively, (and in some cases several times returned, at intervals more or less remote, to the hands of the same workman) each performing upon them every time some single and simple operation, by machinery or by hand, until they were completed. Thus Mr. Whitney reduced a complex business, embracing many ramifications, almost to a mere succession of simple processes, and was thereby enabled to make a division of the labor among his workmen, on a principle which was not only more extensive, but also altogether more philosophical, than that pursued in the English method. In England, the labor of making a musket was divided by making the different workmen the manufacturers of different limbs, while in Mr. Whitney's system the work was divided with reference to its nature, and several workmen performed different operations on the same limb.

It will be readily seen that under such an arrangement any person of ordinary capacity would soon acquire sufficient dexterity to perform a branch of the work. Indeed, so easy did Mr. Whitney find it to instruct new and inexperienced workmen, that he uniformly preferred to do so, rather than to attempt to combat the prejudices of those, who had learned the business under a different system.

When Mr. Whitney's mode of conducting the business was brought into successful operation, and the utility of his machinery was fully demonstrated, the clouds of prejudice which lowered over his first efforts, were soon dissipated, and he had the satisfaction of seeing not only his system, but most of his machinery, introduced into every other considerable establishment for the manufacture of arms, both public and private, in the United States.

The labors of Mr. Whitney in the manufacture of arms, have been often and fully admitted by the officers of the government, to have been of the greatest value to the public interest. In the year 1822, Mr. Calhoun, then secretary of war, now vice-president of the United States, admitted, in a conversation with Mr. Whitney, that the government were saving twenty-five thousand dollars per annum at the two public armories alone, by his improvements. This admission, though it is believed to be far below the truth, is sufficient to show, that the subject of this memoir deserved well of his country in this department of her service; and we regret to learn, that the succeeding officers of the government have already so far overlooked his merits and his claims, as to permit the capital invested in his manufacturing establishment, which constitutes the greater part of the earnings of his life, to lie, in part, idle and unproductive upon the hands of his heirs.

It should be remarked, that the utility of Mr. Whitney's labors during the period of his life which we have now been contemplating, was not limited to the particular business in which he was engaged. Many of the inventions which he made to facilitate the manufacture of muskets, were applicable to most other manufactures of iron and steel. To many of these they were soon extended, and became the nucleus around which other inventions clustered; and at the present time some of them may be recognised in almost every considerable workshop of that description in the United States.

In the year 1812, Mr. W. made application to congress for the renewal of his patent for the cotton gin. In his memorial, he presented a history of the struggles he had been forced to encounter in defence of his right, observing that he had been unable to obtain any decision on the merits of his claim until he had been *eleven years* in the law, and *thirteen years* of his patent term had expired. He sets forth, that his invention had been a source of opulence to thousands of the citizens of the United States; that, as a labor saving machine, it would enable one man to perform the work of a thousand men; and that it furnishes to the whole family of mankind, at a very cheap rate, the most essential article of their clothing. Hence, he humbly conceived himself entitled to a further remuneration from his country, and thought he ought to be admitted to a more liberal participation with his fellow citizens in the benefits of his invention. Although so great advantages had been already experienced, and the prospect of future benefits was so promising, still, many of those whose interest had been most promoted, and the value of whose property had been most enhanced by this invention, had obstinately persisted in refusing to make any compensation to the inventor. The very men whose wealth had been acquired by the use of this machine, and who had grown rich beyond all former example, had combined their exertions to prevent the patentee from deriving any emolument from his invention. From that State in which he had first made, and where he had first introduced his machine, and which had derived the most signal benefits from it, he had received nothing; and from no state had he received the amount of *half a cent per pound* on the cotton cleaned with his machines in one year. Estimating the value of the labor of one man at twenty cents per day, the whole amount which had been received by him for his invention, was not equal to the value of the labor saved *in one hour*, by his machines then in use in the United States. "This invention, (he proceeds) now gives to the southern section of the Union, over and above the profits which would be derived from the cultivation of any other crop, an annual emolument of at least *three millions* of dollars."* The foregoing statement does not rest on conjecture,—it is no visionary speculation,—all these advantages have been realized; the planters of the southern states have counted the cash, felt the weight of it in their pockets, and heard the exhilarating sound of its collision. Nor do the advantages stop here: this immense source of wealth is but just beginning to be opened. Cotton is a more cleanly and healthful article of cultivation than tobacco and indigo, which it has superseded, and does not so much impoverish the soil. This invention has already trebled the value of the land through a great extent of territory; and the degree to which the cultivation of cotton may be still augmented, is altogether incalculable. This species of cotton has been known in all countries where cotton has been raised, from time immemorial, but was never known as an article of commerce, until since this method of cleaning it was discovered. In short, (to quote the language of Judge Johnson,) if we should assert that the benefits of this invention exceed *one hundred millions of dollars*, we can prove the assertion by correct calculation. "It is objected that

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* This was in 1812: the amount of profit is at this time incomparably greater.

if the patentee succeeds in procuring the renewal of his patent, he will be too rich. There is no probability that the patentee, if the term of his patent were extended for twenty years, would ever obtain for his invention one half as much as many an individual will gain by the use of it. Up to the present time, the whole amount of what he has acquired from this source, (after deducting his expences,) does not exceed one half the sum which a single individual has gained by the use of the machine in one year. It is true that considerable sums have been obtained from some of the States where the machine is used; but no small portion of these sums has been expended in prosecuting his claim in a State where nothing has been obtained, and where his machine has been used to the greatest advantage.

"Your memorialist has not been able to discover any reason why he, as well as others, is not entitled to share the benefits of his own labors. He who speculates upon the markets, and takes advantage of the necessities of others, and by these means accumulates property, is called "a man of enterprise"—"a man of business"—he is complimented for his talents, and is protected by the laws. He however only gets into his possession, that which was before in the possession of another; he adds nothing to the public stock; and can he who has given thousands to others, be thought unreasonable, if he asks one in return?

"It is to be remembered, that the pursuit of wealth by means of new inventions, is a very precarious and uncertain one;—a lottery where there are many thousand blanks to one prize. Of all the various attempts at improvements, there are probably not more than one in five hundred for which a patent is taken out; and of all the patents taken out, not one in twenty has yielded a net profit to the patentee equal to the amount of the patent fees. In cases where a useful and valuable invention is brought into operation, the reward ought to be in proportion to the hazard of the pursuit. The patent law has now been in operation more than fourteen years. Many suits for damages have been instituted against those who have infringed the right of patentees; and it is a fact, that very rarely has the patentee ever recovered. If you would hold out inducements for men of *real talents* to engage in these pursuits, your rewards must be sure and substantial. Men of this description can calculate, and will know how to appreciate, the recompence which they are to receive for their labors. If the encouragement held out be specious and delusive, the discerning will discover the fallacy, and will despise it: the weak and visionary only will be decoyed by it, and your patent office will be filled with rubbish. The number of those who succeed in bringing into operation really useful and important improvements, always has been, and always must be, very small. It is not probable that this number can ever be as great as one in a hundred thousand. It is therefore impossible that they can ever exert upon the community an undue influence. There is, on the contrary, much probability and danger that their rights will be trampled on by the many."

Notwithstanding these cogent arguments, the application was rejected by Congress. Some liberal minded and enlightened men from the cotton districts, favored the petition; but a majority of the members from that section of the Union, were warmly opposed to granting it.

In a correspondence with the late Mr. Robert Fulton, on the same subject, Mr. Whitney observes as follows:—The difficulties with which I have had to contend have originated, principally, in the want of a disposition in mankind to do justice. My invention was new and distinct from every other: it stood alone. It was not interwoven with any thing before known; and it can seldom happen that an invention or improvement is so strongly marked, and can be so clearly and specifically identified; and I have always believed, that I should have had no difficulty in causing my rights to be respected, if it had been less valuable, and been used only by a small portion of the community. But the use of this machine being immensely profitable to almost every planter in the cotton districts, all were interested in trespassing upon the patent right, and each kept the other in countenance. Demagogues made themselves popular by misrepresentation, and unfounded clamors, both against the right, and against the law made for its protection. Hence there arose associations and combinations to oppose both. At one time, but few men in Georgia dared to come into court, and testify to the most simple facts within their knowledge, relative to the use of the machine. In one instance, I had great difficulty in proving that the machine *had been used in Georgia*, although, at the same moment, there were three separate setts of this machinery in motion, within fifty yards of the building in which the court sat, and all so near that the rattling of the wheels was distinctly heard on the steps of the court house."*

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* In one of his trials, Mr. Whitney adopted the following plan, in order to show how nugatory were the methods of evasion practised by his adversaries. They

In the midst of these fruitless efforts to secure to himself some portion of his advantages, which so many of his fellow citizens were reaping from his ingenuity, his armory proceeded with a sure but steady space, which bore him on to affluence. For the few following years he occupied himself principally in the concerns of his manufactory, inventing new kinds of machinery, and improving and perfecting the old.

In January, 1817, Mr. Whitney was married to Miss Henrietta F. Edwards, youngest daughter of the Hon. Pierpont Edwards, late Judge of the District Court for the State of Connecticut. The fond and quiet scenes of domestic life, after which he had so long aspired, but from which he had been debarred by the embarrassed, or unsettled state of his affairs, now spread before him in the fairest light. Four children, a son and three daughters,* added, successively, fresh attractions to the family circle. Happy in his home, and easy in his fortune, with a measure of respectability among his fellow citizens, and celebrity abroad, which might well satisfy an honorable ambition, he seemed to have in prospect, after a day of anxiety and toil, an evening unusually bright and serene.

In this uniform and happy tenor, he passed the five following years, when a formidable malady† began to make its approaches, by a slow but hopeless progress, which at length terminated his life.

We are indebted to a near friend and eye witness, for the following account of his last illness. In September, 1822, immediately after his return from Washington, he experienced the first attack of

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were endeavoring to have his claim to the invention set aside, on the ground, that the teeth in his machine were made of *wire*, inserted into the cylinder of wood, while in the machine of Holmes, the teeth were *cut in plates*, or iron surrounding the cylinder, forming a circular saw. Mr. Whitney, by an ingenious device, (consisting chiefly of sinking the plate below the surface of the cylinder, and suffering the teeth to project,) contrived to give to the saw teeth the appearance of *wires*, while he prepared another cylinder in which the wire teeth were made to look like *saw teeth*. The two cylinders were produced in court, and the witnesses were called on to testify which was the invention of Whitney, and which that of Holmes. They accordingly swore the saw teeth upon Whitney, and the wire teeth upon Holmes; upon which the judge declared that it was unnecessary to proceed any farther, the principle of both being manifestly the same.

* The youngest of these died in September, 1823, aged one year and nine months. Two daughters, and a son bearing his father's name, (the youngest of the three,) still survive.

† An enlargement of the *prostrate gland.*

his complaint, which immediately threatened his life. For three weeks the event was very doubtful, during which time he occasionally suffered paroxysms of pain, of from thirty to forty minutes continuance, severe beyond description. These were repeated six or eight times in every twenty four hours. For six weeks, he was confined to his room, at the end of which time, he was able to walk about the house, and to enjoy the society of his friends. Early in January, 1823, he had to endure another period of suffering, not less alarming or distressing than the former. With such alternations of awful suffering and partial repose, he reached the 12th of November, 1824, at which period his sufferings became almost unremitted until the 8th of January, 1825, when he expired,—retaining his consciousness to the last, closing his own eyes, and making an effort to close his mouth.

It was his particular request, that there should be no examination of his body with the view of ascertaining the nature of his disease, and he desired his funeral to be conducted with as little parade as possible.

The strongest demonstrations of respect and regard, were manifested by the citizens of New Haven, in committing his remains to the earth, and the Rev. President Day pronounced over his grave the following eulogy.

"How frequent and how striking are the monitions to us, that this world is not the place of our rest!

"It is not often the case, that a man has laid his plans for the business and the enjoyment of life, with a deeper sagacity, than the friend whose remains we have now committed to the dust. He had received, as the gift of heaven, a mind of a superior order. Early habits of thinking gave to it a character of independence and originality. He was accustomed to form his decisions, not after the model of common opinion, but by his own nicely balanced judgment. His mind was enriched with the treasures which are furnished by a liberal education. He had a rare fertility of invention in the arts; an exactness of execution almost unequalled. By a single exercise of his powers, he changed the state of cultivation, and multiplied the wealth, of a large portion of our country. He set an example of system and precision in mechanical operations, which others had not even thought of attempting.

"The higher qualities of his mind, instead of unfitting him for ordinary duties, were finely tempered with taste and judgment in the business of life. His manners were formed, by an extensive intercourse with the best society. He had an energy of character, which carried him through difficulties, too formidable for ordinary minds.

"With these advantages, he entered on the career of life. His efforts were crowned with success. An ample competency was the reward of his industry and skill. He had gained the respect of all classes of the community. His opinions were regarded with peculiar deference, by the man of science, as well as the practical artist. His large and liberal views, his knowledge of the world, the wide range of his observations, his public spirit, and his acts of beneficence, had given him a commanding influence in society. The gentleness and refinement of his manners, and the delicacy of his feelings in the social and domestic relations, had endeared him to a numerous circle of relatives and friends.

"And what were his reflections in review of the whole, in connection with the distressing scenes of the last period of life? "All is as the flower of the grass: the wind passeth over it, and it is gone." All on earth is transient; all in eternity is substantial and enduring. His language was, "I am a sinner. But God is merciful. The only ground of acceptance before him, is through the great Mediator." From this mercy, through this Mediator, is derived our solace under this heavy bereavement. On this, rest the hopes of the mourners, that they shall meet the deceased with joy, at the resurrection of the just."

In his person, Mr. Whitney was considerably above the ordinary size, of a dignified carriage, and of an open, manly and agreeable countenance. His manners were conciliatory, and his whole appearance such as to inspire universal respect. Among his particular friends, no man was more esteemed. Some of the earliest of his intimate associates were also among the latest. With one or two of the bosom friends of his youth, he kept up a correspondence by letter for thirty years, with marks of continually increasing regard. His sense of honor was high, and his feelings of resentment and indignation occasionally strong. He could, however, be cool when his opponents were heated; and, though sometimes surprised by passion, yet the unparalleled trials of patience which he had sustained, did not render him petulant, nor did his strong sense of the injuries he had suffered in relation to the Cotton Gin, impair the natural serenity of his temper.

But the most remarkable trait in the character of Mr. Whitney, aside from his inventive powers, was his *perseverance;* and this is the more remarkable, because it is so common to find men of great powers of mechanical invention deficient in this quality. Nothing is more frequent than to see a man of the most fertile powers of invention, run from one piece of mechanism to another, leaving the former half finished; or if he has completed any thing, it is usual to find him abandon it to others, too fickle to pursue the advantages he might reap from it, or too sensitive to struggle with the sordid and avaricious, who may seek to rob him of the profits of his invention. We cannot better express our views on this subject, than by transcribing from a letter now before us, the following remarks communicated to us by a gentleman* who had intimately known Mr. W. from early life.

"I have reflected often and much upon Mr. Whitney's character, and it has been a delightful study to me. I wish I had time to bring fully to your view, for your consideration, that particular excellence of mind in which he excelled all men that I have ever heard of. I do not mean that his power of forming mechanical combinations was *unlimited*, but that he had it under such perfect *control*. I imagine that he never yet failed of accomplishing any result of mechanical powers and combinations which he sought for; nor ever sought for one for which he had not some occasion, in order to accomplish the business in hand. I mean that his invention *never failed*, and never *ran wild*. It accomplished, I imagine, without exception, all that he ever asked of it and *no more*. I emphasize this last expression, from having in mind the case of a man whose invention appeared to be more fertile even than Whitney's; but he had it under no control. When he had imagined and *half executed* one fine thing, his mind darted off to another, and he perfected nothing: Whitney perfected all that he attempted; carried each invention to its utmost limit of usefulness; and then reposed until he had occasion for something else."

It would be difficult to estimate the full value of Mr. Whitney's labors, without going into a minuteness of detail inconsistent with our limits. Every cotton garment bears the impress of his genius, and the ships that transported it across the waters were the heralds of his fame, and the cities that have risen to opulence by the cotton trade, must attribute no small share of their prosperity to the inventor of the Cotton Gin. We have before us the declaration of the late Mr. Fulton, that Arkwright, Watt and Whitney, (we would add Fulton

* Hon. S. M. Hopkins.

to the number,) were the three men who did most for mankind of any of their cotemporaries; and, in the sense in which he intended it, the remark is probably true.

Fabrics of cotton are now so familiar to us, and so universally diffused, that we are apt to look upon them rather as original gifts of nature, than as recent products of human ingenuity. The following statements, however, will show how exceedingly limited the cotton trade was previous to the invention of the cotton gin.

In 1784, an American vessel arrived at Liverpool, having on board, for part of her cargo, *eight bags* of cotton, which were seized by the officers of the custom house, under the conviction that they could not be the growth of America.* The following extracts from old newspapers, will exhibit the extent of the cotton trade for the subsequent years.

Cotton from America arrived at Liverpool.

1785.	January.	*Diana*, from Charleston, 1 bag.
	February.	*Tenign*, from New York, 1 do.
	June.	*Grange*, from Philadelphia, 3 do.—5 bags.
1786.	May.	*Thomas*, from Charleston, 2 do.
	June.	*Juno*, from Charleston, 4 do.—6.
1787.	April.	*John*, from Philadelphia, 6 do.
	June.	*Wilson*, from New York, 9 do.
		Grange, from Philadelphia, 9 do.
	August.	*Henderson*, from Charleston, 40 do.
	Dec.	*John*, from Philadelphia, 44 do.—108.
1788.	January.	*Mersey*, from Charleston, 1 do.
		Grange, from Philadelphia, 5 do.
	June.	*John*, from do. 30 do.
	July.	*Harriott*, from New York, 62 do.
		Grange, from Philadelphia, 111 do.
		Polly, from Charleston, 73 do.—282.

The whole domestic exports of the United States in 1825 were valued at 66,940,000 dollars, of which value, 36,846,000 was in cotton only. In general, this article is equal to some millions more than one half the whole value of our exports. The average growth for the three years previous to 1828, was estimated at 900,000

* See Southern Review for May, 1831.

bales, which is nearly THREE HUNDRED MILLIONS OF POUNDS, of which about one fifth was consumed in our own manufactories.*

We cannot close this article without adding one or two reflections that have occurred to us while perusing the papers of Mr. Whitney. President Dwight, in his counsels to his pupils, often insisted on the duty of men of high standing in society, to lend their influence in bringing forward young men of promise; and no one was ever more ready than that great and good man to take by the hand, and lead forward into the world, young men of modest merit. This noble disposition he manifested strongly in his treatment of the subject of this memoir. He smiled upon his enterprising undertakings, encouraged him by the kindest assurances, and commended him strongly to the countenance and support of his friends. When Mr. W. was about to negotiate a sale of his patent right with the state of South Carolina, Dr. D. furnished him with a letter to the Hon. Charles Cotesworth Pinckney, from which we subjoin the following extract. After adverting to the proposed application of Mr. W., Dr. Dwight proceeds: "To you, sir, it will be in the stead of many ordinary motives to know that your aid will, in this case, be given to a man who has rarely, perhaps never been exceeded in ingenuity or industry; and not often in worth of every kind. Every respectable man in this region will rejoice to see him liberally rewarded for so useful an effort, and for a life of uncommon benefit to the public.

"Mr. Whitney is now employed in manufacturing muskets for the United States. In this business he has probably exceeded the efforts, not only of his countrymen, but of the whole civilized world by a system of machinery of his own invention, in which expedition and accuracy are united to a degree probably without example.—I should not have thought it necessary to speak of him in so strong terms, had I not believed that his own modesty would keep him from discovering his real character."

Governor Wolcott, who cherished similar dispositions towards young men of merit and ingenuity, gave him similar letters to Mr. Pinckney and Judge Dessaussure. These testimonials no doubt contributed much to inspire confidence in the leading men at the south. Such efforts on the part of eminent men in favor of rising worth, enrich the modest youth without impoverishing themselves.

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* Niles' Weekly Register.

To a number of respectable gentlemen of New Haven, particularly the Hon. James Hillhouse, the Hon. Elizur Goodrich, and the late Isaac Beers, Esq., Mr. W. was under similar obligations for lending him the credit of their names, and standing sureties for him in the heavy loans which his first great enterprize required, without which aid it could never have been carried forward.

The advantages of a liberal education to a man of mechanical invention, as well as to the man of business, were very conspicuous in the case of Mr. Whitney. By this means his powers of thought, and his materials for combination, were greatly augmented. The letters exchanged between Messrs. Miller & Whitney, both of whom were educated men, are marked by a high degree of intelligence, and are written in a style of great correctness, and sometimes even of elegance. None but men of enlarged and liberal minds could have furnished to their counsel, the arguments by which they gained their first triumph over their legal adversaries. It no doubt also contributed not a little to conciliate the respect of those States which purchased the patent right, to find in the person of the patentee, instead of some illiterate visionary projector, a gentleman of elevated mind and cultivated manners, and of a person elegant and dignified.

In presenting to the public the foregoing sketch of the life of this extraordinary man, the writer has had it constantly in view to render the narrative useful to the enterprising mechanic and the man of business, to whom Whitney may be confidently proposed as a model. To such, it is believed, the details given respecting his various struggles and embarrassments, may afford a useful lesson, a fresh incentive to perseverance, and stronger impressions of the value of a character improved by intellectual cultivation, and adorned with all the moral virtues.

Art. II.—*Reminiscences of the late Mr. Whitney, inventor of the Cotton Gin; by the* Editor.

The preceding memoir has so fully elucidated the character of Mr. Whitney, that the following observations may perhaps appear superfluous. I have however been led to make them, both by affection for the memory of a man so highly valued, and also because it is often in the power of a friend, to give some additional touches, even to a faithful picture.

Mr. Whitney received the degree of A. B. in Yale College, at the same commencement (1792) when I became a member of that institution. I had only a general knowledge of him until 1798, when I was made acquainted with his then pending arrangement with the government of the United States, for the manufacture of arms, and by request I copied some of the papers relating to that contract. In the autumn of 1799, just after I had accepted an appointment in the government of Yale College, I was much interested by an unexpected application from Mr. Whitney, to visit the principal countries of Europe, (all indeed which had cotton-growing colonies, in either hemisphere,) for the purpose of obtaining patents for the Cotton Gin. Gratifying as the application was to my feelings, my recent engagements with the College, and my youth and inexperience, concurred with other reasons to make me decline accepting the overture, which was sufficiently tempting to my curiosity and to the desire of foreign travel.

This affair would not be worth mentioning, except that the confidence which it implied naturally led to a familiar intercourse of friendship, which for twenty five years was never clouded for a moment, and often gave me interesting views of Mr. Whitney's character.

I was frequently led to observe, that his ingenuity extended to every subject which demanded his attention; his arrangements, even of common things, were marked by singular good taste and a prevailing principle of order.

The effect of this mental habit is very obvious in the disposition of the buildings, and accommodations of his manufactory of arms;—although, owing to the infirmities of his later years, and to other causes, his arrangements were never finished to the full extent of his views. The machinery has great neatness and finish, and in its operation evinces a degree of precision and efficiency, which gratifies every curious and intelligent observer. I have, many times, visited the establishment with strangers and foreigners, who have gone away delighted with what they have seen.* Under all the successive administrations of the general government, from that of the first President Adams, repeated contracts have been obtained for the supply of arms.

Mr. Whitney received substantial proofs of the approbation of the government in the terms which he obtained. He was personally acquainted with all the Presidents of the United States, from the beginning of the government, and in every fluctuation of party he retained their confidence, although his own political sentiments were decided and well known.

He was, from frequent and long visits at the seat of government, familiar with the principal officers, and with the leading members of both houses of Congress; and thus he was enabled to sustain the influence which he had acquired, and even to extend it, so as to obtain important contracts from several of the State governments.

The private establishment of Mr. Whitney, has proved a model for the more extensive manufactories which are the property of the nation. Into them, as the writer of the foregoing article has stated, and as I have been informed by Mr. Whitney, his principal improvements have been transplanted, chiefly by the aid of his workmen, and have now become common property.

A few years before Mr. Whitney's death it became necessary to renew the mill dam at the manufactory; it had been originally constructed for a flour mill, and was both defective in plan, and dilapidated by time. Mr. Whitney, then in declining health, superintended every part of the business in person, although its execution was protracted almost into the winter, when massive stones were to be laid, in the midst of cold water and ice. It is necessary only to inspect the work, and the flume ways, and the walled borders of the river below, and the canal which he constructed, to take the water from the dam to the forging shop, to be satisfied, that both genius and taste presided over these useful, although unostentatious constructions. The small river, by and upon which they were raised, washes the foot of the celebrated mountain ridge called the East Rock, as already mentioned in the preceding memoir.

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* The manufactory has advanced, in these respects, since it has been superintended by Mr. Whitney's nephews, the Messrs. Blakes, and to them it is indebted for some valuable improvements.

From its precipices and those of one of its branches, which are composed of greenstone trap, Mr. Whitney selected his materials, with such skill, and arranged them with such judgment and taste that the walls, arches and passages, and some of the shops and other buildings constructed of this rock, are admired both for their solidity and beauty, and will remain to future generations. Some of the works are laid in a cement, composed, in part, of a mixture of iron rust and siliceous and micaceous sand, derived from the grinding of the gun barrels and other pieces of iron upon the grind stones; this cement appears almost as firm as the rocks themselves. There are two buildings for fuel; the one for charcoal, and the other for mineral coal; both are finished with great exactness, by selecting smooth natural faces of the trap rock, which are accurately laid in mortar and carefully pointed; the floors are also of firm stone, laid with equal exactness. These store houses stand by the side of the mountain and at its foot, and by excavating a road in the bank above, the coal carts are driven quite up to the gable end of the building, and their loads are discharged into them simply by tipping up the cart. This notice of these humble buildings is given to show Mr. Whitney's exactness in every thing. It was a maxim with him, which I have often heard him repeat, that *there is nothing worth doing that is not worth doing well.* As far as circumstances permitted, he always acted up to this maxim.

The houses for his workmen, at the manufactory, are beautifully constructed, and arranged upon one plan; they also are of trap rock,* and covered by a white cement, and together with the other buildings, the mountain and river scenery, and the bridge,† they give this picturesque valley no small degree of beauty. It was Mr. Whitney's intention, to erect his own mansion house in this valley, which would doubtless have then received all the embellishment of which it is so susceptible. With this view he had constructed an ample barn,‡ which is a model of convenience, and even of taste and beauty, and contains many accommodations, not usually found in such establishments. It was visited and examined by the late President Monroe,

* Since Mr. Whitney's death, other houses have been built of wood.

† Constructed by that ingenious architect, Mr. Ithiel Town.

‡ There is a farm connected with the manufactory.

during his excursion through the Eastern States in 1816. It is perfectly characteristic of Mr. Whitney that his attention was directed even to the mangers for the cattle, and to their fastenings. The latter are so contrived, by means of a small weight at the end of the halter, that the animal could always move his head with facility, but could not draw out the rope so as to become entangled in it, nor could he easily waste his hay. The fastenings of the doors, as well as all the other appendages and accommodations are equally ingenious.

The great water wheels, which move the machinery of the manufactory, are constructed entirely of wrought iron, combining the greatest strength, durability and beauty, with a projectile power like that of the fly-wheels in steam engines. They are elegant objects, especially when in motion.

Mr. Whitney did not forget the domestic arrangements of his own house, which contained many specimens of that ingenuity which he evinced in common things, as well as in those that are more important. The several drawers of his bureaus were locked by a single movement of one key of a peculiar construction, and an attempt to open any drawer except one, would prove ineffectual, even with the right key, which however, being applied in the proper place, threw all the bolts at one movement. These bureaus are now in the house of Mrs. Whitney.

During the decline of his health, and especially during his severest attacks, I was with him almost daily, and saw how intensely his powerful and acute mind was directed to his own case, of which he made himself perfect master.* It has been already stated in the memoir, that his health was subverted, and his life ultimately terminated by a very painful local affection,† brought on, as he informed me, by exposure and fatigue during the last of his land journeys, through North Carolina, on his way to Georgia, to assert his just claims, so long and

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* Such was the remark made to him by one of the greatest surgeons of this country, who, after a painful examination in one of the great cities, gave him no encouragement to hope for any permanent relief.

† Not only of the prostrate gland, but of the vicinal organs; this was the fatal disease of Mr. Whitney's illustrious friend, the late President Dwight; thus were removed most painfully, from life, two of the greatest and most useful men which this country has produced.

so injuriously frustrated.* He examined, with great care and coolness the best medical writers on his disease; he inspected their plates; conversed freely with his professional advisers, who withheld nothing from him, and he was not satisfied without such anatomical illustrations as were furnished from the museum of an eminent professor of anatomy. He critically recorded such facts in his case as interested him the most, and, in coolness and decision, acted rather as if he himself had been the physician than the patient.

During this period, embracing at intervals several years, he devised and caused to be constructed various instruments, for his own personal use, the minute description of which would not be appropriate to this place. Nothing that he ever invented, not even the cotton gin, discovered a more perfect comprehension of the difficulties to be surmounted, or evinced more efficient ingenuity, in the accomplishment of his object. Such was his resolution and perseverance, that from his sick chamber, he wrote both to London and Paris, for materials important to his plans, and he lived to receive the things he required and to apply them in the way that he had intended. He was perfectly successful, so far as any mechanical means could afford relief or palliation; but his terrible malady bore down his constitution, by repeated, and eventually by incessant inroads, upon the powers of life, which at last yielded to assaults which no human means could avert or sustain. One of the important inventions of that distressing period is in possession of the artist who was employed to construct the instrument,* but it is to be feared that other contrivances, remarkable for their simplicity and efficiency, as well as originality, are but imperfectly remembered by the friends and attendants. I urged Mr. Whitney and the late Dr. Smith, his attending physician, to make sure of these inventions while it was possible, but I believe

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* He made many journeys to Georgia on this painful business, and generally by land in an open sulkey. Near the close of life, he said in my hearing, that all he had received for the invention of the cotton gin, had not more than compensated him for the enormous expenses which he had incurred, and for the time which he had devoted during many of the best years of his life, in the prosecution of this subject. He therefore felt that his just claims on the cotton growing States, especially on those that had made him no returns for this invention, so important to his country, were still unsatisfied, and that both justice and honor required that compensation should be made.

* Mr. Deming.

no record was ever made of them, and it is but too probable that the instruments are lost.

I have mentioned these facts, connected with Mr. Whitney's last illness, merely as instances of his never-sleeping ingenuity and mental acuteness, rendered still more active, without being enfeebled, by intense suffering.

I have seen the same traits manifested on occasions, far less important, but to him, at the time, equally novel. In the summer of 1808, application was made by myself and others to Mr. Whitney for tubes of block tin, for the purpose of drawing, through an innocent metal, the soda water* highly charged with carbonic acid gas. Lead and copper tubes were rejected, on account of their poisonous properties, and there were then no facilities in this country for constructing the tubes that were desired. Mr. Whitney accomplished the object, with his usual precision. The tubes were required to be many feet long, and strong enough to resist a heavy pressure. He caused a mould to be constructed of cast brass; it was in two parts, each containing, for about two feet in length, one half of the cylindrical cavity, corresponding to the desired tube; when the parts of the mould were accurately fitted, by their faces, and screwed together, they contained the entire cylindrical cavity between them, and to secure the duct through the tube, a polished steel rod, of the proper size and made very slightly tapering, was fixed in the centre and the melted metal was cast around it; the rod, being terminated by a ring, was easily knocked out. The separate parts of the tube, thus produced, were then joined into one, by having the contiguous ends of two of them brought, longitudinally, into contact, and included in another mould, containing an enlarged cavity, into which melted tin was poured; the duct was preserved by a steel rod passing through it, as before, and thus the joint was perfected by a knob of metal, which at once united the two tubes into one, gave them great additional strength, and furnished a beautiful ornament. Nothing could be more perfect, for the object. The moulds are still in existence, and were it necessary, tubes could be thus made a mile long. Mr. Whitney did not state that this method was original, nor do I certainly know whether it was, but I have never heard of a similar method of casting block tin

* Then just beginning to be known in this country.

tubes. Mr. Whitney considered it as so valuable, that he chose to pay for the moulds himself, although they were expensive, and he retained them with reference to future use for himself.

The operations of Mr. Whitney's mind were not so remarkable for rapidity as for precision. This arose, not from the want of mental activity and ardor of feeling, but from habitual caution, and from his having made it his rule to be satisfied with nothing short of perfection. Hence, he delayed to mention a projected invention or improvement, until he was entirely satisfied with his own views; he did not disclose them until, in his own opinion, he had hit upon the best conception and the best means of execution, and when these were attained, and not before, he brought his project forward, or, more frequently, put it into successful operation before he divulged his plan. Hence, he rarely found it necessary to retrace his steps. In early life he so effectually disciplined his mind, that he could, not only confine it to the contemplation of one subject, but he could suspend his train of thought and the execution of his inventions, and resume them at distant intervals, without confusion or loss. He was very patient of interruption, and would cheerfully leave his own engagements and interrupt his mechanical arrangements, his repasts, or his business, to attend to the numerous applications which were constantly made to him, both by those who had, and those who had not, any proper claims to his time and services.

No man, as stated in the memoir, knew better how to control the excursions of an inventive mind. I have heard him speak, feelingly, of the ruin often brought by ingenious men upon themselves, by allowing their minds to wander from invention to invention; devising many things and completing nothing; and he considered it equally his own duty and interest, to adhere, inflexibly, to those undertakings which he could carry into successful operation, and to deny himself the luxury of a perpetual mental creation.

With all his contemplative ingenuity, and habitual attention to mechanical details, Mr. Whitney did not allow his mind to be narrowed down to a limited horizon. His views of men and things were on the most enlarged scale. The interests of mankind, and especially of his native country, as connected with government, liberty, order, science, arts, literature, morals and religion, were familiar to his mind, and he delighted in conversing with men of a similar character.

His amiable and generous dispositions also prompted him strongly to social intercourse; his countenance and person were so prepossessing as to excite an active interest, especially whenever he spoke; his gentlemanly manners, marked by a calm but dignified modesty, were still those of a man not unconscious of his own mental powers; he was therefore self possessed, while a winning affability and an agreeable voice, made his conversation as attractive as it was instructive. He abounded in information and in original thoughts; he was always welcome in the best society, both at home, and when he travelled; the first men of the country, and from almost every state in the Union, called on him, and much of his time was necessarily passed in society. Before he had a family, his carriage was often observed standing, till a late hour in the evening, at the doors of some of his friends, and he seemed reluctantly to withdraw to his manufactory, which was two miles from the town. Mr. Whitney was constant and warm in his friendships, and his efficient pecuniary aid, (after he came to be possessed of the means,) was often afforded, not only to his friends, but to persons who had sometimes no claims except those that addressed themselves to his kindness and generosity. Those who relied upon these traits were rarely disappointed, but he did not consider himself as being always requited, either with substantial justice or with gratitude; a case which is, however, not altogether singular in the world. Many thousands of dollars, amounting to a considerable fortune, were lost to Mr. Whitney, through his generosity.

It is perhaps worthy of being mentioned, that Mr. Whitney's amiable dispositions and power of pleasing were manifested in the pleasure which he took in caressing children, and in the ease with which he won their attachment. In my own family, as a visiting friend, he always allured the children, at once, around him, and neither he nor they were soon tired of the little gambols and pastimes, started for their amusement. Such happy dispositions eminently fitted him for the high domestic happiness which he found in his own family, during the few years that he was permitted to enjoy their society. After he became convinced that he could not survive his disease, he manifested a wise prospective forecast for their welfare, and it is characteristic of his peculiar turn of mind, that the ample house which, had he lived, he had intended to have erected, he ordered to be built after his death, for his lady and their children. His fortitude and sense of decorum never forsook him during his long and distressing decline. He almost always saw his friends, and some of them he would never suffer to be denied; even when in intense pain, he was cheerful, social, and courteous, and to the last, he maintained the observance of order, and proper attention to his person. He desired that the writer of these notes should be in the house at the closing scene, and although this was prevented by circumstances, he expressed to him, near the close of life, sentiments, such as we should wish to hear from a dying friend. As is common, in cases where there has been severe suffering, his countenance, after death, assumed its natural expression even in a greater degree than for several weeks before.

His funeral was attended by a large concourse of his fellow citizens, who assembled in one of the churches, to which the body was conveyed, and where an appropriate religious service was performed.

His tomb is after the model of that of Scipio at Rome, a miniature of which, of the same stone of which it was originally made, was sent out cut from Italy by Mr. William C. Woodbridge, and has been adopted in the case of two other eminent men, the late Dr. Nathan Smith, and Mr. Ashmun, the founder of the colony of Liberia. It is simple, beautiful and grand, and promises to endure for centuries.* An accurate drawing of it, by Mr. R. Bakewell, Jr. is annexed.

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* The foundations of the monument are laid at the bottom of the grave, by the sides of the coffin, and lower down than it; an arch of stone is thrown over the coffin, and the structure then rises, solid as an ancient temple. The material of the monument is the fine grained sandstone, of Chatham, Conn. The several layers of stone are composed each of one piece only.

The following observations of a distinguished scholar and statesman, elicited in consequence of a recent visit to the cemetery of New Haven, evince the estimation in which Mr. Whitney's name is held, by one who is fully capable of appreciating his merits. After alluding to the monument of Gen. Humphreys, who introduced the fine wooled sheep into this country, the stranger remarks;—"But Whitney's monument perpetuates the name of a still greater public benefactor. His simple name would have been epitaph enough, with the addition perhaps of 'the inventor of the cotton gin.' How few of the inscriptions in Westminster Abbey could be compared with that! Who is there that, like him, has given his country a machine—the product of his own skill, which has furnished a large part of its population, 'from childhood to age, with a lucrative employment; by which their debts have been paid off;

On Mr. Whitney's tomb is the following inscription:

ELI WHITNEY,
The inventor of the Cotton Gin.
Of useful science and arts, the efficient patron and improver.
In the social relations of life, a model of excellence.
While private affection weeps at his tomb, his country honors his memory.
Born Dec. 8, 1765.—Died Jan. 8, 1825.

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their capitals increased; *their lands trebled in value.*'§ It may be said indeed that this belongs to the physical and material nature of man, and ought not to be compared with what has been done by the intellectual benefactors of mankind; the Miltons, the Shakspeares, and the Newtons. But is it quite certain that any thing short of the highest intellectual vigor—the brightest genius—is sufficient to invent one of these extraordinary machines? Place a common mind before an oration of Cicero and a steam engine, and it will despair of rivalling the latter as much as the former; and we can by no means be persuaded, that the peculiar aptitude for combining and applying the simple powers of mechanics, so as to produce these marvellous operations, does not imply a vivacity of the imagination, not inferior to that of the poet and the orator. And then, as to the effect on society, the machine, it is true, operates, in the first instance, on mere physical elements, to produce an accumulation and distribution of property. But do not all the arts of civilization follow in the train? and has not he who has trebled the value of land, created capital, rescued the population from the necessity of emigrating, and covered a waste with plenty—has not he done a service to the country of the highest moral and intellectual character? Prosperity is the parent of civilization, and all its refinements; and every family of prosperous citizens, added to the community, is an addition of so many thinking, inventing, moral and immortal natures."—*New England Magazine, Nov.* 1831.

§ The words of Mr. Justice Johnson of South Carolina, in the opinion in the case of Whitney *versus* Carter.


ELI WHITNEY.
Born Dec. 8. 1765.
Died Jan. 8. 1825.
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Of useful Science & arts the efficient
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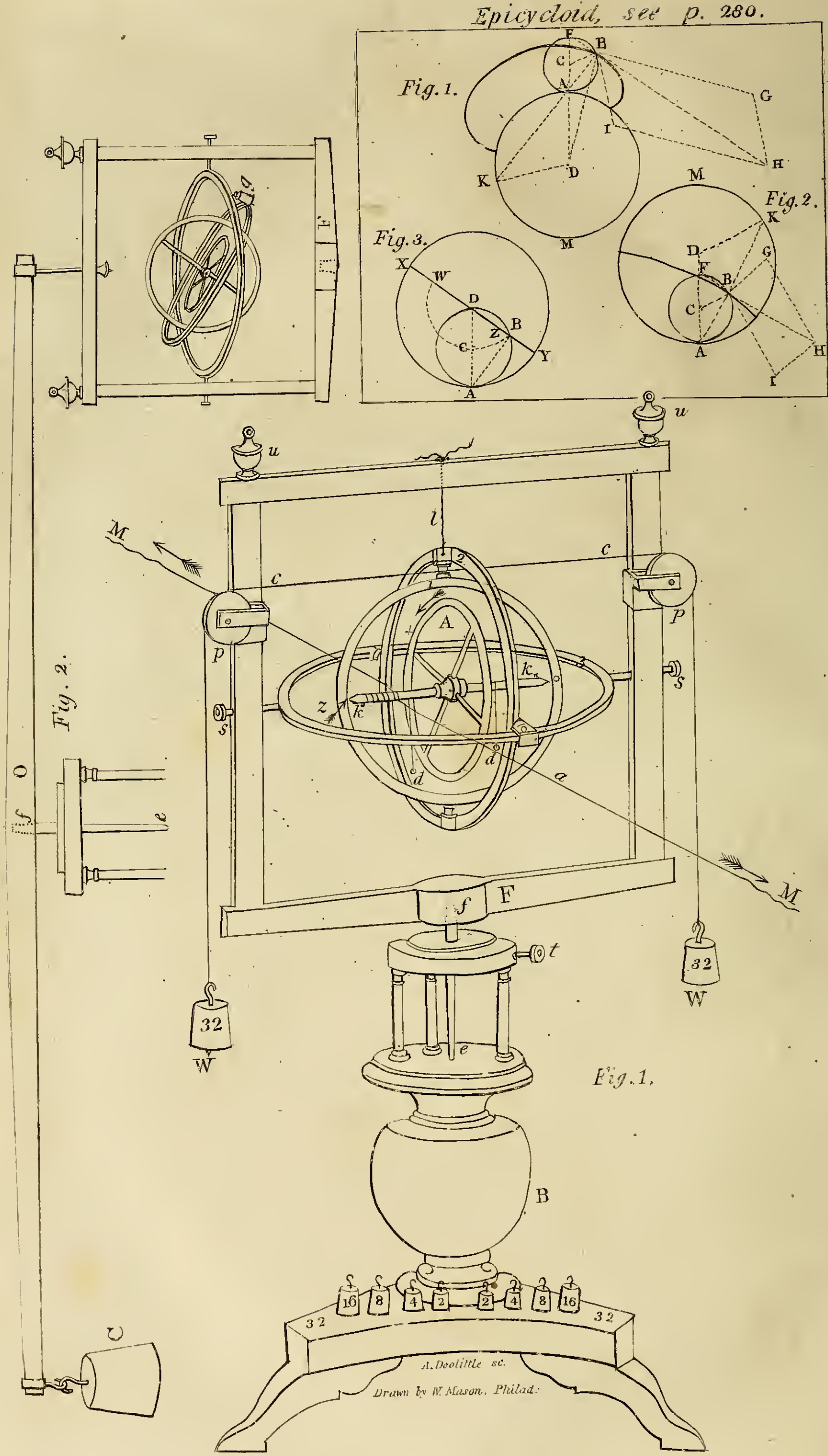

ROTASCOPE by W. R. JOHNSON.

Art. III.—*Description of an Apparatus called the Rotascope, for exhibiting several phenomena and illustrating certain laws of rotary motion; by* Walter R. Johnson, Professor of Mechanics and Natural Philosophy in the Franklin Institute, Philadelphia.

The laws relating to rotary motion, have been frequently made the subjects of profound analysis, and the transactions of some learned societies of Europe contain numerous papers, expressly designed to elucidate this branch of mechanical science.

Nearly all the discussions of the subject, however, which have hitherto appeared, have been of the abstract and transcendental character. Hence they have, in few instances, either interested or instructed the cultivators of practical science, and those who have long been familiar with mechanical forces and motions are frequently quite unacquainted, except by casual occurrences, with any of the curious laws which concern the positions and changes of position in the axes of rotation, in revolving bodies. Our common books of mechanics generally contain concise accounts of the doctrines of rotary motion, limited for the most part, however, to the consideration of central forces, the centre of percussion and of gyration, and the centre of spontaneous rotation, to which may be added that of oscillatory motion.

The forces tending to change the position of the axes of rotation are generally either wholly omitted, or if concisely stated in an abstract form, are apparently regarded as incapable of experimental illustration. The whirling table of Mr. Ferguson is an ingenious apparatus for exhibiting the amount and directions of the several forces exerted by a body in its own fixed plane of revolution. But that instrument makes no provision for the phenomena above referred to.

When we consider that the extensive diffusion of a branch of knowledge often depends on the facility with which its elements can be made apparent to the understanding, we are at no loss in estimating the practical value of philosophical instruments, whether intended for demonstration, or for research. Of this truth the machine of Atwood may be taken as an illustration. This machine gives a most elegant and satisfactory exhibition of the principles of uniform, accelerated and retarded motions, as dependent on the force of gravity. All the motions in the machine may be so slow as to reduce the resistance of the air to an unimportant element, and the friction and inertia of the parts being separately determined and allowed for, the theoretical laws of motion are seen to be perfectly confirmed by the experiments.

As to the manner in which the principles of rotation have generally been explained, it may be briefly stated on the plan of what are called rectangular coördinates. As by referring the effect of any force applied opposite to the centre of gravity of a body at rest, to three lines mutually crossing each other at right angles, the resulting direction which the centre of gravity of that body will take in free space, is inferred; so, by a consideration of three perpendicular axes of revolution within the body itself, we may determine the effect of any number of forces tending to produce rotation. Combining these two together, we have the resultant motions, both of rotation and translation. One of the most important propositions pertaining to the physical character of the subject, is that discovered and demonstrated by Frisi;—that "when a body revolves on an axis, and a force is impressed, tending to make it revolve on another, it will revolve on neither, but on a line in the same plane with them, dividing the angle which they contain so that the sines of the parts are in the inverse ratio of the angular velocities with which the body would have revolved about the said axes separately."

The following elementary experiments and observations were the leading facts, which suggested the construction of the instrument hereafter described.

1. When we take up by its *brazen meridian* a common artificial globe, and, having given it a rapid motion about its axis, attempt to move the poles from their position in space, we shall find our efforts resisted and the globe impelled in various directions, in a manner which will generally surprise those to whom the experiment is new. If the globe be held by the meridian at points over the equatorial circle of the sphere and the axis be placed nearly vertical, and if in this state of things the revolving globe be carried alternately from right to left, and the reverse by the extended arms around in a small orbit or portion of an orbit, the tendency of the sphere to change the position of its axis will be felt in one or both directions of the movement.

2. Whenever we suspend, in the manner of a pendulum, by a rod a few feet in length, an artificial globe, by its brazen meridian, at a point at or near its equator, the globe if not caused to revolve on its axis, may be made to oscillate in any direction, without tending to

vary the relative position of its poles; but if the globe receive a rapid rotary motion, previously to the commencement of its oscillations, there will be a vigorous effort visible at every oscillation, tending to alter the direction of the axis of the globe.

A little observation will serve to ascertain, that the position which the axis affects, is such as to bring the rotary motion referred to the centre of the sphere into the same plane and the same direction as that of the oscillation, referring the latter to the centre or point of suspension of the pendulum. Hence, if we watch the motion of the exterior of the globe, we shall perceive that the *rising side* in the *rotation*, is the *anterior* side in the *oscillation*, and that the inverting takes place, the instant the pendulum begins to descend in the arc of oscillation.

3. There is in use a small apparatus for striking fire, composed of a semi-cylindrical box of tinned iron a few inches in length, at one end of which is a small cavity for receiving the tinder, and above it is mounted on an axis a disk of steel to strike, when in rapid motion, upon a flint, held just above the tinder. The steel disk is put in motion by the friction of a string, drawn briskly over a small pulley on the axis. If, when the wheel, which is about two inches in diameter, is revolving vertically, we hold the whole loosely in the hand extended, and carry the latter alternately right and left before the body, so as to cause the wheel and appurtenances to describe a horizontal curve, to which the direction of its axis at the commencement of the motion is a tangent, we shall perceive a strong tendency in the wheel to leave the vertical and assume the horizontal position.*

4. To illustrate the effect of removing atmospheric resistance and obviating friction, I have constructed a delicate metallic wheel about three inches in diameter, through the centre of which passes a steel axis about one tenth of an inch in diameter and three inches long. Near each end of this axis a hole is drilled to receive a delicate thread of loosely twisted silk, by which the two ends are supported and the axis kept in a perfectly horizontal position; the other ends of the silk threads are fastened to two hooks on the bottom of a cylindrical mass of lead, which is in turn supported by a single hook in the centre of its upper base. The wheel is made to revolve on its

* This neat little experiment had been made, and was first communicated to me by Mr. William Mason, who, to render it the more striking, had mounted the whole box on a pointed axis passing longitudinally through the centre of gravity.

axis, which of necessity winds up the supporting threads, into a spiral about the axis. When wound up, the whole is placed in a tall glass air-pump receiver, open at both ends and furnished with a plate, collar of leathers and hook at the upper end. This receiver is a frustum of a cone, and so large as to allow the wheel to run freely up and down without interfering with the sides. Having exhausted the air, the wheel previously wound up is detached from a hook that had prevented its descent and revolves slowly at first, and increasing in velocity according to the law of gravity, reaches at length the extent of the cords, and being arrested in its downward progressive motion at the moment it has arrived at the maximum velocity of rotation, begins at that moment to wind up the cord in the opposite direction about the axis; while the whole wheel necessarily rises and at length reaches to very nearly the same height as that from which it had descended, when its momentum being lost, it again descends, and so continues to do for many minutes, until the *mere rigidity of the cord* has gradually destroyed all the momentum due to the first descent. I had frequently observed, when performing experiments with this apparatus, both in vacuo and in air, that by swinging the wheel while ascending or descending, there was a decided tendency to a particular arrangement in respect to the position of its axis, compared with that of the direction of oscillation.

5. A carriage is often overset in turning a corner, or describing a curve of short radius. Here the effect is produced sometimes with astonishing suddenness; at other times the inner wheel, or that which according to the direction of the turn, is describing the smaller circle, rises from the ground and revolves for a second or two on its axle without touching the surface; and, if the motion be not too rapid, may possibly return and allow the vehicle to recover its position, and pursue its course. But if the wheel which is revolving in air have any considerable velocity, the body of the carriage will appear to be overset by a force greatly superior to that which is due to the mere centrifugal motion of the carriage from its curve.

6. A disk of metal or other heavy substance, when projected into the air by the hand, receiving at the same time a rapid rotary motion, will sometimes be observed to perform singular evolutions in certain parts of its track.

7. The accurate experiments of Mr. Hutton and others, on gunnery, have proved that a very great deflection of a cannon shot, from the direction of the piece, often takes place, amounting in some instances to an angle of about 15°.

8. The use of a fly-wheel to regulate the motion of machinery in a steam boat was formerly very common, and some of our boats still retain it. In describing a curve with the boat, as in rounding to, near a wharf, or in tacking rather shortly, a close inspection of the wheel will show that a powerful effort is made by it to depress one, and elevate the other of its gudgeons; and that a correspondent effect in racking the boat, or causing it to careen, is produced.

9. A small apparatus said to have been devised by the celebrated La Place to illustrate the precession of the equinoxes, has been made in France, and imitated by an ingenious mechanic of Philadelphia. It is formed of two concentric rings revolving on axes at right angles to each other. Within the inner ring is a small sphere loaded at one of its poles in such a manner as to produce a rotation in the axis of the inner ring, when the sphere is caused to revolve with rapidity. The chief parts of the rotascope had been devised and constructed before I had an opportunity of seeing the above described apparatus.

10. Several ingenious experiments were some time ago contrived and executed by Mr. R. Tyler, a skillful mechanician of Philadelphia, with an apparatus resembling, in some respects, the common *top*, included in a ring, and placed on a whirling table.

In that arrangement, his experiments coincided, to a certain extent, with some of those which are presented with the rotascope on the orbit-rod.—There was wanting however the means of developing and exhibiting the causes which produce the changes, actually seen to take place. This end is most important in whatever concerns the principles of mechanics. It is what constitutes the great beauty of Atwood's experiments, that the action of gravity is made to coincide in principle, with its actual operation when unrestrained; while at the same time the bodies submitted to its action move with velocities which can be readily followed by the eye.

11. Numerous facts in Geology strongly indicate that at some remote periods of duration, the position of the earth's axis with regard to the plane of its orbit was different from what it is at present, and that successive periods of change have at length brought it to its present angle of inclination.

12. It has been observed by Biot and other astronomers as "one of the most remarkable phenomena of our system," that the motions of rotation of all the planets are directed from west to east, like their progressive motions; and this agreement they have generally attributed to the first cause which determined the planetary motions.

From the foregoing facts and observations, the importance of some apparatus to illustrate and, if practicable, to measure the tendency of bodies in rotation to preserve or to alter their planes of motion, and also to exhibit the various effects of combining a progressive curvilinear motion with rotation about a certain axis, will be obvious.

It is believed that no instrument heretofore presented to the public has been constructed for this especial purpose.

The following description refers to the accompanying plate.

A is a fly-wheel about eight inches in diameter, formed in such a manner as to receive but slight resistance from the air. It is supported on the centre of a perfectly cylindrical axis about three eighths of an inch in diameter, terminated by cones to serve as pivot points, on which the wheel runs. The wheel is of brass, the axis of steel, one end, from the wheel toward the pivot, being polished, the other bronzed, for more readily distinguishing the changes of position. The wheel with its axis weighs about two pounds and eleven ounces.

B is the base, or tripod which sustains the instrument.

F is a wooden frame containing the principal moving parts of the apparatus.

1, 2, 3, are concentric metallic circles, or rings, each about three fourths of an inch in breadth, and about two tenths of an inch in thickness. The exterior one (3), being about fifteen inches exterior diameter, is sustained in its place by the screws *s*, *s*, which have their ends conically excavated to receive the pivots.

The axis of the next ring (2), is at right angles to that of 3 and again the axis of 1 is at right angles to that of 2, and the axis of the wheel A, to that of the ring 1.

The centre of gravity of the wheel is likewise that of the whole system, and the axis of motion of each ring passes through that centre.

e is a pivot to the vertical shaft *e f* upon which the frame F, is supported, and upon which it may revolve. The axis of this shaft likewise passes through the centre of the wheel A.

f is a socket and cone furnished with a tightening screw.

t is the thumb-screw to fasten and hold the axis *e f* whenever it becomes necessary to prevent the horizontal motion of the frame F.

p, *p*, are two pullies, attached to the two upright pieces of the frame by metallic bands, and held fast at any convenient height on those supports, by screws on the backside. By taking out the screws *s*, *s*, the pullies may be carried *below* the axis of the outer ring.

u, *u*, are nuts to keep in place the upper piece of the frame. Their heads are perforated to receive cords for suspending the frame when necessary.

M, M, represent moving forces applied to the cord *a*, to give a rapid motion to the wheel. To know precisely what forces are applied to this cord, in experiments requiring the *measure* of those forces, we detach the weights W, W, and their cords *c*, *c*, bring down the pullies *p*, *p*, nearly to the screws *s*, *s*, and turning the rings into such a position that the cord *a* will go over the pullies, substitute weights of equal magnitudes at M, M, instead of the hands of the experimenter. A double series of weights from two to thirty two ounces accompanies the instrument. Each is furnished with a hook at top, and a small conical pin at bottom; the latter serving the double purpose of keeping them in place when deposited on the base of the stand, as seen in the figure, and of attaching them expeditiously to the rings 1, 2, by means of holes drilled to receive them. A weight thus attached is seen at *g*, Fig. 2.

The cord *a*, is attached to the axis by means of the small projecting conical knob *k*, *k*, one of which is near each end of the shaft. The centre of the cord is doubled, and the pin applied to the doubled part, the wheel is then set in motion to wind up the cord, so that one end will be drawn off from above, the other from below, and both tend to turn the wheel in the same direction.

c, *c*, are two cords connected with a small pulley on the axis of ring 1, and passing over the pullies *p*, *p*.

W, W, are weights attached to this cord.

z indicates the direction in which those weights tend to turn the ring 1.

x denotes the direction in which the wheel will move when actuated by the forces M, M, as here represented; but by turning the wheel in the opposite direction, when the cord is applied over the knob, the wheel will be put in motion in the opposite direction.

O is a bar of mahogany called the orbit-rod, with a socket *f*, by means of which it may, when the frame F, is removed, be placed on the pivot *e*, and made to revolve. In this case, the frame containing the wheel, is to be set or suspended at one end, while at the other is suspended the weight C, which exactly counterpoises the frame and its appurtenances. This weight is placed below the bar in order to bring the centre of gravity as low as practicable, and produce a more stable equilibrium.

d, d, are two small metallic beads suspended to the axis by delicate threads, at about one inch distance on each side of the nave of the wheel A. When the wheel is in rapid motion, these metallic particles revolve in planes parallel to it. But when any new force tends to change the position of its plane, they will be seen to persist for a time in the planes which they have acquired; by which means they become indexes of the tendencies of the particles of the wheel itself, while under the influence of such new force.

l is a line or string temporarily connecting the ring 2 with the upper part of the frame F.

The following directions and cautions will be found serviceable in using the Rotascope.

In winding up the *moving cord* around the axis of the wheel, it is necessary to keep the two parts as near to each other as practicable without having one *overlie*, or actually rub against the other, and to have them wound from the beginning to the end of the spiral, parallel to each other without any twists, as the latter will materially obstruct the uncoiling, when the force is applied, and endanger the breaking of the cord. Care should be taken that the uncoiling be made in such a position of the rings that the moving cord will free itself immediately from all contact with the wheel, at the instant it leaves the shaft.

The cords applied to the several pullies on the first and second rings, should be kept closely wound up round their respective pullies when not wanted for immediate use, as they may otherwise become entangled in the wheel, and obstruct its motion, or essentially endanger the accuracy and safety of the whole instrument.

In using the orbit-rod, the weight should be attached first, then the frame F, put in its place, and finally the socket set upon the pivot *e*, when the base B, will sustain the whole. The revolutions should begin with a slow motion and increase in velocity; all shocks and sudden changes of motion should be avoided.

When it becomes necessary to add any weights to the rings or other parts of the apparatus, while on the orbit-rod, an equal weight should be added to the *counterpoise* C, to avoid lateral pressure on the pivot *e*.

When the elementary particles *d, d,* are placed in their position the changes of position of the rings should be made gradually to avoid violent blows of these particles upon the ring 1, otherwise they may bruise its edge, or be thrown off with violence, by breaking their supporting threads.

When the wheel is to be stopped, it is most convenient and safe to do it by applying a moderate friction with the thumb and finger to the axis, which will very soon effect the purpose.

To set the wheel in rapid motion, apply the cord around the axis of the wheel, doubling it for that purpose, and putting the fold at the centre, over the small pin near the end of the axis; having wound up the cord, take one end in each hand, and draw the two ends apart with suitable force, in direction at right angles to the axis, and, as near as may be, in the plane of the first circle, as well as parallel to that of the wheel itself. It will prevent breaking or chafing the moving cord at the pivot, to relax the strain when within two or three coils of the pin.

The following are among the experiments which may be performed by the aid of the rotascope.

1. Remove the wheel and the brass circle 1, from the other parts; give the wheel a rapid motion on its axis, and holding the brass ring at some convenient opposite points of its circumference, carry it forwards or turn the body round, holding it out so as to describe a small curve. The effort to change its plane of motion will be surprisingly vigorous, and require some care to prevent the apparatus from leaping out of the hands.

2. Suspend the detached ring and wheel, used in the first experiment, to a cord attached to the ceiling above, by one end; give the wheel a rapid rotary motion, then give it an oscillatory motion through an arc of sixty or eighty degrees. Different points of attachment may be assumed, by which to connect the cord with the ring. If connected at a point opposite to one end of the *axis* of the wheel, the latter may be raised up so as to form an acute angle with the suspending cord; the oscillatory motion, being given while the axis has this position, will be accompanied by a regular horizontal motion, opposite in direction to that which the wheel would then have if it hung in the position which it would take when at rest.

3. Connect with the ring, at a point opposite to the axis of the wheel, a wooden rod of sufficient strength to bear the weight when held horizontally, and from nine to twelve inches in length. Attach the end of this rod, remote from the wheel, to a cord suspended from the ceiling. Set the wheel in rapid motion, and then bring it up, so that the rod shall be horizontal. Then suddenly abandoning it with the hand, the cord will sustain it as before, but instead of hanging vertically down, the axis of the wheel, and the rod, (which may be re-

garded as its prolongation,) will be kept for some time horizontal; but though thus suspended, as if by some mysterious agency, they constantly perform a circuit which has a vertical, drawn from the point of suspension, for its axis. If the velocity of the horizontal revolution be diminished, the sustaining rod will incline downwards more rapidly than when left to itself, until at length it reaches the position of rest. But if the velocity of that revolution be augmented by any external force, the wheel and ring will rise in opposition to gravity, until the rim of the wheel strikes the suspending cord. The wooden rod will then have come to a position nearly vertical, sustaining the wheel and ring at its upper end, but still continuing the horizontal motion. This paradoxical appearance would continue the longer by having a delicate metallic swivel link in some part of the cord, which should prevent the twist that otherwise soon opposes the horizontal motion, to such an extent as to depress the rod in the course of a few minutes. It will be seen that the revolution in a horizontal direction being the resultant of gravity, combined with the rotary motion of the wheel, must become more rapid in proportion as the velocity of the latter on its axis is diminished; because the force of gravity is then a greater component in the combined forces which act upon the system.

4. Having replaced the wheel and ring 1, in their connection with the frame, set the latter on its pivot, upon the base B. Make the circle or ring 3 fast in a vertical position; apply cords to the pulley on the axis of ring 2, and bringing the pullies *p*, *p*, to a proper elevation, make them fast and pass those cords over them to sustain weights. Having given the wheel a rapid motion, take hold of one of the urns *u*, *u*, and cause the whole frame to revolve horizontally on its pivot. As the persistency of the wheel in the plane of its motion, prevents the ring 2 from revolving, the motion of the frame will gradually wind up the cords about the pulley. At the same time, however, the ring 1 will gradually change its plane, and bring the wheel to a position to obey the action of the weights. The portion of cord which had been previously wound about the pulley will then be uncoiled, and a considerable momentum communicated to the system, composed of the rings 1 and 2, which will, if the tightening screw *t* be made fast, again wind up the cord in the opposite direction about the pulley. As soon as the said rings, however, are again deprived of their momentum, by the action of the weights, the latter will again tend to produce a rotation in the ring 2, which will be op-

posed by the persistency of the wheel. If at this moment the pivot be released from the screw, the whole system, composed of the two weights, the frame and ring 3, will be made to revolve by the gravity of the weights, while the ring 2 remains pertinaciously fixed in its position, until the wheel has had time again to invert its axes. This time will be greater or less, according to the greater or less velocity of rotation in the wheel, compared with the size of the weights hanging over the pullies.

5. Fix the ring 3 in a vertical position by means of a grooved wedge moving in and projecting above the lower piece of the frame F; wind up two cords about the pullies on ring 1, and attach a weight of a few ounces to each; then set the wheel in rapid motion, and abandon it to the action of those weights. The ring 2 will revolve in a certian direction about its vertical axis, until the wheel has come to revolve in the opposite direction, then the direction of the ring will be inverted;—and if the weights continue their action through several revolutions of the ring 1, an inverse motion in the ring 2 will take place at each semi-revolution of the former. If instead of revolving about its vertical axis, the second ring be attached and kept at right angles to the plane of No. 3, by cords leading to the side pieces of the frame, these cords will exhibit alternately a strong tension, as the first ring performs its successive semi-revolutions.

6. Hang a weight of one or two pounds on the ring 1, raise it up till that ring is in a horizontal position, (the third ring being still in its vertical position,) and tie a small cord or thread from ring 1 opposite to the end of the axis, down to the lowest point of circle 2. This thread must be strong enough to support the weight before-mentioned on the opposite end of the axis. Now give the wheel a rapid rotation; there will be no tendency in ring 2 to revolve horizontally. But if we cut or burn off the string, so as to allow the weight to act by its whole gravity at the opposite end, the second ring will begin to revolve horizontally with a rapidity proportioned to the weight when the velocity of the wheel is given.

7. Place the second ring horizontal, hang a weight to its periphery, opposite to the axis of circle 3; then having set the wheel in motion, raise the weight up to a level with the centre of the wheel, or even higher, and let it *rest upon the momentum of the wheel*, until the latter has changed the position of its axis by causing ring 1 to perform half a revolution; then the weight will descend and oscillate

to the other side of the arc, where it will be again arrested by the resistance of the wheel, and thus it may be made to perform several oscillations before the wheel comes to rest.

8. Set or suspend the frame on the orbit-rod, give the wheel a moderate velocity of rotation, and set the whole in motion upon the pivot *e*, all the *circles* being free to move on their respective axes. In whatever direction the wheel revolves, with respect to the plane of the orbit, at the commencement of the *orbicular* revolution, it will soon be observed to conform in direction with the latter. If *this* be reversed, *that* also will soon be reversed.

9. Repeat the eighth experiment with only the addition of a weight of some ounces attached to the second circle, opposite to the axis of the first. The effort of the wheel to take, and maintain in its rotation, the direction of the *orbicular* motion, will be sufficient to keep the weight elevated nearly to a level with the centre of the wheel.

10. Bring circle 3 to a vertical position, and fix it by the grooved wedge. Fix circle 2 in a position at right angles to 3, (its axis of course being vertical,) by cords extending to the side pieces of the frame; suspend a weight on ring 1, and give the whole system a motion in the orbit. In order to allow the wheel to take its position nearly coincident with the plane of the orbit, and a direction corresponding with that of the system, the weight will be raised nearly or quite to a point vertically above the centre of the wheel.

11. Replace the *frame* on its base B, and make the arrangement exhibited in Fig. 1. By the combined action of the rotary motion of the wheel, and the gravity of the weights W, W, the poles of circle 1 will be carried round in a circle, and will stretch the line *l* towards all points of that circle in succession, so as to generate a cone, of which the apex is at the point where the thread *l* is fastened to the upper part of the frame.

12. The rotascope may be made to answer several of the purposes of the whirling table. For this object, and especially for exhibiting and measuring centrifugal force, the brass circles and the wheel, may be removed from the frame F, by loosening the screws *s*, *s*. The pullies *p*, *p*, being raised nearly to the top of the side pieces of the frame, are placed on a level with each other. Hang two equal weights one at each end of a cord, and place it over these pullies, care being taken to bring the two to the same level. Suspend a weight to the middle point between the two pullies sufficient to depress the cord about 30° or 40° from the horizontal position.

Let a small rod extend from the upper piece of the frame, with divisions marked to indicate the depressions and elevations of the cord. Give the frame and weights a rotation of any convenient velocity. The weights will spread out and describe a frustum of a cone, like the two arms of a mill governor; while the increased tension of the cords acting on the principle of the funicular machine, will elevate the weight placed at the centre. Note the height to which it rises, and the velocity of the weights. Bring the frame to rest again. The central weight will descend to its former level, but by adding weights to the end of the cord, it may be again brought up to the elevation which it had during the rotation. The sum of the weights required for this purpose, shows the centrifugal force.

13. In addition to the experiments already detailed, the rotascope furnishes the means of making experiments on the friction of pivots and of verifying the results of other methods employed for that purpose. The mode of experimenting is, to attach to the moving cord, applied about the axis of the wheel, and passing over pullies, weights bearing certain known relations to each other. Thus we may apply at each end of the cord, one fourth of a pound, cause these to descend three feet, uncoiling the cord, and giving a constantly accelerated motion to the wheel, until it quits the knob; after which, the velocity acquired will be gradually diminished, until the wheel is brought to rest by the effect of friction, and the resistance of air. Repeat the experiment, doubling, trebling, or using any other convenient multiple of the weights first employed. In each experiment, note carefully, by a good timekeeper, the time elapsed from the moment the wheel is first allowed to turn in obedience to the weights, till the string quits the axis, and also till the wheel again comes to rest. The *first* will enable us to ascertain how much more slowly the surface of the axis was moving at the maximum velocity of the wheel, than the weight would have moved, after falling the same distance by the full force of gravity. We shall thus know the absolute velocity of the wheel, and, of course, that of its centre of gyration may be ascertained.

By the *second*, we shall be enabled to compare the effects of different weights or forces, to discover the relation between the weights themselves, and the times in which friction destroys those effects, and possibly to establish some points in reference to the relation of *gravity* to time and space respectively, and of friction, to velocity.

The perfection of the workmanship on the pivots and their bearings, will also be tested by this means, and it will be seen whether both ends of the arbor be finished with the same exactness. The friction on one end may, for the purpose of these experiments, be increased in any moderate degree, by furnishing that end with a small ring to form a bearing, through which the conical end of the shaft forming the pivot, may pass, and in which it may rest instead of resting and rubbing solely on the point. This ring will increase the moment of friction, by carrying the rubbing surface of the shaft farther from the mathematical axis of rotation.

The following table presents the results of experiments made by means of weights of various magnitudes employed to produce rotation and shows the times in which the friction of the pivots, brought the wheel to rest; the axis in each experiment being kept *vertical* as long as the motion continued; but reversing the ends in the two separate series. The first column indicates the weights appended to the cords at each trial; the second, the number of seconds from the instant the motion commenced to that of its actual cessation. The third shows the ratios of the times observed with the several weights compared with the time required to bring the wheel to rest after it had been set in motion by *one pound* weight. The fourth column exhibits the square roots of the numbers of pounds. The fifth contains the differences between these roots and the aforesaid ratios, marked + when the root is greater than the ratio, and — when the reverse is true. The sixth column contains the number of seconds in which the wheel would have come to rest on the supposition that the continuance of motion is precisely as the square roots of the weights which produce it.

The departure of these numbers from the observed times is greater in the higher velocities than in the lower, owing, obviously, to the greater resistance of the air in those cases. But in no instance does the experimental differ from the theoretical result by more than ten seconds. This is shown in the last column.

It must be observed that in all the experiments the weights descended through precisely the same distances, and of course developed from the axis the same number of spirals of cord before its centre quitted the knob over which it had been doubled. We might repeat the operations, using all the different weights with different heights. Ingenious persons will find much interest in experiments of this nature.

FIRST SERIES,

With the sharpest point of the axis downwards.

Wt. in lbs.	Observed time in seconds.	Ratios to 115″	Square roots of No. of lbs.	Diff. between ratios and roots.	Theoretical times.	Difference between observed and theoretical results.
½	82″	.7130	.7071	−.0059	81″.3165	− 0″.6900
1	115	1.0000	1.0000	±.0000	115 .0000	0 .0000
2	162	1.4087	1.4142	+.0055	162 .6330	+ 0 .6330
3	196	1.7043	1.7320	+.0277	199 .1800	+ 3 .1800
4	220	1.9130	2.0000	+.0870	230 .0000	+10 .0000

SECOND SERIES,

With the more obtusely pointed pivot downwards, having a greater moment of friction.

½	58″	.7160	.7071	−.0089	57″.2751	− 0″.7249
1	81	1.0000	1.0000	±.0000	81 .0000	± 0 .0000
2	114	1.4074	1.4142	+.0068	114 .5502	+ 0 .5502
3	137	1.6913	1.7320	+.0407	140 .2920	+ 3 .2920
4	152	1.8765	2.0000	+.1235	162 .0000	+10 .0000

It appears from the above tables, that my instrument at the time these trials were made, had a material difference in the friction of its two points. The following table shows, at a view, the differences of time for each weight, the ratios between those differences, and the greater times, and the differences between those ratios themselves taken successively.

Weight employed at each trial.	Differences of times for the two pivots.	Ratios of the differences compared with the greater times.	Differences of the ratios.
½ lb.	82″ − 58″ = 24	24 ÷ 82 = .2926	. . . . . .
1 ..	115 − 81 = 34	34 ÷ 115 = .2956	.2956–.2926 = .0030
2 ..	162 − 114 = 48	48 ÷ 162 = .2962	.2962–.2956 = .0006
3 ..	196 − 137 = 59	59 ÷ 196 = .3073	.3073–.2962 = .0111
4 ..	22 − 152 = 68	68 ÷ 220 = .3090	.3090–.3073 = .0017

As the differences in favor of the smaller pivot, increase with the total amount of time ; and as there is an increasing ratio between the differences and the whole amounts of time given by the smaller pivot, it would lead to the conclusion that friction increased with the increase of velocity. The difference between the theoretical and the experimental results in the higher velocities, might, it is true, lead to the supposition of such an increase, but it could not be with certainty referred to this cause, since the actual amount of the resistance of the air at the velocity obtained from a one pound force, could not be known, unless we could perform the experiment first in vacuo, and then in the open air. But when we find that the higher velocities cause greater proportional losses, on the pivot of greater friction, the air having certainly greater effect there than at the lower velocities and *a fortiori*, greater still on the pivot of least friction, we are compelled to infer that the superior proportional loss must be due to the greater effect of friction at high velocities.

It is evident that as the weight producing momentum in the wheel is increased, it must develope the cord in less time than when the smaller force is employed. But if the forces or weights employed for this purpose were greatly increased so as to bear a high proportion to the size and weight of the wheel, the times in which they would make their descent might approach very nearly to that by which they would descend by gravity alone; and the limit to the increment of velocity in the wheel when set in motion by weights, must obviously be found, when the surface of the axis over which the moving cord is applied, has attained the same velocity as that which gravity would give to any heavy falling body whether great or small, by traversing the same space through which the weights are caused to descend. This velocity it can never absolutely attain, however much the weight may be increased, or the wheel diminished, since the communicating of momentum to any quantity of matter however small implies the loss of a corresponding quantity in the moving body which transfers it. But for all purposes of experiment, the approximation might soon be so near as to render the difference between the velocity due to gravity and that actually attained by the surface of the axis at the moment the cord leaves it, wholly unappreciable.

Art. IV.—*Investigation of the Epicycloid; by* E. F. Johnson, of Middletown, Conn.

1. If a circle, as AMK, (figs. 1 and 2,) remain fixed, and another circle ABF, called the generating circle, be made to revolve upon its circumference, in the same plane with it, either externally or internally, the line described by any point, as B, in the circumference of the generating circle, from the time of its leaving the circumference of the fixed circle until it returns to it again, is called a *plane epicycloid.*

2. It is apparent from the above, that the generating circle, while it moves around upon the circumference of the fixed circle, revolves at the same time about its own center. Any point, therefore, in its circumference, as B, may be considered as having two motions—one about the center C of the generating circle, and the other about the center D of the fixed circle.

3. If the generating circle be moved around upon the circumference of the fixed circle, without revolving upon its own center C; or, in other words, if it be carried around upon the fixed circle in such a manner, that the same point A in its circumference shall always touch the circumference of the fixed circle; the velocities of the several points A, C and B, will evidently be as AD, CD and BD, their distances from the center of motion D respectively. BD may consequently be taken as the measure of the motion of the point B about the center D; which motion being in the direction of a tangent BG drawn to the extremity B of the radius DB, will be correctly represented by the line BG, that line being made equal in length to BD.

4. Again, if the generating circle be allowed to revolve upon the circumference of the fixed circle, the point A in the circumference of the generating circle, (which before moved around the center D of the fixed circle, with a velocity proportional to AD,) will, by the impinging of the two circles, cease to move about the center D, and will take up a new direction around the center C of the generating circle, with a velocity proportional to AD, the same with which it before moved about the center D of the fixed circle; and furthermore, as B is a point in the same circumference with A, it will have an equal motion about the center C; consequently, AD may be taken as the measure of the motion of the point B about the center C, which motion being in the direction of the tangent BI drawn to the extremity B of the radius CB, will be correctly represented by the line BI, that line being made equal in length to AD.

5. As BG and BI are respectively proportional to and in the direction of the two motions by which the point B is governed in describing the epicycloid, if the parallelogram BHIG be constructed, its diagonal BH will represent the resultant of the two motions; that is, the point B will, by the influence of the two motions BG and BI, describe the direction BH, with a motion proportional to BH, and consequently, BH *is a tangent to the epicycloid at the point* B.

6. As BD is perpendicular to BG, if the radius DK be drawn perpendicular to IB or GH, the angle BDK will be equal to the angle BGH; and farther, as BD and BG are equal by construction, and likewise as BI or GH equals AD or DK by construction, the two triangles BDK and BGH are identical, and BK equals BH.

But since BH represents the motion of the point B in the epicycloid, its equal BK may be taken as the measure of the same motion, and as the center C of the generating circle has but one motion, viz. the uniform one about the center D, represented by CD, it follows, that the motion of the center C is to that of the point B as CD to BK. Moreover, as DK and CB are both perpendicular to the same line IB, they are parallel to each other, and as the points A, C and D, are in the same right line, the angles ACB and ADK are equal; hence the two isosceles triangles ADK and ACB are similar and have the vertex A common, and CD : BK : : AC : AB. But, as has been shown, CD is to BK as the motion of the center C of the generating circle to that of the point B in the epicycloid; consequently, AC is to AB as the same two motions; or, *the motion of the center* C *of the generating circle is to that of any point* B *in its circumference, as the radius of the same circle to the chord drawn from the said point* B *to the point of contact of the two circles at* A.

7. The triangles GBH and DBK being identical, and BG in the one being perpendicular to the corresponding side BD in the other, the side BH is likewise perpendicular to the corresponding side BK; and as ABF is a semicircle, BH produced will cut the extremity F of the diameter AF, and as BH is a tangent to the epicycloid at the point B, it follows, that *the chord* BF *in the generating circle is parallel to the tangent drawn to the point* B *in the epicycloid.*

8. When by the revolution of the generating circle the point B arrives at F, the chord AB, which represents the velocity or motion of B, will become equal to the diameter AF or double the radius AC. Hence, *the motion of the point* F *is double that of the center* C.

In like manner, when the point B arrives at A, the chord AB will vanish, and consequently, *the point* A *is at rest.*

9. Since the chords of equal arcs have the same ratio to the radii of their respective circles, it follows, (6.) that the relative velocities or motions of the center and generating point of the same circle in describing corresponding portions of the epicycloidal line remains always the same, and consequently,

The lengths of different epicycloidal lines, formed by the same generating circle, are directly proportional to the distance through which the center of the circle passes in describing the same.

10. If the radius of the fixed circle be extended infinitely, the above properties and relations still obtain, and since, when thus extended, the circumference becomes in effect a right line, and as the epicycloid becomes what is commonly termed a cycloid, it follows, that *every proportion or fact deduced in the above investigation, will apply to all curves or cycloids formed by the revolution of a circle upon a plane.*

11. If the diameter AF of the internal generating circle, (fig. 2,) be made equal to AD, the radius of the fixed circle, the point F will coincide with the point D, and the tangent HF will, in every position of the point B, pass through D the center of the fixed circle; consequently, *the epicycloid will be a right line, equivalent to* XY, (fig. 3,) *the diameter of the fixed circle, or to* 2AD, *twice the diameter of the generating circle.*

12. The diameter of the internal generating circle being supposed equal to the radius of the fixed circle, as in the last case, its center in describing the epicycloid line XY, passes through the arc WCZ, equal to one half of XAY, or equal to one half of the circumference of the same circle, hence by Art. 9,—*The length of an epicycloid is to the distance through which the center of its generating circle passes, as twice the diameter of a circle to one half of its circumference, or as the diameter to one fourth of the circumference, or as* 1 *to* 0.7853981633974830961575.

13. If the radius of the fixed circle be supposed extended infinitely, as in Art. 10, the center of the generating circle will, in one revolution of the same circle, pass through a distance equal to its circumference, and consequently, by the last Art.,—*The length of the epicycloid, or more commonly the cycloid, will be equal to four times the diameter of the generating circle.*

14. As the chord DB of the generating circle, as represented in Fig. 3, is equal to the portion of the epicycloid, intercepted between its middle point D, and its generating point B, and as the center of the generating circle, in describing the said epicycloid, passes over a distance WCZ, equal to one half of its circumference, and likewise, as the length of an epicycloid is directly proportional (9.) to the distance described by the center of its generating circle, and moreover as the said chord DB, maintains in all corresponding positions of

the point B, the same relation to the radius AC, or the line which represents the uniform motion of the center C, it follows that *the portion of any epicycloidal line, intercepted between its middle point and the position of its generating point, bears the same relation to the supplemental chord* DB, *as the distance through which the center of the generating circle passes in describing the whole epicycloid to one half of the circumference of the same circle.*

15. In an epicycloid described upon a fixed circle, having an infinite radius, it appears (13.) that the center of the generating circle passes through a distance equal to its circumference, and hence by reference to the last Art. it follows, that *the portion of the curve called the cycloid intercepted between its middle point and the position of its generating point, is equivalent to twice the supplemental chord* DB, (*Fig.* 3.) *of its generating circle.*

The leading properties of the epicycloid are thus developed by the aid of a few of the most common and elementary principles of geometry and mechanics. Their practical application to the pendulum, —to the motion of carriage wheels,—to the conversion of a rotary into a rectilinear motion, and to the mode of determining the form of the working faces of cogs of different sized wheels, will readily be suggested to those who are at all conversant with the theory and practice of mechanics. The same principles may likewise be applied in the investigation of the vertical motion of particles in a non-elastic undulating medium, and to a new mode of spherical projection.

In conclusion I would state, that the idea of treating the subject of the epicycloid as presented above, was first suggested by a successful attempt of a lamented friend, Mr. Elisha Dunbar, late of Hartland, Vt. to illustrate, by a similar process, some of the leading properties of the cycloid.

Middletown, Conn. October, 1831.

Art. V.—*On Sugar from Potatoe Starch;* by S. Guthrie.

FOR THE AMERICAN JOURNAL.

Mr. Editor.—From the accounts of making sugar from potatoe starch, to be found in most of the recent works on chemistry, I was led to believe that in remote inland districts, where the potatoe grows abundantly, potatoe sugar might be made advantageously, both to the population of the district, and to the manufacturer himself.

Under this impression, about sixteen months ago, I proposed to my friend Capt. E. G. Potter, of this place, to make a trial of it, and on such a scale as should ascertain the practicability of obtaining sugar from potatoe starch, of a quality fitted for domestic purposes, and likewise the probable remuneration to be derived from conducting it as a business. To this proposition he assented, and engaged in it with all the zeal and ability which were required for its successful completion.

A series of experiments was commenced at my laboratory, which were followed up by him, in buildings erected for the purpose, during the ten succeeding months, in which time, the starch was extracted from about four thousand bushels of potatoes, and converted into sugar.

I am not aware that experiments on this subject, to any considerable extent have been made by others, either in this or in any country; the object of this paper therefore is to communicate, on this curious and interesting subject, such information as was acquired in the prosecution of the business, that the subject may be more fully understood, and that those who may be inclined to engage in it, may have, in advance, the advantages to be derived from an extensive experience of others.

The first experiment that succeeded was made in a glass bottle of one gallon capacity. The starch, water, and acid, in the usual proportions, were put together into the bottle, and the bottle placed in a sand bath. In order to insure a boiling heat, within the bottle, of about 230° Fahrenheit, a valve was fitted to its nozzle, and loaded with seven pounds to the square inch. On applying the necessary heat, in three hours the whole starch was converted into a sweet, fine flavored syrup, and eventually by neutralizing the acid, and by evaporization, into a rich, fine flavored sugar, or rather molasses; for, neither in this experiment nor in any subsequent one, did the product, when pure, exhibit the slightest tendency to crystallize.

In a subsequent trial the bottle exploded; and as sulphuric acid, largely diluted with water, was supposed to have very little, if any action on lead, a strong leaden vessel of seven or eight gallons capacity, capable of sustaining a pressure of ten pounds to the square inch, was fitted up for future operations. Many experiments were made with this vessel, all of which failed of giving a product that was not more or less contaminated with lead, and therefore unfit for use. The sugar made in this vessel had the property, especially when much charged with lead, of crystallizing into a firm, tough, white mass, with minute indistinct crystals, acquiring weight by absorbing water of crystallization from the atmosphere, and uniformly bursting the earthen vessels in which it had been crystallized. The conversion of the starch to sugar was always completed in about three hours. When the heat was continued eight or ten hours, the sugar was much more contaminated with lead, and crystallized more promptly, but acquired, from the continuance of the heat, no increase of saccharine properties.

After a sufficient number of experiments had taught the way, the following apparatus, and mode of working were adopted, and, as it appeared, seemed scarcely to require, or be susceptible of improvement.

For grinding the potatoes, the following very ingenious and efficient contrivance was devised, and executed by Capt. Potter. He obtained a true, smooth cylinder of hard wood, two feet long, and one foot in diameter, provided with gudgeons and a whirl. The face of this cylinder was covered, by winding and nailing upon it long strips of sheet iron, *about two inches wide*, punched full of holes, so as to give them a strong, rough, grater surface. This cylinder or grater was so hung, as to constitute the anterior side of a box or hopper, and made to revolve very near the anterior edge of its bottom, being driven by a band from the drum of a waterwheel. On filling the hopper with potatoes, and giving to the grater the necessary motion, the potatoes were reduced with surprising rapidity to a fine pumice, from which, by the aid of a seive and water, the starch, in great purity, was readily obtained. This apparatus ground three thousand five hundred bushels of potatoes, without requiring the least repair, and apparently was capable of grinding one thousand bushels more without impairing its efficiency.

The next step, in the operation, was to convert the starch into sugar. For this purpose a strong wooden vessel was formed, capable of sustaining a pressure of ten pounds to the square inch, and of the capacity of four hundred gallons. This vessel was charged with two hundred and twenty five gallons of water, being the necessary quantity for dissolving six hundred pounds of wet starch, equal to three hundred and seventy pounds of dry starch, the amount commonly converted at each operation. A steam pipe from a strong sheet iron boiler, was continued to the bottom of the tub or converter, and the steam let into it until the water had acquired a temperature nearly sufficient for dissolving the starch,—say 158°. A part of the water was then drawn off, and mixed with the starch, when the whole was poured into the converter, and constantly agitated, until, by the agitation and the increase of heat, the whole of the starch was dissolved. Four pounds of sulphuric acid had been mixed with the water in the converter, before the starch was added to it. The aperture, through which the starch had been introduced and agitated, was then closed. A throttle valve within the steam pipe *was loaded with ten pounds to the square inch*, and a safety valve upon the converter *was loaded with five pounds.* The steam was then driven into the converter, until the whole of the starch was converted into sugar, which usually required five or six hours. This point was ascertained at first, by the test of iodine added to a little of the product, drawn occasionally from the converter; but, by a little experience, it was readily and accurately ascertained by the flavor alone; as, before it became fully converted, it had a raw, disagreeable flavor, which entirely subsided on that event, and gave place to one sweet and pleasant.

The syrup was then drawn, whilst yet hot, into receivers, and the acid neutralized by adding caustic lime, and the point of neutralization ascertained by test paper or red cabbage, but better by the taste, and the syrup was then left to settle its impurities. It was remarked that less time was required to neutralize the acid, when used whilst the syrup was yet hot, and that the impurities settled more promptly and completely, leaving a more transparent and beautiful syrup.

The boiler was composed of a sheet of copper, seven feet and a half long, by four feet and a half broad, made of sheets of sixteen ounce copper, tinned upon the side intended for the upper one, tacked and soldered together, and nailed upon a wooden frame, six inches deep, of the same dimensions, divided into two partitions by a strip of plank crossing its centre. This vessel was set over an arch, and when adjusted, it was scarcely possible to desire a more cheap and useful instrument for the purposes for which it was designed.

With the above apparatus, about thirty gallons of sugar, or product, weighing nearly twelve pounds to the gallon, were completed from the starch and put up for market each day.

All the authorities I have seen speak only of crystallized sugar derived from starch, and the reader would expect to see his product crystallize as a thing of course; but I suspect few of them have taken the trouble to ascertain whether it will crystallize or not. Careful evaporation, carried to every possible degree of consistence, has been ineffectually tried. Crystals of muscovado and loaf sugar have been thrown into it, and have lain in it for months without acquiring any accession of size; and unless the sugar be contaminated with lead, I suspect it will be made to crystallize with difficulty, if at all.

A bushel of potatoes weighs about sixty pounds, and gives eight pounds of pure, fine, dry starch. This amount of starch will make five pints of sugar, of the weight of nearly twelve pounds to the gallon, equal to seven pounds and a half to the bushel of potatoes, or a little less than a pound of sugar to the pound of starch. The sugar is not as sweet as the muscovado sugar, nor is it actually as sweet as its taste would indicate.

This sugar may be used for all kinds of domestic purposes. It ferments with great liveliness and spirit, when made into beer, yielding a healthful and delicious beverage, and on distillation, a fine cider brandy flavored spirit. It would however be most useful in making sweetmeats, and may be used upon the table in lieu of honey, for which it is a good substitute. It has already become a favorite with most people who have become acquainted with it. Its taste is that of a delicious sweet, and as an article of diet is unquestionably *more healthful, and less oppressive to the stomach than any other sweet ever used.**

Sacket's Harbor, July, 1831.

Art. VI.—*Remarks on various Chemical Preparations; in a letter from* S. Guthrie *to the Editor, dated Sacket's Harbor, N. Y., Sept.* 12, 1831.

1. Fulminating Preparations.

Dear Sir—I have delayed sending the chlorate of potash I promised you, together with some other things, that I might be enabled to add a sample of nitrated sulphuret of potash, or a modification of fused "fulminating powder" of the old books, and likewise complete some experiments I have been making on the action of caustic potash on fulminating mercury.

I send to day the promised box. It contains one pound of chlorate of potash. It is contained in two papers—the lesser one has some fine crystals of larger size than usual, but the whole is remarkably fine and pure.

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* The use of a bottle (one fifth of a gallon) in my family, fully supports Mr. Guthrie's statements.

You will find a bottle containing some condensed fumes, arising during the preparation of fulminating mercury. I am now satisfied that the fumes contain spirits of nitrous ether, nitrous acid and mercury, and some uncondensable gas or gases, and vapor of water. Sixteen measured ounces of alcohol give ten measured ounces of condensed fluid. I have ascertained that nitric acid, of sp. gr. 1.34, can be made to *compensate for its weakness*, by increasing the proportion of it to the mercury and alcohol. One hundred grains of mercury, to two measured ounces of acid of this strength, and two measured ounces of alcohol, made as good fulminating mercury as I have ever seen.

I send you two small phials of nitrated sulphuret of potash, or yellow powder, as it is usually called in this country. It is far less perfect than such as I used to make, when in the habit of preparing it some years ago. You will perceive by burning it, in small parcels, upon the hearth or otherwise, that it takes fire with readiness, and burns much quicker than common powder. I have made some hundred pounds of it, which were eagerly bought up by hunters and sportsmen for *priming* fire arms, a purpose which it answered most admirably; and, but for the happy introduction of powder for priming, which is ignited by percussion, it would long since have gone into extensive use.

With this preparation I have had much to do, and I doubt whether, in the whole circle of experimental philosophy, many cases can be found involving dangers more appalling, or more difficult to be overcome, than melting fulminating powder and saving the product, and reducing the process to a business operation. I have had with it some eight or ten tremendous explosions, and in one of them I received, full in my face and eyes, the flame of a quarter of a pound of the composition, just as it had become thoroughly melted.

The common proportions of 3 parts of nitre, 2 parts of carbonate of potash and 1 part of sulphur, gave a powder three times quicker than common black powder; but, by *melting together* 2 parts of nitre and 1 of carbonate of potash, and when the mass was cold adding to 4½ parts of it, 1 part of sulphur—equal in the 100, to 54.54 dry nitre, 27.27 dry carbonate of potash and 18.19 sulphur—a greatly superior composition was produced, burning no less than eight and one half times quicker than the best common powder. The substances were intimately ground together, and then melted to a *waxy* consistence, upon an iron plate of one inch in thickness, heated over a muffled furnace, taking care to knead the mass assiduously, and remove the plate as often as the bottom of the mass became pretty slippery.

By the previously melting together of the nitre and carbonate of potash, a more intimate union of these substances was effected than could possibly be made by mechanical means, or by the slight melting which was admissible in the after process; and by the final melting of the whole upon a *thick* iron plate, I was enabled to conduct the business with facility and safety.

The melted mass, after being cold, is as hard and porous as pumice stone, and is grained with difficulty; but there is a stage when it is cooling in which it is very crumbly, and it should then be powdered upon a board, with a small wooden cylinder, and put up hot, without sorting the grains or even sifting out the flour.

In filling an order for one ton of the powder, I blew up fifty pounds of the composition in the grinding mill, and I then exchanged the manufacture of it for that of percussion powder.

Although it was eight and a half times quicker in burning, yet in an equal charge it did not project a ball with more than one half the force of black powder. At first, I was timid in using it in the barrel of the gun, but I soon found that quickness was not power, and that the power of the powder in projecting a ball was in proportion to the bulk of the flame when burned in open air. The same I have found true with fulminating mercury. I have many times used it in the barrel of a rifle, in free doses, and have always found the ball to be projected by a feeble force. From the small amount of permanent gases evolved in burning this powder, compared with those from gunpowder, and the rapidity with which it is done, the force is, probably, after the first instant, a receding or diminishing force; but in burning common powder the resulting gases are of greater amount, and the inflammation is not complete, even when the ball leaves the gun; hence the power at first applied to the ball, whilst it acts upon it, is a constantly increasing one.

For nearly three years, in which I hunted very much, I used yellow powder exclusively, and arrived at the conclusion, that for throwing ball and shot, and that with accuracy and steadiness, no other powder could compete with it. It attracts moisture from the atmosphere greedily, and is soon decomposed. Hunters were in the habit of carrying the powder in well corked phials, and throwing out the priming, if they had no occasion to use it, once or twice a day.

I send you a few canisters of percussion powder, from chlorate of potash. It is, in my opinion, preferable to all other kinds of composition for igniting gun powder. It is used, one grain at a time, for priming, except the No. 2, which is used in magazine locks. The No. 8 is used here for firing cannon. The red is coated, to make it water proof. It is perfectly safe in use, projecting no fragments of copper, as is done with the caps, whilst it is one hundred times more certain to discharge a gun, and costs ninety per cent. less.

From an expression in your Chemistry,* I suspect you doubt the possibility of using fulminating mercury as a certain means of firing guns loaded with common gun powder. Fulminating mercury alone used for that purpose is useless, because the heat does not continue a sufficient time to ignite the powder; not, that it is not hot enough, for, if it be ground with some material that retains heat some little time, it makes one of the most certain primings that can be used. I instituted a great number of experiments to ascertain this fact; and likewise what substance would best answer the purpose, and finally selected oxide of tin. Three parts of fulminating mercury and one part of oxide of tin, ground together with a stiff solution of *starch*, gave a powder of which I have manufactured a great deal, and so far as I know, it has scarcely ever, if at all, missed firing the piece in which it was used. Starch was the only thing that I could find that would give cohesiveness to the grain without injuring its explosive qualities under percussion; and it was a curious fact that solutions of shellac in alcohol should be harmless in powder from chlorate of potash, and ruin that from fulminating mercury; whilst starch was harmless in fulminating mercury, and spoiled powder from chlorate of potash. I send you a little of this kind of priming, under the name of metallic-priming, in two canisters. It is not very handsome, but as we construct our own gun locks, I suspect there is not a grain amongst it that will not set a gun off with the celerity of lightning.

2. Purification of oil of Turpentine.

Few things that have engaged my attention, have cost me so much trouble as divesting spirits, or rather oil of turpentine, of the last particle of its resin. If you have given the sample I sent you a comparative trial with common oil of turpentine, you will perceive that I have accomplished my object, whether or not to any good

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* Vol. II. pa. 33. par. at bottom.

purpose, others will judge. My first object was to obtain a perfect and clean solvent for caoutchouc. My second one will appear by and bye. Take sulphuric acid (and water?*) equal weights, mix, and when cold add a quantity of it to a quantity of oil of turpentine, and agitate thoroughly: the acid will become colored by uniting with, or charring the resin; let the acid subside, and decant the clear spirits. Repeat the operation until the acid subsides without being discolored. The oil of turpentine thus prepared, with *warmth and strong solar light*, is, as I believe, a *perfect solvent of caoutchouc*. This process is somewhat expensive and troublesome, and after a great number of fruitless trials with various articles, I found that alkalies and alkaline earths, especially lime, would attack resin, but not pure oil of turpentine. On distilling oil of turpentine from caustic lime and water, I found a great deal of resin remaining in the still on the first operation, but *none* at any subsequent one; hence the resin was an adventitious body. I likewise found, by the sulphuric acid test, that the oil was pure; and I likewise found that the oil thus purified was not a good solvent of caoutchouc, probably because in distilling the oil it had acquired water which it held in combination.

3. Safe process for manufacturing gun powder.

I have always supposed that gun powder, the materials being the same, was good in proportion to the intimacy with which its component parts were united. The almost infinite subdivision of paints effected by grinding them in oil, it appeared to me might be imitated by grinding the materials composing gun powder in some fluid, in which these materials were insoluble. Nitre and charcoal are insoluble in alcohol, and sulphur is nearly so; hence in a properly constructed mill these substances may be ground in alcohol, and the greater part of the alcohol drained and pressed out, whilst the small residue will evaporate with great readiness. I made the experiment, and obtained a good powder at the first operation. Alcohol, however, was rather too volatile, and a substitute that was less so, was a desideratum. This substitute was found in pure oil of turpentine: the resin having been previously completely removed, the oil when used was readily evapo-

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* The author has, in his MS., omitted to state what is mixed with the acid: we have ventured to fill the void as in the text; for the strong acid would blacken and char the oil of turpentine.—Ed.

rated, and left the powder entirely free from adventitious matters. A few hundred pounds were made by grinding impure materials in pure oil of turpentine, and a sample is inclosed in the box. The advantages to be derived from this project, if any, are, 1st. It will obviate all danger of explosion in uniting the materials, for a coal of fire, if not in flame, *will be* promptly extinguished if immersed in the composition whilst in the act of grinding; and 2d. A better powder may be made with less machinery, than can be made by the usual process; because the texture of the ingredients can be more effectually broken down. The disadvantage of the process is the additional cost of whatever turpentine is lost in the operation, which I think would be some ten or twelve cents in a quarter cask of twenty-five pounds. I think well of the process, and shall give it a thorough trial.

4. Fulminic acid and fulminates.

I was greatly surprised to-day, and somewhat chagrined, by reading your observations on fulminic acid, &c., to find myself anticipated in what I was about to claim as a discovery of my own, to wit, that fulminic acid could be *transferred* to caustic potash, and a salt obtained from the union; and that that salt, at less than a boiling heat, would be decomposed, and yield *ammonia*. I have been occupied with the subject these two weeks, and beg leave to request you to repeat the following experiment; and to give you the least possible trouble, I have sent you a small phial of fulminating mercury, covered by water. If the subject be familiar to you, it will have no interest; if not, I think it will have enough to repay the trouble of making the experiment.

Into a wine glass put a quantity of fulminating mercury merely wet, but with no water standing upon its surface—then pour upon it as much saturated solution of caustic potash as shall make it into a paste—in an hour or two it will be found to be *thick and stiff.* Dilute it again and again until it shall cease to become *stiff*, which will be, probably, at the end of forty eight hours—it will then have acquired four times its original bulk. At the end of the first day take out a small parcel of the composition, and wrap it in a piece of common factory cloth and press it as dry as possible, between two small pieces of boards, in a blacksmith's vice or other powerful press. It must then be dried on an iron plate, drawn from boiling water, which heat it will probably bear—if not, it will bear 200°. A few grains only should be dried at once, and this dried as near its exploding heat as may be. Having dried it, burn a few grains upon paper, when the explosion will be found equal to that of detonating silver. The paper will be shivered to pieces, and the coal of fire annihilated, *if the powder be well dried.*

I think the powder burns with most violence taken after the alkali has acted on the fulminating mercury two days, but a great change is effected upon the composition in a little time. Examine the contents of the glass on the fourth day, and the fulminating mercury will be found subsiding; the peculiar action, by which its *stiffness* was created and kept up, having gone by, and the detonating qualities of the powder being lost. If the composition be now pressed and dried, it will explode very mildly, and *without flame,* or at least without *appearance* of flame in a light room.

I poured a saturated solution of caustic potash into one ounce of *dry* fulminating mercury, and the next day I pressed it as dry as I conveniently could, and laid it aside for half an hour, when it exploded spontaneously. I observed when I took it out of the press that it had become hot, but thought no more of it until it exploded.

Into a ladle of boiling solution of caustic potash I stirred a quantity of fulminating mercury, and then poured the mixture upon a filter: on cautiously pressing the filter, the composition took fire whilst it was yet as thin as paste.

I think the powder cannot be dried so as to preserve its detonating qualities. The potash, though retarded in its operation, nevertheless continues it, and in a few days fulminate of potash is generated. I prepared a quantity of these crystals to send you, but they have deliquesced, and I have not inclosed them. These are NOT "*true fulminates*," having no fulminating disposition; and the term can be true only as applied to the triple compound, whilst a peculiar action is going on between the fulminite of mercury and the potash, so far as caustic potash is concerned. Lime water, carbonate of potash, carbonate of soda, and ammonia, all blacken fulminating mercury, and generally improve the explosive qualities in the first instance, but injure or ruin the preparation soon after. Solution of chloride of lime has no action upon fulminating mercury; iodine gives the mass a vermillion color, and spoils its fulminating qualities.

The exploding point of fulminating mercury and caustic alkali *is varied* by the concentration of the caustic potash. If the potash be diluted to various degrees of strength, there will be corresponding points of temperature at which the product will be ignited. There will likewise be corresponding powers of *detonation.*

After all, I have only verified M. Liebeg's discovery of fulminic acid, and devised a detonating compound of tremendous power, which can be prepared with more safety, and at less expense than detonating silver.

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A bottle and phial contain alcoholic solution of chloric ether. The contents of the phial are as strong as I could conveniently prepare them, but not equal to some which I made not long ago. It is a lively spirited preparation.

Since writing my article on starch sugar, I perceive in Gray's Operative Chemist, a direction that the wooden converter should be lined with lead. This is wrong—in the first place, it is entirely unnecessary, as the acid so much diluted does not act on wood. In the second place, either the acid or the syrup or both *will act* upon the lead and poison the product.

You have told me to write freely, and I trust you will not complain of the length of this communication. Nor must you complain against the fulminating character of my letters; for I have lived for many years in the midst of explosions, and even whilst writing this letter, I have been interrupted by the noise of a heavy explosion, followed by the thrill scream of "fire" from my alcohol distillery. The history of the accidents, effects of explosion, danger, escapes, and contrivances growing out of my yellow powder business would fill a volume; and with the percussion powder which I now make I have had probably one hundred explosions more or less severe. Thirty pounds of the powder is the largest quantity I have had burn at one time; but the most distressing accident I have encountered, scarcely excepting the severe burn which I sustained from yellow powder, arose from putting my hand into a keg containing about four pounds of percussion powder, and cracking a piece of it between my thumb and finger, by which it took fire; roasting my hand and arm, and tearing off most of the skin of my breast, neck, and face. But enough of this. I am now making two hundred pounds of the chlorate of potash, and when I get through, I shall be able to estimate the comparative value of carbonate and caustic potash in making this salt.

With great respect, your obedient servant,

SAMUEL GUTHRIE.

Sacket's-Harbor, Sept. 12, 1831.

Mr. Guthrie's preparations have all arrived, and although I reserve the trial of most of them, to my winter course of experiments, I am impressed with admiration both at his skill and intrepidity.—ED.

Art. VII.—*On the production of regular double refraction in the molecules of bodies by simple pressure, with observations on the origin of the doubly refracting structure; by* David Brewster, LL.D. F.R.S. L. & E.*

[Read before the Royal Society, February 11, 1830.]

In various papers already printed in the Philosophical Transactions, I have had occasion to show that the phenomena of double refraction may be produced artificially, by certain changes in the mechanical condition of hard and soft solids.† In all these cases the phenomena are related to the form of the mass in which the change is induced; and in the case of hard and elastic solids, they vary with any variation of form which alters the mechanical state of the particles. In isinglass and other bodies to which double refraction has been communicated by induration, the particles take a permanent position, which is not altered by any change of shape; but still the phenomena exhibited by a given portion of the mass are related to the surfaces where the indurating cause operated, and also to those by which the isinglass was bounded; and they depend on the position which that portion occupies in the general mass.

In all these cases the phenomena are entirely different from those of regular crystals, and in none of them is the doubly refracting force a function of the angle which the incident ray forms with one or more axes given in position.

As long ago as 1814, I communicated to the Royal Society the following experiment on the depolarizing structure of white wax and resin:

"When resin is mixed with an equal part of white wax, and is pressed between two plates of glass by the heat of the hand, the film is almost perfectly transparent by transmitted light, though of a milky white appearance by reflected light. It has not the property of depolarization when the light is incident vertically; but it possesses it in a very perfect manner at an oblique incidence, and exhibits the segments of colored rings."‡

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* Received, by the kindness of the author, with several other of his more recent papers on Light, which will appear in successive numbers of this Journal.

† Phil. Trans. 1814; 1815, pp. 1, 30, 60; 1816, pp. 46, 56.

‡ Ibid. 1815, pp. 31, 32.

The subject of double refraction was then so little developed that this experiment excited no notice; and it was only brought to my own recollection by the accidental appearance of the specimen itself. This depolarizing film has suffered no change by remaining fifteen years between the plates of glass. The vertical line along which it is destitute of the property of depolarization is a single axis of double refraction; and the colored rings at oblique incidences are produced by the inclination of the refracted ray to the axis of double refraction. In order to examine this remarkable effect under a more general aspect, I made a considerable number of such plates with different kinds of wax, and with various proportions of resin, and I was led to results which seem to possess considerable interest.

When the white wax is melted alone and cooled between two plates of glass, it consists of a number of minute particles, each possessing double refraction, but having their axes turned in all possible directions. If the film of wax is made extremely thin, the particles are not sufficiently numerous to exhibit any action upon polarized light.

When resin alone is melted and cooled in a similar manner, it exhibits no doubly refracting structure, whether it indurates slowly or under the influence of pressure.

If resin and white wax are mixed in nearly equal proportions, the compound possesses considerable tenacity. When a proportion of it is melted and cooled between two plates of glass, it shows the quaquaversus polarization of bees' wax, the axes of the elementary particles being turned in every direction. It possesses a considerable degree of opalescence, and a luminous body seen through it is surrounded with nebulous light. This imperfect transparency evidently arises from the reflexion and refraction of the rays in passing from one molecule to another, occasioned by a difference in the refractive power of the ingredients, or by the imperfect contact of the particles, or by both these causes combined.

In order to observe the modifications which these phenomena received from pressure, I took a few drops of the melted compound and placed them in succession on a plate of thick glass, so as to form a large drop. Before it was cold, I laid above the drop a circular piece of glass about two thirds of an inch in diameter, and by a strong vertical pressure on the centre of the piece of glass, I squeezed out the drop into a thin plate. This plate was now almost perfectly transparent, as if the pressure had brought the particles of the substance into optical contact.

If we expose this plate to polarized light, we shall find that it possesses one axis of positive double refraction, and exhibits the polarized tints as perfectly as many crystals of the mineral kingdom. The structure thus communicated to the soft film by pressure does not belong to it as a whole, nor has it only one axis passing through its centre like a circular piece of unannealed glass. In every point of it there is an axis of double refraction perpendicular to the film, and the doubly refracting force varies with the inclination of the incident ray to this axis, as in all regular uniaxal crystals. When the two plates of glass are drawn asunder, we can remove one or more portions of the compressed film, and these portions act upon light exactly like films of uniaxal mica or hydrate of magnesia, and develope a doubly refracting force of equal intensity.

This remarkable experiment presents an interesting subject of inquiry. That the regular double refraction of the film is developed by the agency of pressure cannot be doubted; but it does not at first sight appear whether it is the immediate effect of the pressure, or is the same doubly refracting force which produces the quaquaversus polarization that takes place when the resinous film indurates without constraint. In this state of the film the axes of double refraction are clearly turned in every conceivable direction; and it is impossible to suppose that a pressure in one direction could suddenly arrange all these axes in parallel positions. The double refraction of each particle of the film has therefore been developed by the compressing force similarly applied to them; and in producing this effect, it must have deprived each particle of the doubly refracting structure which it previously possessed. The substitution of one doubly refracting structure for another may be easily effected in many bodies. Even in regular crystals we can by heat or pressure modify or remove their double refraction. Nay, we can take away one axis from a biaxal crystal, and communicate a second axis to an uniaxal one. When the doubly refracting structure is produced by induration, we can remove it wholly by pressure, and replace it with another even of an opposite character; and when it is generated by the living principle, as in the case of the crystalline lenses of animals, we can take it away entirely, and substitute a new and more powerful doubly refracting structure by induration.

We may therefore consider it as clearly established that the uniaxal double refraction of the resinous mass has been communicated to the individual molecules by simple pressure; the increased transparency arising from the molecules being brought into closer contact, and the regular double refraction from the variable density impressed upon each elastic molecule, and symmetrically related to the axis of pressure. The effect thus produced on the resinous mass is precisely the same as what would take place by subjecting elastic spheres to a regular compressing force. The axis of pressure becomes an axis of positive double refraction, and the double refraction increases with the inclination of the ray to the axis, and becomes a maximum in the equator of the molecules.

By this view of the preceding facts, we are led to a very simple explanation of the origin and general phenomena of double refraction in regular crystals. That this property is not inherent in the molecules themselves may be easily proved. The particles of silex, for example, do not possess it in their separate state. In tabasheer, in many opals, and in melted quartz, there is not the slightest trace of the doubly refracting structure: but when the particles of silex in solution are allowed to combine, in virtue of their polarities or mutual affinities, they then instantly acquire, at the moment of their combination, the property of double refraction, and they retain it while they continue in this state of aggregation. The manner in which this takes place may be easily conceived: a number of elastic molecules existing in a state of solution, or in a state of fusion, are kept at such a distance by the fluid in the one case, and by the heat in the other, as to preclude the operation of their mutual affinities; but when, in the process of evaporation or cooling, any two molecules are brought together by the forces or polarities which produce a crystalline arrangement, and strongly adhere, they will mutually compress one another, and each will have an axis of double refraction in the directions of the line joining their centres, in the same manner as if they had been compressed by an external force.

From the phenomena of crystallization and cleavage, it is obvious that the molecules of crystals have several axes of attraction, or lines along which they are most powerfully attracted, and in the direction of which they cohere with different degrees of force. Guided by the indications of hemitrope forms, and supposing the molecules to be spherical or spheroidal, we infer that their axes are three in number and at right angles to each other, and are related in position to the geometrical axis of the primitive form. In like manner the phenomena of double refraction are related to the same axis of the primitive form, and may be all rigorously calculated by a reference to three rectangular axes. In uniaxal crystals, the three axes A, B, C, must be such that two of them are equal and of the same name; while the third, corresponding with the apparent axis, may be of the same or of a different name. In biaxal crystals, the three axes A, B, C, are unequal, and in crystals with no double refraction the axes are equal and destroy each other.*

This approximation of these two classes of facts is too remarkable to be accidental, and would go far to establish their dependence, even if it were not indicated by other arguments which I shall proceed to illustrate.

Among those crystals which have the obtuse rhomboid for their primitive form, there are many with one axis of negative double refraction, and only one or two with one axis of positive double refraction. In the former, the negative doubly refracting structure will be produced round the axis of the rhombohedron by the compression arising from attractions in the direction of two equal rectangular axes A, B, which will dilate the molecules in the direction of the third axis C, and make it a negative axis of double refraction, equal in intensity to either of the other two. Here we require the combination only of two axes; but if we suppose that there is in the direction of C a third axis of attraction either more or less powerful than the other two, then if it is less powerful, the compression of the molecules produced by it will diminish the dilatation arising from the united action of A and B, but will still leave an unbalanced dilatation, or a single negative axis of double refraction in the axis of the rhomb.

If C, on the contrary, is an axis in which the attractive force of the molecules is greater than along A and B, the compression which it produces will exceed the dilatation arising from A and B, and we shall have an axis of compression along C, or an axis of positive double refraction as in quartz and dioptase.† The same observations are applicable to minerals that crystallize in the pyramidal form.

* In uniaxal crystals, the resultant of the two equal axes A, B, may have any relation to C but that of equality; excepting when C is of a different name from A and B. In biaxal crystals, any two axes A, B, may be converted into three, A+C, B±C, ±C. See Phil. Trans. 1818.

† Since this paper was written, I have seen the very valuable researches of M. Savart on the structure of crystallized bodies as developed by sonorous vibrations. The curious result of his experiments, that the axis of calcareous spar, a negative axis of double refraction, is the axis of least elasticity, while the axis of quartz, an axis of positive double refraction, is the axis of greatest elasticity, harmonizes in a remarkable manner with the above views.

When the three axes A, B, C are all equal, the three rectangular compressions, produced by the aggregation of the molecules, will destroy one another at every point of the molecule, and the body which they compose will have no double refraction, and cleavages of equal facility. Hence all crystals in which it is known by cleavage that the particles cohere with equal force in three rectangular directions, have actually no double refraction.

If the three attractive axes A, B, C are all unequal, the difference of density which they produce in the molecules will be related to two axes of double refraction, the strongest of which will be negative or positive according as the compression along C is less or greater than the dilatation produced along C by the united compressions of A and B. Hence all crystals belonging to the prismatic system, in which we are informed by cleavage that the particles cohere with unequal forces in three directions, have invariably two, or, as we have already explained, three unequal axes of double refraction, of which the strongest is sometimes positive and sometimes negative.

We have supposed the elementary molecules of bodies to be spherical when existing singly, or beyond the sphere of their mutual action; but although their form must, in the case of doubly refracting crystals, be changed into oblate, prolate or compound spheroids, yet the deviation of these spheroids from the sphere may be so small, that the forms of the bodies which they compose may be regarded as arising from the union of spherical molecules. It is more probable, however, that the form of the molecules suffers a considerable change, and we may consider that change as determining the exact primitive form of the crystal and the inclination of its planes.

The circumstance of almost all rhombohedral crystals having negative double refraction, which can only be produced by axes of compression in the equator of a prolate spheroid, excludes the supposition, that the ultimate molecules are sperical particles converted by the forces which unite them into those oblate and prolate spheroids, by means of which, according to the views of Huygens, all the varieties of rhombohedrons may be formed;* for if this were the case, the obtuse rhombohedrons should possess one positive axis, and the acute ones, one negative axis of double refraction. We are constrained therefore to suppose that in rhombohedral crystals the mole-

* See Huygens's Traité de la Lumière, chap. v. and the Edinburgh Journal of Science, No. xviii, pp. 311, 314.

cules have the form of an oblate spheroid, with its axes so related, that the change superinduced upon it by the forces of aggregation determines the exact form of the combination. In carbonate of lime for example, where the precise inclination of the faces of the rhombohedron can be produced only by oblate spheroids whose polar is to their equatorial axis as 1 to 2.8204, we may suppose that the spheroids were originally more oblate, and that the forces by which they receive the doubly refracting structure dilated them in the direction of the smaller axis, so as to produce a spheroid having its axis as 1 to 2.8204. Hence if we could suppose the molecules placed together without any forces which would alter their form, they would compose a rhombohedron with a greater angle and having no double refraction. But when they are combined by the attractive forces of crystallization, they compose a rhombohedron of 105°, possessing negative double refraction.

In this view of the subject, the form of the ultimate molecules of crystals existing separately, may be regarded as determining within certain limits the primitive form to which they belong; while the doubly refracting structure and the precise form of the crystal are simultaneously produced by the action of the forces of aggregation.

These views receive a remarkable illustration from a new doubly refracting structure, which I discovered many years ago in chabasie, and which will form the subject of a separate communication. In certain specimens of this mineral, the molecules compose a regular central crystal, developing the phenomena of regular double refraction; but in consequence of some change in the state of the solution, the molecules not only begin to form a hemitrope crystal on all the sides of the central nucleus, but each successive stratum has an inferior doubly refracting force till it wholly disappears. Beyond this limit it reappears with an opposite character, and gradually increases till the crystal is complete. In this case the relative intensities of the axes or poles from which the forces of aggregation emanate, have been gradually changed, probably by the introduction of some minute matter, which chemical analysis may be unable to detect. If we suppose these axes to be three, and the foreign particles to be introduced, so as to weaken the force of aggregation of the greater axis, then the doubly refracting force will gradually diminish with the intensity of this axis, till it disappears, when the three axes are reduced to equality. By continuing to diminish the force of the third axis, the doubly refracting force will reappear with an opposite character, exactly as it does in the chabasie under consideration.

From the mutual dependence of the forces of aggregation and double refraction, it is easy to understand the influence which heat produces on the doubly refracting structure, as exhibited in the phenomena discovered by M. Mitscherlich in sulphate of lime and calcareous spar, and in those which I detected in glauberite.* This eminent philosopher has found, by direct experiment, that heat expands a rhomb of calcareous spar in the direction of its axis, and contracts it in directions at right angles to that axis;† that the rhomb thus becomes less obtuse, approaching to the cubical forms which have three equal axes, and that its double refraction diminishes. All these effects are the necessary consequences of the preceding views. The expansion in the direction of the axis, and the contraction of all the equatorial diameters diminish the compression of the axes of the oblate spheroidal molecules, and must therefore diminish its double refraction, as well as the inclination of the faces of the rhomb. In like manner it will be found that in sulphate of lime and glauberite the expansions and contractions will be so related to the three axes, as to explain the conversion of the biaxal into the uniaxal structure, and the subsequent reappearance of the biaxal structure in a plane at right angles to that in which the axes are found at ordinary temperatures.

The phenomena exhibited by fluids under the influence of heat and pressure, and those of doubly refracting crystals, exposed to compressing or dilating forces, are in perfect conformity with the above views; so that even without the fundamental experiment described in this paper, we might have been entitled to conclude that the forces of double refraction are not resident in the molecules themselves, but are the immediate result of those mechanical forces by which these molecules constitute solid bodies.

Allerly, October 5, 1829.

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* See Edinburgh Transactions, Vol. XI.

† It follows from this fact, that massive carbonate of lime, in which the axes of the molecules have every possible direction, should neither expand nor contract by heat, and would therefore form an invariable pendulum. As there must be, in any given length of massive carbonate of lime, as many expanding as there are contracting axes, then, if the contractions and expansions in each individual crystal are equal, they will destroy one another; but if they are proportional to their lengths, the contractions will exceed the dilatations. In this case, we have only to combine the marble with an ordinary expanding substance, to have an invariable pendulum. The balances of chronometers might be thus made of mineral bodies.

Art. VIII.—*Experimental Inquiries respecting Heat and Vapor, with some practical applications; by* Walter R. Johnson, Professor of Mechanics and Natural Philosophy in the Franklin Institute, Philadelphia.

The developement of the law of action between a heated surface and water of different temperatures, has been, in part, presented by preceding courses of experiments.

To persons conversant with this subject it will readily occur, that the facts and principles connected with vaporization are highly important to the arts, independently of their relation to the steam engine. The numerous processes of manufactures, in which liquids are to be reduced by boiling, are often performed in a manner totally at variance with philosophy, as well as with economy. The manufacture of salt by vaporization, for example, is an extensive and increasing branch of our national industry, and is generally carried on with very little attention to the saving of fuel, by any of those devices and arrangements which the practical science of the present age might suggest.

The chief points proposed to be examined at present, are—

1. The *temperature of most rapid vaporization* under atmospheric pressure.

2. The nature of the phenomena exhibited at that point, as well as immediately above and below it.

3. Effects of lubricating the surface of the metal, of covering the surface of the water with a thin fibrous texture, and of thickening it with a farinaceous substance.

4. The influence of mechanical pressure in bringing the liquid in contact with the metal and accelerating the vaporization.

5. The action of hot metal on other liquids, particularly alcohol.

6. Some opinions which have gained currency in regard to the temperature of repulsion, and the degree of rapidity with which heat may be imparted to liquids, will likewise require attention.

1. To ascertain the temperature at which the most rapid action takes place, two methods have been employed. The *first* was by using a basin of wrought iron, having at the bottom a small quantity of mercury, into which the bulb of a thermometer was plunged. Upon the surface of the iron, near the mercury, small measured portions of water were successively deposited, while the basin was pla-

ced over an argand spirit lamp. These portions were not of sufficient amount or frequency to prevent the increase of temperature in the metal, and consequently the times of vaporization were diminished to a certain point, after which they were observed to increase. The temperature had then reached the point where repulsion begins. The temperature at the moment when the point of repulsion appeared to have been attained was noted, and the experiments continued until an unequivocal increase in the time of evaporating the unit of water was observed. The lamp being now withdrawn, the temperature was allowed to descend, and the rapidity of vaporization was of course augmented; still lowering the temperature, the point of greatest action was passed, and the production of steam became slower from want of sufficient heat.

By thus reversing the temperatures, and alternately passing and repassing the point of most vigorous action, the limits of that action were determined to a certain degree of exactness. It soon became evident, that it was far below the boiling point of mercury, and considerably above that of water boiling in open air. It was not difficult to ascertain too, that the range of most rapid action lay between 300° and 350°. In order to vary the mode of experimenting, and, at the same time, to give more exact indications in several particulars, the *second* method, above referred to, was devised. This consisted in employing a bar of iron, about 14 inches long, $1\frac{7}{10}$ wide, and $1\frac{1}{10}$ thick. A number of cylindrical holes, half an inch in diameter, and one inch apart, (from centre to centre,) were bored along one of the sides, extending nearly through the thickness of the bar. Adjacent to each of these holes, which were five in number, were sunk small conical cavities, $\frac{3}{10}$ of an inch deep and $\frac{7}{10}$ of an inch in diameter at top, forming basins or *cups* to receive drops or other small measured portions of liquids. The cylindrical holes were to receive mercury, into which the bulbs of thermometers could be plunged, to ascertain the temperature of the part of the bar and of the cup opposite. The thermometers were supported from above, by hooks bent over the bar and placed in proper positions to allow the bulbs to descend just far enough to be completely immersed in the reservoir of mercury, but not to carry the centre of the bulb below the level of the bottom of the contiguous cup.

By this means the temperature of the mercury was measured, at a point where it must have been the same as that of the generating surface. The five receptacles of mercury were placed near the middle part of the bar, leaving a part four and a half or five inches long at each end, without holes; but the line of cups already mentioned was extended in both directions, nearly to the extremities of the bar. By this means the nature and mode of action could be observed, at points above that of mercurial ebullition.

Heat was applied at one end of the bar, either by means of a spirit lamp, or by thrusting the end into an opening through the side of a furnace. As the temperature rose, the cups near the end next the fire, were, of course, first brought to a vaporizing temperature; then the cup opposite to the nearest mercurial reservoir and the others in succession, with greater or less rapidity according to the tension of the heat at its source. It was generally found most advantageous to employ, for a source of heat, the convenient chemical spirit lamp with argand burner, which has been devised by Dr. J. K. Mitchell. When the temperature was sufficiently raised, drops of water were simultaneously projected into two or more of the cups, and by the inequality in the times of final disappearance, their relative influence was easily perceptible. This mode of operating, by allowing the temperature to be gradually raised admitted of a succession of five series of trials, one for each cup, so that when the time of vaporization, in one, had begun to *increase*, that is, when the time of most rapid action in that cup had been passed, and the action had become slow through excess of heat, it was only necessary to commence with the next cup, more remote from the source of heat. The period of greatest rapidity was now perceived to lie between 304° and 320°. The range of temperature through which the most rapid action existed was hence limited between two points, equally remote from 312°, or from 100° above the boiling point of water.

2. The nature of the effect here observed resembled that of vigorous attraction. This necessarily creates a constant struggle between the vapor which is quitting, and the liquid which is approaching any given point of the metallic surface. On brass, the action appeared more vigorous, and the temperature of repulsion higher than in the case of iron. On mercury, at 500°, a drop of water was, on one occasion, found to remain seventy seconds; but at 340° a drop of this metal formed a good nucleus, about which the water when repelled by a surface of iron, at the same temperature, would gather, and thence obtain heat to vaporize itself, while portions not in contact with the mercury would lie upon the iron almost quiescent.

At temperatures considerably below that of most rapid vaporization, there was constantly exhibited, in the various series of experiments, a decided tendency in the water to adhere to the metallic surface, and when by contact with a given portion of surface, and by receiving and rendering latent in vapor, the heat which the latter had possessed, the temperature of that portion was somewhat reduced, the stratum of water was observed to glide away to other, hotter parts of the surface, even against the force of gravity.

This effect was observable in the cylinders with which the *second course* on *variable rapidity*, was performed. Towards the conclusion of each series, the water, after ceasing to boil in the bottom of the cylindrical cavity, ascended in many instances quite to the top of the cylinder, and even spread outward on all sides wherever it met with a higher temperature than 212°.

The same phenomenon was noticed in the basin already described, and in the bar above mentioned. To make this effect the more distinct, a broad shallow pan of extremely thin iron, commonly called by the tin plate workers, "black tin," was procured. In the centre of this, a slight elevation, about one tenth of an inch high, was made, with a corresponding cavity on the under side, or bottom of the pan.

A lamp being applied beneath the elevated part, the iron soon obtained a dull red heat in the dark. Water was then laid upon the basin so as to surround completely the centre, and form a sort of island of heated surface. As the heat extended by degrees, and reached the line of water, the latter was observed to start upwards from its line, and moisten a portion of the surface not before wetted.

By agitating the water with a hair pencil, and creating a wave towards the centre, the *line of vaporization* became distinct. By raising the waves still higher, that of repulsion was manifest, and by causing a surge high enough to break quite over the insulated elevation, the alternate attractions and repulsions were seen in the drops and masses which, having been driven forcibly beyond the first line of vaporization, or that which they encountered on their ascent, were subsequently rolled quite over the centre of the elevated embossment, but arrested with great promptitude as they rolled down and reached the line of vaporization on the opposite side.

3. In order to ascertain the influence of certain lubrications in reducing the rapidity, I placed the bar over a spirit lamp in such a manner as to bring two of the mercurial reservoirs, and their adjacent cups at equal distances from the centre of flame. Having allowed

the temperature to reach 300°, I applied equal portions of water to each cup, and found their actions precisely alike. I then placed and spread, as lightly as possible, a minute portion of olive oil, forming a thin film over the surface of one of the cups, allowing the other to remain clean. On renewing the applications of water, it was found that the oiled took four times as long as the clean surface to vaporize a certain quantity of water. On elevating the temperature, the oil itself was gradually evaporated, and the water found occasional admittance to the surface. Hence the difference was gradually diminished, and the wonted action of the iron restored, but the addition of fresh portions of oil, again reduced temporarily the vaporization on the surface to which it was applied. But as the temperature was more elevated than before, the oil likewise became sooner dissipated.

By exposing the bar in a similar manner, and ascertaining that two contiguous cups, equally remote from the centre of flame, were, when both clean, precisely alike in regard to the rapidity of evaporation at a high temperature, I lubricated one with plumbago, laid on by rubbing a piece of that substance over the interior, without however leaving any dust or small bits of the mineral to serve as *nuclei* for the water to seize upon. The other cup was left clean as before. Equal portions of water at 60° were now laid simultaneously upon the bottom of the two cups. The mean result, of six experiments in each, was that the cup with plumbago required eighty four seconds to evaporate its liquid, while the cup without plumbago took but forty one for that purpose. The portions of liquid used were single drops for the respective experiments.

To ascertain the effect of thickening the water into a thin paste, I put a large tea-spoon full of flour into an ounce of water, and laid one-fourth of an ounce of the mixture on the bottom of the iron basin, kept red hot over the fire. The evaporation took place, and the paste became dry in seventy-eight seconds. Under precisely the same circumstances, clear water, of the same temperature as that mixed with the flour, required one hundred and thirty-eight seconds to evaporate one-fourth of an ounce.

The action on clear water was rendered much more rapid, however, by covering the surface with a circle of white paper laid on immediately after the water was put into the basin. The evaporation then took place in seventy-two seconds. In another experiment, in which the circle of paper was smaller than that of water, the time was increased to ninety seconds. In both of these cases, the acceleration appeared to proceed, in part, from the obstruction which the paper opposed to the rotation of the circle of water. When a very small circle of paper, or any other light body, was placed upon the surface, it soon acquired the motion of the fluid, and the exceeding velocity of the latter became manifest to the eye. The rotary motion is not however the uniform result of such experiments.

There will often be seen a scalloped figure with a greater or less number of re-entering curves, destroyed and reproduced with astonishing rapidity and regularity. A slight humming noise was also occasionally perceived, as the liquid was alternately raised and depressed by this species of movement. Gravity was here put in equilibrium with the repulsive force of caloric, and as the equilibrium must from the nature of the fluid be *unstable*, there was a constant effort of those parts of the fluid which happened for a time to be less resisted than others by the heat, to obey gravity and come nearer the surface; but as they descended they came to be, in turn, more vigorously resisted, and sent up again with energy, even beyond the distance of equilibrium. A new descent was the consequence, and the alternation once established, was easily maintained by the momentum of the fluid and the perfect elasticity of the spring on which it constantly impinged. This phenomenon is similar in character, and probably admits a similar explanation to that of an experiment of Mr. Faraday, in which a segment of a cylinder of metal has a narrow groove cut longitudinally along the convex side, forming two *straight edges* one or two tenths of an inch asunder. If this segment, heated to four or five hundred degrees, is laid on another polished metallic plane surface, so as to rest upon the two edges, it will soon acquire a rapid oscillatory motion, bringing the two edges alternately in contact with the plane below. This oscillation may be sufficiently rapid to cause a ringing or humming noise. In this case the radiation is from the oscillating body *downwards*, while in that of a fluid undergoing evaporation, it is from the fixed plane to the oscillating body or liquid *upwards*.

The temperature of the liquid while resting over the red hot surface of iron, was found to be 210°.

4. The resistance to actual contact, which is furnished by heat in both the cases just mentioned, is exemplified in many processes of art. The attempt to perforate a bar of hot iron with a cold steel *bit*, will present a sensible illustration of this point. The resistance may however, by mechanical pressure, be overcome to such an extent as to

bring the solid in one case, and the liquid in the other, into such contiguity, as to restore in some degree the adhesion of the liquid or the abrading power of the steel. The pressure may be applied directly to the liquid when placed upon a metallic plate, by means of another smooth metallic surface pressed immediately upon the drop of liquid. Smart vigorous explosions may be thus produced, similar to the well known cracking under a smith's hammer which has been dipped in water and then applied to a hot bar of iron, or to the overheated face of an anvil.

The pressure of an elastic gas or vapor may, in like manner, be employed to urge the liquid into contact with the metal; and, it is evident, must become at every instant the more effectual, both as the pressure is increased by the accumulating mass of steam, and as the temperature is diminished towards the point of most rapid action. It will be understood that the calculation formerly made respecting the power which an overheated boiler of given dimensions could produce, was intended only to exhibit the *amount of atmospheric steam.*

5. It becomes interesting to inquire whether any other liquid than water is affected, in a similar manner, by the overheated metallic surface. The trial soon convinced me that in regard to alcohol, at least, the same general phenomena take place. It may at first appear singular, that a given portion of this liquid, (the boiling point of which is at 174° Fahr.) should require for its evaporation a longer time when laid upon a plate of iron at 400° or 500° than when poured into the hand of the experimenter, the temperature of which is not above 98°. Such however appears to be the fact. When one sixteenth of an ounce of alcohol was laid upon the centre of an iron basin, heated to at least 500°, the time of its final disappearance was one hundred and forty five seconds; while an equal quantity of the same spirit required but ninety seconds to evaporate it from the palm of the hand. It is true, that in the latter case, the extent of surface occupied by the spirit was unavoidably greater than that on the iron. The liquid was diffused by capillary attraction, or perhaps by its attraction for heat, over the whole surface of the palm, notwithstanding the efforts to confine it to a single spot. At a temperature when the iron became barely red in the dark, the time of disappearance was from one hundred and ten to one hundred and twenty seconds.

The next thing was to determine the time requisite to vaporize one sixteenth of an ounce of alcohol, *when the metal was at a temperature* *to give a maximum energy of action* between it and the spirit. By several trials for this purpose, it was found to be three and a half seconds. The *greatest length of time* during which the same quantity had been found to remain was one hundred and fifty seconds. Whence it appears, that the relation between the two is $\frac{3.5}{150}=\frac{7}{300}$, or $\frac{1}{43}$ nearly. The only remaining question was the actual temperature at which the spirit disappeared in the least time. For this purpose, recourse was had to the bar with mercurial reservoirs and cups, already described. On raising the temperature to 312°, where water had been observed to be most rapidly vaporized, it was manifest that the alcohol was clearly and strongly repelled.

The temperature was then lowered to 280°, when occasional signs of adhesion were manifested, and a corresponding diminution in the time of evaporating a given quantity of liquid was the result.

By lowering the temperature of the iron to 260°, the time was again perceived to increase on account of a *deficiency* of heat. By thus passing and repassing several times between 260° and 280°, the limits of range became circumscribed between 270° and 278°, and finally the point of most vigorous action seemed to rest at 274°, the arithmetical mean of the above mentioned limits. This, it will be recollected, is 100° above the boiling point of alcohol. It will be observed also, that this is exactly as much above its boiling point, as the temperature of most activity on water is above the boiling point of that liquid.

6. An allusion has already been made to the opinion of some writers, that the repulsion of a liquid from metal begins at the temperature of incandescence, and increases as the temperature rises. The facts already detailed in this paper, will serve to show that the former opinion is wholly without foundation. Indeed, when we reflect for a moment on the nature and cause of that diminution of the liquid which takes place after *vaporization has ceased through an excess of temperature*, we must perceive that as the effect is an *evaporation*, due to the radiation of heat, the rapidity with which the latter will disperse a given quantity of water must be proportionate to the *tension* of the heat at the radiating source; that is, the surface of the metal. Evaporation must commence where vaporization ceases, and the former must be slow when the tension is barely sufficient to elevate the liquid out of the sphere of contact, or of contiguous attraction. This cannot however prevent an increase of rapidity, when the tension at the source is sufficiently elevated to allow the radiated heat to communicate temperature to a *transparent medium*.

To place the matter beyond a doubt, the iron basin already mentioned was used. When exposed to the white heat of a forge fire, a given weight (one eighth of an ounce) of water was evaporated in sixty seconds. At the bright red heat of an anthracite stove, eighty seconds were required to produce the same effect. When exposed on an open grate of anthracite, in such a manner as to maintain the centre only of the basin at a very faint red heat in the dark, the time was extended to three hundred and fifteen seconds.

Another comparison, made upon portions of water of one sixteenth of an ounce each, gave the following results. On the metal, at the bright red heat of the stove, the water lay sixty six seconds; on the centre of the basin dull red, as before, in the dark, it continued one hundred and eighty three seconds; while over a spirit lamp, the metal being constantly black and the temperature probably not above 600°, it remained two hundred and eighty six seconds.

In all the above experiments, the heat was constantly supplied, and the temperature may be regarded as having been uniform during each trial. Hence, the opinion that repulsion increases with the temperature, appears not to be sustained. When the temperature has decidedly surpassed the point where contiguous attraction can take place, every elevation of temperature is attended with a corresponding diminution of time required for evaporation.

In order to illustrate more fully this branch of the subject, a series of experiments was made with the iron basin, placed over a coal fire and supplied with doses of one sixteenth of an ounce of alcohol, sp. gr. .854, (32.5° Baumé.) The first experiment was made at a temperature about 400° to 500°.

The following was the succession.

Exp. 1	142″	Exp. 3	140″
2	145	4	117

The temperature of the metal continued to rise notwithstanding the application of the successive portions of spirit, and as the time for each experiment was obviously decreasing through an *excess of temperature,* the basin was removed from the fire and allowed to stand for some time, until it was cooled below the point of *minimum activity.* It was then again placed upon the fire, and when the fifth portion of liquid was placed upon it, exhibited symptoms of a slight tendency to attract the latter. The sixth experiment was made after sufficient time had elapsed again to permit a rise of temperature.

Exp.	5	87″	Rapidity increased by deficiency of temperature to maintain the repulsion uninterrupted.
	6	150	Iron kept some time on the fire without liquid before this experiment.
	7	143	
	8	134	
	9	123	
	10	120	—Very faintly luminous in the dark.
	11	115	Redness gradually increased.
	13	113	
	14	100	
	15	95	
	16	82	

The surface of the basin about the spirits exhibited when the room was darkened, a very distinct luminousness, like a faint lambent flame, owing, probably, to the vapor being heated nearly to redness at the moment of production. A similar appearance had been observed in the vapor of water, produced from metal at a white heat.

Having now removed the basin from the fire, the experiments were continued, and the time was observed to increase from eighty two seconds to one hundred and five, and then to one hundred and thirty five, after which it began to diminish, as the establishment of cohesion between the liquid and the metal became more decided, thus

Exp.	17	105″	Exp. 20	17″
	18	135	21	10
	19	90		

The above series of experiments is in accordance with several of those made upon water, where the initial temperature of the iron was very great and the mass sufficient to supply heat of a high tension, to the evaporating surface, for a considerable length of time after being removed from the fire. This was the case in the *first*, *second*, *fifth* and *eighth* series in the *second course* on the rate of decrease.* In those cases, the times exhibited either a succession of numbers nearly equal, or an actual increase during the first five or six experiments of each series. This is particularly remarkable in the eighth series, of which a projection has been given. The order of magnitudes, for the first six experiments, beginning with the highest, was followed in that projection, merely for the purpose of exhibiting the

* See page 76 of this volume.

extremes of retardation, both by excess and by deficiency of temperature, in the production of vapor. The reader will perceive however that the actual order of occurrence of these six experiments which began at a *white heat* and lasted, including intervals, 218.7 seconds, was 27.5, 28, 34, 39, 30, 33. It needs hardly be stated, that the idea of *instantaneous* action between iron and water, derives no confirmation from any of the foregoing series of experiments.

Art. IX.—*To describe an Hyperbola; by* Rowland G. Hazard.

Extract of a letter from Mr. Hazard, dated Hopkinton Springs, Feb. 22, 1831.

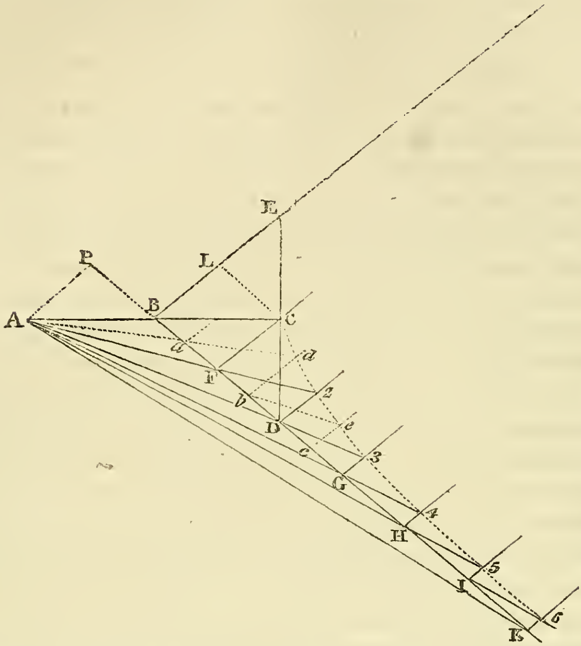
TO PROFESSOR SILLIMAN.

Dear Sir—Annexed is a mode of describing the hyperbola, which I think more simple and easy than the one usually given, besides having the advantage of showing very clearly the continual approximation of the curve to its asymptote, without the possibility of meeting it. I shall be gratified, if you think it worthy of a place in your Journal. The manner in which it first occurred to me, may not be uninteresting to you. About fourteen years since,* when at school, sitting near one corner of a long room, in one side of which were three windows inserted in a thick brick wall, it occurred to me that I could see a less distance into the recess of the second than of the first, and still less into the third, and that a line drawn through the extreme points of vision and continued in a similar manner, would form a curve which would always approach, but could never meet, the inner superficies of the wall. I at first used a figure drawn in exact accordance with this first suggestion, to convince some of my incredulous companions of the possibility of drawing a curve possessing that property, but afterwards reduced the intermediate spaces to right lines, and finding that I thus obtained a pretty and regular curve, commenced investigating its properties, and found, under certain circumstances, the coincidence with the hyperbola which is shown in the demonstration.

Make AC equal to the transverse axis, and DE, at right angles to it and bisected by the point C, equal to the conjugate. Bisect AC by the point B; draw the asymptotes BE, BD produced indefinitely. Through the point C draw CF, parallel to BE, and with the distance BF find the equidistant points D, G, H, &c. from which draw lines parallel to BE. Draw AF and produce it to meet the next parallel

* Other occupations frustrated the purpose, which I then entertained, of pursuing the subject.

in the point 2, and proceed in a similar manner to find the points 3, 4, 5, 6, &c. which will be points in the hyperbola.



To find intermediate points, in BF assume any point *a*, and with the distance BF find another series of equidistant points *b*, *c*, &c. and proceed as at first to find the corresponding points *d*, *e*, &c. in the hyperbola. By assuming other points in BF as many points may be found in the curve as are required.

Demonstration.

Let it be required to prove that the point 4 is in the hyperbola.

Produce DB and draw AP parallel to BE; then by similar triangles

PG : PA : : GH : H4, or by substituting equals

BH : CF : : BF : H4; hence, (Euc. prop. 16, b. 6,) the parallelogram BH4 completed would be equal to the parallelogram BFCL, which is the property of the hyperbola. In the same manner, it may be demonstrated that any other of either series of points is in the curve. In this construction, the continual approximation of the curve to its asymptote, without the possibility of ever arriving at it, is very obvious; the distance of any point of the asymptote from the curve, measured on the parallel from that point, being always equal to BF^2, divided by the distance of the point from the centre of the hyperbola. In the first series, if BF or FC be the unit, the distance of the points in succession will be $1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}$, &c.

Art. X.—*Supposed Agency of Galvanism in transferring Colors through animal substances;* in a letter from Dr. Alexander Jones, of Athens, (Geo.) to *Geo. W. Carpenter*, of Philadelphia.

(Communicated for this Journal by G. W. C.)

Having seen it stated in a late number of the American Journal of Medical Sciences, that, if a fluid colored blue, was inclosed within a bladder, and then immersed in another fluid colored red, that on standing for some hours, it was found that a portion of its coloring matter had found its way through the coats of the bladder, and had mixed with the red fluid, while a portion of the red fluid had passed from without into the bladder and mixed with the blue fluid, thus demonstrating that two currrents had been formed through the bladder. Reflecting on the cause of this double transposition of the coloring fluid, I was led to believe, if the experiment was true, that it depended probably on galvanic agency : that one colored fluid was positive, while the other was negative ; and that a change of position took place, the process of which might be called *electrical percolation.* The experiment appeared so interesting to me, that I determined to repeat it in various ways. For this purpose I formed a voltaic pile of about forty pairs : between the wires of the negative and positive pole I placed three wine glasses. Two of the glasses in which the positive and negative ends of the wires were made to terminate, were nearly filled with clear water. The middle glass was filled with an infusion of cochineal. I also inclosed a small quantity of an infusion of litmus in a piece of beef's bladder, which was securely tied and immersed in the middle glass, containing the infusion of cochineal. I connected the glasses by means of small pieces of brass wires. In a short time I found that a portion of the enclosed infusion of litmus had found its way through the coats of the bladder, and commingled with the infusion of cochineal on the sides of the bladder next the negative pole. I removed the pieces of wires, and connected the glasses with moistened strips of beef's bladder. In two or three hours I found a portion of the litmus coloring matter had passed through the connecting slip of bladder, and collected in the negative wine glass of clear water, so far as to communicate to it a sky blue tinge. The clear glass of water at the positive pole, remained unchanged in color : on adding a small quantity of sulphuric acid to the negative glass, it was changed to a pale red, proving the presence of the litmus color. On opening the piece of bladder enclosing the infusion of litmus, I found it had assumed a reddish or purple hue, in consequence of some of the cochineal infusion having found its way through the coats of the bladder, and mixed with the litmus. The same experiment succeeded more slowly without the aid of the galvanic circle ; but it was greatly expedited with it, showing I think that the exertion of the agency of galvanism was the cause of all the phenomena of the experiment.

To satisfy myself more fully, I filled two glasses with the infusion of litmus ; in one I placed a bladder having a small quantity of very dilute sulphuric acid, securely inclosed within it. In the other I placed a bladder containing a weak solution of potassa. I filled a third glass with an infusion of cochineal, and placed in it an infusion of litmus. In less than twenty-four hours, I found changes had ensued in every glass. In the first the litmus had become red, while the acid within had assumed a similar color. In the second glass the litmus was green, while the infusion of potassa presented the same color within the bladder. In the third glass the infusion of cochineal became more or less purple from the admixture of the litmus, while the infusion of litmus within the bladder had also assimilated its color to that of the fluid without. In each glass there had evidently been established two currents, one passing from without to the fluids within the bladders, and the others from the enclosed fluids to the infusion without, and continuing to do so probably, till there was a complete assimilation of color both without and within the bladder.

May not some process of this sort take place in the human body ? May not pure water, and the water of melons, reach the kidneys, by a similar electrical percolation ? It appears as probable to me that this operation may ensue in the animal system, as that water of melons when carried to the stomach, is discharged from the bladder in twenty or thirty minutes after being swallowed, although conveyed to it by the very circuitous route of the circulation. Would it not require a longer time for the water to reach the bladder in this case, provided it had first to pass into the duodenum, from thence to the small intestines, there to be converted into chyle, and by the lacteals conveyed to the *thoracic duct*, and thence conveyed to the subclavean vein, and there enter the right auricle by the descending vena cava, and from thence to the right ventricle, and from thence to the lungs, and from them by the pulmonary arteries to the left auricle, and from that to the left ventricle, and from there by the aorta to the venal arteries, and thence to the kidneys, and after being secreted, to be conveyed to the bladder by the uterus ? Can so complicated and circuitous a process take place within twenty or thirty minutes ? It has always appeared to me as highly probable that there was some shorter way for fluids to reach the bladder, than by the round about road of the circulation.

Coffee, spirits of turpentine, balsam copaiva, madder, and various other substances, are detected, by their smell or color, in the urine, sometimes, within a few minutes after they are swallowed. Can they appear so soon in the urine, by their passage through the long channel of the circulation? The same substances often appear in the perspiration and other secretions—may they not reach their destination, in these cases also, by electrical percolation? may not sudden salivation be explained on the same principle?

A difference of opinion has prevailed among chemists, as to the mode by which nitrogen and oxygen unite to form the air. Some maintain that they unite chemically, while most others regard their union as only mechanical. As there are objections to both these theories, as well as to all others, may not their union also take place on the principle of electrical percolation?*

From analogies and reasoning on the subject, I am induced to believe, that the skin of our system performs the office of our lungs, by decomposing the surrounding atmosphere. The oxygen, being a negative body, must be attracted by the human body, which must always be in a positive state. It is known that bodies which have the smallest attraction for oxygen, readily disengage it, from its weak union with nitrogen. Why may not the human frame have this effect, as well as metal, or any other more positive substance than nitrogen? If this be true, it accounts for the continuation of life in pulmonary patients, who sometimes, before death, suffer an entire loss of one lung and a partial decay of the other. In such an instance, may not oxygen be supplied to the blood, through the medium of the skin? I am, moreover, led to believe, that the skin also decomposes water, when applied to it for any length of time. In this case, the skin takes up the oxygen, while the hydrogen is set at liberty, being a positive body and therefore repelled by the body which is positive. I think I have smelt impure hydrogen, exhaling from my body after being made thoroughly wet in a shower.

I merely throw out these suggestions as hints, intending when I get leisure and a fair opportunity to improve upon them by experiments.

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* See Mr. Dalton's theory, explained in Turner's Chemistry, art. Atmospheric Air.

Art. XI.—*An account of the Sapphire and other minerals in Newton township, Sussex County, New Jersey;* by Samuel Fowler, M. D.

The valley including Sparta, Franklin, Warwick and Newton, for its mineral treasures, useful as well as curious, has very justly been compared to Arendal, in Norway; both regions abound with magnetic ore of iron, connected also with the same rock formations, but neither of them is truly primitive, though including beds of gneiss and granitic sienite. All the peculiarly curious minerals of this region are uniformly connected with subordinate beds of white crystalline limestone, and they occur chiefly near the line of junction which this rock forms with the granitic sienite. In this situation occur the spinelles, ceylonites, garnets, &c. as well as the beds of curious zinc, and manganesian ores; and most of them are entirely peculiar to this part of the world. This valley continues uninterruptedly from Byram, in the county of Sussex and state of New Jersey, which is the south western extremity of the white carbonate of lime, to mounts Adam and Eve, in the township of Warwick, in the county of Orange and state of New York, which is the north eastern extremity of the white limestone, a distance of twenty five miles. In this whole distance we observe the white carbonate of lime running in a north easterly and south westerly direction. The Franklinite and red zinc ore accompany the same, beginning half a mile north-east of Franklin Furnace, and ending two miles south-west of Sparta, a distance of nine miles. It is in different parts of the township of Warwick that so many curious and splendid things have occurred; and it is here the calcareous valley is the widest. Several years ago, sapphire as well as spinelle was discovered at Franklin, but apparently only in a single block of stone probably detached from its original bed, so that the spot was no sooner discovered than exhausted, and all subsequent attempts to trace out more of this interesting mineral have proved in vain. It was blue and white or particolored, and imbedded in a rock of compact scapolite and feldspar, in connection with black spinelle and black tourmaline.

About four years since, in company with my neighbor, Mr. Inglis, in the township of Newton, six miles from Franklin and one mile west of the calcareous bed of Byram, we discovered sapphire imbedded in a whitish feldspar, near the junction of the granitic sienite and white limestone. This bed of white limestone is quite detached and independent of the large bed heretofore described, and a high ridge intervenes between this and that bed.

The sapphire is blue and white, the central color of a bright berlin blue, becoming pale till towards the edge of the mass the color is nearly white. In the feldspar, crystals of the red oxide of titanium commonly occur, of a bright steel gray with a tinge of red, a metallic lustre and translucent at the edges. Smaller masses of sapphire, sometimes in regular hexahedral prisms, are commonly imbedded in a massive rock of slightly yellowish gray hornblende, bearing some resemblance to anthophyllite. Wherever the sapphire occurs, there is a coating or bedding of carbonate of lime, the cellular surfaces of these masses of rock likewise present nests of spinelles of the same curious gray tint crystallized in perfect octahedrons, some of them measuring an inch on each surface of the plane, also occasionally associated with hexahedral copper colored mica; and now and then masses of large crystals of brown and yellowish brown idocrase, fragments of these crystals have occurred from three to four inches in diameter, and prisms a span in length. Steatite is here a common ingredient, and has presented the pseudomorphous form of quartz, scapolite and spinelle.

The octahedron or steatitive imitation of this last substance is of a pale straw white, and of rather rare occurrence. They project from cavities, and are not imbedded like those we formerly termed pseudolite, and which we found at Warwick. In the weathered cavities of the rocks the sapphire often presents a conchoidal appearance arising from the branching and connection of clusters of imperfect prisms, sometimes having two or three sides of the regular prism visible. These masses are not unfrequently imitated by the protean steatite which seems to mould itself to every form. I term this mineral sapphire rather than corundum, from its beautiful and full color, though it is merely translucent and not transparent, but in this respect it also varies considerably; very seldom it is white or nearly colorless as well as gray and occasionally also of a blue, as dark as indigo and the more so when imbedded in the feldspar, some masses have been found in this substance of the weight of two and a half pounds. Contiguous to the same rock, though not so distinctly connected with it, occur also masses of scapolite in four-sided prisms as large as a man's wrist, and straw colored Brucite, all of which as usual are concomitant with the other minerals, and imbedded in the carbonate of lime.

Art. XII. *A sketch of the Mineralogy and Geology of the Counties of Orange (N. Y.), and Sussex (N. J.); by* Charles U. Shepard, Lecturer on Botany in Yale College.

The adjoining counties of Orange and Sussex constitute a mineralogical district, second in interest to no other in the United States. The variety and rarity of its productions began to attract attention as early as 1820; since which period, it has received frequent visits from mineralogists from abroad, and has been examined with a high degree of zeal and success by its own inhabitants: the result of which investigations is, that, in a mineralogical point of view, no region of the same extent, in our country, is at present better understood. The individuals who deserve to be mentioned as having taken the lead in these researches, are Mr. Nuttall of Cambridge, Dr. Torrey and Baron Lederer of New York, Dr. Fowler of Franklin, N. J., Dr. Young, of Edenville, Dr. Horton, of Goshen, and Dr. Heron, of Warwick, N. Y. The principal information hitherto presented to the public concerning this district, is contained in a description of the mineralogy of Franklin and Sparta, by Mr. Nuttall, in this Journal, (Vol. V, p. 239.) a list of the minerals of Warwick, by the same gentleman, in the appendix to Robinson's catalogue of American minerals, (p. 296,) and some notices by Dr. Torrey in the Annals of the New York Lyceum of Natural History, (Vol. III, p. 8.)

A geological and mineralogical map of the district above alluded to, having been forwarded to Prof. Silliman, by Drs. Young and Heron, for publication in the American Journal, accompanied with a request that I would undertake to give a more detailed account of the mineralogy of the region than has hitherto been published, is the occasion of the present sketch. My visit to these counties, which was made last year, was unfortunately of too short duration to allow of the personal inspection of each locality of which I shall speak; but the statements concerning such deposits as I was prevented from seeing, are founded upon specimens and information furnished me since, by Dr. Young, to whose correspondence I am much indebted in the preparation of these notices.

I shall commence with that part of the country which first fell under my observation. Leaving the village of Goshen, which is situated upon the same Argillite that had characterized the whole country, as seen in my ride from Newburgh to that place, my road lay over an undulatory country, under a high state of cultivation, until I entered the *Drowned Lands.* The country thus denominated is a morass of unusual extent for the Northern States, and celebrated for the yearly inundation to which it is subject, and the malaria to which it gives rise during the latter part of summer. Its length is twenty miles, and its breadth, in different places, varies from one mile to five. Through it, flows the Walkill with a scarcely perceptible current; to whose waters, when swollen by the spring freshets, it owes its annual inundations. It consists of an immense accumulation of vegetable matter, whose surface is imperfectly converted into a soil, abounding with carbonaceous matter, empyreumatic oil, and gallic acid, and covered, in midsummer, with a rank and luxuriant vegetation. Wherever it has been ditched to any considerable depth, as has been the fact in several places in the construction of the roads that cross it, peat of an excellent quality has been brought to light. Several islands rise at various intervals above its surface, the largest of which is two hundred acres or more in extent, consisting of excellent land, which is improved for agricultural purposes; the smaller islands are uninhabited and, for the most part, covered with wood, among which I observed the beautiful flowering shrub, *Rhododendron maximum* growing in the greatest abundance. The rocks in view upon these islands, as well as those observed about the borders of this extensive morass, reveal the formation on which it reposes to be, the Blue, cherty Limestone. The small island near Woodville (see map) is the only exception to this remark, which consists of primitive Limestone, the rock of the adjoining country.

In an economical point of view, it is doubtful whether the Drowned Lands have received the degree of attention which they merit. At present, with the exception of here and there a strip bordering upon the high land, they are abandoned as mere pasturing ground to cattle, which, on the subsidence of the spring inundation, range over its wide surface for a few weeks only, leaving it for the rest of the year a desolate waste. The canal of three miles in length, now cutting at immense expense, with a view, primarily, to avoid a bar of rocks in the Walkill, it is confidently believed will redeem a large portion of these lands from inundation,—a result to be desired, no less on account of its bearing upon the health of the vicinity, than upon the agricultural resources of the country. Nature herself offers an inducement of no small consideration to the completion of this enterprize, in the facility with which she will enable the agriculturalist to command the material requisite in subduing these lands to useful purposes; for limestone of the best quality is every where at hand in that vicinity, as well as wood and Peat for converting it into quick lime.

The road by which I crossed the Drowned Lands lay across Big Island, from which it takes a southerly direction over a small stream, called Quaker Creek, and enters Edenville just at the northern base of Mount Eve, a fine elevation four hundred feet in height, of a conical form, and visible for ten or fifteen miles up and down the valley in which it is situated. Here the mineralogical district may be said to commence; but before entering upon the enumeration of localities, I shall allude for a moment to the geological features of the country.

The general character of the country is primitive; consisting of lengthened swells of high land with broad valleys, whose direction is from north-east to south-west. A correct idea of it may be obtained from a cross section, as delineated on the accompanying map of Messrs. Young & Heron. The section coincides with the New York and New Jersey states' line. The Argillite is far removed in its character from Mica Slate, or even that of the glazed Roofing Slate, nor has it any intermixture of Anthracite, like the same rock in many places in New England; but, it is every where dull, soft, and extremely liable to decomposition. The White Limestone is highly crystalline throughout, and although its association with the Blue Limestone, might tend to confound it with more recent rocks, yet its imbedded minerals, hereafter to be mentioned, clearly demonstrate its primitive character. The Blue Limestone abounds with Hornstone, and in some places with distinct fossils. At one spot, No. 8 on the map, it has exhibited the oolitic character which belongs to the same formation in the vicinity of Saratoga. The juncture of the White Limestone with the Argillite has no where been observed, as the Blue Limestone, or soil every where intervenes between these two rocks at the surface. That it is a contemporaneous formation however, with the gneissoid Sienite and the Argillite, scarcely admits of any more doubt than that the Blue Limestone of Warwick belongs to the same period with that in the corresponding valley of Edenville. The inclination and direction of the strata of these different rocks, I have not been able to determine with that degree of precision I could wish. The general direction of the primitive strata is coincident with the elongation of the chains of mountains, or swells, to which they severally belong, and the dip is uniformly to the west, varying from 40° and sometimes under, to a position nearly vertical. The Blue Limestone is nearly horizontal, though occasionally thrown up at a pretty high angle, as in one or two spots south of the village of Edenville. The superficial extent of these formations within the district under consideration, may be viewed from a glance at the geological map. Suffice it to say of the White Limestone, (the only rock which here interests the mineralogist) that it commences at Mount Eve, and extends in an uninterrupted line twenty-five miles south-east to Byram, with a width varying from two and a half miles to that of a few rods. Its greatest breadth is at the states' line. Its elevation, except at its northern extremity, upon Mts. Adam and Eve, is low, often falling below the adjoining Limestone of a more recent date. It crops out only here and there in large masses, and its continuity is often to be made out solely by scattered bowlders and loose stones of a smaller size, scattered over the surface of the ground. Although Byram is spoken of generally, as the southern limit of the formation, yet it is highly probable it extends, with occasional breaks perhaps, to Easton upon the Delaware.

The first mineral deposit, of which I have to speak, is situated upon the southern base of Mount Eve, on the land of Isaac Allison. It is marked No. 12 on the map. Like another locality to which I shall have occasion to allude in this paper, and indeed many others in our country, it owes its discovery to the want of mineralogical information. An ignorant foreigner, calling himself an old countryman, (a declaration which has until lately been too sure a passport to confidence among our people in all matters relating to metallurgy,) persuaded some persons in the neighborhood to commence mining operations here, under the idea of obtaining gold and silver. The only metallic substance afforded by the place was Iron Pyrites. A pit was accordingly sunk to a very considerable depth, and a reduction forge erected. How long their operations were persevered in, I am unable to say, but the degree of success it is easy to imagine. The result was, that immense heaps of Limestone, abounding with crystallized minerals, were thrown out; and though they have been considerably culled, they still continue to reward the mineralogist with many substances worthy of his attention. The principal of these in interest is a distinctly *crystallized Hornblende*, disseminated through an aggregate of Limestone and Scapolite. The crystals vary in dimensions from one line to half an inch in diameter, are terminated at both extremities by dihedral summits, reposing on the lateral solid angles, and very often modified by the truncation of the lateral edges. They are short, in proportion to their length; and possess unusually brilliant cleavages, which take place, not only parallel with the lateral, but with the terminal planes. Their colors are a leek-green, grass-green and hair-brown. Next to the Hornblende, the crystals of *Zircon* are worthy of mention. These are contained in the same aggregate as the Hornblende, though for the most part imbedded in the Scapolite. They are very small, but eminently perfect, and possessed of the highest finish, as respects their lustre. The form is that of four-sided prisms, surmounted by four-sided pyramids, having the edges between the pyramid and prism truncated. Their color is a chocolate-brown. The *Scapolite* is always massive, and usually without discernible cleavages. The other minerals which occur at this spot, are *Augite*, *Brucite*, *Spinel* and *purple Fluor;* but these last in specimens, for the most part, undeserving of regard.

The next locality south of the one just described, is upon land owned by H. W. Raynor, and situated three quarters of a mile north of the village of Edenville. It is marked No. 9 on the map. This spot affords a handsome hair-brown *Hornblende*, in highly perfect crystals of the form above described, though occasionally with terminations more complicated, among which may be found the modification denominated *Amphibole acceléré* of Haüy. The prisms are sometimes very short, insomuch that the terminal faces come into contact. The crystals are disseminated through an aggregate of White Limestone and brown Mica, and vary in size from very small to an inch in diameter. Dr. Young possesses a crystal from this place, four inches long by three in breadth. So peculiar is this Hornblende in its color, that it has obtained in collections, the distinctive name of *Edenite*, from its locality. In some specimens, it is nearly white and semi-transparent.

No. 10 upon the map is upon the land of H. W. Houston. The most interesting substances it affords are *Brucite* and *Rutile*. The Brucite is thickly disseminated through Limestone bowlders, in grains of large dimensions and very handsome colors, as orange-yellow and garnet-red; the same masses frequently embracing crystallized, greenish Hornblende, which has been designated *Pargasite*. Associated with the Brucite, in the same aggregate, is found a well crystallized, *reddish brown Mica.* This vicinity also affords the Edenite in loose blocks, with which, Dr. Young has found large and brilliant crystals of Rutile, possessed of numerous geniculations.

Distant about forty rods from the last mentioned spot, upon the land of B. Hopkins, is found the locality marked No. 11 upon the map. It consists of a vein of Arsenical Iron, situated in the White Limestone, but which here abounds with grey, massive Hornblende and Augite. The vein has been explored to the depth of eight or ten feet. The only mineral worthy of attention here is the *Arseniate of Iron*, or *Cube Ore*, which occurs upon one side of the vein. This interesting substance forms druses of considerable size, which, when examined with the microscope, present extremely minute facets, whose form cannot be detected with certainty in any specimens I have seen. Its color is a dark green, with a tinge of yellow and blue. It has formerly been regarded as Arseniate of Copper. In connection with this vein, is found the Flos ferri variety of *Arragonite*, in seams of moderate extent. The branches or stalactites are short, but possessed of a pure white color, and sometimes handsome. Scapolite, Augite and Sphene, have also been found in the immediate vicinity.

The minerals next to be described, No. 5 on the map, are of a still more interesting character. The spot where they occur is a small field owned by William Raynor, situated about fifty rods northeast of Amity meeting house. It is partly cultivated and partly covered by wood. On an elevated knoll upon the border of the wood, and where the limestone comes into view in patches of limited extent, the diggings for minerals have been made. These are scattered over about a quarter of an acre of ground. The Limestone rocks have been blasted only in one or two places at this spot; the loose stones and crystals found in the soil constituting the chief objects of research. *Bronzite*, *Spinel*, *Hornblende*, *Augite*, and *Plumbago* are the substances here found. The Bronzite has been described by Mr. Finch in Vol. XVI, p. 185 of this Journal. It is now no more obtained in large plates, by following the rock which originally afforded it; but handsome foliæ, many inches across, are still procured loose in the soil, or attached to masses of Hornblende. The Hornblende is rarely found in regularly terminated prisms, but occurs in otherwise very regular and well finished crystals, sometimes half an inch in diameter, and one and a half in length. It is found both in loose crystals, imbedded in Limestone, and contained in veins and cells in the massive Hornblende. Delicate six-sided tables of Graphite are often found implanted upon the Hornblende crystals, especially where the Hornblende occurs shooting into cavities with Calcareous Spar. The Augite, found in like manner, in loose masses and disseminated through the Limestone in place, is not remarkable for its crystals, but for the variety of colors it exhibits. The prevailing hue is an hair brown, often deeply tinged with red. It is either in small rounded grains disseminated through the Limestone, or in entire masses, the grains of which are sharply angular. It was called for a time Pyrallolite, and afterwards Hornblende; but the cleavages it presents leave no doubt concerning its true character. It is in breaking up masses of this rock, that we sometimes meet with seams of Calcareous Spar filled with small octahedral Spinels of a black color and a very high degree of lustre. Spinels of a dull, greenish black hue in single crystals, having triangular cavities upon their faces are found loose in the soil. These are often upwards of an inch in diameter, and sometimes hemitropes in form. Brucite is also found here, possessed of a garnet red tinge, diffused through the Limestone along with Mica in small crystals of the same color, and liable, at first view to be confounded with Bronzite.

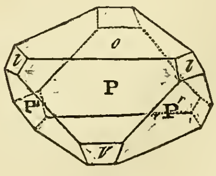
Following the knoll through the wood to the northwest, for the distance of five or six rods from the spot above described, we come to a place where the Limestone crops out, and where the marks of considerable labor appear. The blasting has been confined to one spot of not above ten or twelve feet in length, and of about half this width. Upon one side of the trench, the White Limestone affords *Spinel*, and upon the other *Pargasite* and *Idocrase*. The Spinel is distinguished for the perfection and distinctness of its crystallization. The form of its crystal is the octahedron with equally produced faces. The most frequent color is a dark greenish black, from which it passes through bluish tinge to purplish grey. The crystals are opake, or but slightly translucent. They vary in size from that of a pea to that of a hazle-nut and being thickly interspersed through the snow-white Limestone, which is here in large foliated concretions, and equally penetrated, also, by large grains of wax colored crystals of Brucite, the specimens they form are possessed of unusual beauty and interest. Upon the other side of the excavation, the Brucite and Spinel are replaced by Pargasite and Idocrase, the one predominating to the exclusion of the other, and occurring so plentifully as to form the major part of the rock. This Pargasite has generally been called Coccolite, but it is easy to detect in it the peculiar crystallization of Hornblende, the form of the crystal being that of the Mount Eve variety of the same mineral, except that the angles of the crystals are more rounded. Its color is a bottle-green, and it resembles in every respect the same variety of Hornblende, from Pargas in Finland. The Idocrase is for the most part massive; the individuals presenting a granular or columnar structure. Its color is a yellowish green. The granular variety is undoubtedly the substance described and analyzed by Dr. Thomson, under the new denomination of Xanthite, an account of which is contained in the Annals of the Lyceum of Natural History of New York. Although, as respects its hardness, it does not agree with that description, the words of which are, "easily crushed to powder by the nail of the finger. It is therefore soft: it does not scratch calcareous spar." It consisted of

Silica, - - - -	32.708
Lime, - - - -	36.308
Alumine, - - - -	12.280
Per ox. Iron, - - - -	12.000
Protox. Manganese, - - -	3.680
Water, - - - -	.600
	97.576

Of late, some distinct, nearly transparent crystals, from one fourth of an inch to more than one inch in length, have been found at this spot, having their lateral and terminal edges truncated. Associated with them, occur small grains of dark green Pargasite, and white, massive Scapolite. Just above this trench, a digging has been made, also, from whence handsome crystals of *Zircon* have been obtained. It likewise affords a reddish *Garnet*, *Sphene* and *Phosphate of Lime.* But these last mentioned substances are not found plentifully, or in valuable specimens with the exception of the Zircon, which, though rare, is in large and highly colored crystals.

The next place to be described is one which has afforded those specimens of *Black Spinel* that have excited, by their extraordinary dimensions and perfection of form, the astonishment of the whole mineralogical world. It is situated in the road contiguous to the farm of J. Layton, one mile southwest of Amity meeting house, and is marked No. 2 upon our map. We owe its discovery to Dr. Fowler, of Franklin, who observed, about nine years ago, the first specimens lying loose in, or near, the cart-path. His observation led to repeated researches in the soil, until at length a space sixteen feet long, eight wide and seven deep, has been completely dug over and examined. This space was occupied by earth, through which were interspersed loose blocks of an aggregate of Limestone Brucite and Serpentine, Spinel in single crystals and in groups, crystals of *Brown Hornblende* and of *Specular Iron Ore.* These substances appear to have constituted, originally, a series of crystalline cavities in the Limestone, into which water and soil having freely infiltrated from above, they at length became changed to the condition of loose materials.

The Spinel is possessed of the following colors: black, greyish black, bluish black and reddish brown. The former color has been the most abundant: the latter has never been noticed until lately, and occurs only in one particular spot in this digging; its gangue is white Limestone. The first mentioned colors belong to crystals either found loose or associated with the Serpentine and Brucite, and are often penetrated by crystals of Specular Iron Ore; whereas the reddish brown crystals are penetrated by a crystallized mica of the same color, the plates of which are disposed parallel with the octahedral faces of the Spinel. Nearly all the Spinels of this place are possessed of extraordinary dimensions, varying from one to sixteen inches round the base. A very common size has been from six to eight inches. Nor, as is generally true, is the size at the expense of the perfection of the crystal, the largest being equally perfect, as respects the smoothness and lustre of the faces, with the smallest. We frequently observe a tendency of smaller crystals to unite to form a large one, or of a great number of crystals connected in such a manner that their similar faces are parallel. The only form beside the primitive, in this mineral, is the ordinary hemitrope; of which several of enormous size are said to have been found. But they have not often been met with of late at this locality.



The crystals of Specular Iron, above alluded to, and which are almost invariably found penetrating the Spinel, are extremely interesting on account of their size and form. For a long time their true character appears to have been misunderstood; and they are still often found in cabinets under the name of Titaniferous Iron, or believed to be some undescribed ore of Columbium. The annexed diagram illustrates their figure, which is that of the *Fer Oligiste imitatif* of Haüy. They have been found one inch in diameter, though their average size is considerably less. The Hornblende of this place is of a reddish brown color, often in very large and perfect six-sided prisms, with three and four sided terminations.

Three quarters of a mile south-west of the above locality, in the middle of a bye-path leading west from the main road, and distant about forty rods from it, (No. 1. on the map,) are found handsome beryl colored crystals of *Apatite*, associated with a purplish brown *Augite*, which is sometimes in distinct crystals of considerable size, but more frequently in granular concretions. In the same connection, also occurs, a snowy white Scapolite, not well crystallized, together with crystals of Plumbago. These minerals are imbedded in the Limestone, in a vein-like cavity which has been pursued down to the depth of a man's head, and for a length of six or eight feet, and a breadth of about half this extent. The vein in which the minerals occur is said to have narrowed finally to about the width of two feet, and is probably near being exhausted. It is not improbable, however, that similar nests will be discovered on examination ; for it is not rare to find in the Limestone, partial veins of the Scapolite in this vicinity.

About half a mile north of the last mentioned deposit, No. 3, on the land of Daniel Layton, are a number of interesting substances. I did not visit the spot, nor am I informed of their mode of occurrence, but from the account furnished me by Dr. Young, I should imagine, that they are found in loose masses distributed through the soil, in conformity with the usual circumstances under which the minerals of this region occur. These minerals are *Spinel*, in greyish red octahedrons and hemitropes, from one to four inches in circumference, whose crystals are often coated with steatite, and present various shades of green, yellow and black. Associated with them are tabular crystals of Serpentine, destitute of lustre, and in a commencing state of decomposition ; also, Sphene and Augite,—these last resembling specimens from Roger's Rock on Lake George.

Locality No. 4, which is half a mile south-east of Amity meeting house, on the land of Moses Post, affords brown *Spinel* in large octahedral crystals, but inferior in perfection to those of the Layton locality. Dr. Heron possesses a single crystal from this place, weighing fifty-nine pounds. A portion of one of its pyramids is detached by a fracture, and reveals a small cavity that contains crystals of Corundum. This spot has furnished a number of handsome crystals of bluish white Corundum, attached to loose masses of grey Hornblende.

Locality No. 6, is one mile north of Amity church, upon land owned by Wm. Raynor, and situated in a wood. The Limestone merely crops out over an extent of a few rods, and is filled with Brucite of various colors, but mostly dull; black *Spinel* in hemitropes, and Magnetic Iron in large octahedral crystals, whose faces are rough; it also contains Hornblende and blackish Serpentine. The aggregate is in a decomposing state, apparently from the presence of the Octahedral Iron.

No. 13 is situated upon the land of Isaac Smith, two and a half miles north of Edenville. It affords handsome groups of *Spinel* crystals. To obtain them, it is necessary to dig into a side hill, and roll over large blocks of an aggregate consisting of Hornblende, Mica and Limestone, upon whose surfaces and in veins traversing them, we often find druses of large octahedral crystals, varying in size from a quarter to one inch in diameter. Their form is well defined, the edges of the octahedrons being sharp and their surfaces perfectly flat. They are of a dark green, almost black, color; and are often possessed of a good degree of lustre. This place produces, occasionally, handsome crystals of Zircon, straw colored Brucite, and green and black crystallized Hornblende.

No. 14 is a spot between Mt. Adam and Mt. Eve, upon the farm of Wm. Davis, which affords red and black *Spinel*, red *Brucite*, *Augite*, green *Hornblende*, *Idocrase* and *Scapolite*.

No. 15 situate upon the declivity of Bellvale Mt. affords handsome four-sided prisms of Rutile, terminated by four-sided pyramids. They are about half an inch in diameter, of a brownish black color, and free from those striæ common in the crystals of this substance. The gangue is a sienitic Granite, which also contains handsome crystals of brown *Zircon* and lengthened prisms of *White Iron Pyrites*, terminated at both of their extremities by dihedral summits.

The Magnetic Iron deposit, No. 16, is described as occurring in the blue Limestone; but it is more probable that it belongs to the primitive, which may approach the surface at this spot. A perpendicular excavation, twenty five or thirty feet in depth, was made here many years ago for the purpose of working the ore; but the limited quantity in which it occurred, caused the undertaking soon to be abandoned. The ore existed in isolated masses from the size of a man's fist, to pieces weighing a hundred pounds. It possesses unusually strong magnetic power. The neighbors, about the mine, say that masses of it have been known to lift a pair of kitchen tongs. A great abundance of specimens may be obtained from the heaps of rubbish about the excavation.

It was my intention to have entered into a description of the Newton minerals, from the specimens of them in my possession, and the notices respecting their deposit sent to me from, time to time, by Dr. Young; but Dr. Fowler having just forwarded an article relating to them for insertion in this Journal, and which appears in the present number, I shall content myself with adding a few particulars not noticed by him, with a view to elucidate still farther the condition of this remarkable locality. What I have to add is wholly abstracted from the letters of Dr. Young. It is situated twenty miles south-west from Amity meeting house, two and a half miles south-west of Hamilton's inn, upon the Sparta and Milford Turnpike. It lies in a narrow trough formed by two ranges of Limestone, which are elevated about sixty feet above the general level of the country. This trough, or narrow valley contains soil, through which are disseminated blocks of Limestone containing occasionally the various minerals mentioned by Dr. Fowler. Several excavations were made in this trough, many years ago, by some ignorant persons with a hope of finding silver. The substance which encouraged these undertakings, probably was Iron pyrites, which is occasionally found here along with the Hornblende and Sapphire. It was among the loose masses thrown out by the authors of this enterprise, that the first pieces of Sapphire were found. In 1829, Dr. Young and Dr. Horton visited the spot and found few or no signs of much examination having been made for the Sapphire. They turned over a number of stones around the excavation which afforded the minerals, from which, as well as from the soil, they obtained the Sapphire in small quantity. In 1830, they visited it again, and found but one small block of Limestone, which contained the mineral, and which afforded them a great number of handsome crystals of this precious substance. In July, 1831, they spent two or three days there, assisted by five laborers, who were employed in digging, blasting, and breaking the blocks which were thought likely to afford the Sapphire. They found the mineral confined to a bason eighteen feet long and six feet wide, which they sunk to the depth of nine feet, taking out and examining every stone they met with. The bottom of this trench, they sounded with iron bars to the depth of four or five feet, but were unable to perceive any thing but fine soil. The side walls consisted of solid Limestone, free from minerals, and gradually sloping on both sides towards the middle of the trough. They obtained on this occasion a very fine supply, not only of the Sapphire but of the other minerals found in connexion with it. Dr. Young mentions a single crystal of Sapphire in his possession, that weighs five ounces avoirdupois. He also alludes to crystals of the supposed Idocrase in six-sided prisms with trihedral terminations at both extremities,—a form which would seem to indicate that this substance is rather Garnet than Idocrase, as has been believed. It is possible, indeed, that both substances occur there ; though all the specimens I have seen from the spot have uniformly consisted of large foliated masses, having three polished planes inclining to one another under angles of 120°, which goes to strengthen the opinion I have here ventured to suggest.

Concerning the minerals of Franklin and Stirling, scarcely any thing remains to be said after their full description in the various papers alluded to, at the commencement of this article. The mineral formerly called manganesian Feldspar, crystallized siliceous oxide of Manganese, and Ferro-silicate of Manganese, has very happily been endowed with the trivial name of Fowlerite ; a change which will undoubtedly be readily acquiesced in by mineralogists, no less on account of the greater convenience of a short name, than the propriety of calling so interesting a substance after Dr. Fowler, of Franklin, to whose zeal in mineralogy the cultivators of this science are so much indebted. The crystallization, hardness and specific gravity of the Fowlerite bring it under Mohs' natural order *Baryte*, and probably within the genus *Parachrose-Baryte.*

The Stirling mineral, formerly known as a silicate of Zinc, and since ascertained by Dr. Thomson, to be a Ferruginous silicate of Manganese, has been found of late in distinct crystals. These are of a form which justifies the opinion originally entertained by Dr. Troost concerning their primary form, which he suggested to be that of a cube. Mr. Ingliss, of Hamburg, has an isolated crystal of this substance, upwards of an inch in length ; its form is that of a rhombic dodecahedron with its acute solid angles replaced by tangent planes. Its hardness is a little below that of feldspar, and its specific gravity and form approximate it to the Genus Garnet, among whose species it will probably receive a place in the Natural History system. When freshly broken, it presents an asparagus green color : on a short exposure to the weather, it changes to a dull yellow, and at length its surface passes to black.

Several doubtful substances have been found in the vicinity of Amity, of which I have taken no notice in the foregoing remarks, and whose character can only be completely elucidated by a better supply of specimens than their localities have as yet afforded.

Art. XIV.—*On Central Forces; by* Prof. Theodore Strong.

(Continued from p. 69, of this volume.)

I will now suppose A = const. and $F=\frac{A}{r^3}=-\frac{A}{2}\frac{d\left(\frac{1}{r^2}\right)}{dr}$: also by the general forms of F, I have $F=-\frac{c'^2}{2}\frac{d\left(\frac{1}{p^2}\right)}{dr}$; hence $c'^2 d\frac{1}{p^2}=Ad\frac{1}{r^2}$, whose integral is $\frac{c'^2}{p^2}=\frac{A}{r^2}+c$, (1), which is the general equation of the curve described by the particle; the origin of r being at the centre of force, and $p=$ the perpendicular from the centre of force to the tangent at the extremity of r, also $c=$ the arbitrary const. which is easily found in terms of A, c', and the initial values of r, p. Let $V'=$ the velocity of a particle of matter describing a circle around the centre of force at the distance r, $V=$ the velocity in the curve at the same distance, then $F=\frac{A}{r^3}=\frac{V'^2}{r}$ or $A=V'^2r^2$, and $\frac{c'^2}{p^2}=V^2$; hence (1) is easily changed to $V^2-V'^2=c$, (2); let $\psi=$ the angle at which r cuts the curve, then $p=r\sin.\psi$ and (1) becomes $\frac{c'^2\,\text{cosec.}^2\psi}{r^2}=\frac{A}{r^2}+c$, (3). Again, $c'^2=\frac{r^4dv^2}{dt^2}$ gives $dt=\frac{r^2dv}{c'}$, (4), $dt=$ the element of the time, $dv=$ the element of the angle described by r around the centre of force; also $p^2=\frac{r^4dv^2}{dr^2+r^2dv^2}$, hence and by (1) $dv=\frac{\pm c'dr}{r\sqrt{cr^2+A-c'^2}}$, (5), and (4) becomes $dt=\frac{\pm rdr}{\sqrt{cr^2+A-c'^2}}$, (6), the sign + being used when t, v, r increase, and the sign − when t, v increase and r decreases. The species of curves denoted by (1) or (3) depends on A, c' and the initial values of r, p (or r sin. ψ,): if $A=c'^2$ $r=p$ at the origin, $c=0$, and the particle evidently describes a circle whose centre is at the centre of force, and its radius = the initial value of r; but if ψ is not a right angle at the origin and c'^2 cosec.$^2\psi=A$, $c=0$, $\therefore$ cosec.$\psi=\frac{\sqrt{A}}{c'}=$ const. at all points of the curve, which shows the curve to be the logarithmic spiral, its centre being at the centre of force. c'^2 cosec.$^2\psi=A$ gives $\tan.^2\psi=\frac{c'^2}{A-c'^2}$, hence and because $c=0$, (5), (6) become $dv=\frac{-\tan.\psi dr}{r}$, $dt=\frac{-\tan.\psi r dr}{c'}$, supposing r to decrease; hence by taking the integrals on the supposition that v, t commence when $r=R$, I have $v=\tan.\psi\times h.l.\frac{R}{r}$, $t=\frac{\tan.\psi}{2c'}\times(R^2-r^2)$; or $r=\sqrt{R^2-2c'\cot.\psi\times t}$, $v=\tan.\psi\times h.l.\frac{R}{\sqrt{R^2-2c'\cot.\psi\times t}}$, or $t=\frac{R^2}{2c'\cot.\psi}\times\left(1-e^{-2v\cot.\psi}\right)$, $h.l.e=1$; the values of r and v in terms of t will give r, v at any time which is less than $\frac{R^2\tan.\psi}{2c'}=$ the time from the extremity of R to the centre of the spiral, as is evident by making $r=0$ in the value of t, at which time v becomes infinite. If ψ is not a right angle at the origin, but $A=c'^2$, then by (3) $r^2\tan.^2\psi=\frac{c'^2}{c}=$const. which shows the curve to be the hyperbolic spiral. (Vince's Fluxions, prop. 129, ex. 2.) In this case (5), (6) become $dv=\frac{c'}{\sqrt{c}}\times\frac{-dr}{r^2}$, $dt=\frac{-dr}{\sqrt{c}}$, supposing r to decrease; by taking the integrals on the supposition that t, v commence when $r=R$, I have $v=\frac{c'}{\sqrt{c}}\times\frac{R-r}{Rr}$, $t=\frac{R-r}{\sqrt{c}}$, or $r=R-t\sqrt{c}$, $v=\frac{c'}{R}\times\frac{t}{R-t\sqrt{c}}$, and the time from the extremity of R to the centre of the spiral $=\frac{R}{\sqrt{c}}$; hence the values of r, v are easily found at any time which is less than $\frac{R}{\sqrt{c}}$. By taking the value of the integral of $dv=\frac{c'}{\sqrt{c}}\times\frac{-dr}{r^2}$ between r and r infinite, (supposing v to commence when $r=$ infinity,) I have $rv'=\frac{c'}{\sqrt{c}}$, $v'=$ the value of v between r, and r when infinite; but $r\tan.\psi=\frac{c'}{\sqrt{c}}$, hence in this spiral $v'=\tan.\psi$: it is also evident that if a perpendicular $=\frac{c'}{\sqrt{c}}=r\tan.\psi$ is erected at the centre of the spiral to r infinite, and a line is drawn through the extremity of the perpendicular parallel to r infinite, the line thus drawn is an asymptote to the spiral. If c'^2 is $\angle$ A, but $c'^2 \operatorname{cosec.}^2\psi >$ A, c is evidently positive; then by putting $\frac{A-c'^2}{c}=R^2$, (5), (6) become (supposing r to decrease) $dv=\frac{c'}{\sqrt{c}}\times\frac{-dr}{r\sqrt{r^2+R^2}}$, $dt=\frac{1}{\sqrt{c}}\times\frac{-rdr}{\sqrt{r^2+R^2}}$, whose integrals are $v=\frac{c'}{R\sqrt{c}}\times h.l.\left(\frac{R'\sqrt{R^2+r^2}+R'R}{r\sqrt{R^2+R'^2}+rR}\right)$, $t=\frac{\sqrt{R^2+R'^2}-\sqrt{R^2+r^2}}{\sqrt{c}}$, ($v, t$ commencing when $r=R'$,) or $r=\sqrt{(\sqrt{R^2+R'^2}-t\sqrt{c})^2-R^2}$. This value of r, when substituted in the value of v, gives v in terms of t and known quantities, whence r and v are easily found at any time which is less than $\frac{\sqrt{R^2+R'^2}-R}{\sqrt{c}}=$ the time from the extremity of R′ to the centre of the spiral. By taking the integral of $dv=\frac{c'}{\sqrt{c}}\times\frac{-dr}{r\sqrt{r^2+R^3}}$, between r, and r infinite, $v'=\frac{c'}{R\sqrt{c}}\times h.l.\left(\frac{\sqrt{R^2+r^2}+R}{r}\right)$, $v'=$ the value of v between r and r infinite; hence by substituting the value of r, in terms of t, in v', the position of r infinite becomes known at any time; this curve evidently has an asymptote parallel to r infinite, at a distance $=\frac{c'}{\sqrt{c}}=$ the perpendicular from the centre of the spiral to the asymptote; as is evident by making r infinite in (1), which gives $p=\frac{c'}{\sqrt{c}}$. If c'^2 is $\angle$ A, and $c'^2\operatorname{cosec.}^2\psi\angle$ A, c in (3), (1) becomes negative, and its sign must be changed, also the signs of the terms involving c in (5), (6) must be changed; hence by putting $\frac{A-c'^2}{c}=R^2$ they become $dv=\frac{c'}{\sqrt{c}}\times$

$\frac{-dr}{r\sqrt{R^2-r^2}}$, $dt=\frac{1}{\sqrt{c}}\times\frac{-rdr}{\sqrt{R^2-r^2}}$; the value of r in these equations is never greater than R, and it is evident that when $r=R$, it cuts the curve at right angles: by taking the integrals of these equations, supposing t, v to commence when $r=R$, I have $v=\frac{c'}{R\sqrt{c}}\times h.l.\frac{R+\sqrt{R^2-r^2}}{r}$ (7), $t=\frac{1}{\sqrt{c}}\times\sqrt{R^2-r^2}$ or $r=\sqrt{R^2-ct^2}$ (8), $v=\frac{c'}{R\sqrt{c}}\times h.l.\frac{R+t\sqrt{c}}{\sqrt{R^2-ct^2}}$ (9), r, v are easily found by (8), (9) at any time which is less than $\frac{R}{\sqrt{c}}=$ the time from the extremity of R to the centre of the spiral. (7) agrees with Newton's construction of this case of the general question; Prin. prop. 41, cor. 3, see his fig. 5. for R= his CV, v=VCP, r=CT=CP, and $h.l.\frac{R+\sqrt{R^2-r^2}}{r}$ is as the hyperbolic sector VCR.

If c'^2 is $>A$, c is positive, as is evident by (1) or (3); or if the central force should be repulsive c will be positive, for A is negative in this case; and the signs of the terms involving A in (1), (3) must be changed: hence by putting $\frac{c'^2\mp A}{c}=R^2$, (the sign $-$ being used when the force is attractive, and the sign $+$ when it is repulsive,) (5), (6) become $dv=\frac{c'}{\sqrt{c}}\times\frac{dr}{r\sqrt{r^2-R^2}}$, $dt=\frac{1}{\sqrt{c}}\times\frac{rdr}{\sqrt{r^2-R^2}}$; the least value which r can have in these equations is evidently R, and it is evident that r cuts the curve at right angles when it $=R$; hence, supposing that v, t commence when $r=R$, by taking the integrals, I have $v=\frac{c'}{R\sqrt{c}}\times\text{arc}\left(\text{sec.}=\frac{r}{R}\right)$, $t=\sqrt{\frac{r^2-R^2}{c}}$, or $r=\sqrt{ct^2+R^2}$, $v=\frac{c'}{R\sqrt{c}}\times\text{arc}\left(\text{sec.}=\left(\frac{\sqrt{ct^2+R^2}}{R}\right)\right)$, whence r, v are easily found at any time; also $r=R\times\text{sec.}\left(\frac{R\sqrt{c}}{c'}v\right)$, (10).

(10) agrees with Newton's construction; Prin. prop. 41, cor. 3, see his fig. 5. for R= his CV, v= ang. VCP, r=CT=CP, $\frac{R\sqrt{c}}{c'}v$ is

as the elliptic sector VCR; see also cor. 6, prop. 44: in this case (see his fig. 3.) $CV=R$, $VCp=v$, $VCP=\frac{R\sqrt{c}}{c'}v$, $CP=Cp=r$. Let $P=$ the semi-circumference of a circle (rad.$=1$), then it is evident by (10) when $\frac{R\sqrt{c}}{c'}v=\frac{P}{2}$, or $v=\frac{Pc'}{2R\sqrt{c}}$ that r is infinite; also by (1) when r is infinite $p=\frac{c'}{\sqrt{c}}$; hence it is evident that this spiral has an asymptote parallel to r infinite, at a distance $=\frac{c'}{\sqrt{c}}$; indeed by supposing the particle to descend from r infinite, it will approach the centre of force until it arrives at the extremity of R, when it will recede from the centre of force on the opposite side of R, and will describe the remaining portion of the curve, which is evidently equal and similar to the portion in which it descended and will go off to an infinite distance when r becomes infinite, which it will be when $-v=\frac{Pc'}{2R\sqrt{c}}$; hence it is evident that the whole curve has two asymptotes, which are respectively parallel to r infinite in the descending branch, and to r infinite in the ascending branch of the curve; the distance of the asymptotes from r infinite being $=\frac{c'}{\sqrt{c}}$, in both branches of the curve; also the angle made by R and r infinite in the descending branch $=$ the angle made by R and r infinite in the ascending branch $=\frac{Pc'}{2R\sqrt{c}}$.

If c' is supposed to be indefinitely small (5) does not exist, and (6) becomes $dt=\frac{\pm rdr}{\sqrt{cr^2+A}}$ (11). In this case it is evident the particle may be considered as moving in the right line drawn from the centre of force through its initial position: its distance from the centre of force at any time (t) being denoted by r. By (11) $V=$ the velocity $=\pm\frac{dr}{dt}=\frac{\sqrt{cr^2+A}}{r}$ (12); also let $R=$ the initial value of r, then by taking the integral of (11) $t=\frac{\pm\sqrt{cr^2+A}\mp\sqrt{cR^2+A}}{c}$ (13), the upper signs being used when the particle moves from the centre of force, and the lower signs in the contrary case. If the particle falls from rest $v=0$ at the origin, and by (12) $c=-\frac{A}{R^2}$, hence (12), (13) become $V=\frac{\sqrt{A}}{Rr}\times\sqrt{R^2-r^2}$, $t=R\times\sqrt{\frac{R^2-r^2}{A}}$; if the particle is at rest at the origin, but the force repulsive, the sign of A must be changed; hence $c=\frac{A}{R^2}$, $V=\frac{\sqrt{A}}{Rr}\times\sqrt{r^2-R^2}$, $t=R\times\sqrt{\frac{r^2-R^2}{A}}$.

I will now suppose that φr=any function of r, and $F=\frac{\varphi r}{r^3}$, to determine the motion; supposing the particle commences its motion at right angles to the initial direction of r, and that the curve which it describes differs very little from a circle, whose centre is at the centre of force. Let R=the value of r at the origin, and $r=R+x$, x being always very small; put $\frac{d\varphi R}{dR}=\varphi' R$, then by Taylor's theorem, or by (n) Vol. XX, p. 71, $\varphi r=\varphi(R+x)=\varphi R+x\varphi' R$, neglecting terms of the orders x^2, x^3, etc. I also have (as heretofore,) $dt=\frac{r^2dv}{c'}$ (14), t=the time, v=the angle described by the radius vector (r) around the centre of force in the time (t), $\frac{c'}{2}$=the area described by the radius vector in a unit of time; I shall suppose that t and v commence when the particle is at the extremity of R, or at the origin. Let V′=the velocity of a particle of matter, describing a circle around the centre of force at the distance R, V=the velocity in the curve at the origin, (or at the distance R;) then (at the origin,) $F=\frac{\varphi R}{R^3}=\frac{V'^2}{R}$, or $\varphi R=R^2V'^2$; $\frac{c'^2}{R^2}=V^2$, or $c'^2=R^2V^2$; $\therefore \frac{\varphi R}{c'^2}=\frac{V'^2}{V^2}$, put $R\left(1-\frac{V'^2}{V^2}\right)=e'$ and $\frac{R\varphi' R}{\varphi R}=m^2$; then e' is a very small quantity because the described curve differs very little from a circle (rad.=R.) Let ψ=the angle at which r cuts the described curve, then (since $\frac{dr}{rdv}=\cot.\psi$,) I have by (H), Vol. XVI. p. 286, $F=\frac{c'^2}{r^3}+\frac{2c'^2\cot.^2\psi}{r^3}-\frac{c'^2}{r^4}\frac{d\left(\frac{dr^2}{dv^2}\right)}{2dr}$, or by neglecting the term

$\frac{2c'^2 \cot.^2\psi}{r^3}$ as a quantity of the second order of minuteness, (because the described curve differs very little from a circle,) I have $F=\frac{c'^2}{r^3}-\frac{c'^2}{r^4}\frac{d\left(\frac{dr^2}{dv^2}\right)}{2dr}$; by comparing this value of F with its assumed value there results the equation $c'^2\frac{d\left(\frac{dr^2}{dv^2}\right)}{2dr}=r(c'^2-\varphi r)$, (15). Substituting $R+x$ for r, in (15), and reducing it becomes $\frac{d\left(\frac{dx^2}{dv^2}\right)}{2dx}=$ $(R+x)\times\left(1-\frac{\varphi R}{c'^2}\right)-(R+x)\times\frac{x\varphi' R}{c'^2}$; but $1-\frac{\varphi R}{c'^2}=1-\frac{V'^2}{V^2}=$ a very small quantity, ∴ by neglecting quantities of the order $x\left(1-\frac{V'^2}{V^2}\right)$, and quantities involving x^2, also putting $\frac{x\varphi' R}{c'^2}=\frac{x\varphi' R}{\varphi R}$, (which may be done by neglecting quantities of the order x^2;) I have $\frac{d\left(\frac{dx^2}{dv^2}\right)}{2dx}=$ $e'-m^2x$, multiplying by $2dx$, and taking the integral $\frac{dx^2}{dv^2}=2e'x-m^2x^2$, (16), which needs no correction, since $\frac{dx}{dv}$, and x are each $=0$ at the origin. Put $2e'x-m^2x^2=\frac{e'^2}{m^2}\sin.^2\varphi$, then $x=\frac{e'}{m^2}(1-\cos.\varphi,)$ hence and by (16) $dv=\frac{d\varphi}{m}$ whose integral (since v and φ are each $=0$ at the origin, where $x=0$;) gives $\varphi=mv$ ∴ $x=\frac{e'}{m^2}(1-\cos. mv)$, and $r=R+x=R+\frac{e'}{m^2}-\frac{e'}{m^2}\cos. mv$, (17). Let P = the semi-circumference of a circle, (rad. $=1$,) then it is evident by (17) that r is a maximum when $mv=P$, or $v=\frac{P}{m}$, (18), at which time $r=R+\frac{2e'}{m^2}$; it is also evident that this value of r cuts the curve at right angles, and that v as given by (18), is the angle included by the greatest and least distances, or (as it is usually called,) the angle between the apsides; it is also evident that the particle after arriving at the greatest distance will approach the centre of force, and after describing an angle$=\frac{P}{m}$ will be at a distance$=$R from the centre of force, and that the portion of the curve described in passing from the least to the greatest distance is equal and similar to the portion described in passing from the greatest to the least distance, and that these portions are similarly situated on opposite sides of the greatest distance; also after having arrived at the distance R, the angle $\frac{P}{m}$ will be repeated and the particle will arrive at the greatest distance $R+\frac{2e'}{m^2}$, when it will again approach the centre as before, and so on perpetually. Put $R+\frac{e'}{m^2}=R'$, and $\frac{e'}{m^2R'}=e$, then (17) becomes $r=R'(1-e\cos. mv)$, (19), which is the equation of the curve described by the particle. Put $\frac{c'^2}{R'}=g$, $\sqrt{\frac{g}{R'^3}}=n$, then by (19) neglecting quantities of the order e^2, $r^2=R'^2(1-2e\cos. mv)=\frac{c'}{n}(1-2e\cos. mv)$, hence and by (14) there results $ndt=dv-2e\cos. mvdv$ whose integral gives $nt=v-\frac{2e\sin. mv}{m}$, which needs no correction, since t and v commence at the origin; or $mv=mnt+2e\sin. mv$, and by neglecting quantities of the order e^2, $v=nt+\frac{2e\sin. mnt}{m}$, (20), and $r=R'(1-e\cos. mnt)$, (21); (20) and (21) are sufficient to find the place of the particle at any time (t). Let v° denote the degrees in v as given by (18), then since $\frac{1}{m}=\sqrt{\frac{\varphi R}{R\varphi' R}}=\sqrt{\frac{dh.l.R}{dh.l.\varphi R}}$; (18) becomes $v^\circ=180^\circ\sqrt{\frac{\varphi R}{R\varphi' R}}$, (22), or $v^\circ=180^\circ\sqrt{\frac{dh.l.R}{dh.l.\varphi R}}$, (23); (22) evidently agrees with the method given by Newton in the ninth section of the Principia, for determining the angle between the apsides in orbits, which differ very little from circles; but it appears to me that (23) will generally be more convenient in practice; and it may be observed that by neglecting quantities of the order eR, in comparison with R, we may write r instead of R in (22), (23). Let $\frac{\varphi r}{r^3}=\frac{Ar^n}{r^3}$, A$=$

const. then $h.l.\varphi r = h.l.A + nh.l.r \therefore \frac{dh.l.r}{dh.l.\varphi r} = \frac{1}{n}$ and $v^\circ = \frac{180^\circ}{\sqrt{n}}$, (see Prin. B. I, prop. 45, ex. 2,) if $n=1$, $v^\circ = 180^\circ$, and $F = \frac{A}{r^2}$; in this case $m = \sqrt{\frac{R\varphi' R}{\varphi R}} = 1$, and (19) becomes $r = R'(1 - e\cos. v) = \frac{R'}{1+e\cos. v}$, (24), neglecting quantities of the order e^2; it is evident by (11), given at p. 73, Vol. XVII, that (24) shows the curve described, in this case, to be an ellipse, the centre of force being at the focus, R'=the semi-axis=the semi-parameter, neglecting quantities of the order e^2; also in this case (20), (21) become $v = nt + 2e\sin. nt$, $r = R'(1 - e\cos. nt)$ which agree with (s), given at p. 73, Vol. XX, and (1), given at p. 291 of the same Vol., by neglecting quantities involving e^2, e^3, etc. in those formulæ.

Art. XV.—*Remarks on the Coal Region between Cumberland and Pittsburgh, and on the Topography, Scenery, &c. of that portion of the Alleghany Mountains;* in a letter, dated Pittsburgh, Nov. 30, 1831, from Samuel Wyllys Pomeroy, Esqr.; written by request of the Editor.

Dear Sir—The advanced stage of the season will deprive me of the pleasure of furnishing so promptly as I could wish, in accordance with your request, an account of the statistics, as well as facts relating to the geology and mineralogy of the coal fields on the banks of the Ohio. The detention here has exceeded our anticipations a fortnight. I cannot, however, relinquish the hope that winter will permit me to stop a few days on our way to Cincinnati, where we shall remain while the navigation is obstructed by the ice, which seldom continues more than six weeks, when from the knowledge obtained by explorations, that occupied three or four months last year, I confidently expect to be able to put you in possession of the desired information by the 1st of March, so far as I may be competent to the pleasing task.

I am gratified, however, that a fortuitous circumstance has enabled me to present an imperfect sketch or outline of the coal formation of a section of the whole chain of the Alleghanies, from their base at Cumberland. But I must premise that I have no pretensions to any attainments in geological science, further than what pertains to a single branch, and that to a single object of practical utility, namely, the coal formation in the valley of the Ohio. To this pursuit my attention has been sedulously directed, ever since steam-boats began to ply on the western waters. And eighteen years ago, a faithful and intelligent agent, who when a stripling, emigrated with the first settlers, and subsequently acted as a land surveyor in search for salt springs, became intimately acquainted with the country, and by my direction, explored the banks of the Ohio and their vicinity, for coal, from Pittsburgh to Louisville, a distance of seven hundred miles. Having myself since verified, personally, most of the facts stated in his report, and made further researches, I am enabled to say that all the localities worthy of note, bordering near the Ohio and its tributaries, that are accessible for water transportation, are familiar to me, having seen most of the strata in place, and I have also witnessed the combustion in the large way, of the coal from a great portion of them.

Before proceeding over the mountains, it may be well to remind you of the *rocky strata* for some distance before approaching them from the east. A day's stay at Hagerstown afforded an opportunity of viewing a part of that charming vale, where the luxuriance and dark tints of the herbage, so late as the 12th of November, indicated a soil capable, with judicious management, of everlasting fertility; being incumbent on strata of blue limestone, lying near the surface, and often appearing above it. From the extent of water power in the district, which I was told sends annually to Baltimore near a hundred thousand barrels of flour, we may suppose there can be no lack of moisture; and doubtless when reviewed with a farmer's eye, it must be pronounced (combining, as it does, wheat and grazing systems,) the "*heart of Maryland.*"

The road from Frederick to Cumberland is a macadamized turnpike; and for some distance before entering Hagerstown, to its uniting with the national road, a distance of more than sixty miles, the surface material is mostly of the same dark blue limestone, and we may therefore infer that the formation extends to the foot of the Alleghanies. I would here remind you, that some of the ridges of this stupendous chain, including their adjuncts, are designated by local names. For instance, the mountain over which the ascent commences, is called *Shavers*, in Maryland: the same ridge in Pennsylvania is known as *Wills*, where the next ridge is designated the *Great Alleghany*, which divides the waters that run into the Potomac from those that feed the Father of Rivers; and stretching across the state to Virginia, it reassumes its former cognomen.

When getting into the coach at Cumberland, the leaders were standing on the celebrated *Cumberland road*—alike dreaded by travellers and legislators of tender consciences; on which large sums of the nation's treasure have been sunk by its injudicious construction; but much larger dissipated on the popularity course in the halls of Congress, during a succession of "*long heats and repeats.*" We crossed Shaver's mountain in the dark; before day light we were ascending the Great Savage, and had passed the coal bed on the east side, from whence it is hauled ten miles to the Potomac at Cumberland; during the higher stages of water, it is sent down in flats, and known as Cumberland coal, of which much has of late been said. I observed its combustion for some hours in a grate in the reading room of the inn at Hagerstown, and also in a smith's forge. The fracture and general characters very much resemble those of the coal from several localities on James' river in Virginia; it is equally fragile, and if large pieces are laid lightly on the grate, it burns with more flame; but the *small coal cakes* and stops the ventilation. Its specific gravity appears rather to exceed that of the Virginia coal: an intelligent smith stated that it was a *strong coal*, but contained considerable sulphur that often proved destructive to his iron; and appeared grateful for the information that, I could assure him on unquestionable authority, that a little *salt* sprinkled occasionally on the fire when well ignited, would protect the metal from the effects of sulphur.

I was not able with a strong lens to detect any organic vegetable remains or impressions. At Frostown, near the top of the Great Savage, we found a good breakfast and cheerful fires of blazing coal, which our host Mr. Frost informed me was taken from the west side of the mountains, where the coal is of a much better quality than from the bed on the east. In reply to a question as to "the position of the *strata*, he said that when the coal is dug out, basins are formed in the under stratum of rock, from which it becomes necessary often to drain the water, which is however no difficult job, as it only requires a narrow trench to be cut through the slate, and perhaps a few inches into soft sand-stone that forms the pavement, from which is a fall some hundreds of feet. Having, in a former tour, crossed

Shaver's mountain by day light, I am able to say that its structure resembles that of the Savage to near its top.

The location of the road reflects great credit on the engineers; the contour is admirable, and must be highly valued by geologists, as it presents a profile section across the whole range, clinging on one side to the mountains, that, in some places, seem to tower miles above and so near *walls*, formed by the *cut*, that the carriage wheels often graze them; and on the other, a precipice almost perpendicular, leading to a gulf below that the eye cannot fathom. The sandstone strata which are almost constantly in sight from the base of Shavers to near the greatest altitude of the Savage, incline 15° or 20°, as well as I could judge in passing rapidly—the *dip* opposite the setting sun in the middle of November. From thence it declines by gradations hardly perceptible to near the western base, and there becomes horizontal, like all the strata far beyond the Ohio.

There are several varieties of sandstone; the most common has a yellow or ferruginous tinge,—the layers are of sufficient thickness for all the masonry on the whole line of road, and for this purpose it has been used in the numerous bridges, culverts and embankments, which are constructed with skill; but the cement has entirely failed, owing probably to substituting *loam* for *sand*, which appears to be rare in these regions; I have never been able to discover a pebble, or a handful of silex except in the beds of water courses, or that which is coherent in the sandstone, on any of these mountains,—the soil being a fine friable loam. The *parapet* walls of all these constructions exhibit a mortifying appearance of dilapidation, they are all fast crumbling, some already even with the pavement, and fatal accidents may soon be expected to follow.*

In many *cuts* on the Savage, the sides next the mountains present a mural front of sandstone, in layers resembling regular masonry; reminding one of those walls described by Lewis and Clarke on their route to the Rocky Mountains, although upon a much smaller scale. On the principal elevation, I observed extensive patches of the surface

* Cannot the want of sand be supplied by heating the sandstone itself red hot, by piles of brushwood, and then throwing the fragments into cold water, or sprinkling it upon them? A few strokes of the stone hamner would then, probably reduce them to grains or fragments, sufficiently fine for mortar; this suggestion is made upon the supposition that the sandstone is siliceous, of which the observations of Mr. Pomeroy can leave no doubt; as silex is indispensable in mortar, it would justify, in this case, even a heavy expenditure in transporting sand and gravel, from a distance, provided it can be obtained in no other way.—*Ed.*

actually flagged with sandstone, so close as to exclude any herbage or shrubs; the forest trees, however, have forced their way through the joints. Some of the slabs seem as true as if dressed for foot-pavements in cities; they are of an elegant material, granular quartz, strongly coherent, exhibiting a light pearl color, and when pulverized nearly as white as flour. I hope to hand you specimens on my return.*

There are extensive settlements along the whole line of the road; scarce a tract of *table land*, gentle slope, valley or wide glen, but is under cultivation. From the innumerable caravans of six horse-waggons that are constantly passed or met, it may well be supposed that *blacksmiths* drive a profitable trade; they are located at almost every cluster of houses or near taverns, of which there are many, affording great facility for collecting specimens, and information of the various coal beds in their vicinity. The quality of the coal continues to improve till we reach the *Youghiogeny*, where there is little room. The coal on this stream justly deserves the reputation of superiority to any in this whole region. I examined a large heap at Smithfield, where we crossed the Youghiogeny, and could not find a single piece that was not beautifully *iridescent* throughout and exceeded, in richness of tints, those elegant specimens of anthracite which I viewed in your cabinet; perhaps the fracture being *cubical* may have displayed them to more advantage; the same distinctive mark of the *rainbow* attaches to the coal on the banks of the stream till it falls into the Monongahela. Owing to the length, and the difficult navigation, and low price of coal at Pittsburgh, it is seldom sent down there and it is only at high stages of water that the river is navigable.

We began to ascend the *Laurel mountains* in a few hours after crossing the Youghiogeny, but daylight left us before reaching the summit. The natural scenery on this ridge exceeds that of all the others; the forest trees are of larger growth, the luxuriant and beautiful laurel, (*magnolia glauca*) being almost the entire undergrowth. This ridge, together with Chesnut ridge, the last of the chain, and which we also crossed in the night, extends into *Clearfield county*, on the head waters of the West Branch of the Susquehanna, where, I am informed, extensive beds of *bituminous* coal have been discovered, which, from specimens in my possession, appears to be of good quality; and the time probably is not far distant when it will make frequent visits to enlighten its *elder brothers*, the great anthracite formations, in the valleys of the Susquehanna and Schuylkill.

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* What better material can be desired for a cement?—*Ed.*

The national road crosses the Monongahela at Brownsville, sixty miles (following the stream) above Pittsburgh. This village is founded on a bed of coal, of a quality superior to that of Pittsburgh; the precipitous banks directly opposite, present the first limestone in strata which I met with, but no coal is near, nor is any limestone found on the Brownsville side, unless in thin layers high above the coal. From this to Washington, Penn., the country becomes more level, and the coal banks are less frequent. There we turned off the national road to Pittsburgh, distant twenty six miles. The banks of Chartier's creek, which we crossed three or four times, are full of fine coal, which is hauled six miles to supply the borough of Washington and its neighborhood. I have *memoranda* that may enable me at a future time, to give you further particulars relative to this immense coal formation and its attendant strata, but you must be at present satisfied with this crude and hasty sketch, and a *parady* of your remark, published in the XIX Vol. of the Journal of Science, relative to the anthracite in the eastern section, "that the sun and the *bituminous* coal of Western Pennsylvania will *burn out together*."

Art. XVI.—*On the Utility of fixing Lightning Conductors in Ships; by* W. S. Harris, Esq. Member of the Plymouth Institution.

[From the Edinburgh New Philosophical Journal.]

1. A thunder-storm is the result of a great natural action subsisting between an extensive stratum of cloud, and a corresponding portion of the earth's surface, together with the intervening atmosphere; and is the result of some powerful agency, the nature of which is as yet undiscovered.

2. The active principle of a thunder-storm, however, may be considered as an extremely subtle species of matter universally pervading nature, and distributed in bodies, in quantities proportionate to their capacities for it, so that when accumulated in and about certain bodies, and abstracted at the same time from other bodies, a tendency to regain the previous state of proportionate distribution is marked by a certain train of phenomena; thus, a concentrated action is frequently set up between the overcharged and undercharged bodies, which produces all the effects of a violent and terrific expansive force, for the original state of proportionate distribution is often restored by a rapid explosion, at which instant the most compact bod-

ies are broken; whilst, at the same time, there is such an evolution of heat, that substances directly in the line of action are sometimes inflamed, fused, and ignited.

3. This easy and elementary view of electrical action may not be altogether useless; for to investigate any branch of physical science with success, it is always advantageous to arrange our ideas in some determinate order, by means of which the details assume a clear and connected form; for although it must be admitted, that every theory is merely a way of picturing to ourselves the course of nature, it may be always sufficient, and admissible, so long as it is consistent with the observed phenomena, and not contradicted by any known fact.

4. In the progress of electrical inquiries, it has been found, that some substances oppose but comparatively little resistance to the passage of the electrical agency, whilst, on the contrary, other substances seem to arrest its course altogether; a fact which induced electricians to consider bodies as possessed of these peculiar properties, and to classify them in relation to this *conducting* or *non-conducting* power. Substances which oppose but comparatively little resistance to an electrical explosion, have therefore been termed *conductors*, whilst those which offer resistance to its progress, have been termed *non-conductors*, or, occasionally, from the same cause, *insulators*. In the conducting class, we find, all the metals, concentrated acids, water, well burnt charcoal, wood, diluted acids, and saline fluids, most earths and stones, flame, smoke and steam. If any of these substances resting on the ground, be put into contact with an electrical machine, whilst a current of sparks is passing from it, the sparks will immediately cease; in consequence of the electric matter being transmitted by them to the earth:—an easy and striking experiment. Non-conductors of electricity, or insulators, are all vitreous and resinous substances;—dry, permanently elastic fluids, such as air; baked wood, silk, pure carbon, and most precious stones, oils, dry vegetable substances, as also, dry marble, chalk, and lime, wool, hair, feathers, dry paper, parchment, and leather. If, whilst a current of sparks is passing from the electrical machine, any of these bodies be put into contact with it, and rest as in the former instance on the earth, little or no difference will be perceived, the sparks will continue.

5. Although for general purposes, the various bodies in nature may be considered as belonging to one or the other of these classes, a gradation of effect is observable from one class to the other; so that the

conducting or insulating power of some substances, compared with that of others, may be considered as imperfect: hence has arisen a third class, which consists of the remote extremes of the other two, and which may be considered in the power of arresting or transmitting certain electrical actions as appertaining to either. Thus wood, hemp, stone, and the like, may become insulators to a state of low electrical action, and conductors to a high one.

6. The manner in which accumulations of atmospheric electricity proceed, may be referred to the following principle: When two substances of the conducting class are directly opposed to each other, and are separated by a substance of the non-conducting or *insulating* class, leaving the one free and the other insulated, the proportionate state of electrical distribution may become deranged to the greatest possible extent. Now, in nature, the conditions of such an experiment are found in the relative situations of the sea and clouds, and intervening air; so that when, from any cause, an evolution of natural electricity takes place, and heavy masses of vapor are present in the atmosphere, we have immediately an insulated conductor, (a cloud,) directly opposed to a conductor in a free state (the sea or land,) and an intervening non-conducting or insulating medium, the air; hence results a charged battery of enormous power: the attraction of the opposite electrical states, therefore, may become at length so powerful, that the electric matter breaks down the intervening resisting air, with a terrific and dense explosion—an effect perfectly analogous to the explosion which frequently occurs at the time of conveying a high charge to an electrical battery, and which is attended by a peculiar fracture of the interposed glass.*

7. The year 1752, which marks an important era in electrical science, from the celebrated discovery of the principle just mentioned, under the form of the Leyden jar, gave to the natural philosopher an easy method of concentrating large quantities of electricity produced by artificial means, so as to discharge it upon or through bodies with an instantaneous and violent explosion. From the time, therefore, that the cause of lightning became *identified* with that of ordinary electricity, and that the gigantic attempt of Dr. Franklin and other philosophers, of actually drawing down the matter of lightning from

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* An explanation of some of the phenomena of thunder-storms on this principle will be found in my printed letter to Sir T. B. Martin, K. C. B. Comptroller of his Majesty's Navy.

the clouds, was fully accomplished, the effects produced on bodies by these minor electrical discharges with their mode of action acquired a new interest; and many important experimental researches into the laws and operation of the great natural action, were successfully carried on by means of the ordinary artificial one.

8. Amongst the many important results arrived at by such inquiries, are the following:—

First, In every case of electrical explosion, there are universally two points of action, one *from* which the electric matter may be supposed to proceed, and another *towards* which it may be considered as determined.

Secondly, At the instant before which an explosion takes place, the stream of electricity moving to restore the equilibrium of natural disposition, seems by a wonderful influence to feel its way, and mark out as it were, in advance, the course it is about to follow; which course is *invariably determined through the line or lines of least resistance* between the points of action.

A few illustrations from experience of damage by lightning, may serve to render these facts evident.

(*a.*) The brig Belisle, of Liverpool, in November, 1811, was lying afloat, abreast of Mr. Evan's yard, at Bideford, when a vivid flash of lightning shivered her fore-top-mast and fore-mast, tore up the forecastle deck, and struck a hole through her starboard side, starting several butts in the bends, whence it passed into the sea.

(*b.*) The French ship Coquin, at anchor in the bay of Naples, was struck by lightning in the afternoon of Christmas day, 1820. The electric matter passed, in this case, close to the main hatchway, upon a spare anchor, and from thence through her bottom a little below the water's edge on the larboard side. The boats of the squadron in Naples Bay, assisted to slip her cables and run her ashore in the mole.

(*c.*) The United States ship Amphion, Blone master, of and thirteen days from New York, bound to Rio, was struck by lightning on the 21st of September, 1822. The lightning descended by her mizen-mast, destroyed the compasses and cabin furniture, splintered and tore to pieces the ceiling, bulk-heads, and rudder trunks, shivered two hold beams, and passed out through the quarter into the sea, tearing off part of the sheathing in its course.*

* Extracted from the log of the brig Mirabiles, and given to Mr. Lockyer, Comptroller of the Customs at Plymouth.

(*d.*) His Majesty's frigate Palma, commanded by Captain Worth, was struck by lightning in 1814, in the harbor of Carthagena, Spanish America. The fore-top-mast was knocked over the side, the lightning guttered or scooped its way, two inches deep, and one inch and a half wide, under the hoops of the mast, without injuring them, as far as the main deck. Here it fell upon the wet cable which had been just shortened in, and was lying against the after-beam; it knocked out a piece of the beam, and passed by the wet cable out of the hawse hole, the lead of which bore evident merks of the explosion. It was perfectly calm at the time, and the lightning, besides striking the ship, *struck also down upon the sea* several times, and within a short distance of the ship.

(*e.*) The packet ship New York, in her passage from New York to Liverpool, was struck by lightning twice in the same day, April 19, 1827. The first explosion shattered the main-royal-mast and mast-head, penetrated the deck, and demolished the bulk-heads and fittings in the store-rooms below,—then dividing, one part fell upon a lead tube, which it traversed as far as the side of the ship, and passed out into the sea, starting the ends of three four-inch planks; another portion passed into one of the cabins, and shivered to atoms the plate of a large mirror, without hurting the frame; after this, it fell upon a piano-forte, which it touched with no very delicate hand, and left it dismounted and out of tune; from thence it passed through the whole length of the cabin floor, which was damp at the time, and out of the stern windows into the sea.

(*f.*) The operation of the second explosion was very different from this;—it fell upon a spike at the mast-head, and from thence passed down a small metallic chain, which it disjointed and partly fused, into the sea, without doing any damage to the vessel.*

(*g.*) His Majesty's ship Bellerophon, under the command of Captain Rotheram, was struck by lightning, at sea, in August, 1807. A violent explosion took place in several parts of the ship at the same time; the main-top-gallant-mast totally disappeared, except the heel; the rigging of it was cut and burned in pieces; main-top-mast shivered in splinters from head to heel; main-mast damaged, and thirteen feet of the fish on the fore-part disappeared. The explosion also fell on the mizen-top-mast, which it likewise shivered; it de-

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* This conducting chain had been set up immediately after the first explosion happened.

scended down the mizen-mast in a spiral direction, broke the hoops, and damaged the mast; it passed through the coat of the mizen-mast on the larboard side, and through one of the poop beams on the other side; it passed into the ward-room, into one of the officers' cabins, started the butt end of a plank in the ship's side, and split a rider underneath on the lower deck. The electric matter on the larboard hand went close into the ship's side, in a perpendicular direction, and through the main and lower decks; it cut the clamp of the main-deck beams, entered the steward's room, where it ripped up the tin lining, and then passed through the orlop-deck into the butter room. The vessel was not damaged in the final escape of the electric matter into the sea.

(*h*.) In January, 1830, H. M. S. Etna, under the command of Captain Lushington, was struck by lightning in the Corfu Channel, in the Adriatic, at the time of coming to anchor. In this instance, three tremendous explosions came down a metallic chain, attached to the main-mast, and passed into the sea, without damage to the mast; the ship at the time seemed covered with sparks.

9. It may be observed by an attentive examination of these few cases, 1st, That the points *to* and *from* which the electric matter is eventually determined, are out of the ship; and, according with what has been stated in 1, 2, 6, are in the clouds and sea, so that the vessel is merely, as it were, an intervening object; the only action, therefore, which can be conceived to belong exclusively to the ship, is that which may be required to neutralize the opposite electrical state, induced upon the whole mass of the vessel, as being a point of the great surface opposed to the electrified clouds, and which is very small and of little consequence, compared with the capacity of the surrounding sea. Cases *a*, *b*, *c*, *d*, *e*, *f*, more particularly shew this. 2dly, That the points through which the explosion is determined, are invariably in the line or lines of least resistance between the points of action—that is, through the best conductors. Cases *d*, *f*, *h*, clearly illustrate this; and the same may be traced in all the others.

10. It may be also observed in these, as in every other case of damage from lightning, more especially on ship-board, that the greatest mischief occurs where good conductors cease; the electric matter being then enabled to produce all the disastrous effects of an expansive force, as if, whilst in the conducting body, it was in a diffused and low state, and again condensed and brought into a narrow focus, at the moment of leaving it. The damage, therefore, may be

in this case considered to happen, not where the best conductors *are*, but where they *are not;* so that the mariner has to contend with a constantly exploding principle, which continues its devastations in all those points where it ceases to be transmitted; thus determining for itself a passage between the points of action through such line or lines as may, upon the whole, oppose to it the least resistance.

11. Such effects being constantly observed, not only on ship-board, but on shore, it became a grand question of scientific consideration, how far it would be prudent to provide for the electric matter an efficient conducting line, between the highest points of a ship and the sea, so as to offer the least resistance to the progress of such a powerful agency, and transmit it in a state of low tension between the points of action; on the same principle that persons, dreading an inundation, would provide a channel to carry off the water as easily as possible; an idea, as is well known, first suggested by the celebrated Dr. Franklin, and since carried into practice with considerable success; the conducting line having the name of Lightning-Conductor or Lightning-Rod.

12. Although the application of lightning-conductors to buildings on shore is always judicious, and their advantages are very apparent, yet on ship-board, where the effects of lightning are most to be dreaded, the introduction of this means of defence has been slow and imperfect. The conductor hitherto employed at sea consists of long flexible chains or links of metal, about the size of a goose-quill, sometimes of iron: those employed in H. M. Navy, however, are of copper; they are usually packed in a box, and are intended to be set up from the mast-head to the sea when occasions require, so that, as observed by Mr. Singer, in his excellent work on electricity, partly from inattention, and partly from prejudice, they frequently remain in the ship's hold during long and hazardous voyages quite unemployed; a remark, the truth of which is but too frequently verified in the damage so constantly happening at sea during lightning-storms.*

13. The necessity of providing the best possible security against the effects of lightning on ship-board has been long admitted; but continuous and fixed metallic rods have been deemed inapplicable to

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* Case (*f.*), p. 351. A minute account will be found in the Liverpool Commercial Chronicle, in May, 1827. The conducting chain, at the time of the first explosion, was stowed away in its box below, although set up in time to prevent the effects of the second explosion.

ships, in consequence of their masts, the only parts to which they can be attached, being exposed to chances of injury, to motion in a variety of ways, to frequent elongation and contraction, and to the necessity which frequently arises for removing the higher masts altogether, and placing them on deck. It was probably from these causes that the small flexible chains or links above mentioned were employed. Such conductors, however, will probably, on examination, be found less applicable than fixed continuous lines of metal, and, in every point of view, inefficient substitutes for them. Their great want of continuity, as well as their want of mass and surface, is very unfavorable to the transmission of severe explosions, the electric matter becoming sensible at the points of junction, as is evident by the sparks which appear upon them at the time of the discharge, so that in some instances they have been actually disunited: they are likewise objectionable as being liable to every species of injury incident to a ship's rigging, and much difficulty is experienced in keeping them in their position, and unbroken, more especially during gales of wind, and at night, when the ship is under sail, and when it is perhaps required, as is already observed, to remove some portion of the higher masts. It has therefore been long considered desirable to apply, if possible, a permanent conductor, which should be always in its place, and ready for action; and various attempts have been made and suggestions advanced, at different times, to apply fixed lightning conductors in ships, as the subject from time to time has demanded further consideration.

14. To protect a ship effectually from damage by lightning, it is essential that the conductor be as continuous and as direct as possible, from the highest points to the sea—that it be permanently fixed in the masts, throughout their whole extent, so as to admit of the motion of one portion of the mast upon another; and, in case of the removal of any part of the mast, together with the conductor attached to it, either from accident or design, the remaining portion should still be perfect, and equivalent to transmit an electrical discharge into the sea.

15. To fulfil these conditions, pieces of sheet copper, from one-eighth to one-sixteenth of an inch thick, and about two feet long, and varying from six inches to one inch and a half in breadth, may be inserted into the masts in two laminæ, one over the other; the butts or joints of the one being covered by the central portions of the other. The laminæ should be rivetted together at the butts, so as to form a

long elastic continuous line; the whole conductor is inserted under the edges of a neat groove, ploughed longitudinally in the aft side of the different masts, and secured in its position by wrought copper nails, so as to present a fair surface. The metallic line thus constructed, will then pass downward from the copper spindle at the mast-head, along the aft sides of the royal-mast and top-gallant-mast, being connected in its course with the copper about the sheeve-holes. A copper lining in the aft side of the cap, through which the top-mast slides, now takes up the connection, and continues it over the cap, to the aft side of the top-mast, and so on as before, to the step of the mast. Here it meets a thick wide copper lining, turned round the step, under the heel of the mast, and resting on a similar layer of copper, fixed to the keelson. This last is connected with some of the keelson-bolts, and with three perpendicular bolts of copper, of two inches diameter, which are driven into the main keel upon three transverse or horizontal bolts, brought into immediate contact with the copper expanded over the bottom. The laminæ of copper are turned over the respective mast-heads, and secured about an inch or more down on the opposite side; the cap which corresponds is prepared in a somewhat similar way, the copper being continued from the lining in the aft part of the round hole, over the cap, into the fore part of the square one, where it is turned down and secured as before, so that when the cap is in its place, the contact is complete. In this way, we have, under all circumstances, a continuous metallic line, from the highest points to the sea, which will transmit the electric matter directly through the keel,* being the line of least resistance.

16. From what has been already observed, it will be apparent, that, in whatever position we suppose the sliding-masts to be placed, whether in a state of elongation or contraction, still the line of conduction will remain perfect, for that part of the conductor which necessarily remains below the cap and top, when the sliding masts are struck, is no longer in the line of action, consequently its influence need not be considered.

17. The following table exhibits the mean proportion of a conductor thus constructed on one mast of a fifty gun frigate, as com-

* Since the mizen-mast does not step on the keelson, it will be necessary to have a metallic communication at the step of the mast with the perpendicular stancheon immediately under it, and so on to the keelson as before, or otherwise carry the conductor out at the sides of the vessel.

pared with the copper links usually furnished to the British navy, together with the necessary equivalent in copper or iron bolt, in order to obtain a conductor of the same mass.

The resulting quantities in the last line at the bottom of the table, represent, with the exception of the proposed conductors, the masses, surfaces, and diameters of cylindrical metallic rods, supposed to extend the whole length of the mast. Thus in column 2, we have the diameter and surface of a copper rod, containing 2423 cubic inches of metal, being an equal quantity of matter to that in the proposed conductors, and from which it is calculated. The sums, therefore, are not the result of the addition of the successive masts. The same may be observed in column 3; taking the equivalent in iron. In the third and fourth columns, we have the mass and surface of a copper rod of half an inch in diameter, generally allowed to be adequate to any shock of lightning yet experienced: and, lastly, in column 4, we have the mass and surface in the conductors now furnished to the British navy; which we find, as compared with the mass in the proposed arrangement, is only as 94.4 : 2423.

TABLE.

SUCCESSION OF MASTS.	Proposed conductors		Equivalent in a copper rod.		Equivalent in an iron rod; taking conducting powers only as 4 to 1.			Mass and surface in a copper rod of ½ in diameter.		Mass and surface in present conductors.	
	Mass.	Surface.	Diameter.	Surface.	Mass.	Surface.	Diameter.	Mass.	Surface.	Mass.	Surface.
	cub. in.	sqr. in.	in.	sqr. in.	cub. in.	sqr. in.	in.	cub. in.	sqr. in.	cub. in.	sqr. in.
Royal Pole. Conductor 18 ft. 3 inch. long, 2 in. wide; two laminæ, each one sixteenth of an inch thick.	54	1752	.56	385	216	770	1.12	42	343	10.5	171
Top-gallant-mast. Conductor 17 ft. long, 2½ in. wide; two laminæ, one one-eighth of an in. thick, the other one-sixteenth.	95	2040	.77	493	330	986	1.54	40	320	10	160
Top-mast. Conductor 50 ft. long; copper 4 in. wide; two laminæ, each one-eighth of an in. thick.	600	9600	1.1	2070	2400	4140	2.2	117	942	19.2	471
Lower-mast. Conductor 93 ft. long; copper 6 in. wide; two laminæ, each one-eighth of an inch thick.	1674	26784	1.38	4837	6696	9675	2.76	219	1753	57.7	876
	2423	40176	1.2	8064	9692	16128	2.4	418	3358	94.4	1678

18. The manner in which conductors here proposed are applied to the mast, gives the form of the whole,—that of a flattened, conical surface,—wide at the base, and diminishing gradually to a point. It has been stated by one of the most eminent of the French philosophers, that this form is the best possible for a lightning-rod.

19. The objections made to fixing lightning-conductors in ships, are for the most part such as have been urged against lightning-rods generally; and are principally as follows:—It is said, that by fixing continuous lines of metal in the masts, we *invite* an electrical discharge from the atmosphere, and that by means of an attractive power, which, it is assumed, the metal is possessed of, the explosion is drawn exclusively upon the vessel; that, inasmuch as we can never come to know the absolute quantity of electric matter which may be discharged from a thunder-cloud, it is possible that the transmitting power of any conductors we can apply, may be inadequate to the end in view, so that they may possibly become fused; and hence it is inferred, that much damage may be the consequence:—That in fixing lightning-conductors in the masts, we can only have *surface;* whereas, the properties of a conductor depend on the *mass*, and not on the *surface* of the metal: hence the metallic surface is calculated to do considerable mischief, by conducting the lightning into the body of the vessel. Such are the principal objections to this application, and which, it is hoped, are fairly stated. They are highly deserving serious consideration, but they will be found, on examination, to be inconsistent with experience, and with the known laws of electrical action. We shall, however, by a candid inquiry, give these objections all the attention which their connection with so important a question demands.

20. The notion that a lightning-rod is a positive evil, will be found to have arisen out of the fact already mentioned (8), namely, that lightning invariably passes through the line or lines of least resistance between the points of action; hence it seizes on all those substances which oppose the least resistance to its passage; metallic vanes, vane spindles, iron bars, knives, and pointed metallic bodies, generally, will therefore be very commonly found in the course of the explosion; and from this circumstance, they have been considered to exert an attractive force upon the matter of lightning, so as to draw it aside from its destined course, to the destruction of the substances in connection with them.

21. It will be found, however, that the action of pointed metallic bodies is purely passive; that they only afford by the aptness of their parts an easy transmission to the electric matter; so that they can no more be said to attract the matter of lightning, than a dike can be said to attract the water which necessarily flows through it at the time of heavy rain; and, as in the one case, the water is drawn down by a force not peculiarly appertaining to the dike, so, in the other case, the electric matter is determined to a given point, in a somewhat similar way, by a force not appertaining to the metal. Moreover, it may still further be reasoned by analogy, that, as the quantity of water transmitted will depend on the capacity of the dike, and the final protection it gives in conveying the fluid on the length to which it is continued; so, on the other hand, the protection afforded by a lightning-rod will also depend on *its* capacity, and the distance to which it runs. If, in both cases, the length be extended until the force in action be satisfied, the protection received will be as the capacity for transmitting the current: if both be perfect, the protection will be complete; if the dike be not present, the water must be supposed to run loose and undirected; or, if its continuity be frequently interrupted or narrowed to a small compass, the damage must then be supposed to happen in the intermediate spaces. Such is, in fact, the way in which all bodies of the conducting class already mentioned (4) operate in conveying electrical discharges; and it must never be forgotten as an important feature in this discussion, that, whenever we erect an artificial elevation on the earth's surface in the ordinary way, we do, in fact, set up a conductor of electricity, upon which the electricity of the atmosphere will fall, and no human power can prevent it. Hence, if metallic bodies be present, those will be first assailed; if not, then the electric matter will fall on the bodies next in conducting power, and so on.

22. A curious illustration of this principle will be found in an extract from the Memoirs of the Count de Forbin, which is given in the forty-eighth volume of the Philosophical Transactions. "In the night," says the author of these memoirs, "it became extremely dark, and it thundered and lightened dreadfully. As we were threatened with the ship being torn to pieces, I ordered the sails to be taken in. We saw upon different parts of the ship above thirty of St. Elmo's fires; amongst the rest there was one upon the top of the vane of the main-mast more than a foot and a half in height; I ordered one of the sailors to take it down. When this man was on the top, he

heard this fire; its noise resembled that of fired wet gunpowder. I ordered him to lower the vane and come down, but scarcely had he taken the vane from its place, *when the fire fixed itself upon the top of the main-mast*, from which it was impossible to remove it."

23. Since, then, the conducting power of bodies differs only in degree, and that the action by which they are assailed is the result of a great natural agent quite independent of them, we may expect to find all bodies liable to be assailed by lightning, though the effects may be most apparent when the conducting power is imperfect. Thus we find cases on record, of ships struck by lightning in which no metallic spindles were present, or other iron work about the mast-head;* moreover, it is by no means an uncommon circumstance to find trees and rocks rent asunder by lightning, and to hear of men and quadrupeds, even in a plain and open country, destroyed at the time of a thunder-storm, when the electric matter strikes the earth's surface. [A sequel is promised, which has not arrived.]—*Ed. of Am. Jour.*

Art. XVII.—*The Geological Age of Reptiles; by* Gideon Mantell, Esq. F. R. S. &c. &c.

[From the Edinburgh New Philosophical Journal.]

Among the numerous interesting facts which the researches of modern geologists have brought to light, there is none more extraordinary and imposing than the discovery, that there was a period when *the earth was peopled by oviparous quadrupeds of a most appalling magnitude*, and that reptiles were the *Lords of the Creation*, before the existence of the human race! These creatures of the ancient world, many of which, from their extraordinary size and form, rival the fabled monsters of antiquity, existed in immense numbers, and in latitudes now too cold for the habitation of modern oviparous quadrupeds. Their remains occur in strata far more ancient than those which contain the reliquiæ of viviparous animals, and are found in marine as well as in fresh water deposites. Some of them, from their organization, have been evidently fitted to live in the sea only, while others were terrestrial, and many were inhabitants of the lakes and rivers. The animal and vegetable remains with which the fossil

* See Philosophical Transactions, vols. xlix. and lxix. damage done to the sheer hulk at Plymouth, and on board the Atlas, East Indiaman.

bones are associated, belong also to a very different order of things from that in which the modern oviparous quadrupeds are placed; and we are compelled to conclude that the condition of the earth, at the period when it was peopled by reptiles, must have been wholly different from its present state, and that it probably was then unfit for the habitation of animals of a more perfect organization. It is, moreover, interesting to remark, that some of these ancient and lost races are, as it were, the types of the existing orders and genera; and that in the pigmy *Monitor* and *Iguana* of modern times, we perceive striking resemblances to the colossal *Megalosaurus* and *Iguanodon* of the ancient world.

It is also worthy of observation, that, as in the present epoch the herbivorous quadrupeds are those of the greatest magnitude, so at the period when reptiles were the principal inhabitants of our planet, the herbivorous were those of the most gigantic proportions. The geological period when the existence of reptiles commenced must, according to the present state of our knowledge, be placed immediately after the formation of the coal measures; the remains of Monitors having been found in the bituminous slate of Thuringia; and those of a crocodile in the gypseous red sandstone of England: but it is not till we arrive at the *Lias* that the remains of reptiles occur in any considerable quantity. At that period the earth must have teemed with oviparous quadrupeds; and the *enaliosauri*, or those which inhabited the sea, appear to have been equally numerous with those of the land and rivers. The prodigious quantity of the remains of these animals which has, within a comparatively short period, been found in England alone, is truly astonishing; and if to these we add the immense numbers that have been discovered in France, Germany, &c., and reflect that for one individual found in a fossil state, thousands must have been devoured or decomposed; and that even of those that are fossilized, the number that comes under the notice of the naturalist must be trifling compared with the quantities unobserved or destroyed by the laborers, we shall have a faint idea of the myriads of "*creeping things*" which inhabited the ancient world.

In England, the lias contains more especially the remains of two extinct marine genera, the *Ichthyosaurus*, (fish-like lizard,) and *Plesiosaurus*, (animal resembling a lizard,) whose osteology is most extraordinary, combining characters observable in the cetacea, fishes, and saurians, but yet decidedly belonging to the order of Reptiles. The Ichthyosaurus, of which several species have been discovered, had a large head, enormous eyes, a short neck, and very long tail; it was furnished with four broad and flat paddles, and was evidently destined to live in the sea; it sometimes attained a length of from twenty to thirty feet. The Plesiosaurus, which in some respects resembled the Ichthyosaurus, being also furnished with four paddles, but is yet more nearly allied to the Saurians, differs, however, from it, and from all other animals, by the extreme length of the neck, and the great number of cervical vertebræ. The neck of reptiles is in general composed of from three to eight cervical vertebræ; and even birds (which have the maximum) have but from nine to twenty three; while one species of Plesiosaurus (P. dolichodeirus) has thirty vertebræ. This extraordinary creature, unlike the Ichthyosaurus, appears to have been but little calculated to make rapid progress through the sea, and was still less fitted for progressive motion on the land; it is therefore probable that it swam on or near the surface of the water, carrying its neck like a swan, and darting on its prey, its food consisting of fishes, cuttle-fish, &c. Contemporary with the animals above mentioned, were several herbivorous reptiles, whose remains have been found in the lias at Boll, in Wurtemburg, also a species of crocodile; and at Guildorf, a salamander of enormous size. The remains of tortoises and turtles occur also, but very sparingly, although, from the foot-marks observable in the red sandstone at Corn Cockle Muir, in Dumfriesshire, this family of reptiles must have existed at a still earlier period. In this bed also, several species of the Pterodactylus, or flying reptile, first make their appearance; animals which, with the wings of a bat, and the structure of a reptile, had jaws furnished with sharp teeth, and claws with long hooked nails.

The entire series of deposites composing the oolite formation, of which the lias is the inferior, or lower member, abounds with the remains of the animals of this order, and these are associated with vast quantities of marine shells, principally belonging to the ancient multilocular genera, namely, Ammonites, Nautilites, Belemnites, &c. the whole formation having manifestly been deposited by an ocean. The only apparent exceptions to this conclusion are the Stonesfield beds, composed of thin strata of calcareous sandy slate, which occur in the lower division of the oolite, and contain not only marine plants, shells, and bones of reptiles, but also the outer cases or *elytra* of winged insects, and jaws of animals allied to the opossum, (*Didelphis.*) The occurrence of terrestrial mammalia in beds of this ancient epoch has not been satisfactorily explained, and it would be foreign to our present purpose to enter into any discussion upon the subject; the intermixture of terrestrial remains with those of marine origin, may of course have been effected by the agency of a river or current. In the Stonesfield slate we first meet with the remains of that gigantic reptile, the Megalosaurus, (Great Lizard.) This monster, which, from the form of its teeth and skeleton, is evidently allied to the Monitor, must have been nearly forty feet in length, and seven or eight in height, and was probably a terrestrial animal. The crocodiles of this ancient epoch appear to have been exceedingly numerous, and belonged to species distinct from those of the present period, a great proportion being referrible to the *Gavials;* that division which has long slender snouts.

In the fresh-water formations that intervene between the oolite and the chalk, namely, the Purbeck, Hastings' sands and clays, and the Tilgate grit, the remains of several of the genera of the reptiles we have before noticed, occur; but those which are strictly marine, such as the Ichthyosaurus, are either altogether wanting, or of very rare occurrence. At the period of the formation of these deposites, turtles, both marine and fresh-water, existed in great numbers, having for contemporaries the Megalosaurus, one or more species of Plesiosaurus, several species of Gavials and Crocodiles, and probably Pterodactyles. At this epoch we have also an enormous herbivorous reptile, essentially differing from any of the oviparous quadrupeds now existing, and surpassing in magnitude even the Megalosaurus. This is the *Iguanodon*, (so named from its teeth resembling those of the recent Iguana.) A thigh-bone of this creature, twenty three inches in circumference, has been discovered in the grit of Tilgate forest; the teeth are as large as the incisors of the rhinoceros, and the vertebræ, claw-bones, and other parts of the skeleton, bear the same relative proportions. This creature, like some of the recent species of Iguanas, had *warts* or *horns* on its snout, and an appendage of this kind has been found of the size and shape of the lesser horn of the rhinoceros! From the prevailing character of the form of the bones, it is probable that this animal was shorter in proportion to its bulk than the recent lizards, to which it is more nearly allied; and marvellous as it may appear, we cannot but infer that some individuals attained a height of nine or ten feet, and were from sixty to a hundred feet in length! A circumstance even more extraordinary than its magnitude, is that of its having performed mastication like the herbivorous mammalia, its teeth, which are of a very peculiar form, being in general worn down by the operation of grinding its food.

The vegetables associated with the remains of the Iguanodon are all of a tropical character, and consist of various kinds of ferns, and of large plants allied to the dragon-blood plant. The strata in which they are found, unlike those of the oolite which preceded, and of the chalk which followed these deposites, have clearly been formed in the bed of a river; while those of Stonesfield, which contain a somewhat similar association of fossils, have as evidently been deposited by a current which ran into the ocean of the oolite, and carried with it remains of terrestrial and fresh-water animals, the shells in the last named strata being, as before remarked, marine, and precisely similar to those of the deposites above and below them; while the shells of the Hastings' beds are decidedly fluviatile or lacustral. Besides the remains of the reptiles above mentioned, teeth and bones of other gigantic oviparous quadrupeds have been found, but the characters and relations of the latter have not yet been accurately determined.

In the extensive marine formation, the chalk, which covers the Hastings' beds, reptiles are less numerous, and the Megalosaurus, Iguanodon, and other herbivorous genera, disappear altogether; no traces of their existence occurring after the last named strata were deposited. At the epoch of the chalk formation, the Ichthyosaurus, and one or more species of crocodile, and marine turtles, existed; and another extraordinary reptile, the Mososaurus, (lizard of the Meuse,) or fossil animal of Maestricht, first appears. This creature, so celebrated in Oryctology since the first discovery of its head and jaws by Hoffman, attained the size of the crocodile, and held an intermediate place between the Monitors and Iguanas. It appears to have been aquatic, swimming in the manner of a crocodile, and moving its vast tail, from side to side, as an oar. With the chalk, the "age of reptiles" may be said to terminate—the greater part of the genera above noticed appears to have become extinct during the changes which took place on the surface of the earth at that period; the crocodiles, turtles, &c. alone survived, a new order of things commenced, and in the tertiary formations which succeeded, we perceive an approach to the modern condition of the earth.

MISCELLANIES.

(FOREIGN AND DOMESTIC.)

Notices Extracted by Professor J. Griscom.

CHEMISTRY.

1. *Manganese.—Mode of ascertaining the commercial value of its ores; by* Edward Turner, M. D. Prof. of Chemistry in the University of London.—The method of manipulating is as follows :—About ten grains of the ore, in fine powder, are introduced into a flask capable of containing about an ounce of water, and into its neck is fitted, by grinding, a bent tube, about two inches long, which conducts the chlorine from the flask into a tube about sixteen inches in length, and five eighths of an inch wide, full of water, and inverted in a small evaporating capsule, employed as a pneumatic trough. The apparatus being adjusted, the flask is half filled with concentrated muriatic acid, the conducting tube instantly inserted, and heat applied by means of a spirit lamp. The air of the flask together with the chlorine is then collected, the greater part of the latter, if the gas is not very rapidly disengaged, being absorbed in its passage; and consequently the receiving tube, at the close of the process, will be about half full of gas. When the ore is completely dissolved, the last traces of the chlorine are expelled from the flask by muriatic acid gas. In order that the chlorine thus collected may be entirely absorbed, the aperture is closed by a ground stopper, or still more conveniently by the finger, and the gas is well agitated until the chlorine is wholly absorbed. As the solution in the inverted tube may become too saturated to dissolve all the chlorine, it is convenient to fill a pipette with pure water, and with the aid of the mouth, force a current to ascend into the tube, and thereby cause the heavier solution to flow out into the capsule.

The absorption being complete, the solution of chlorine is introduced into a six or eight ounce stoppered bottle, and a dilute solution of green vitriol, made, for example, with a hundred grains of the crystallized salt and a pint of water, is added in successive small quantities until the odor of chlorine just ceases to be perceptible. The quantity of liquid required for the purpose may be conveniently measured in a tube about sixteen inches long, and three fourths of an inch in diameter, divided into two hundred parts of equal capacity, and supplied with a lip, so that a liquid can be poured from it without being spilled. In conducting this part of the process, the operator will perceive two odors :—at first, the characteristic odor of chlorine, accompanied with the peculiar irritation of that gas; and subsequently, an agreeable, somewhat aromatic odor, unattended with the slightest irritation. The object is to add exactly so much solution of iron as suffices to destroy the former of these odors, without attempting to remove the latter; a point which, with a little practice, may be readily attained. The whole of the iron is thus brought into the state of peroxide.

The first trial is generally accompanied with some loss of chlorine, and should only be used as a guide to a second and more precise experiment. Accordingly, a weighed portion of the same ore is dissolved, and the chlorine collected as before, except that the solution of green vitriol, in quantity rather less than sufficient, is at once introduced into the inverted tube and capsule. A more ready and perfect absorption of the chlorine is thus effected, and the subsequent addition of a small quantity of sulphate of iron suffices for completing the process.

The principal sources of error in this method are the two following :—loss of chlorine, by smelling repeatedly, and exposure to the air when the gas is absorbed by pure water; and oxidation by the air when the absorption is made directly by means of the solution of iron.

The small flask and inverted tube are apt to retain the odor of chlorine, and should, therefore, be rinsed out with the absorbing liquid. It should be remembered, also, that a given quantity of chlorine will emit a more or less distinct odor, according as it is more or less diluted. But by operating always in the same manner, and employing such weights of different ores, that equal quantities of the solution may contain nearly equal quantities of chlorine, it is easy to be independent of these errors of manipulation, by causing them to affect each experiment to the same degree.

It will accordingly be found, with a little practice, that results of surprising uniformity may be thus obtained; and even the constitution of pure oxides of manganese may be ascertained by this method, almost with the same accuracy as by directly determining the quantity of oxygen.—*Jour. of Roy. Inst. I.* 293.

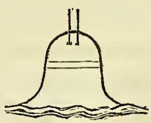
2. *Iodine and bromine in mineral waters;* by PROFESSOR DAUBENY.—The proportion of iodine to chlorine varies in every possible degree, and even springs that are most strongly impregnated with common salt, are those in which the smallest trace of iodine could not be detected. The same remark applies to bromine; whence he concludes, that although those two principles may, perhaps, never be entirely absent where the muriates occur, yet their relative distribution is exceedingly unequal. The author conceives that these analyses will tend to throw some light on the connection between the chemical constitution of mineral waters and their medicinal virtues. Almost the only two brine springs, properly so called, which have acquired any reputation as medicinal agents, namely, that of Kreutznach in the Palatinate, and that of Ashby de la Zouche, in Leicestershire, contained a much larger proportion than usual of bromine; a substance, the poisonous quality of which was ascertained by its discoverer, Balard. The author conceives that iodine and bromine exist in mineral waters in combination with hydrogen, forming hydriodic and hydro-bromic acids, neutralized, in all probability, by magnesia, and constituting salts which are decomposable at a low temperature. He has no doubt that a sufficient supply of bromine might be procured from English brine springs, should a demand for this new substance ever arise.—*Id. p.* 337.

3. *Illumination of Light Houses.*—(Lieutenant Drummond.)—A small ball of lime only three eighths of an inch in diameter, ignited by the combustion of oxygen and hydrogen, emitted a light so brilliant as to be equal in quantity to about thirteen Argand lamps, or one hundred and twenty wax candles; while in intensity or intrinsic brightness, it cannot be less than two hundred and sixty times that of an Argand lamp. In the best of the British revolving lights, as that of Beachy Head, there are no less than thirty reflectors, ten on each side. If, then, a single reflector, illuminated by a lime ball, be substituted for each of these ten, the effect of the three would be twenty six times greater than that of the thirty. On account of the smaller divergence of the former, it would be necessary to double their number, placing them in a hexagon, instead of a triangle. In this case the expense is estimated at nearly the same. This method was lately tried at Purfleet, in a temporary light house, erected for the purpose of experiments by the corporation of the Trinity house, and its superiority over all the other lights, with which it was com-

pared was fully ascertained and acknowledged. On the evening of the 25th of May, when there was no moon light, and the night dark, with occasional showers, the appearance of the light viewed from Blackwall, a distance of ten miles, was described as being very splendid. Distinct shadows were discernible, even on a dark brick wall, though no trace of such shadows could be perceived when the other lights, consisting of seven reflectors with Argand lamps, and the French lens, were directed on the same spot. Another striking and beautiful effect peculiar to this light was discernible when the reflector was turned, so as to be itself invisible to the spectator. A long stream of rays was seen issuing from the spot where the light was known to be placed, and illuminating the horizon to a great distance. As the reflector revolved, this immense luminous cone swept the horizon, and indicated the approach of the light long before it could itself be seen from the position of the reflector. These effects, however, on a moon-light night, or in hazy weather, cease to appear.—*Ibid.*

4. *Original decomposition of Potash.*—Dr. Paris, in his interesting biography of Sir Humphrey Davy, after giving an account of the preliminary experiments which led to the final and most successful result, has taken from the manuscript Journal of the Laboratory of the Royal Institution, a fac-simile of the minute, in Davy's hand writing, of the successful experiment of October the 19th, 1807. It is highly interesting and characteristic, but it should have been accompanied by the substance of it in print, (say the reviewers.) for it is not every one who will be able to decipher it. It runs thus—

"Oct. 19. When potash was introduced into a tube, having a platina wire attached to it, and fixed into the tube so as to be a conductor, i. e. so as to contain just water enough, though solid, and inserted over mercury, when the platina was made negative, no gas was formed, and the mercury became oxidated, and a small quantity of the alkaligen was round the platina wire, as was evident from its quick inflammation by the action of water. When the mercury was made the negative, gas was developed in great quantities from the positive wire, and none from the negative mercury, and this gas proved to be pure Oxygen.—Capital Experiment, *proving the decomposition of* Potash."



Those who knew Davy, will best conceive the enthusiasm with which this hasty record of his success was dashed off, and will recognize ευρηκα in his "capital experiments !"—*Ibid.*

5. *Decomposition of Water by Atmospheric and by common Electricity.*—Mr. Bonijol, conservator of the reading society of Geneva, has constructed many very delicate apparatus, by means of which water may be readily decomposed by the electricity of the ordinary machine, and also by atmospheric electricity. The electricity of the atmosphere is gathered by means of a very fine point fixed at the extremity of an insulated rod; the latter is connected with the apparatus, in which the water is to be decomposed, by a metallic wire, of which the diameter does not exceed half a millemeter, ($\frac{1}{50}$ of an inch.) In this way the decomposition of the water proceeds in a continuous and rapid manner, notwithstanding that the electricity of the atmosphere is not very strong. Stormy weather is quite sufficient for the purpose. M. Bonijol has also succeeded in decomposing *potash* and the chloride of silver, by placing them in a very narrow glass tube, and passing a series of electric sparks from the ordinary machine through them. The electricity was conducted into the tube by means of two metallic wires fixed into the ends. Where a quick succession of electric sparks had taken place for about five or ten minutes, the tube containing chloride of silver was found to contain reduced silver; and where potassa had been submitted to the electric current, there the potassium was seen to take fire as it was produced.—*Ibid.*

6. *On the state of Chlorides, Iodides, &c. in solution.*—Carlo Matteuci, decomposed the Chlorides and Iodides, by means of the pile, with the expectation of being able to deduce the nature of these compounds when dissolved in water. If it were possible to decompose these combinations by means of electric currents, incapable of decomposing water, one might then justly conclude that their composition was not changed by solution in that liquid. He, therefore, took a pile composed of two elements only, charged with water rendered slightly saline, and which had no power of decomposing water even a little acidulated. The platina conductors were then dipped in a solution of muriate of copper, and after some time, the negative conductor was covered with metallic copper, whilst the positive conductor evolved bubbles of gas. Having replaced the latter conductor

by one of silver, it soon became covered with a yellow film gradually changing to violet, which was considered as chloride of silver. The experiment was repeated with the iodides of zinc and iron; the platina poles had scarcely touched the solutions before the iodine, with its distinctive color, appeared at the positive pole, and the metals were reduced, and deposited upon the negative pole.

'After these experiments, it appears,' says Mr. Matteuci, 'that we may affirm with certainty, that these combinations, even when dissolved in water, do not change in their nature, and are not converted, as is often imagined, into muriates, hydriodates, &c. of the oxides of the metals present.—*Id.*

7. *On discolored Chloride of Silver.*—(M. Cavalier.)—Chloride of silver blackened by sun-light is perfectly well known. M. Cavalier obtains it in a similar state by dissolving the recent chloride in ammonia with elevation of temperature, evolution of azote, &c. takes place, and ultimately the liquid becomes turbid, and the chloride of silver appears first as a grey, and then, when the ammonia is entirely decomposed, as a violet precipitate.

This precipitate dissolves entirely in ammonia, and is precipitated in a perfectly white state by pure nitric acid. If twenty grains of it be decomposed by zinc in dilute sulphuric acid, it yields fifteen grains of white chloride. Hence the difference of the chloride in these two states cannot be referred to difference of composition, but solely to some variation in molecular arrangement.—*Id.*

8. *Whewell's written nomenclature for Chemical Compounds.*—Extract from Professor Whewell's Essay on Mineralogical Classification and nomenclature:—Professor Whewell's mode of designating the combinations of chemical elements is different from that of Berzelius and of Beudant, but the alterative seems to be absolutely necessary. According to their method, the first combination of elements into binary compounds is indicated by writing the symbols together, without any connecting sign; as if they were algebraically multiplied: and the number of atoms of each element is denoted by figures written as indices of powers generally are. Thus $\ddot{C}+2\ddot{c}$ they would represent by $\ddot{C}\ddot{c}^2$, and $3\ddot{C}+2\dddot{S}$ by $\ddot{C}^3\,\dddot{S}^2$, &c. Now this notation is in the highest degree inconvenient, besides violating all

symmetry and analogy. For when the substance is indicated by $2\dddot{A}\dddot{S}+\ddot{C}^3\dddot{S}^2$, there is no longer any obvious identity with $2\ddot{A}+3\ddot{C}+4\ddot{S}$, which is the real result of the analysis.

Substance.	*Berzelius' Notation.*	*Whewell's Notation.*
Phos. lime,	$\ddot{C}^3\overset{:\cdot:}{P}^2$	$3\ddot{C}+2\overset{:\cdot:}{P}$
Felspar,	$\ddot{K}\dddot{S}^3+3\dddot{A}\dddot{S}^3$	$(\ddot{K}+3\dddot{S})+3(\dddot{A}+3\dddot{S})$
Alum,	$\ddot{K}\dddot{S}^2+2\dddot{A}\dddot{S}^2+48 \cdot Aq.$	$2\cdot(\dddot{A}+3\dddot{S})+\dddot{K}+2\dddot{S}+48 : Aq.$

Coefficients are, in all cases, used instead of indices.—*Id.*

9. *Preservation of Blood.*—Sugar refiners and others are often inconvenienced by the difficulty of obtaining blood at the time when it is required for use. M. Toursel has endeavored, in part, to remove this difficulty, by proposing a method of preserving this agent for some time without injury. It consists in putting the blood into bottles or other vessels with very narrow mouths, and being careful to fill them up to the neck; a layer of oil, to the depth of at least half an inch, is then put upon it, to cut off communication with the atmosphere, and the whole is left to itself. M. Toursel states that he has in this manner preserved blood, with all its physical and chemical qualities, from the first of December, 1827, to January, 1829.

10. *Presence of Manganese in the Blood.*—(Prof. Wurzer, of Marburg.)—In some analyses of human blood, according to Engelhart's method by liquid tests, Prof. W. was led to suspect that, besides the usual results, he had also obtained a small quantity of manganese; not being, however, quite sure of the correctness of his analyses, he was induced to repeat them in the following manner:—The blood, which had been obtained by venesection, on the day before the experiment was ignited in an open crucible, the incinerated mass oxidized by nitre, and then diluted with water; the residuum was dissolved in muriatic acid, and the iron precipitated from the solution by succinate of ammonia. As the precipitate contained also some phosphate of lime, it was again ignited, and then dissolved in muriatic acid; the phosphate of lime was separated from the solution by alcohol, the excess of the latter expelled by heat, and the iron precipitated by ammonia. By boiling the filtered liquid with carbonate

of soda, the manganese was precipitated, and then dissolved in nitric acid, and again ignited. In two grammes of the coal was found 0.108 oz. of iron, and 0.034 protoxide of manganese.

11. *On the Expansion of Bismuth and its Alloys during congelation.*—(Prof. Marx, of Brunswick.)—Bismuth is known to be a very remarkable instance of apparent exception from the general rule, that fluids contract when becoming solid ; and it corresponds with water in this respect also, that it communicates this property to other bodies, particularly metals, if it forms a certain portion of the alloy. Where the maximum of density lies, and in what degree the volume of the solid metal exceeds that of the fused, has, as far as we know, not yet been ascertained ; but the former is probably very near the point of congelation ; and of the latter, an approximate evaluation may, according to Prof. Marx, be made in the following manner. If a quantity of bismuth be fused in an iron spoon or a glass tube, and then removed from the fire, the mass remains fluid for some time ; it then congeals at the surface, but after the whole seems to be quite solid, all at once a large quantity of globular masses protrude from the surface, which are always proportional to the quantity of the metal employed, and may perhaps serve to determine the quantity of the expansion : this was according to several experiments of Prof. Marx, found to be about $\frac{1}{53}$ of the weight of the whole, and consequently less than a third of the expansion of water. The force with which bismuth expands is so considerable as to break glass tubes in which the fused metal is allowed to cool ; thus, if a thermometer tube is plunged into fused bismuth, and then filled with it by sucking the metal up, it always breaks within a short time, with a loud cracking, and in several directions, but mostly longitudinally, so as to form long parallel glass fibres. For the success of this experiment, it is, however, necessary to make the column of metal long enough, otherwise its longitudinal increase will cancel the expansion.

12. *Bismuth, Tin and Lead.*—The alloy $B^2T^1L^1$, is known for its great fusibility, the point of fusion being below 180° F. On becoming solid, the surface is rather depressed, and the mass seems accordingly to contract ; and in most cases, however, the thermometer tubes burst longitudinally a long time after the mass has become solid. The tin seems accordingly, under these circumstances, to overbalance the equalizing force of lead.

13. *Crystals of Oxalate of Lime in Plants.*—M. Turpin has discovered that the cellules of Cereus Peruvianus contain an immense quantity of crystals of oxalate of lime. He represents them as appearing to the naked eye like very fine glittering sand, and, under the microscope, as rectangular prisms with tetrahedral points, and a square of parallelogrammic base; their size is variable; they are sometimes found collected in groups of three or four, but more commonly forming radiating spheroidal clusters, composed of crystals of various sizes. They existed in such abundance in some parts of the tissue, as to form at least an 80th of the whole mass. The presence of such crystals in the tissue of plants, has lately become well known to botanists, and they are distinguished by the name of raphides. They may be found abundantly, in the form of needles, in the common Hyacinth, and in most succulent Monocotyledons, and in Phytolana decandria they give a kind of silvery appearance to the subticular tissue; but in no plants had they been previously seen so abundantly or so large, as in the plant which forms the subject of M. Turpin's memoir.

14. *To restore the Elasticity of a damaged Feather.*—A feather, when damaged by crumpling, may be perfectly restored by the simple expedient of immersing it in hot water. The feather will thus completely recover its former elasticity, and look as well as it ever did. This fact was accidentally discovered by an amateur ornithologist of Manchester. Receiving, on one occasion, a case of South American birds, he found that the rarest specimen of it was spoilt, from having its tail rumpled in the packing. Whilst lamenting over this mishap, he let the bird fall from his hands into his coffee-cup; he now deemed it completely lost, but, to his agreeable surprise, he found, that after he had laid it by the fire to dry, the plumage of the tail became straight and unruffled, and a valuable specimen was added to his collection.—*Id.*

15. *On the Produce of Gold and Silver in the Russian Empire.*—(Alexander von Humboldt.)—The yearly produce of the Russian gold and silver mines has lately been variously stated; and, as I am afraid that some of these statements may be attributed to me, I take the liberty of giving the following numerical exposition of the fact.

According to official documents, the Russian mines yield annually about 22,000 marks of gold, and 77,000 of silver. In 1828, the produce of gold was 22,256 marks, (318 puds, of which 115 were obtained from imperial, and 203 from private mines;) of silver, 76,498 marks, (1093 puds;) and of platina 6570 marks, (94 puds;) and the respective value was, of gold 4,896,000 Russian dollars, (£700,000 sterling;) and of silver, 1,071,000 dollars, (£153,000 sterling.) The gold mines of Ural yielded in

1826	232 puds.
1827	282 "
1828	291 "

In the first six months of 1829, they gave 142 puds of gold, (46 from imperial, and 96 from private mines,) and 43 puds of platina.

The total produce of the Ural mines, from 1814 to 1828 is 1551 puds of the value of about £3,413,000 sterling; the last five years alone yielded 1247 puds. The annual produce of gold in Europe and in Asiatic Russia, amounts to 26,500 marks of gold, and 292,500 of silver, of which the Russian Empire alone yields 22,200 marks of gold, and 76,500 of silver.—*Id.*

16. *British association for the promotion of science.*—The meeting of men of science which was held at York on the 22nd of Sept., instituted an association whose objects are to give an additional impulse and a systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate science in different parts of the British Empire with one another, and with foreigners,—to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress.

All those who attended the first meeting,—the Fellows and members of chartered societies in any part of the British Empire,—the officers, bearers and members of the council, or managing committee of all philosophical institutions, and other members of such institutions recommended by the council or managing committee thereof, shall be entitled to become members of the association.

The amount of the annual subscription shall be one pound, to be paid in advance upon admission, and the amount of the composition in lieu thereof, five pounds.

The association shall meet annually for one week or longer. The place of each meeting shall be appointed by the general committee at the previous meeting, and the arrangement for it shall be entrusted to the officers appointed at a preceding meeting in concert with the local committees.

The general committee consists of all members present who have communicated any scientific paper to a philosopical society, which paper has been presented in its transactions, or with its concurrence. The members of philosophical institutions, who may be sent as deputies from those institutions to any meeting of the association, shall be members of the committee for that meeting.

Officers elect of the association.

Rev. W. Buckland, D. D. F. R. S., &c. President.

David Brewster, LL. D. F. R. S. Rev. W. Wheewell, F. R. S., &c.	Vice Presidents.
William Gray, Jun. John Phillips, F. G. S., &c. Ch. Daubeny, M. D. F. R. S., &c. Rev. B. Powell, F. R. S., &c. John Robinson, F. R. S., &c. Rev. J. Yates, F. L. S., &c.	Secretaries.

Local committees were appointed for London, Edinburgh, Dublin and India. Professor Airy has undertaken to prepare a report on the state and progress of Astronomy; Dr. Brewster, a similar report on Optics; Prof. Whewell, on Mineralogy; Mr. Johnston, on Chemistry; and Mr. Forbes, on Meteorology.—*Phil. Mag. Nov.* 1831.

17. *Conducting Powers of Liquid Gases.*—(H. T. Kemp.)—By making liquefied sulphurous acid gas a part of the circuit of the galvanic battery of 250 pairs of plates, shocks were received, water was decomposed, and the galvanometer was acted on, as if a continuous metallic communication had existed. Liquid sulphurous acid is therefore an excellent conductor of electricity. Cyanogen, on the contrary, was found to be a perfect non-conductor, even to a voltaic current of 300 pairs of plates. Liquefied chlorine was also found to be a perfect non-conductor of electricy from a battery of 250 pairs of plates. The author then tried liquefied ammoniacal gas, but could not ascertain whether it was a conductor or non-conductor of electricity. It is in all probability a non-conductor.

18. *Power of Carbon to destroy the Bitterness of certain Bodies.*—M. Duburga observed that charcoal destroyed the bitterness of a tincture of gentian root, whilst it had no action on that of the centaury; in consequence of which observation, Dr. Kopff made many experiments on different bitter substances, and found great varieties of action. Each experiment was made with two ounces of distilled

water, twenty grains of bitter extract of the particular plant, and about sixty grains of the recently pulverized charcoal; they were digested at temperatures from 78° to 86° F., and examined at intervals, being compared with similar solutions without the charcoal.

Wormwood, centaury, gentian, quassia, were not changed; orange peel, camomile, yarrow, soapwort, and Iceland moss, lost all their bitterness. Endive, rhubarb, &c. &c. were nearly deprived of their bitterness. When animal charcoal, freed from phosphate of lime, &c., by digestion in muriatic acid, was used in place of vegetable charcoal, similar results were obtained.

19. *Combustion of an Alloy of Tin and Lead.*—(R. W. Fox.)—When tin and lead have been strongly heated together, (in the flame of a blowpipe for instance) the alloy continues ignited a considerable time after it has been removed from the flame, throwing out numerous and brilliant ramifications without cessation, till the whole becomes oxidated, if the quantity be small. The addition of gold does not impede the process, and it appears to be converted into a purple oxide, though I have as yet only slightly examined it. With platinum in combination, the oxidation is more partial, and a porous alloy remains, which is easily pulverised.

The metals may be treated on mica, or any other imperfect conductor, capable of resisting a high temperature. The resulting oxides emit a bright light when acted upon by the blowpipe, owing probably to the presence of the oxide of tin, which yields an intense light, and so does the oxide of zinc; but the white ashes of the burnt leaves of shrubs or trees exceed all other substances, in this respect, that I am acquainted with, not excepting lime.

20. *Vauquelin's Process for obtaining Metallic Chromium.*—The following is his own account of the process. "When attempts are made to obtain chromium from the oxide and carbon, they never succeed well, whatever the heat employed. Chromic acid is reduced with less difficulty, and from 72 parts 24 of metal were obtained. The muriate of chromium is the most favorable substance, and the following, which is the correct process, has not been yet described: Chromate of lead, in very fine powder, is to be digested in four or five times its weight of muriatic acid, until all is dissolved. The liquid is to be evaporated to dryness, the residue digested in alcohol, which dissolves the chloride of chromium; the solution evaporated to

a syrup, and then formed into a ball, with sufficient oil, and, if necessary, a little charcoal. This being put into a crucible lined with charcoal, and that placed in another, containing powdered charcoal, and the whole heated well for about an hour, will yield the metal chromium.

21. *On the Acidification of Iodine by means of Nitric Acid; by* Arthur Connell, Esq. A. M.—The methods which have been hitherto followed for the oxidation of iodine with a view to the formation of iodic acid, may apparently be reduced to three: *first*, The action of alkaline solutions, giving rise to the formation of a hydriodate and an iodate, from the latter of which the iodic acid may be separated by the original method of M. Gay-Lussac, and more perfectly by the recent processes of M. Serullas;* *secondly*, The action of euchlorine, as suggested by Sir H. Davy; and, *thirdly*, The action of water on the perchloride of iodine, and subsequent separation of iodic acid by means of alcohol, as also proposed by M. Serullas.† The agency of nitric acid, under certain management, offers another method, which I have been unable to observe noticed any where, and which, perhaps, will be found to equal in facility of execution any of the preceding processes.

This agency may be advantageously studied on the small scale. If a little iodine be boiled with a small quantity of nitric acid in a common test tube about five inches long, the iodine is dissolved, and a red solution formed. If the liquid be now farther boiled, and the orifice of the tube kept slightly stopped with a piece of cork, the iodine sublimes, and condenses on the sides of the tube. The iodine is then to be washed back again into the liquid by agitation; the liquid again boiled, and the sublimed iodine again washed back into the fluid; and this process is to be continued until no iodine any longer appears, and the liquid is colorless. If the boiling be then continued for a little, so as to increase the concentration of the liquid, it usually becomes milky; and if it be poured out and evaporated to dryness, a white mass is left, which is iodic acid, retaining a little nitric acid.

Having made these observations on the small scale, I proceeded to try the process with larger quantities of the materials, with a view to its employment as a method for the preparation of iodic acid. The

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* Annales de Chimie et de Physique, xliii. 127 and 217. † Ibid. xlv. 63.

vessel I used was a rather large and tall flask, having a narrow orifice. In one trial I used twenty five grains of iodine, and half an ounce measure of fuming nitric acid; and in another, I employed twice these quantities of the materials. After introducing the iodine and acid into the flask, the liquid was made to boil. As soon as any iodine sublimed and condensed on the sides of the vessel, it was washed back again into the liquid by agitation. After the process had been continued some time, a precipitation of white crystalline grains was observed to take place; and the operation of boiling and washing back the sublimed iodine was continued until the free iodine had to a great extent disappeared. The whole was then decanted into a shallow basin, and evaporated to dryness. Any free iodine which had remained was soon dissipated by the heat. The residue of the evaporation consisted of whitish crystalline grains, which were iodic acid, retaining a little nitric acid, from which they appeared to be freed by one or two solutions in water, and re-evaporations, when they lost much of their crystalline appearance, and became a whitish deliquescent mass, occasionally with a slight purplish tint, from a tendency to decomposition by the heat of evaporation.

The general properties of the matter thus obtained, sufficiently identified it with iodic acid. Exposed to a sufficient heat, it was decomposed, and iodine sublimed. Its solution in water gave a precipitate with nitrate of silver, soluble in ammonia. Saturated with potash, it gave by evaporation a salt composed of grouped cubical crystals, and deflagrating on hot charcoal.

The quantity of the acid obtained by this process, of course, must vary, according to the care taken to prevent the dissipation and loss of iodine. Where no particular precautions were taken to prevent its loss in the state of vapor, and where the process was not continued until the entire disappearance of iodine, the quantity of acid obtained approached that of the iodine employed. In operating with the relative proportions of iodine and acid which I have mentioned, I have no doubt that a farther addition of iodine might be made to the liquid, after the acidification of what had been at first introduced; and the process might then be farther continued, as before.

I find, conformably to the observation of M. Serullas, that iodic acid does not attack gold. Its solution seems to have no action on that metal even when aided by heat. It is equally inert in regard to platinum. Zinc is at first attacked by it with effervescence, especially when diluted; but the action ceases almost immediately, apparently from the formation of a sparingly soluble iodate; and when more zinc is added, the liquid becomes milky. No effervescence ensued when iron filings were thrown into the solution of iodic acid, whether concentrated or diluted; but when the liquid was boiled, a white powder precipitated.

The solution of the acid reddened litmus paper permanently. The permanency of the color may possibly be owing to a trace of nitric acid still adhering; as, according to Davy, the acid ultimately bleaches vegetable blues.—*Edin. New Phil. Jour. June*, 1831.

MECHANICAL PHILOSOPHY.

1. *Influence of Electricity in communicating phosphorescence and color;* by Thomas J. Pearsall, Chemical Assistant in the Laboratory of the Royal Institution.—The numerous experiments of the author, conducted with great perseverance, and detailed with much minuteness, prove that those mineral substances which are phosphorescent by heat, and which lose this property by exposure to a very high temperature, will have their phosphorescent powers very much increased, and will regain them after ignition, by the agency of ordinary electricity. The method generally pursued by the author, was to place the fragments in the cavity of a piece of ivory, into which were inserted two wires, and to pass regulated discharges through them from a Leyden jar of about two square feet of coated surface.

Various substances which were not known to be phosphorescent, had the power conferred upon them by the electric discharge.—Among these were statuary marble, calcined ivory, calcined mother of pearl, calcined oyster shells, calcined cuttle-fish bone, calcined scollop shells, chalk, and common egg shells. Some of these exhibited by heat, after electrization, light and color of exquisite delicacy.

The finest effects were from different varieties of fluor, the phosphorescence of which was immediately restored, and the natural power exalted by electricity. Several varieties exhibited a light equal to the finest chlorophane.

Some of the substances were heated and electrified above fifteen times, (the shocks and temperature being very variable and intense) without any deterioration of the phosphoric light.

The number of electrical discharges requisite to restore phosphorescence, varies in different substances. In the green fluor from Cumberland, a single discharge enabled the specimen to shine with a faint purple light when heated, and the effect continued to increase as far as one hundred and sixty discharges.

While all the calcareous minerals may be rendered phosphorescent by the electric discharge, none of the specimens of quartz, siliceous or aluminous minerals that were tried, either possessed naturally or would receive phosphorescence.

Voltaic electricity was tried by the author as a source of phosphorescent power, but without effect.

One conclusion which appears to be deducible from the author's experiments is, that the natural color of fluors, as well as the light which they emit when heated, is dependent on the variations of structure produced by electricity and heat.—*Jour. of Roy. Inst. I.* 267.

2. *Difference in brilliancy of the primary and secondary rainbow.*—(Alfred Ainger.)—The superior brilliancy of the primary bow is not, I think, quite accurately accounted for, when it is ascribed to the circumstance of its rays having suffered but one reflexion; for the double reflexions are made at angles so favorable, as nearly to counterbalance this difference. I apprehend that the faintness in the latter case is owing to the following causes:—

1. That the rays, which suffer the maximum deviation in the primary bow, arrive at the surface at a much smaller angle of incidence than those which suffer the minimum deviation in the secondary bow; the latter, therefore, are more copiously reflected from the first surface, and enter the drop in much smaller quantities.

2. That the angle, at which the ray is afterwards refracted from the inner surface to the air, is, in the secondary bow, similarly favorable to reflexion, and unfavorable to refraction, so that only a small portion of the already reduced quantity of admitted light is refracted.

3. That the extent of the dispersion is increased by the second reflexion, as is shown by the greater width of the secondary bow.

The last circumstance may, perhaps, be considered as included in the expression that the faintness is owing to the second reflexion, though it is not very obvious that such is the meaning.—*Idem.*

3. *On the discharge of a jet of water under water;* by R. W. Fox, Esq.—Having observed that a communication of mine "on the discharge of a jet of water under water" inserted in No. XLVII of the Philosophical Magazine, has been noticed in the last number of the Journal of the Royal Institution, I will take this opportunity of men-

tioning, that when a jet of water is discharged under mercury the results are the same, under a given force, as when it takes place in water or air, the quantity discharged being in all cases the same in the same time. Hence, it appears that the force with which a moving or spouting fluid recoils, is not affected by the surrounding medium, however rare or dense it may be; and thus we may understand why the attempts, which have been made to propel vessels, by forcing water through them against water, have not proved advantageous. The well known fact that large rivers penetrate in a direct course, far into the ocean, notwithstanding its agitation by tides and currents, is somewhat analogous; and were it not for this remarkable degree of mobility in water, the sediment which is now mostly deposited at a considerable distance in the sea, would accumulate near the mouths of rivers and divert them from their courses. Whilst making my experiments on the jet of water, I noticed that where sand was dropped into the water near the orifice from which the jet issued, it was drawn laterally toward the hole, till it distinctly appeared to enter it, but it was in fact only an optical deception, the grains of sand being carried away by the jet, as soon as they come into contact with it, with such great velocity as to be perfectly invisible.—*Idem.*

4. *On the discharge of a jet of water in water.*—It has been proved by Rob. W. and Alfred Fox, Esqs., of Falmouth, that a jet of water discharges the same quantity in water as in air, in a given time, without reference to the depth or motion of the water, at least within certain limits. When the head of water was six feet, the quantities discharged were equal in air, in still watet, and in a rapid stream, and when the jet was turned with the current or against it; and when by lengthening the tube, the aperture was submerged to the depth of fifteen feet, the effect was the same as at the surface, under the pressure of an equal column above it.—*Phil. Mag. and Annals.*

5. *Clement's experiment.*—An easy mode of performing this experiment is this.—Holding the open hand horizontally, with the palm downwards and the fingers close together, apply the lips to the interval between the second and third finger, nearest the roots, and then blowing with force, a strong jet of air will, of course, issue from the aperture at the under side of the hand. Now put a piece of paper or card three or four inches square against that aperture, and again blow; the paper will not be blown away, nor fall by its own weight,

but will be pressed upwards against the hand as long as the current continues. The moment it ceases, the paper falls by its gravity. M. F.—*Jour. of Roy. Inst. I.* 368.

6. *An acoustic rainbow.*—(Poggendorf's Annals.)——Professor Strehlke states that a sounding plate, covered with a layer of water, may be employed to produce a rainbow in a chamber which admits the sun. On drawing the violin bow strongly, so as to produce the strongest possible intensity of tone, numerous drops of water fly perpendicularly, and laterally upwards. The size of the drops is smaller as the tone is higher. The outer and inner rainbows are very beautifully seen in these ascending and descending drops. Each eye sees its appropriate rainbow, and four rainbows are perceived at the same time, particularly if the floor is of a dark color. The square plate was made of brass nine inches in length, and half a line in thickness. The experiment succeeds best if, when a finger is placed under the middle of the plate, and both the angular points at one side are supported, the tone is produced at a point of the opposite side, one fourth of its length from one of its angles. An abundant shower of drops is thus obtained.—*Idem.*

7. *Compression of fluids.*—From a series of experiments on this subject, Prof. Oersted was led to the following results:—

1. The compressibility of fluids up to the pressure of seventy atmospheres, is proportional to the pressure.

2. Up to the pressure of forty eight atmospheres, no perceptible degree of heat was developed in water.

3. The compressibility of quicksilver does but very little exceed the millionth part of its volume for every atmosphere.

4. The compressibility of sulphuric ether is three times as great as that of alcohol, twice that of sulphuret of carbon, and one and a half that of water.

5. Water which contains salts in solution is less compressible than pure water. At 32° F. pure water is by one tenth more compressible than at 55° F.; at higher temperatures its compressibility also decreases, though not to such an extent as between 32° and 55°.

6. The compressibility of glass is very small, much less than that of quicksilver.

Mr. Perkins found the compressibility of water more than double that resulting from Mr. Oersted's experiments; a difference which, according to Mr. Oersted, must be accounted for by the circumstance, that in Mr. Perkin's experiments, the compression was produced by percussion, the force of which cannot be calculated.—*Idem.*

8. *Proportion between the metre and English yard.*—M. Francœur, in an elaborate memoir "on the proportion between French and English measure" has found that the metre is equal to 39.37079 English inches, and the English imperial yard equal to $0^m.91438348$ numbers which may be relied on with the utmost confidence.

9. *Dip of the magnetic needle at St. Petersburgh.*

Observed by M. Hansteen in June 1828,	71° 17.3′
By M. de Humboldt, (applying an instrumental correction) in May 1829, - - - - - -	71° 14.5′
By M. de Humboldt in December 1829, -	71° 11.5′
" M. Kupffer in May, 1830. - - - -	71° 11.3′

It would appear from these observations, that the annual decrease of the dip at St. Petersburgh is about 3′.

NATURAL HISTORY.

On habits of cleanliness in birds; by W. Ainsworth.—It is a fact, not generally known, that the claws of birds are used as combs to rid the plumage of vermin; whence birds which have short legs are most infested by insects. The expedients, which birds, characterized by short feet,—the waders which, from the inflexible nature of their legs, and the geese tribe, from the opposition to scratching, offered by the membrane between the toes, are put to, in order to get rid of their vermin, are well dserving of attention, as illustrating the ingenuity of animals, and the curious provisions made by nature for their cleanliness. When birds, by accident or imprisonment, are deprived of the natural means of ridding themselves of vermin, they often fall victims to their attacks. The author, walking on the coast of Northumberland, disturbed a bird which flew heedlessly, as if injured. On shooting it, he found it was covered with vermin, especially about the head, and on further examination ascertained that it had lost one leg, and was thus deprived of the means of ridding itself of these insects. A nest of young swallows had been hatched and they had attained considerable size when a change was made in the window, which frightened the parents; from that time they continued to feed their offspring, but never entered the nest. The young ones soon became sick and perished, and on examination the nest was found to be crowded with acari of large size.

Poultry which run about in stony or paved yards, wear away the points of their claws by friction and digging, which renders them unfit to penetrate their coating of feathers; they are, therefore, more covered with vermin, and in consequence more sickly than fowls from the country.—*Jour. of Roy. Inst. Feb.* 1831.

NOTICES AND COMMUNICATIONS.

1. *Copper Ore of Strafford, Vt. &c.*, extracted from a letter to Mr. C. U. Shepard, from Mr. Richardson of Franconia, N. H. Sept. 26, 1831.

I have not any thing new to write respecting my works—the magnetic machine* continues to answer a valuable purpose. Mr. Browning has recently put one of his machines in operation, in Peru, which brings into use an ore bed that was before worthless. I am making about the same quantity of iron that I have been, say two tons per week—and also at the lower works, every thing goes on as it did when you was here.

The copper mine at Strafford, is owned by the Vermont Mineral Company, to which company the copperas works also belong. The copper is in the same hill with the copperas ore, called Mount Prospect or Copperas hill. They have driven a drift into the hill horizontally, to the distance of three hundred and thirteen feet, with a very slight inclination, just sufficient to admit the running off of the water, and a fathom in height and width—at the termination of this distance is excavated a large chamber, say forty feet in diameter by fifteen feet in height, and from this chamber proceed six other drifts of twelve, eighteen, twenty five, thirty, fifty and sixty feet in length. The copper ore is promiscuously connected with copperas ore, and the vein of copperas ore in which copper is found, is at seventy feet in width; from the chamber above alluded to, there is a perpendicular air shaft one hundred feet in height to the surface of the hill—there are twelve miners at work, all of whom blast by the contract, so much a cubic fathom—the ore after it is blasted is taken out of the mine in a car working on a rail road laid the whole distance of the main drift, and when arriving at the mouth of the mine, the copper

* See Vol. XVIII, p. 289, of this Journal.

ore is sorted from the copperas ore, by men with hammers—the copper ore appears to be in abundance, yet it bears but a small proportion to the copperas ore with which it is connected; after being sorted from the copperas ore, it is piled in heaps of from eighty to one hundred tons on a layer of wood and charcoal; the wood and coal are then set on fire, and owing to the sulphur contained in the ore, the whole becomes readily ignited, and in this manner it is allowed to roast for about one month. It is then taken to the smelting furnaces, of which they have two in operation, and are building two more, the whole about one mile from the mine. Here the ore passes through three operations of smelting—the first does not produce any copper; what runs out of the furnace is broken up and passes through a second process of roasting, and is again smelted, which produces some copper—the slag is again broken up and roasted as before—the third operation of smelting obtains all the copper except about half per cent. which remains in the slag, and this slag is thrown away. The ore has yielded thus far about ten per cent. The fuel is charcoal.

2. *Scientific names of certain plants.*

Philadelphia, Oct. 31, 1831.

To the Editor.—*Dear Sir*—I annex the popular names of several plants, natives of the United States, with the view of asking the favor of some of your botanical correspondents to furnish their scientific appellations.

1. Physic Root, or Indian Olive of the South.
2. Tallow Nut of the South.
3. Emetic Bean of Louisiana.
4. Beaver Root.
5. Silver Root.
6. Abelo, or Trumpet Weed.
7. Blue Paint Root.
8. Alexanders, an umbelliferous plant.
9. Snakebite, or Saceahjara of the West.
10. Shittim Wood of Canada.
11. Yellow Root. Schinga of the Indians; vernal yellow blossoms, like those of Blood Root.
12. Jestis Weed of South Carolina; said to be a certain remedy for bites of rattlesnakes, according to Mr. Haynesworth of Santee Hills. See Barton's Medical and Physical Journal, Vol. III, p. 57, for proofs of its powers. J. Mease.

3. *Graduation of the Mohawk and Hudson Rail Road;* communicated by S. DeWitt Bloodgood, of Albany.—The account which was published in the last number of this Journal, of the Hudson and Mohawk Rail Road, was intended as a popular illustration of an important subject, rather than a minutely accurate description of all its parts. In consequence, the character of the graduation of the road, was, among other things given only in general terms.

The annexed profile* is accurately drawn, on a horizontal scale of 200 chains to an inch, and on a vertical scale of 800 feet to an inch, and is furnished by Mr. Jervis, with his usual kindness.

Graduation of Mohawk and Hudson Rail Road.
Horizontal scale, 200 chains to an inch.
Vertical do. 800 feet do. do.

1. From the Canal to the foot of the inclined plane, is 26 chains—level.

2. Inclined plane, ascent 1 foot in 18—31 chains. Total rise, 115 feet.

3. Level, 3 miles 42 chains.

4. Descent, 1 in 450—2 miles 11 chains, fall 25 feet.

5. Level, 1 mile 40 chains.

6. Descent to centre of road, 1 in 225—1 mile 53 chains, fall 62.50.

7. Level, 1 mile 7 chains.

8. Descent, 1 in 270—3 miles 12 chains, fall 61.50.

9. Level to inclined plane, 3 chains.

10. Inclined plane, descent 1 in 18—51 chains, 185.01 feet.

11. Foot of plane to Hudson river, 12 chains.

The total length is 14 miles 48 chains.

Since the setting in of winter, the locomotive engines have been withdrawn, and horses are used to drag the cars over the road. The wheels of the engines were found to slip during the very cold weather, but the snow that fell,

* Reduced one half, to bring it within the page.—*Ed.*

had very little effect upon the road. From the manner in which the blocks are surrounded by the broken stone, which has, during the late season been carefully placed along the line of the rails in large quantities, it is presumed that the action of the frost will be successfully resisted.

4. *Notice of Inflammable Gas issuing from water pipes in New-York;* by Wm. N. Blakeman.

New York, Oct. 8th, 1831.

To the editor.—*Sir,*—I have just observed what to me appeared a phenomenon which may be worthy of your notice. It occurred at the corner of Bedford and Carmine streets in this city. The corporation are laying down pipes for the conveyance of water about the city to extinguish fires; the pipes are about ten inches in diameter, and extended from the fountain at the junction of the Bowery and Thirteenth streets, at which place they were filled with water from the fountain by means of a steam engine, which raised the water from below the surface. The distance is about one mile from Bedford street, one half of the distance was filled with water, the other with air; at the end was a stop cock, on the side is an orifice, to which was attached a piece of hose with pipe, the orifice of which was about one half inch in diameter.

When the water was let into the pipes, the air began to rush out at the small orifice in the pipe attached to the hose, with a noise resembling the letting off of steam from a boiler; after a few moments, a blue flame was to be seen issuing from the tube which continued for fifteen minutes, about three inches in diameter and two feet in length. The sun's rays were at the time partially obscured by passing clouds. After the air had all passed out, the water followed with a force sufficient to elevate it to a height of about fifty feet. The quantity of air imprisoned, was about one half mile in length, and ten inches in diameter.

5. *Remarks on the Fine Arts; by* Prof. Gimbrede *of the Military Academy, West Point; abridged from a lecture delivered to the Cadets.*—Volumes have been written, to describe many of the rare productions of genius in the fine arts.

It is my task to direct your efforts, in selecting from nature, some of the best forms for imitation; and while engaged in the performance of this duty, I shall, I trust, virtually prove the necessity of establishing this department in all the public seminaries in this Union. The elements of the graphic art were furnished to man by his maker, and consequently if we cultivate the imitative arts, we obey a natural law. Man, in his primitive state, surrounded by innumerable and dissimilar forms, and possessing only a limited language, soon found that he was unable fully to pourtray the vivid impressions made on his faculties; but by availing himself of the *straight* and *curve* line, he was able to represent every thing, living or material. Thus, man, as by a new creation, multiplies resemblances of all he sees or admires on the globe, and joyfully discovers that with *two lines* he can give apparent life and animation. If any acquirement is capable of elevating the character of man, or of making him proud of his profession, it is that, which by such simple means, can produce such effects.

Natural History, *Botany*, *Mineralogy*, the art of writing, *music* and many other arts cannot, at this day, be taught, successfully, without borrowing the *two lines of Nature.* Even mathematics, in their best and most useful applications, would be unintelligible without a previous knowledge and use of the *straight* and *curve* line. In delineating, in circumscribed space, the forms, position and dimensions of bodies; in linear perspective; in descriptive geometry; in optics, &c., the general properties of lines and angles are employed; and in surgery thousands are saved by an exact knowledge of anatomy, enlightened by correct drawings of every part of the complicated structure of our frame. If it were possible to obliterate from the memory of man, all he has acquired, or invented by his graphic powers, we should bring him back to the age of ignorance and barbarism. While, therefore, contemplating the magnificent and beautiful works of the creator, let us be thankful for the enjoyments which they thus afford, especially by the aid of an art, which has furnished such proofs of the genius of man, and operated both as a cause and effect of his civilization. Can we then any longer give these arts the slighting name of an *accomplishment?*

What models shall we select, to improve our graphic faculties, and to form our taste? Two distinct classes of objects naturally present themselves to us; *regular* and *irregular*. Among the many regular forms, the figure of *man* stands the most conspicuous, for beauty and symmetry and for intellectual expression. In the attempt to delineate such a difficult subject, correct principles and well selected rules will enable the pupil to establish a perfect harmony betwixt the eye and hand, *the faithful messengers of the mind*—and to enrich the memory with the best combination of lines and contour. Then it may be said that we are best prepared to apply our graphic knowledge to many of the pursuits and occupations of life. The contrary effects would be produced by the selection of *irregular forms*. Such as in *foreground*, and distances in landscape, where thousands of forms being invisible to the eye, we can only attempt to sketch a few; as, for instance, the ever moving clouds, *cracks* and *appearances* in large masses of rocks, the variety of plants and foliage, the forms and number of trees, &c. This characteristic looseness of style in drawing forever prevents the eye and hand from being correct. Consequently the best schools of Europe have selected the *human* figure as the best model to perfect our graphic faculties, our taste and coup d'œil.

Michael Angelo in speaking of this last property, has said that "a good drafts-man always carries a *pair of dividers in his eyes*." *Finally*, in this country, having no large armies to support, all its citizens could be prepared, in time of peace, in the "*science of war*." The character of modern warfare depends no longer for its success, as in former ages, on strength of body and personal courage; it is united with many scientific principles and applications; as in the construction of arms, of redoubts and of fortreses, combined with systematical means of attack and defence. By the aid of a good draftsman furnishing an exact configuration of the grounds on which forces are to act, a small army may be able sometimes to resist a powerful one.

By cultivating, therefore, science and the arts, and maintaining the majesty of the laws, we shall, in this favored land, lay the surest foundation of national *honor* and *glory*.

LITERARY NOTICES.

1. *American Translation of Cuvier's Règne Animal.* G. & C. & H. Carvill: New York.—Dr. McMurtrie is entitled to the thanks of the cultivators of Natural History, for his very faithful and able translation of this most perfect system of zoology; in which the entire circle of sentient beings is arranged according to their organization and essential resemblances. The publication of the present work, we are confident, will form an era in this country, as respects the popularity of this department of knowledge. The American edition is handsomely printed, in four large 8vo. volumes, of about five hundred pa-

ges each, with numerous engravings, and is afforded at a price so low as to render it worthy of being held up as an example to the *trade.*

2. *Prof. Eaton's Geological Text-Book.*—We understand that a new edition of this work will be published in March, and that the enlarged system of American Geology which was announced, (Vol. xiv, p. 400, of this Journal,) is for the present relinquished.

3. *American edition of Prof. Lindley's Introduction to the Natural System of Botany,* one volume 8vo. G. C. & H. Carvill: N. Y.—This is not merely a reprint of this invaluable work, but its value is greatly enhanced by the additions of Dr. Torrey, which consist of *an outline of the first principles of Botany,* (that had been published by Prof. L. in a separate form,) and an appendix of his own, containing a catalogue of the North American genera, arranged according to the order in the text, with the number of species belonging to each genus, as far as they are at present determined, besides several tables exhibiting the relative proportions of the different families, and an index.

4. *Elementary Work on Conchology.*—We understand that a Professor in one of our colleges, well known for his attainments in this branch, will publish, in the course of a few months, a work intended expressly for learners; in which the improved, modern arrangement in this science will be presented, accompanied with descriptions of American Shells, and whatever is requisite in the way of a glossary, and of engravings, for the illustration of the subject generally.

5. *Conrad's Marine Conchology.*—The 2d No. of this beautiful work was published in September, and contains figures and descriptions of two species of *Lima,* three species of *Solecurtus* and two of *Solen.*

6. *New Work on Mineralogy.*—Mr. Howe, of this city, has in press, Part the first of a new Treatise on Mineralogy, by Mr. C. U. Shepard. It will be confined to the developement of the first principles of the science, as a branch of Natural History; to the elucidation of the geometrical relations of crystals, and of the natural properties in general; and to the proposal of an artificial method, or a series of analytical tables, for the determination of minerals, found-

ed upon the natural properties of form, specific gravity, hardness and lustre.

7. *The Journal of a Naturalist.* Philadelphia: Carey & Lea: 1831.—This small volume of scientific literature comprises much valuable knowledge, and rational entertainment. The observations shew the curious taste, and the discriminating researches of a keen and practised naturalist. While he discourses of most objects which fall under the eye of one engaged in rural concerns, he avoids the classifications and technicalities, which render science repulsive to the merely general reader; and treats the various topics in a language which, although occasionally quaint and careless, is yet intelligible to the learner, and acceptable to the scholar.

There is an enthusiasm which compensates the student of nature for the toils and dangers of scaling mountains—descending into mines—inhaling pestiferous gases—examining volcanoes—and investigating the mysteries of animal and vegetable life. The writer of "the Journal of a Naturalist" enjoys this exulting pleasure, and his admiration of the wonders and beauties of the creation, not unfrequently rise to sublime conceptions of the Creator.

Nor is the book deficient in practical information. In giving directions for producing a permanent *green* color, he says, "The power of the sun's rays in augmenting the intensity of the hues of many things is well known. There is an admirable color for foliage to be obtained from the union of light Prussian blue with dark Gamboge; but I could never acquire this clear and lustrous, without compounding it in the light of the sun. As the young artist will find this a most useful pigment, I may in addition say that a small bit of the light Prussian blue, with three or four times the quantity of Gamboge, must be laid on the pallet or saucer, and with a few drops of water, only enough to make it work easily, be most thoroughly united and incorporated by the finger, *with the sun shining upon the mixture*, adding more Gamboge repeatedly during the operation, until the blue is subdued, and a clear green produced. It is a tedious operation, yet perseverance will ultimately produce a very brilliant permanent green." The union of Prussian blue and Gamboge, in the common way, though bright at first, soon turns brown after it is used.

The work does not purport to be a treatise, but merely miscellaneous notices, commencing with soils and husbandry, and proceeding thence to botany, ornithology and entomology, recording many facts, and replete with moral and scientific instruction.

8. *Chancellor Kent's address before the society of* Φ B K *of Yale College*, delivered Sept. 13, 1831.—It was a circumstance of singular interest that the venerable and celebrated author delivered an address, at the commencement anniversary, just fifty years before, and that he was one of the first founders of the Φ B K society in Yale College. Of his class, consisting, originally, of twenty seven members, twelve still survive, after the lapse of half a century from the time of their being graduated at Yale College, and eight of these attended the commencement of 1831 in that institution, and dined in company at the house of one of their number, the Hon. Simeon Baldwin. Under such circumstances, it is not surprising that the speaker felt, warmly, the inspiration of the place and occasion, and it is impossible to read the address without feeling it too.

It is quite enough to say that it is every way worthy of its distinguished author, in whom youth and age combine their peculiar traits of warmth and wisdom. This address is learned, glowing and eloquent, full of delightful reminiscences of distinguished men, and of years gone by; a high example of the "severe simplicity" which it recommends, and a powerful appeal in favor of good learning of every kind and of elevated christian virtue. Chancellor Kent fully sustains the peculiar claims both of classical and scientific education; he would neither impair nor relinquish either of them, and the profound jurist and mature scholar evinces that he is not indifferent to, or ignorant of the discoveries and improvements in physical science, with which this age so much abounds. It is remarkable that this address, which held the audience in the most interested and delighted attention, appears, if possible, still better on an attentive perusal. Its gems are set in burnished gold, and both appear more splendid and valuable the more they are scrutinized.

The author, is one of his country's most estimable and admired ornaments, and in literature and jurisprudence, his name has become identified with our national honor.

Remark.—Absorbing engagements in public duty and other causes beyond his control, have prevented the Editor from examining several works on Chemistry and other subjects, which have been received from their authors or publishers.

APPENDIX.

Experiments on the Disinfecting Powers of Increased Temperatures, with a view to the suggestion of a substitute for Quarantine; by* William Henry, M. D. F.R.S. &c.

To the Editors of the Philosophical Magazine and Annals.

Manchester, Oct. 14, 1831.

Gentlemen—Several years have elapsed since I was requested, by an eminent merchant of this town† extensively concerned in the importation of Egyptian cotton, to take into consideration, whether any effectual method could be devised of guarding against the introduction of the Plague into this country by means of that raw material, without incurring the serious commercial sacrifices, which then attended the enforcement of the quarantine laws on large cargoes of that article.‡ Chlorine might have been proposed for the purpose; but it was evidently inapplicable, not only on account of its chemical activity on vegetable substances, but of the necessity of washing and drying the cotton, in order to free it from any adhering portions of that powerful agent, the smallest remains of which would be injurious to the spinning machinery. In proposing any new method of destroying contagious matter, it was represented to me as quite essential that it should be incapable of impairing, by its chemical action, the tenacity of the fibre, as this would unfit the raw material for the operations through which it has subsequently to pass.

By this restriction, the ground for experiment was considerably narrowed; and after giving much attention to the subject, no means occurred to me of effecting the object in view, but that of applying to the raw cotton such a degree of heat as, while it should do no injury to the staple of the article, might yet be sufficient for the destruction of any contagious virus which it might have imbibed.

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* A revised copy of Dr. Henry's paper having been just received, (Dec. 28, 1831,) from the author, with additional remarks in the form of notes, the whole is now printed, instead of an abstract of the original paper by Mr. Griscom, which was already in type.—*Ed.*

† William Garnett, Esq.

‡ The evils of quarantine are much greater than is generally supposed. Cargoes of cotton, from the Mediterranean, have been detained three months at Milford Haven, to the great injury of the owners. Nor is the evil compensated by any security whatsoever, for the cotton is not unpacked, as it is at the lazarettoes on the continent of Europe.

That the contagion of the plague, supposing it to be present in the state of *fomites*,* might be rendered innoxious by a temperature below that of boiling water, appeared to me not improbable, from the evidence of a fact recorded by various writers; viz. that the plague, in countries where it prevails, ceases as soon as the weather becomes very hot. "Extreme heat," says Dr. Russell in his Natural History of Aleppo, (vol. ii, p. 339,) "seems to check the progress of the distemper; for though the contagion and the mortality increased during the first heats in the beginning of the summer, a few days continuance of the hot weather diminished the number of new infections. July is a hotter month than June; and the season, wherein the plague always ceases at Aleppo, is that in which the heats are most excessive." In another part (p. 284) of the same volume, Dr. Russell states the greatest heat at Aleppo in June to have been 96° of Fahrenheit, and that of July 101°, in the shade.

Arguments, also, derived from chemical reasoning, appeared to me to strengthen the probability that a temperature, raised to no great extent, would suffice for the decomposition of infectious or contagious matter.† Of the nature of contagion we are, it is true, entirely ignorant. But we are entitled to conclude that it is in no case identical with any one of the simple or compound gases, with which chemistry has made us acquainted, and which are unchanged by a temperature below 212°; because each of those gases has been breathed, many of them very frequently, without exciting a specific disease. The subtile poisons which propagate contagious distempers, being the products of organic life and of morbid conditions of the animal body, are, it is probable, of a complex nature, and owe their existence to affinities which are nicely balanced and easily disturbed; even more easily than those maintaining some of the products of vegetable life, which lose their original properties, and acquire new ones, when exposed to temperatures of no great amount. Thus, starch is convert-

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* *Fomites* (the plural of *fomes*, fuel) expresses contagious or infectious matter existing in absorbent substances, such as wool, clothing, &c. In this state of confinement, it seems to acquire increased virulence and activity.

† I use the terms 'infection' and 'contagion' as synonymous, because no sufficient distinction has been established between them. It would be unseasonable to enter, in this place, into a disquisition about words; but those who take an interest in the verbal part of the subject, will find an excellent view of it (pointed out to me by my son, Dr. Charles Henry) in the *Dictionnaire de Médecine*, art. *Contagion*, vol. v, p. 549. Paris: 1822.

ed, by a moderate heat, into a substance somewhat resembling gum; and, by weak chemical agents, into sugar. Among inorganic compounds, we have a remarkable instance of the effects of heat, (raised however to a higher degree,) in the change of *phosphoric* into *pyrophosphoric acid.* In most cases of this kind, it is probable that increased heat produces no change, either in the *number* or *proportions* of the atoms of the substances; but that, in some way which chemical science has not yet prepared us to explain, it modifies only the *arrangement* of the atoms, and thus confers new distinctive characters.

In pursuing the inquiry experimentally, two circumstances seemed to me to require to be established.

1st, That raw cotton, and other substances likely to harbor contagion, would sustain no injury by the temperature conceived to be necessary for their disinfection.

2dly, That in at least some one unequivocal instance, contagious or infectious matter should be proved, by actual experiment, to be destructible at that temperature.

I. To ascertain the first point, I submitted, in August, 1824, a quantity of raw cotton to a dry temperature* of 190° Fahrenheit, which was steadily kept up in the inner compartment of a double vessel heated by steam, during two hours. When the staple of the cotton was examined by Mr. Garnett, he pronounced it to be so essentially injured, as to set at rest, on a first view, all intentions of adopting this method of purification. The same unpromising appearance was presented also by cotton yarn, which, after being spun, had been heated during two hours at 190° Fahrenheit. After being allowed to cool during a quarter of an hour, it was compared with yarn of the same fineness which had not been heated, with the following result:

	lbs. avoird.
A hank of mule twist (40 to the pound) not heated, required a weight, to break it, of - - - - - -	$246\frac{1}{4}$
A hank of ditto, ditto, heated to 190° and just cooled, -	$166\frac{3}{8}$

The strength of the yarn, measured by its power of supporting weights, had therefore suffered a diminution, by being heated, of fully one-third. The remainder of the yarn so heated having been laid aside in a cellar, was accidentally examined on the fourth day,

* I use the expression *dry temperature*, in order that it may be distinctly understood, that the cotton was not in contact with steam, which was used merely as the vehicle of heat.

and had undergone an obvious alteration, which led to a renewed trial of its strength. It was now found that a hank of the same yarn supported a weight of 241¼ pounds, and it had therefore recovered very nearly its original tenacity.

At this period I was obliged, by unavoidable circumstances, to abandon the inquiry; and the inducement to resume it ceased in a great measure to exist, in consequence of the discontinuance, for a season, of the pressing inconvenience which had given birth to it. It was only recently that my attention was recalled to the subject by the well grounded alarm which has overspread the continent of Europe, and in a less degree extended over this country, in consequence of the devastating effects of a disease, (*cholera*,) the contagious nature of which is rendered highly probable, and which, like other contagious diseases, may be presumed to be capable of being conveyed by *fomites*.* It is therefore of the greatest importance to devise effectual and easily practicable means of extinguishing the first sparks of that distemper which may show themselves in this country, avoiding at the same time greater injury than is necessary to individual interests or to general commercial prosperity.

The first step which appeared to me desirable, on resuming the investigation, was to decide, beyond all doubt, whether raw materials, as well as manufactured goods and articles of clothing, could be exposed without injury to a dry heat approaching 212°. Of raw materials, I took cotton as the one which, from local advantages, I could best submit to the necessary trials; and I had the benefit of the zealous assistance of a friend† engaged in the spinning branch of that manufacture. Raw cotton, of ordinary dryness, as recently taken from the bag, was exposed, during two or three hours, to a steady temperature of 180° Fahrenheit, in a vessel heated by steam of common density. It lost, generally, between two and three ounces from the pound. The effect on the staple, as determined by the inspection of persons versed in the article, was apparently such a degree of injury, as to forbid all expectation that the cotton could be rendered

* Whether cholera be or be not contagious, I do not feel myself called upon to discuss; the question being still one of great uncertainty and difficulty. From all the facts, with which I am acquainted, it appears to me probable, that the contagion of cholera (if such be the character of the disease) requires, like some other contagions, the concurrence of particular states of the atmosphere. If the question should be decided in the negative, so far as respects cholera, the suggestions of this paper will still apply to other ascertained contagions.

† Peter Ewart, Jun. Esq.

useful. It was pronounced to be rotten, and what is technically called '*fuzzy*,' and to be unfit even for those operations which are preparatory to its being spun into yarn. After being left, however, during two or three days, in a room without fire, a great change had taken place in its appearance, and it was found on trial to be as capable of being spun into perfect yarn, as cotton employed in the ordinary manner. On an accurate trial of the twist which had been spun from it, a hank supported fully an equal weight with a hank of the same fineness spun from cotton fresh from the bag. This fact, established by repeated experiment, proves that with the recovery of its hygrometrical moisture, cotton, which has been heated, regains its tenacity, and becomes as fit as ever for being applied to manufacturing purposes.

Articles of cotton, silk, and wool, after being manufactured, both separately and in a mixed state, into piece goods, for clothing, were next submitted to the same treatment. Among them were several fabrics, which were purposely chosen, of the most fugitive colors and delicate textures. After being exposed three hours to a temperature of 180°, and then left a few hours in a room without fire, they were pronounced, by an excellent judge of the articles who furnished the specimens, to be perfectly uninjured in every respect. Furs and feathers, similarly heated, underwent no change; and there can be no doubt that if the apparatus had enabled me conveniently to have raised steam of increased density, a temperature above 212° Fahrenheit would have done no injury to the delicate and costly articles submitted to it.*

II. The most important point to be ascertained, and that on which the utility of the inquiry hinges, is whether a temperature below 212° Fahrenheit is capable of destroying the contagion of *fomites*. The investigation is one of great nicety, and involves considerable difficulties. It was entirely out of my power to try the agency of heat on those contagions which propagate the formidable diseases of cholera, plague, scarlatina, typhus, &c. The only way, in which I could arrive at an analogical inference respecting the decomposing power of heat over such contagions, was by determining its effect on some

* I have since found that most of those fabrics may be raised to nearly 300° Fahrenheit, without injury to their texture. Some delicate colors, however, especially greens, are then injured. Writing paper begins to turn brown a little below that temperature; but the ink is not defaced, as it is by the disinfecting agents applied to letters, which reach this country from infected places abroad, and which are often scarcely legible.

kind of infectious matter which assumes a tangible form, and can in that form be submitted to experiments; and which admits also of being afterwards tested by justifiable trials on healthy persons. Nothing presented itself to me, on consideration, so well adapted to fulfil all these conditions, as the matter of cow-pock. On mentioning my views to Mr. Roberton, one of the surgeons of the Manchester Lying-in Hospital, he obligingly supplied me with vaccine lymph, taken from pustules of unequivocal character; and after the lymph had been subjected to high temperatures, he directed the insertion of it to be made, in the usual way, into the arms of healthy children. The trials were conducted, and the results registered, by Mr. Gee, the House-Apothecary of the Hospital.

1. Vaccine lymph, dried at the temperature of the atmosphere on small bits of window-glass, was exposed to a heat of 180° Fahrenheit during four hours. Three healthy children of proper age were inoculated with this matter without any effect; but being afterwards vaccinated with fresh matter, they all took the disease.

2. Lymph heated, during the same period, at a temperature varying from 120° to 140°, generally 130°, was inserted without effect into the arms of two healthy children, who were afterwards successfully vaccinated with recent matter.

3. Four pieces of window glass, on which recent vaccine lymph was placed, were heated during intervals varying from two to three hours, at a temperature never below 160°, nor above 165° Fahrenheit. The trials were judiciously varied by Mr. Gee, by inserting each specimen of the matter which had been dried, into one arm only of a healthy child; while into the other arm of the same child recent matter was inserted. In every instance, the heated matter proved inefficient; while the matter which had been dried at the temperature of the atmosphere produced a satisfactory pustule.

4. For the sake of obtaining a sufficient number of instances, I requested Mr. Marshden, House-Surgeon of the Manchester Royal Infirmary, to make trial of some genuine vaccine lymph which I had received from him, and had then submitted to heat. One specimen had been placed two hours in a steady temperature of 150°; a second four hours in the same temperature; a third two hours, and the fourth four hours, in the temperature of 172°. In no one instance, did any of these specimens, when inserted in the usual manner, produce the vaccine pustule.

5. Descending in the scale of temperature, another portion of vaccine lymph was exposed to an uniform heat of only 120° Fahrenheit

for three hours. Two children, inoculated by Mr. Gee with this matter, received the infection, and the pustules were, in each case, remarkably well characterized. From their arms matter was taken, with which upwards of forty children have been vaccinated, who have gone through the disease in the most satisfactory manner.

It may be considered, then, as established by the experiments which have been related,—1st. That vaccine matter is not destroyed by a temperature of 120° Fahrenheit; and it is even probable that it would sustain, without losing its efficiency, a heat several degrees higher;—2ndly, That vaccine lymph is rendered totally inert by exposure to a temperature of 140° Fahrenheit. May we not hence infer, that those subtile animal poisons which lie dormant in the state of *fomites*, are likely to be disarmed of their terrors by the same simple means? The expectation, I am aware, rests entirely on analogy; but the analogy appears to me sufficiently strong to render it desirable that it should become the parent of experiments. It is with that view only that I propose it to the enlightened physicians of this and other countries, who have the means of verifying or disproving the inference by experiments on the more diffusible and active contagions. Until, indeed, the soundness of the analogy has been established by a sufficient number of facts of the latter class, no extensive practical measures can safely be grounded upon it.

If a favorable result should, however, issue from these suggestions, nothing can be more easy or less expensive in construction, or more manageable in use, than an apparatus for subjecting articles inported from unclean places, in any quantity, however large, to the disinfecting agency of a dry heat, without even the slightest injury to the quality of those substances. A double vessel, made of copper, or of tinned or cast iron, of any convenient shape, with a sufficient space between the two vessels for containing steam, and an interior cavity of due size for a receptacle of the articles to be disinfected, is the essential part of the arrangement. To avoid all risk of the escape of any portion of the virus in an undecomposed, and therefore active state, a pipe, open at each extremity, may be carried from the receptacle into the flue of the chimney, or, better still, into the fire-place under the boiler, which will ensure the destruction of the contagious effluvia. The articles should be introduced into the receptacle, not closely packed, but so opened out, that every part of them may be exposed to the necessary temperature. If injury should be apprehended from over-drying any substance, a small quantity of steam may be suffered to pass through a pipe from the boiler into the receptacle. At every sea-port to which ships are bound with unclean bills of health, an apparatus of this kind should be provided, on a scale sufficient for the emergency. And on the Continent, similar provision should be made, at every barrier which is destined to prevent the introduction of contagious diseases.*

It must be obvious that these precautions offer no security against the danger of a contagious disease breaking out in a person who has already been exposed to infection, but in whom symptoms of the disease have not yet manifested themselves. Risks from this source constitute, however, a very small proportion, compared with those arising from *fomites;* and they may be easily and effectually guarded against, by insulating the person supposed to be infected, for a period of time exceeding that, during which the seeds of the disease have been ascertained to lie dormant in the animal system. Nor is this proposal meant to supersede the employment of chemical disinfectants, especially of preparations of chlorine, in the apartments of the sick; or their application to articles and fabrics which sustain no injury by exposure to those agents.

I am, Gentlemen, your obedient servant, William Henry.

Notice of the Volcanic Island thrown up between Pantellaria and Sciacca. By William Ainsworth, Esq., M. R. S. L., Member of the Royal Geographical Society, &c.

[From the Magazine of Natural History, &c.]

The ejection of volcanic masses, or the elevation of the strata of the earth above the level of the soil or sea by natural causes, is of importance, remotely to all theories of the earth, and proximately to the true origin and formation of pseudo and active volcanic rocks and of craters of elevation.

This branch of geological inquiry has received a new impulse from the late researches of De Buch and Elie Beaumont, and every circumstance which tends to give consistency to opinions more or less theoretically deduced is advantageous to science.

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* No importance is annexed by the writer to any particular form of apparatus; nor is steam preferred, as the vehicle of heat, for any other reason, than that it affords an effectual security against such a temperature as would be injurious to the substances intended to be disinfected. If, in the further progress of inquiry, it should be found that any kind of contagion requires a heat not greatly above 212° Fahrenheit, it may easily be attained, (the articles being still secure from damage) by using steam of higher pressure than that of the atmosphere.

The elevation of Graham Island, in lat. 37° 11′ N., and long. 12° 44′ E., in the Mediterranean Sea, between Pantellaria and Sciacca, which took place in the month of July, 1831, has been observed at different stages of its progress, and has been attended with phenomena of such decided utility to this inquiry, that they will be my excuse for intruding upon your pages some remarks connected with its origin and general character.

The drawings which accompany this notice are from the pencil of Mr. W. Russell, of His Majesty's Ship St. Vincent, and are facsimiles of the drawings sent by the same gentleman to His Royal Highness the Duke of Sussex, and since published by Ackermann; and of those transmitted to the Admiralty, and published in the *Journal of the Royal Geographical Society.* In both these cases the artists have made such alterations, in rounding the outline and altering the true configuration of the island, as materially to affect their utility in a scientific point of view.

According to published documents (*Times*, August 31, 1831; *Journal of the Royal Geological Society of London*, 1830–31) the Neapolitan schooner Psyche discovered, on the 12th of July, smoke on the water between Sicily and Pantellaria, where the island is now situated; and, on the 17th of July, the master of the brig Adelaide, from London, distinguished fire; and it is probable that at this period the land rose to the surface. On the 18th of the same month, Commander C. H. Swinburne observed, from on board His Majesty's ship Rapid, a long irregular column of smoke or steam, accompanied by eruptions of fire, bearing south by east; the town of Marsala bearing by compass east half north 9 miles. On nearing, a small hillock of a dark color was observed a few feet above the sea. The volcano was at this period in a constant state of activity, discharging dust and stones with vast columns of steam. The island appeared to be 70 or 80 yards in its external diameter, and the lip as thin as it could be, consistent with its height, which might be 20 ft. above the sea in the highest, and 6 ft. in the lowest part, leaving the rest for the diameter of the area within.

From information accompanying Mr. Russell's sketch, it appears that the circumference of the island on the 23d was $\frac{3}{4}$ of a mile. The highest point was 80 ft. above the level of the sea, and the jets of water rose to a height of from 800 to 1000 ft., and bore up immense quantities of cinders and stones, which sometimes attained nearly double that height.

On the 3d of August, Captain Senhouse of the St. Vincent effected a landing in the Hind cutter, and hoisted the British flag, calling it Graham Island. The form of the crater was found to be nearly a perfect circle, and complete along its whole circumference except for about 250 yards on its south-eastern side, which were broken and low, not apparently more than 3 ft. high. The height of the highest part was found, upon a rough computation, to be 180 ft.; the whole circuit of the island was from a mile and a quarter to a mile and a third. It bore the general appearane of two longitudinal hills, connected by intermediate low land sending up smoke and vapor in abundance. The circular basin, the centre of the island, was full of boiling salt water, of a dingy red color; and the vapor was very oppressive, causing nausea and faintness.

Captain Senhouse informs us that the fragments of rock brought away by the Hind cutter are compact and heavy, and that the whole surface of the island is dense and perfectly hard under the feet. No variety of lava was procured, nor even any jet or streams of lava seen; and Mr. Osborne, surgeon to His Majesty's ship Ganges, states that the substances of which the island is composed are chiefly ashes, the pulverized remains of coal deprived of its bitumen, iron scoriæ, and a kind of ferruginous clay, or oxided earth. The scoriæ occur in irregular masses, some compact, dense, and sonorous, others light, friable, and amorphous, with metallic lustre, slightly magnetic, barely moving the loadstone. A piece of limestone was also found thrown up with the other substances, having no marks of combustion. There were, according to the same observer, no traces of lava, no terra puzzolana, no pumice, nor other stones, usually found on volcanic hills.

The principal phenomena attendant on the elevation of Graham Island are the form of the ejected mass and its composition; and more information will be contained in the study of these two features, than in any hypothetical surmises on the mode of ejection, and on the character and nature of the action by which this took place.

It will at once be observed, in the sketches of the island which accompany this notice, that its appearance differs very much according to the distance at which it is viewed. In Fig. 1, it is the summit of a volcano, a cone of eruption slightly elevated above the level of the sea; but, on a nearer approach, its form is found to be that of a circular crater with more or less perpendicular walls (Fig. 2.), like most of the craters of elevation surrounding the internal craters of volcanoes, or the islands and insulated formations of supposed similar origin. The internal crater on the left hand side of Fig. 2, which presents the most striking manifestation of this disposition, has been obliterated in the sketch contained in the *Journal*

Fig. 1.

of the Royal Geographical Society, and occupied by smoke and a prodigious flash of lightning.

There is every reason to believe that volcanic eruptions take place at the bottom of the sea, in the same manner as on the surface of a continent; and Mr. Osborne points out the fact that, in the elevated sides of the external ridge of the island, the sides fall down in abrupt precipices; and each stratum could be distinctly discerned, the water evaporating having left an incrustation of salt, which now appears a white firm layer, plainly marking the regular progress and formation of the island. It is very evident that this kind of action and succession could not have taken place above the level of the waters either of the sea or of the internal crater; as it further demonstrates that horizontal beds of volcanic matters, accumulated over each other, can be directed on a given point without any violent contortion or derangement of their symmetry and parallelism. Nor have we, in the present case, any invasion of the sea or explosions posterior to the formation of the cone, if we may judge from the details transmitted to us of the elevation and appearance of the island, to account for the well characterised circus or mural precipice which surrounds the canal of communication or crater of eruption.

Fig. 2.

It does not farther appear, from the soundings, that this island is the summit of a cone of eruption with an open crater. Captain Swinburne found, within 20 yards on the western side, 18 fathoms soft bottom; and Capt. Smith found, at 100 yards, the island bearing from N. to N. W., from 60 to 64 fathoms; at 80 yards, the island bearing N. E., 70 to 75 fathoms; at 150 yards, the island bearing E., 62 fathoms, cinders: the soundings continuing the same to the distance of five or six miles; that is to say, varying from 60 to 70 and 80 fathoms, sand and small gravel. The extent of the action by which this island was elevated from below is uncertain. It is a curious fact, that the tides were higher at that period at Gibraltar than they were ever known to be; but the connexion of this phenomenon with the elevation of submarine formations requires the evidence of correlative observations.

Captain Swinburne observed the interior of the crater to be filled with muddy water, violently agitated, dashing up and down, and shooting hot stones and cinders into the air; and occasionally running into the sea, over the edge of the crater, which was broken down to the level of the sea on the west-south-west side for the space of 10 or 12 yards. This edge he supposed, from these appearances, to be formed of cinders and mud: a supposition which is contradicted by the consideration that an embankment of such materials, and of such slight thickness, could never retain the mass so violently agitated in the interior; and is farther opposed to the statements of Captain Senhouse and Mr. Osborne.

The isolation of the volcanic action is also demonstrated by the fact, that the temperature of the sea, within ten or twelve yards of the crater, was only 1° higher than the average; and to the leeward, in the direction of the current, it was not at all affected, though a mirage played on the island. (*Captain Swinburne; Report to Admiral Sir H. Hotham.*)

There was at a subsequent period of the eruption, on the south-west side of the island, adjoining the principal crater, a terrific ebullition and agitation of the sea, apparently seated in another canal of communication; attended by the emission of a dense white steam, and a temperature increased to 190° Fahr. (*Letter of Mr. Osborne*); and the information has, I believe, since reached the Admiralty, that this crater is now elevated above the level of the waters. De Buch has already pointed out, that the internal action which manifests itself at the surface of the soil or sea by a crater of elevation, may constitute at the same time a permanent volcanic crater beneath; the eruptions of which may take place sometimes by the centre of the crater of elevation, sometimes by neighboring points.

Though it is difficult, from the meagre details hitherto obtained, to form any correct opinion of the mineralogical character of the upraised mass, yet there is nothing in those details to warrant the supposition that there is no stability or permanence in the composition of the island. The pulverised remains of coal deprived of its bitumen, the hard scoriæ, dense and sonorous (phonolites?), the amorphous rocks with metallic lustre and ironstone clay, would appear to associate the eruption with the rocks of the carboniferous series; an opinion which receives additional probability from the ejection of unchanged pieces of limestone: as we see, between Pettycur and Bruntisland in Fifeshire, beds of limestone and of non-bituminous coal elevated by rocks of plutonic origin, and argillaceous and argillo-calcareous rocks changed into leucostines and spilites. If this is the case, a farther and more accurate investigation of the mineralogy of Graham Island will be of as much utility to the study of changes produced by volcanic action, as the forms and characters of the upraised formations have been in pointing out their geological age and associations.

CHLORIC ETHER.

Referring to the important communication of Mr. S. Guthrie, upon chloric ether, (p. 64 of this Vol.) I proceed to quote the passage from my Elements of Chemistry, Vol. II, p. 20, by reading which, Mr. Guthrie says, in his correspondence with me, that his attention was first directed to the subject; it is as follows—

"(*h*) *Properties.—Resembles an oil, color yellowish, but white, when purified; sinks in water in distinct globules,* which readily run together. Sp. gr. at 45° 1.22. By much agitation, is diffused in the water, and partially dissolved, imparting to the water its own peculiar taste, which is *sweetish, aromatic and agreeable. Taken internally, it is stimulating and reviving.* For this purpose, it is dissolved in alcohol, which happens instantly by agitation in a vial, and the alcohol can then be diluted to any desired degree. Its medicinal powers, have not been ascertained, but from its constitution and properties, it is highly probable that it would be an active diffusive stimulant." It is well known to practical chemists, that this ether is usually formed, by mingling equal volumes of chlorine and olefiant gas, both of which are speedily condensed into the fluid form, but the process is troublesome, as only a small volume of fluid is obtained from a large volume of the gases. Still I have been in the habit, for many years, of preparing an alcoholic solution of this ether, diluting it with water to the proper degree, and then calling the attention of the medical students to its remarkably grateful properties as a cordial, suggesting at the same time the probability that it might prove a valuable medicine. I am not aware, however, that this trial had been any where made, and probably the subject would have still slumbered, had it not been for the very ingenious, and far as I knew, original process of Mr. Guthrie, (p. 64 of this Vol.) I have this day repeated this process and obtained an alcoholic solution of the chloric ether, perfectly similar to that transmitted by Mr. Guthrie, and to that which I had been accustomed to prepare, in the way already indicated. Mr. Guthrie's liberality having placed it in my power, I have recently distributed several bottles among my medical friends, and the report as far as it has been received, is highly satisfactory. Dr. Eli Ives, Professor of the Theory and Practice of Medicine, in the Medical Institution of Yale College, has, at my request, favored me with the annexed statement which is corroborated by one from his son.

Statement of Prof. Ives.

Dear Sir—I have witnessed the effect of the chloric ether, with which you were so kind as to furnish me, and in some other instances where you had furnished individuals who wished to try its effect.

I have given it to a female, 60 years of age, who had been subject to severe paroxysms of pain in the chest and difficulty of breathing, called asthma. The paroxysm, for which I gave the chloric ether, was thought more severe than any she had had before; she took the remedies, as she had ordinarily taken them, previous to the use of the chloric ether, without very obvious effect. The chloric ether was given in doses of half a tea-spoon full, once in two hours, for twelve hours. It was given in the course of the night, and in the morning the patient was very much relieved, more suddenly than she had been in any previous illness of the kind. The patient and the friends attributed the speedy and effectual relief to the chloric ether. It appeared to me that the ether was the efficient article that had produced the relief.

Mr. D. W. with pulmonic disease, has inhaled the chloric ether to obviate general debility and difficult respiration. The article has been effectual to obviate those symptoms, its immediate effect beside giving relief, is that of giving a pleasant sensation.

I have given the chloric ether to children in the ulcerated sore throat. A child of Mr. P. was attacked with ulcerated sore throat, (called scarlet fever; Rosalia of Dr. Good,) this child died on the fifth day. This child took no chloric ether, indeed, it was so deranged that it was difficult to administer any medicines. A brother of the same child attacked with similar disease, had deep ulcers in the throat, and high fever with derangement. The chloric ether was given every two hours in doses of thirty drops, diluted with an ounce of water; the child was at all times ready to take this medicine, and it was continued until the fever abated. The child began to mend after the fifth day. The ether was thought to allay the irritation in the nervous system, abate the heat of the skin, and to have a good effect upon the ulcers in the throat.

This patient recovered very rapidly.

I have given the chloric ether in several other cases of scarlet fever in cases of adults, giving it in doses of a tea-spoon full, diluted with water. I have been pleased with the operation of this ether, it is diffusible in its action like the other ethers, it posseses the peculiar properties of chlorine, and it has this advantage over the sulphuric or other ethers, that it is always grateful. I have known no child refuse it.

Yours, &c. E. Ives.

January 2, 1832.

N. B. The last vial you furnished me, I gave to a female, fifty years of age, who has been affected with paroxysms of asthma for more than twenty years. I have seen the patient but once since the medicine was given, when she was evidently better, and said she thought the medicine had done her good. I have used the ether for spasmodic cough, and am so much satisfied with the beneficial effects of the remedy in such cases, that I shall use it more extensively as soon as I shall be able to furnish myself with a quantity of it. E. I.

Dear Sir.—I have been much pleased with the effects of the "chloric ether" with which I was favored through your kindness. The first case in which I administered it was in that of Mr. Coffing, who was severely ill with atonic quinsey,—he was unable to swallow. The ether was injected by means of a syringe, with the happiest effect. After using the syringe he was able to swallow and took the same article internally with benefit. I have also witnessed its beneficial effects in pneumonic cases.

Respectfully yours, Nathan B. Ives.

Professor Silliman, &c.

I have not yet received the statements of the other medical gentlemen, but have understood that the chloric ether has generally proved grateful, soothing and reviving, and the patients have sent to me repeatedly for a renewal of their supply, as the ether is not to be obtained in the shops. It appears to have been particularly acceptable in various maladies induced by the prevailing influenza. Having been requested, by some of our physicians, to obtain a supply for regular use, I have written to Mr. Guthrie, and received from him an answer dated Sackett's Harbor, Dec. 24, 1831, from which the following is an extract:

"I have been confined by sickness most of the time since the 7th of October, but am now recovering rapidly, and hope within a very few days to be able to go into my laboratory, when I shall prepare, and forward to the care of Van Buren, Wardell & Co., New York, the chloric ether you advised me to send, and they will immediately forward it to the gentleman you designated. The price of chloric ether, you must be aware, will form no objection to its general use as a medicine."* As regards the moral effect of using chloric ether as a medicine, there is no more danger than from other medicines of which alcohol is the vehicle. Some highly respectable physicians, it is true, are of the opinion that no such preparations should be used medicinally, but this appears not to be the general opinion of the faculty.

At present, no other vehicle than alcohol is known by which chloric ether can be rendered manageable; in alcoholic solution it may be given, either in small doses, or freely, if largely diluted with water.

Remark.—As no accurate examination has been made in point of theory, we cannot say precisely what takes place during the distillation of alcohol from chloride of lime. It is, however, worthy of notice that, as alcohol is believed to be composed of olefiant gas and water, (or at least of elements in such relative equivalents that they may admit of being so assorted) and as ether has a similar constitution, although in a different ratio of the equivalents, and as chloric ether has been heretofore produced by the combination of chlorine and olefiant gas, it seems hardly to admit of a doubt, that in distilling alcohol from chloride of lime, the latter gives its chlorine to the olefiant gas of a part of the former, and thus produces chloric ether which passes over, in solution, in another portion of the alcohol, while the water of that portion of the alcohol which afforded the olefiant gas, or the water which may be supposed to be produced by a combination of the elements, is detained by the lime.

Can any method be devised by which the alcohol can be detached from the chloric ether, and the latter obtained concentrated and in quantity?—Editor.

Yale College, January 6, 1832.

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* Mr. Guthrie even names a price at which it may probably be afforded, and although it might be premature to mention it now, I may remark, that it is very low. Mr. G., or his agents in New York, will supply the chloric ether in any quantity, and send it in any direction.

INDEX TO VOLUME XXI.

E.

F.

G.

H.

I.

J.

K.

L.

M.

N.

O.

P.

R.

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