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TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I.

TO THE
KING.

SIR,

I AM defired by the Members of The Royal
Society of Edinburgh, humbly to requeſt
Your MAJESTY to accept the firſt fruits of
their Philoſophical and Literary labours.

To

To Your Majesty, as the Founder and Patron of the Society, they, of right, fhould be prefented.

If they fhall be found worthy of the approbation of a Monarch, who has diftinguifhed His Reign by the utility of His Inftitutions for improving the elegant Arts, as well as by the fplendour and fuccefs of His undertakings to extend the knowledge of Nature, The Royal Society of Edinburgh may hope to occupy a refpectable place among thofe Bodies of learned Men, who, by their united efforts, have contributed,

buted, fo eminently, to the progrefs of Science and of Tafte in Europe. I am, with the higheft refpect,

Your MAJESTY's dutiful fubject,

and devoted fervant,

BUCCLEUGH.

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* *N. B.* PART I. comprehending the HISTORY, is contained under one fet of pages; and PART II. comprehending the PAPERS, is contained under two fets, *viz.* PAPERS of the PHYSICAL CLASS under the one, and PAPERS of the LITERARY CLASS under the other.

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*** *The Society is indebted to* Robert Adam, *Esq; for the Design of the engraved* Frontispiece.

TRANS-

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I. PART I.

HISTORY OF THE SOCIETY.

HISTORY

OF

THE SOCIETY.

THE inftitution of Societies of learned men, who have united their labours for the cultivation of Philofophy, or of Literature, is of an ancient date in feveral polifhed nations of Europe. It is, however, for the honour of Great Britain to have fet the firft example of an inftitution for thefe purpofes, incorporated by charter from the Sovereign, and carrying on its refearches under his patronage. A hint of this kind, to the Prince then reigning, is found in the works of Lord BACON *, who recommends, as one of the *opera verè bafilica*, the eftablifhment of Academies or Societies of learned men, who fhould give, from

(A)   time

* BACON de Augment. Scient. l. 2.

time to time, a regular account to the world of their researches and discoveries. It was the idea of this great philosopher, that the learned world should be united, as it were, in one immense republic, which, though consisting of many detached states, should hold a strict union and preserve a mutual intelligence with each other, in every thing that regarded the common interest. The want of this union and intelligence he laments as one of the chief obstacles to the advancement of science; and, justly considering the institution of public societies, in the different countries of Europe, under the auspices of the Sovereign, to be the best remedy for that defect, he has given, in his fanciful work of the *New Atlantis,* the delineation of a Philosophical Society, on the most extended plan, for the improvement of all arts and sciences; a work, which, though written in the language, and tinctured with the colouring of romance, is full of the noblest philosophic views. The plan of Lord BACON, which met with little attention from the age in which he lived, was destined to produce its effect in a period not very distant. The scheme of a *Philosophical College,* by COWLEY, is acknowledged to have had a powerful influence in procuring the establishment of the Royal Society of London, by charter from CHARLES II. *; and COWLEY's plan is manifestly copied, in almost all its parts, from that in the *New Atlantis.* The institution of the Royal Society of London was soon followed by the establishment of the Royal Academy of Sciences at Paris; and these two have served as models to the Philosophical Academies of highest reputation in the other kingdoms of Europe.

In Scotland, similar associations for the advancement of science and of literature have, even without the benefit of Royal patronage, and with no other support than the abilities of their members, attained to no common degree of reputation.

In

* SPRAT's History of the Royal Society of London, 2d edit. p. 59.

In Edinburgh, a Society was inftituted in 1731, for the improvement of medical knowledge, by collecting and publifhing Effays and Obfervations on the various branches of Medicine and Surgery, written by the members themfelves, or communicated to them. The Secretary of this Society was the elder Dr ALEXANDER MONRO, the firft profeffor of Anatomy in the Univerfity of Edinburgh, and the founder of the medical fchool which has fince attained to fuch eminence and celebrity. Under his care, the Tranfactions of this Society were publifhed at different periods, in five volumes 8vo, with the title of *Medical Effays and Obfervations*, &c. ; a work which has undergone many editions, which has been tranflated into many foreign languages, and is honoured with the encomium of HALLER, as one of the moft ufeful books in the fciences of Medicine, Anatomy and Surgery.

Soon after the publication of the above mentioned volumes of Medical Effays, *viz.* in 1739, the celebrated Mr MACLAURIN, profeffor of Mathematics in the Univerfity of Edinburgh, conceived the idea of enlarging the plan of this fociety, by extending it to fubjects of Philofophy and Literature. The inftitution was accordingly new-modelled, by a printed fet of laws and regulations, the number of members was increafed, and they were diftinguifhed, from that time, by the title of *The Society for improving Arts and Sciences*, or, more generally, by the title of *The Philofophical Society of Edinburgh*. They chofe for their Prefident JAMES Earl of Morton, afterwards Prefident of the Royal Society of London : Sir JOHN CLERK of Pennycuik, one of the Barons of Exchequer, and Dr JOHN CLERK, were elected Vice-prefidents ; and Mr MACLAURIN and Dr PLUMMER Secretaries of the inftitution. The ordinary members were fome of the moft diftinguifhed men of letters in Scotland at that time.

A few years after the Society had received its new form, its meetings were interrupted, for a confiderable fpace of time, by the

the diforders of the country during the rebellion in 1745 ; and no fooner was the public tranquillity re-eftablifhed, than it fuffered a fevere lofs by the death of Mr MACLAURIN, whofe comprehenfive genius, and ardour in the purfuits of fcience, peculiarly qualified him for conducting the bufinefs of an inftitution of this nature. The meetings of the Society, however, were renewed about the year 1752 ; and the new Secretaries, who were the celebrated Mr DAVID HUME and Dr ALEXANDER MONRO, *junior,* were directed to arrange and prepare for the prefs fuch papers as were judged worthy of being fubmitted to the public eye. The firft volume of the Tranfactions of the Philofophical Society of Edinburgh was accordingly publifhed in 1754, under the title of *Effays and Obfervations, Phyfical and Literary ;* the fecond volume was publifhed in 1756, and the third in 1771.

IT has been always obferved, that inftitutions of this kind have their intervals of languor, as well as their periods of brilliancy and activity. Every affociated body muft receive its vigour from a few zealous and fpirited individuals, who find a pleafure in that fpecies of bufinefs, which, were it left to the care of the members in general, would be often reluctantly fubmitted to, and always negligently executed. The temporary avocations, and, ftill more, the deaths of fuch men, have the moft fenfible effect on the focieties to which they belonged. The principle of activity which animated them, if not utterly extinguifhed, remains long dormant, and a kindred genius is required to call it forth into life.

FROM caufes of this kind, the Philofophical Society of Edinburgh, though its meetings were not altogether difcontinued, appears to have languifhed for fome time, till about the year 1777, when its meetings became more frequent, and, from the uncommon zeal and diftinguifhed abilities of the late HENRY HOME, Lord KAIMES, at that time elected Prefident of the inftitution,

ftitution, its bufinefs was conducted with renewed ardour and fuccefs.

About the end of the year 1782, in a meeting of the Profeffors of the Univerfity of Edinburgh, many of whom were likewife members of the Philofophical Society, and warmly attached to its interefts, a fcheme was propofed by the Reverend Dr Ro-bertson, Principal of the Univerfity, for the eftablifhment of a New Society on a more extended plan, and after the model of fome of the foreign Academies, which have for their object the cultivation of every branch of fcience, erudition and tafte. It appeared an expedient meafure to folicit the Royal Patronage to an inftitution of this nature, which promifed to be of national importance, and to requeft an eftablifhment by charter from the Crown. The plan was approved and adopted; and the Philofophical Society, joining its influence as a body, in feconding the application from the Univerfity, his Majefty was moft gracioufly pleafed to incorporate The Royal Society of Edinburgh, by the following Charter:

GEORGIUS, *Dei Gratia, Magnæ Britanniæ, Franciæ, et Hiberniæ Rex, Fidei Defenfor, OMNIBUS probis hominibus, ad quos præfentes Literæ noftræ pervenerint, Salutem. QUANDOQUIDEM, Nos confiderantes quod Petitio humilis Nobis oblata fuerit, a* Henrico *Duce de* Buccleugh, Roberto Dundas *Armigero, Domino Præfide Curiæ Seffionis;* Jacobo Montgomery *Armigero, Domino Capitali Barone Curiæ Scaccarii in Scotia;* Thoma Miller *Armigero, Domino Juftitiario Clerico;* Joanne Grieve *Armigero, Domino Præpofito Civitatis Edinenfis; Domino* Alexandro Dick *Baronetto; Domino* Georgio Clerk *Baronetto; Reverendo* Gulielmo Robertfon, *S. S. Theologiæ Doctore, Academiæ Edinenfis Præfecto;* Gulielmo Cullen *et* Alexandro Monro, *Medicinæ Doctoribus;* Hugone Blair *et* Joanne Walker, *S. Theologiæ Doctoribus;* Adamo Fergufon, *Legum Doctore, et* Andrea Dalzel, Joanne Robifon, *et* Allano Maconochie, *in Academia Edinenfi Profefforibus;* Ilay

Campbell

Campbell *Armigero, Solicitatore noftro Generali pro Regno Scotiæ;*
Jacobo Hunter-Blair *et* Adamo Smith, *Armigeris, et* Joanne
Maclaurin, Gulielmo Nairne, *et* Roberto Cullen, *Armigeris, Advocatis ; ab iis fcilicet, atque in eorum nomine: In qua Petitione
enarratur, Eruditorum hominum Societates ufu compertas effe admodum idoneas ad promovendam Scientiam, et bonum de re Literaria
Judicium, ubicunque gentium inftitutæ fuerint ; Atque adeo multos
effe homines, aut Loco aut Literis eminentes, qui votum diu extulerint,
ut Societas Literaria Edinburgi inftitueretur, ad Statum illius partis
Imperii noftri qnæ Scotia vocatur accommodata, perfuafiffimum habentes ejufdem Labores et Indagationes emolumento Reipublicæ haud
afpernando futuras: Quem ad finem Petitores fupradictos fpectantes
Societatem inter fe, fi modo Patrocinio noftro digni haberentur, inire
conftituiffe, eofdemque fubmiffe fperare Nobis pro gratia noftra placiturum, ut eos in unum Corpus formemus, una cum aliis quicunque in
eorum numerum fint cooptandi, ad Societatem conftituendam, quæ non
folum in Scientiis Mathefeos, Phyfices, Chemiæ, Medicinæ et Hiftoriæ Naturalis, verum etiam in iis quæ ad Archæologiam, Philologiam
et Literaturam fpectant, verfetur: Precantes igitur, ut iis concedamus regiam noftram Cartam, feu Literas patentes, fub Sigillo iutus
fcript. Nominantem, Conftituentem, Erigentem, et Incorporantem dictos Petitores, et alios quales poftea affumentur feu eligentur Socii, In
unum Corpus Politicum et Corporatum, feu legalem Incorporationem,
per Nomen et Titulum, et fub Ordinationibus in his poftea dictis:
ET NOS certiores facti Confilium Petitorum effe laudabile et dignum
quod promoveatur: IGITUR Conftituimus, Ereximus et Incorporavimus, ficuti Nos, regia noftra prerogativa, et Gratia fpeciali, pro Nobifmetipfis noftrifque regiis Succefforibus, per has præfentes, Conftituimus, Erigimus, et Incorporamus PRÆFATOS* Henricum *Ducem*
de Buccleugh ; Robertum Dundas *Armigerum, Dominum Præfidem Curiæ Seffionis ;* Jacobum Montgomery *Armigerum, Dominum Capitalem Baronem Curiæ Scaccarii in Scotia ;* Thomam Miller *Armigerum, Dominum Juftitiarium Clericum ;* Joannem Grieve
Armigerum, Dominum Præpofitum Civitatis Edinenfis ; Dominum
<div align="right">Alexandrum.</div>

Alexandrum Dick *Baronettum; Dominum* Georgium Clerk *Baronettum; Reverendum* Gulielmum Robertfon, *S. S. Theologiæ Doctorem, Academiæ Edinenfis Præfectum;* Gulielmum Cullen *et* Alexandrum Monro, *Medicinæ Doctores;* Hugonem Blair *et* Joannem Walker, *S. Theologiæ Doctores;* Adamum Fergufon, *Legum Doctorem, et* Andream Dalzel, Joannem Robifon *et* Allanum Maconochie, *in Academia Edinenfi Profeffores;* Ilay Campbell *Armigerum, noftrum Solicitatorem Generalem pro Regno Scotiæ;* Jacobum Hunter-Blair *et* Adamum Smith, *Armigeros, et* Joannem Maclaurin, Gulielmum Nairne, *et* Robertum Cullen, *Armigeros, Advocatos, atque alios viros quales poftea affumentur feu eligentur Socii, IN UNUM CORPUS POLITICUM ET CORPORATUM, vel LEGALEM INCORPORATIONEM, per Nomen et Titulum REGALIS SOCIETATIS EDINBURGI, ad promovendas Literas et Scientiam utilem, utque talis exiftens, et per tale nomen Perpetuitatem habeat et Succeffionem; atque ut potens et capax fit capere, tenere et frui proprietate reali feu perfonali, et petere, Caufas agere, defendere et refpondere, et conveniri in Jus, trahi, defendi et refponderi in omnibus feu ullis noftris Curiis Judicaturæ: ET NOS poteftatem damus Petitoribus primum eorum Congreffum tenendi, quarto die Lunæ menfis Junii proximi, in Bibliotheca Academiæ Edinenfis, hora duodecima meridiana, cum poteftate comperendinandi, atque, vel ad dictum Congreffum, vel ad tempus in quod idem, per majorem Suffragiorum numerum eorum qui aderunt, comperendinatus fuerit, eligendi Præfidem et tot Socios quot idoneos ad complendam Societatem judicaverint; ibique, necnon ad eorum Congreffus fubfequentes, ordinandi Canones, ad quos Res Societatis fint adminiftrandæ, Præfefque et Socii fint eligendi; qui, tameu, Canones mutari vel augeri poffint, majore fuffragante numero Sociorum qui ad ullum Congreffum Societatis aderunt, fi modo quæ funt mutanda vel adjicienda, propofita fuerint in Congreffu habito uno menfe ante illum Congreffum ubi de his judicandum fit: ET NOS ordinamus, ut cunctæ Res antiquæ, Tabulæ publicæ, Librique Manufcripti, quos acquifiverit dicta Societas, deponantur in Bibliotheca Facultatis Ju-*

(B) *ridicæ,*

ridicæ, atque ut univerſa Corpora quæ ad Hiſtoriam Naturalem pertinent, quæque eadem Societas acquiſiverit, deponantur in Muſæo Academiæ Edinenſis, ita ut utraque Collectio aperta ſit Sociis, et e re publica ſit, quantum fieri poteſt: ET dicti Petitores, atque ii ex quibuſcunque poſtea conſtabit dicta Societas, per has Literas patentes, poteſtatem habebunt privatas ferendi Leges ad ejus adminiſtrationem idoneas, et in aliis rebus procedendi, agendi et faciendi, congruè cum Generali Lege et Praxi noſtri Regni Scotiæ in talibus caſibus. IN CUJUS REI TESTIMONIUM, præſentibus Sigillum noſtrum per Unionis Tractatum cuſtodiena. et in Scotia, Vice et Loco magni Sigilli ejuſdem, utend. ordinat. appendi mandavimus: APUD Aulam noſtram apud St James's, vigeſimo nono die menſis Martii, anno Domini millesimo septingenteſimo et octogeſimo tertio, Regnique noſtri anno vigeſimo tertio.

1783.

<div align="center">*Per Signaturam Manu S. D. N. Regis ſupraſcript.*</div>

<div style="float:left">June 23.
1ſt General
Meeting of the
Royal Society.</div>

THE firſt general meeting of the Royal Society of Edinburgh was held, in terms of the above Charter, on Monday the 23d day of June 1783, and the Right Honourable THOMAS MILLER of Barſkimming, Lord Juſtice-Clerk, was choſen Preſident of the meeting.

IT was then unanimouſly reſolved, That all the members of the Philoſophical Society of Edinburgh ſhould be aſſumed as members of the Royal Society: And it was likewiſe reſolved, That the Lords of Council and Seſſion, the Barons of Exchequer for Scotland, and a ſelect number of other gentlemen, ſhould be invited to a participation of the Society's labours.

THE meeting afterwards proceeded to eſtabliſh the form or conſtitution of the Society, and to frame a ſet of regulations for its future proceedings.

Mr JOHN ROBISON, Profeſſor of Natural Philoſophy in the Univerſity of Edinburgh, was unanimouſly elected General Secretary, and Mr ALEXANDER KEITH, writer to the Signet, Treaſurer of the Society.

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THE meeting was then adjourned to Monday the 4th day of August 1783.

THE Society having met, in terms of the adjournment, the Secretary gave in a lift of thofe noblemen and gentlemen who had accepted of the invitation to become members. He alfo informed the meeting, that he had been directed by the Vice-Prefident and members of the Philofophical Society of Edinburgh, to deliver their minute-book, and all fuch differtations and papers as were in their Secretary's hands, to the Royal Soceity. The minute-book and papers were accordingly received, and given in charge to the General Secretary.

THE members then confidered anew the ftatutes and regulations which had been propofed at laft meeting, and enacted a body of fundamental laws, afcertaining their conftitution, and directing their future proceedings.

IT is judged unneceffary to give a minute account of thefe laws. The public is interefted only in what relates to the fcientific proceedings of the Society, the general duties of its members, and the election of candidates.

THE Royal Society of Edinburgh confifts of *Ordinary* and *Honorary* members; and the honorary places are reftricted to perfons refiding out of Great Britain and Ireland.

THE election of new members is appointed to be made at two ftated general meetings, which are to be held on the fourth Monday of January, and the fourth Monday of June.

A CANDIDATE for the place of an ordinary member muft fignify, by a letter addreffed to one of the members, his wifh to be received into the Society. He muft then be publicly propofed at leaft a month before the day of election. If the propofal be feconded by two of the members prefent, his name is to be inferted in the lift of candidates, and hung up

in

in the ordinary place of meeting. The election is made by ballot, and is determined in favour of a candidate, if he fhall have the votes of two thirds of thofe prefent, in a meeting confifting of at leaft twenty-one members.

THE general bufinefs of the Society is managed by a Prefident, two Vice-Prefidents, with a council of twelve, a General Secretary, and a Treafurer. Thefe officers are chofen by ballot, annually, on the laft Monday of November. All public deeds, whether of a civil or of a literary nature, are tranfacted by this board, and proceed in the name of the Prefident or Vice-Prefident.

IT is requefted and expected of each of the members, that he will favour the Society, from time to time, with fuch effays or obfervations on fubjects of fcience, literature, or other ufeful knowledge, as his leifure and opportunities may render convenient.

The Society divided into two Claffes.

As it was thought that the members would have a greater inducement to punctual attendance on the meetings of the Society, if they had fome general intimation of the nature of the fubjects which were to be confidered, and made the topics of converfation, it was therefore refolved, to divide the Society into *Two Claffes*, which fhould meet and deliberate feparately.

The Phyfical Clafs.

The one of thefe claffes is denominated the PHYSICAL CLASS, and has for its department the fciences of Mathematics, Natural Philofophy, Chemiftry, Medicine, Natural Hiftory, and whatever relates to the improvement of Arts and Manufactures.

The Literary Clafs.

THE other is denominated the LITERARY CLASS, and has for its department Literature, Philology, Hiftory, Antiquities, and Speculative Philofophy.

EVERY

Every member is defired, at his admiffion, to intimate which of thofe claffes he wifhes to be more particularly affociated with; but he is, at the fame time, entitled to attend the meetings of the other clafs, and to take part in all its proceedings.

Each of the claffes has four Prefidents and two Secretaries, who officiate by turns.

The meetings of the Phyfical Clafs are held on the firft Mondays of January, February, March, April, July, Auguft, November and December; and the meetings of the Literary Clafs are held on the third Mondays of January, February, March, April, June, July, November and December, at 7 o'clock afternoon.

<div style="float:right">Times of meeting.</div>

At thefe meetings, the written effays and obfervations of the members of the Society, or their correfpondents, are read publicly, and become the fubjects of converfation. The fubjects of thefe effays and obfervations are announced at a previous meeting, in order to engage the attendance of thofe members who may be particularly interefted in them. The Author of each differtation is likewife defired to furnifh the Society with an abftract of it, to be read at the next enfuing meeting, when the converfation is renewed with increafed advantage, from the knowledge previoufly acquired of the fubject.

<div style="float:right">Bufinefs of the Meetings.</div>

At the fame meetings are exhibited fuch fpecimens of natural or artificial curiofities, fuch remains of antiquity, and fuch experiments, as are thought worthy of the attention of the Society. All objects of natural hiftory prefented to the Society, are ordered by the Charter of the Inftitution to be depofited, on receipt, in the Mufeum of the Univerfity of Edinburgh, and all remains of antiquity, public records, or ancient manufcripts, in the Library belonging to the Faculty of Advocates at Edinburgh.

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THE ordinary members, whofe ufual refidence is in the city of Edinburgh, or its immediate neighbourhood, are expected to attend regularly the monthly meetings; and are required to defray, by an annual contribution, the current expences of the inftitution. The members who refide at fuch a diftance from Edinburgh, that they cannot enjoy the advantages arifing from a regular attendance on the meetings of the Society, are not fubjected to any contribution for defraying its expences, but have a right to attend thofe meetings when occafionally in Edinburgh, and to take part in all their proceedings.

Committee for Publication.

THE compilation of the printed tranfactions of the Royal Society of Edinburgh, is to be made in the following manner: The papers read at the monthly meetings, and depofited in the hands of the Secretaries of the two claffes, are fubjected to the review of *the Committee for publication*, which confifts of the Prefident, Vice-Prefidents and Council, the General Secretary and Treafurer of the Society; together with the Prefidents and Secretaries of the two claffes. This Committee makes a felection of papers, and determines the order in which they are to be publifhed. It is not, however, to be underftood, that thofe papers which do not appear in the Tranfactions of the Society, are thought unfit for the public eye. Several papers have been communicated with the fole view of furnifhing an occafional entertainment to the members; and that end being anfwered, have been withdrawn by their authors: Effays, obfervations, and cafes, are often read at the meetings of the Society, in order to obtain the opinions of the members on interefting or intricate fubjects: Some papers intended for a future publication have been withdrawn for the prefent by their authors, in order to profit by what has occurred in the converfations which the reading of the papers has fuggefted; and others, of acknowledged merit, the Committee has found it neceffary to referve

for

for a fubfequent volume. Nor is the publication of any paper to be confidered as expreffing any concurrence in opinion with the author. It only intimates that the Committee judges the paper to be worthy of public notice, on account of the ufeful information it contains, the hints which it may fuggeft, or the ingenuity which it difplays.

AFTER the enactment of the Laws of the Society, the meeting proceeded to the election of the office-bearers of the enfuing year. [See the Lift fubjoined to Part firft of this volume.]

THE *Phyfical Clafs* of the Royal Society of Edinburgh met, for the firft time, on the 4th of November 1783; and Dr WIL-LIAM CULLEN, Profeffor of Medicine in the Univerfity of Edinburgh, was requefted to take the chair. The meeting then proceeded to the election of four Prefidents and two Secretaries, for directing and recording the proceedings of this Clafs. [See the Lift of the office-bearers fubjoined to Part firft of this volume.] The meeting then appointed a Committee for framing regulations for conducting the bufinefs of the Phyfical Clafs.

THE *Literary Clafs* of the Royal Society of Edinburgh met, for the firft time, on the 17th of November 1783, and the Reverend Dr ROBERTSON, Principal of the Univerfity, was requefted to prefide. The firft bufinefs of the meeting was the election of four Prefidents and two Secretaries, for directing and recording the proceedings of this Clafs. [See the Lift of the office-bearers fubjoined to Part firft of this volume.] The meeting then appointed a Committee for framing regulations for conducting the bufinefs of the Literary Clafs.

Phyf. Cl. AT a meeting of the Phyfical Clafs of the Royal Society, the Reverend Dr WALKER read the firft part of a paper,

per, entitled, Experiments on thc Motion of the Sap in Trees. The paper is publifhed in this volume. [No. I. *Phyf. Cl.*]

AT the fame meeting, Mr JAMES RUSSELL, furgeon, read an account of fome experiments made by him on antimony. The object of thefe experiments was to find an eafy and a cheap method of obtaining a folution of regulus of antimony in the muriatic acid, with a view to the preparation of tartar emetic, according to the directions in the laft edition of the Difpenfatory of the Royal College of Phyficians in Edinburgh; the ufe of butter of antimony, as there directed, implying a very tedious, complicated, and expenfive procefs. Mr RUSSELL endeavoured to obtain pure dephlogifticated muriatic acid in a fluid form, by adding to it the black calx of manganefe, (freed from particles of iron by digeftion with vitriolic acid, and afterwards calcined by heat,) and then diftilling it: But he found it impoffible to condenfe the fumes of the muriatic acid when thus dephlogifticated, (as it appeared to be by the black calx of manganefe becoming white,) though he ufed a very long-necked retort, and had the receiver, containing water, immerfed in fnow; for this acid, contrary to what happens to all the others, becomes much more volatile on being dephlogifticated.

HE then tried the effect of the vapours of this dephlogifticated muriatic acid on regulus of antimony placed in the receiver, and in the neck of the retort. This fucceeded to his wifh; the regulus diffolving quickly and copioufly. As regulus of antimony is an expenfive preparation, he made a trial of crude antimony inftead of it; and he found that the muriatic vapours very foon diffolved the metallic parts of it, and at laft began to decompofe the fulphur, as, on trial, he found they did pure flowers of fulphur. This he judged to be of little confequence to the ultimate object, as the affinity of the muriatic acid to antimony is much ftronger than that of the vitriolic.

vitriolic. From a retort with fome manganefe in it, he diftilled five ounces of muriatic acid on two ounces of crude antimony, moiftened with water, raifing the heat towards the end of the procefs, to make the fand-pot red-hot. After the procefs, there were found in the receiver fome fulphur, fome undecompofed antimony, and a complete folution of the metal in the muriatic acid. This folution had all the properties of butter of antimony; and its precipitate, either by means of water or alkalis, was exactly fimilar to the common one. Some tartar emetic, prepared from it, appeared, as to all its chemical properties, to be without fault; but Mr RUSSELL had not tried it medicinally. The quantity of precipitate, obtained from five ounces of acid and two of antimony, was about half an ounce. This muft be perfectly free from all mixture of a mercurial falt or corrofive fublimate, which, it has been fufpected, may be found in the common preparation. It may likewife be obtained with much more eafe, and at lefs than a tenth part of the expence.

Lit. Cl. Mr ALLAN MACONOCHIE, Advocate, read the firft part of a Differtation on the Origin and Structure of the ancient European Legiflatures. The Differtation is printed in this volume. [No. I. *Lit. Cl.*]

Phyf. Cl. Dr WALKER read the continuation of his paper on the motion of the Sap in Trees. [No. I. *Phyf. Cl.*]

Dr ROEBUCK read fome Obfervations on the ripening and filling of Corn.

SUMMER 1782 having been remarkably cold and unfavourable, the harveft was very late, and much of the grain, efpecially oats, was green even in October. In the beginning of October, the cold was fo great, that, in one night, there was produced on ponds near Kinneil, in the neighbourhood of Borrowftounnefs,

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ftounnefs, ice three quarters of an inch thick. It was apprehended by many farmers, that such a degree of cold would effectually prevent the further filling and ripening of their corn. In order to afcertain this point, Dr ROEBUCK felected feveral ftalks of oats, of nearly equal fulnefs, and immediately cut thofe which, on the moft attentive comparifon, appeared the beft, and marked the others, but allowed them to remain in the field fourteen days longer; at the end of which time, they too were cut, and kept in a dry room for ten days. The grains of each parcel were then weighed; when eleven of the grains which had been left ftanding in the field, were found to be equal in weight to thirty of the grains which had been cut a fortnight fooner, though even the beft of the grains were far from being ripe. During that fortnight, (*viz.* from October 7. to October 21.) the average heat, according to FAHRENHEIT's thermometer, which was obferved every day at 8 o'clock in the morning and 6 in the evening, was a little above 43. Dr ROEBUCK obferves, that this ripening and filling of corn in fo low a temperature, fhould be the lefs furprifing to us, when we reflect, that feed-corn will vegetate in the fame degree of heat; and he draws an important inference from his obfervation, *viz.* That farmers fhould be cautious of cutting down their unripe corn, on the fuppofition, that, in a cold autumn, it could fill no more.

Mr Profeffor DUGALD STEWART read the firft part of a paper, communicated by Dr BLANE, Phyfician to the Fleet lately in the Weft Indies, giving an account of the Difeafes in that fleet in 1782 and 1783. It is unneceffary to give here any abftract of this paper, as the fubftance of it is publifhed by Dr BLANE in his *Obfervations on the Difeafes of Seamen.*

Lit. Cl. The Reverend Mr THOMAS ROBERTSON, minifter of Dalmeny, read the firft part of a Differtation on the Theory

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of Inflection in Languages. This paper, and its continuation, which was read at the next meeting of the Literary Clafs, forming a detached chapter of a work compofed by Mr ROBERTSON on the *Theory and Hiftory of Languages*, which he intends to offer to the public in a future volume of his *Enquiry into the Fine Arts*; it was, on that account, judged improper to prefent it here in a mutilated or imperfect form.

A GENERAL meeting of the Royal Society was held for the election of Members.

Phyf. Cl. Mr Profeffor DUGALD STEWART read the remainder of Dr BLANE's Paper on the Difeafes of the Fleet in the Weft Indies in 1782 and 1783. [See *fupra*, Jan. 5. 1784.]

Feb. 2.
Dr Blane on the
difeafes of the
fleet.

Dr HUTTON read the firft part of a Differtation, entitled, The Theory of Rain, which is printed in this volume. [No. II. *Phyf. Cl.*]

Dr WALKER read a paper, communicated by the Earl of DUNDONALD, containing an account of a new method, invented by his Lordfhip, for purifying fea-falt. His Lordfhip, who was prefent, added, *viva voce*, fome obfervations on the fubject, which the Society requefted he would communicate in writing at a fubfequent meeting.

THE Earl of DUNDONALD's procefs for purifying fea-falt proceeded upon this obfervation, That the common fea-falt poffeffes a confiderable mixture of ingredients, which render it, in a great degree, unfit for preferving victuals. Thefe ingredients appear, by experiment, to be naufeous, bitter and cathartic falts, having an earthy bafis, (magnefia falita and magnefia vitriolata or Epfom falt) which are intimately mixed with the proper fea-falt.

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To purify common falt, by diffolving it in water, decompounding the bitter falts, and precipitating their earthy bafis, by adding a fixed alkali, whether foffil or vegetable, is a tedious procefs, and by far too expenfive to be employed for œconomical or mercantile purpofes. It is even imperfect; as it is almoft impoffible, after that procefs, to feparate from the fea-falt the Glauber falt, or vitriolated tartar, or falt of Sylvius, which are produced according as the foffil or vegetable alkali is ufed.

Lord DUNDONALD obferved, That hot water faturated with fea-falt, will ftill diffolve a great part of the bitter earthy falts. His method, therefore, of purifying the common falt from thefe bitter falts is, To take a conical veffel, having a hole in the fmall end of it, which is to be undermoft; to place it, filled with common falt, in a moderate heat; to take one twentieth part of the falt contained in it, and putting it in an iron pan, to diffolve it in its proper proportion of water, fo that the water fhall be completely faturated with the falt; and then to pour this folution boiling hot on the falt in the conical veffel, which is to be purified. The boiling water being already faturated with fea-falt, will diffolve no more of it, but will diffolve much of the bitter earthy falts; and this folution will gradually drop out at the hole in the bottom of the cone. When it ceafes to drop, the fame procefs is to be repeated by means of frefh portions of the fame parcel of falt, already partly purified, till it be brought to the required degree of purity. Lord DUNDONALD reckons, that three fuch wafhings make the common falt of this country purer than any foreign falt; that each wafhing makes it $4\frac{1}{2}$ times purer than before; fo that (difregarding fractions) after the fecond wafhing it will be 20 times, after the third 91 times, after the fourth 410 times, and after the fifth 1845 times purer than at firft.

THE fuperiority of falt thus purified to common falt, is equally obvious to the tafte, and by its effect in preferving fifh,

flefh

flesh and butter; for it hath been often and carefully tried. Lord DUNDONALD conceives, that the simplicity, facility and cheapness of this method of purifying salt should recommend it to common practice, as it is an object of great public importance. He adds, that as all salt made by boiling has a portion of uncombined magnesia mixed with it, it is proper to add a little muriatic acid to the first brine poured on the salt, in order to dissolve the magnesia, and carry it off.

Lit. Cl. The Reverend Mr THOMAS ROBERTSON, minister of Dalmeny, read the remainder of the Essay begun by him, January 23. on the Theory of Inflection in Languages.

Mr JOHN MACLAURIN, Advocate, read a Dissertation to prove that Troy was not taken by the Greeks. This Dissertation is published in this volume. [No. II. *Lit. Cl.*]

Phys. Cl. The Reverend Mr JOHN PLAYFAIR read the first part of an Essay on the Causes which affect the Accuracy of Barometrical Measurements; which is published in this volume. [No. III. *Phys. Cl.*]

AT this meeting Dr ALEXANDER MONRO was elected a President of the Physical Class, in the room of Sir GEORGE CLERK-MAXWELL, Baronet, deceased.

Lit. Cl. Mr Professor DUGALD STEWART read an Essay on the Idea of Cause and Effect, and on the Object of Natural Philosophy. This Essay the author afterwards withdrew, on account of its connection with other papers which he did not chuse to publish at present.

Mr Professor DALZEL, one of the Secretaries of the Literary Class, read a short biographical Account of the deceased Dr WILLIAM LOTHIAN, the first member whom the Society had

1784.

had the misfortune to lose. Having found it to be the general opinion of those members with whom he had an opportunity of conversing upon the subject, that such biographical accounts would form a proper appendix to the historical part of these Transactions, he had prepared this brief detail, preceded by some general observations, as an introduction to future accounts of the same kind. The plan was approved of by the Society; and the Reader will find this Essay followed by others of a similar nature, forming an appendix to the historical part of this volume.

April 12.
Mr Greenfield
on negative
quantities in
algebra.

Phys. Cl. THE Reverend Mr WILLIAM GREENFIELD read a paper on the use of Negative Quantities, in the Solution of Problems by Algebraic Equations; which is published in this volume. [No .IV. *Phys. Cl.*]

Dr Hutton's
theory of rain.

Dr HUTTON read the continuation of his paper on the Theory of Rain, published in this volume. [No. II. *Phys. Cl.*]

Earl of Dundonald on sea-salt.

Dr WALKER read a letter from the Earl of DUNDONALD, giving an account of some further experiments on the purification of sea-salt, which his Lordship communicated in compliance with the request of the Society, at their meeting in February. The substance of the Earl's observations will best appear from the following table. Each portion of salt was purified by four washings, according to the method formerly described.

TABLE.

TABLE.

	Salt employed.		Purified Salt.		Magnesia falita. Magn. vitriol.		which is equal nearly to	
	lb.	oz.	lb.	oz.	lb.	oz.		
Salt hot from the pan first drawn,	56	00	49	00	6	05	$\frac{1}{9}$	of falt employed.
Salt hot from the pan laft drawn,	56	00	33	09	22	06	$\frac{2}{5}$	Ditto.
Medium of the above,	56	00	41	04	14	05	$\frac{1}{4}$	Ditto.
Salt 6 weeks old,	56	00	47	00	7	00	$\frac{1}{8}$	Ditto.
Salt firft drawn, dripped 24 hours,	56	00	52	12	3	00	$\frac{1}{18}$	Ditto.
Salt laft drawn, dripped 24 hours,	56	00	44	08	11	00	$\frac{1}{5}$	Ditto.
Medium of the two laft,	56	00	48	10	7	00	$\frac{1}{8}$	Ditto.
Spanifh great Salt,	10	00	9	$15\frac{1}{2}$	00	$00\frac{1}{2}$	$\frac{1}{640}$	Ditto.
Bafket fine Salt,	3	00	3	00	00	00		

(bracket labels: "contained of", "and of")

Dr CULLEN delivered to the Society five volumes written by Dr SAMOILOWITZ of St Peterfburg, prefented at the requeft of the Author, to the Royal Society of Edinburgh. The titles of thefe are to be found in the lift of Donations, at the end of Part I. of this volume.

Lit. Cl. Dr JAMES ANDERSON read obfervations on a peculiarity in the Englifh language, ufually called a *Genitive* Cafe.

Dr ANDERSON is of opinion, that the Englifh noun admits of no inflection by cafes, and therefore that the term *genitive cafe* is improper. He contends that the addition of the letter *s* with an apoftrophe, to a noun, as *John*'s *ftaff*, is not an inflection of the noun, and therefore cannot be termed a Cafe. He affirms that when a noun undergoes a change of this fort, it ceafes to be itfelf a noun, and becomes immediately a definitive; the office of which is to limit and render more precife the general meaning of another noun, with which it is neceffarily connected. Thus the general word *ftaff* has its meaning limited, by the

prefixing

prefixing of the definitive. *John*'s. He further obferves, how-ever, that all Englifh nouns do not admit of this converfion into definitives. The names of animated beings, or corporeal ob-jects, he confiders as readily fufceptible of fuch a change; but fuch nouns as fignify abftract ideas, as *holinefs*, *diligence*, *white-nefs*, he confiders as incapable of being thus convertible into de-finitives. He concludes, by recommending to grammarians, as an object worthy of inveftigation, the afcertaining the differ-ence betwixt fuch definitives and adjectives, to which they bear a near refemblance.

Mr Profeffor JOHN HILL read the firft part of an Effay on the Principles of Hiftorical Compofition; with an Application of thefe Principles to the Writings of TACITUS. The Effay is printed in this volume. [No. IV. *Lit. Cl.*]

THE Reverend Dr ALEXANDER CARLYLE read a Poem com-pofed by the late Mr WILLIAM COLLINS, on the Superftitions of the Highlands of Scotland, addreffed to JOHN HOME, Efq; au-thor of *Douglas*, &c. being the Ode mentioned by Dr SAMUEL JOHNSON in his life of COLLINS, which the biographer there gives up for loft. An authentic copy of this beautiful Poem, from the manufcript in Mr COLLINS's hand-writing, is printed in this volume, preceded by a particular account of the manner in which it has been preferved and difcovered. [No. III. *Lit. Cl.*]

Phyf. Cl. Dr WALKER, one of the Secretaries of the Phyfi-cal Clafs, read a paper by Mr PATRICK WILSON, Profeffor of Aftronomy in the Univerfity of Glafgow, containing Experiments and Obfervations on a remarkable Cold which accompanies the Separation of Hoar-froft from a clear Air. The paper is pu-blifhed in this volume. [No. V. *Phyf. Cl.*]

Mr

Mr John Clerk *junior* of Eldin, Advocate, read a short biographical account of Sir George Clerk-Maxwell of Pennycuick, Baronet, late President of the Physical Class of the Royal Society of Edinburgh. This account is printed in the Appendix to the historical part of this volume.

Lit. Cl. Mr Alexander Fraser-Tytler, one of the Secretaries of the Literary Class, read an Essay, written by Mr Professor Richardson of Glasgow, on the Ancient or Dramatic Form of Historical Composition; which is printed in this volume. [No. V. *Lit. Cl.*]

Mr Professor Dalzel, the other Secretary of the Literary Class, read a paper, written by Mr Professor Hunter of St Andrew's, entitled, A Grammatical Essay on the Nature, Import and Effect of certain Conjunctions. The Essay is printed in this volume. [No. VI. *Lit. Cl.*]

A general meeting of the Royal Society was held for the election of general Office-bearers for the ensuing year; when his Grace the Duke of Buccleugh was re-elected President, and the Right Honourable Lord Justice-Clerk, and the Right Honourable Henry Dundas of Melville, Vice-Presidents. The General Secretary and Treasurer of the preceding year were continued in office.

Phys. Cl. Dr Black read a paper, communicated by Dr John Grieve, late Physician to the Russian army, containing an Account of the Method of making a Wine, called by the Tartars *Koumiss*. The paper is published in this volume. [No. VI. *Phys. Cl.*]

There were also read two Medical Cases, communicated by Dr Mudie, Physician at Montrose; the one, An Instance of a

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complete and permanent Cure in Afcites ; the other, A Cafe of fevere nervous fymptoms occurring from a flight fuperficial wound.

Lit. Cl. Mr ALLAN MACONOCHIE, Advocate, read the remainder of his Differtation on the Ancient European Legiflatures ; which is printed in this volume. [No. I. and No. VII. *Lit. Cl.*]

Phyf. Cl. Dr JAMES ANDERSON read a paper on fome œconomical ufes to which caft iron may be applied. He obferved, That, in feveral mechanic arts, maffes of great weight, fize and ftrength, are required for bruifing or grinding various fubftances ; that it is often difficult to procure ftones of fufficient fize and ftrength for thefe purpofes ; that caft iron, though proper in point of ftrength, and eafily made of almoft any fize or fhape, is fometimes inconvenient from its weight, and is, for many purpofes, too expenfive. He propofed, therefore, that, inftead of pure iron, the moulds in which fuch maffes are to be caft fhould be nearly filled with ftones, or what would be ftill better, with bricks, as thefe could be eafily moulded into the exact fhape required ; a proper fpace being left for an axle where needed, and an interftice between the outermoft of them and the mould ; that then melted iron fhould be poured in to fill up every chink. This iron, cooling and confolidating, will unite or cement the ftones or bricks firmly together, and cover them with an uniform furface of metal. Thus, Dr ANDERSON thinks, that maffes of any fize, fhape and weight, and of fufficient ftrength, may be procured at a cheap rate ; as a very fmall quantity of metal would be fufficient for a cement and coating to the ftones or bricks.

IN the fame way, the Doctor thinks many architectural ornaments might be made very cheap and very durable ; and he fuggefts the application of this method to the important purpofe

pose of bridge-building, where very large ftones are often re-
quired for the conftruction of arches. Inftead of fuch large
ftones, he propofes to ufe compound maffes, fuch as thofe above
defcribed, cemented with iron, and exactly moulded, fo as to
form, if required, an entire rib of an arch without a fiffure;
and he thinks that, in this way, a number of arches might be
accurately and firmly put together.

Mr Robison, General Secretary, read a paper, communicated
by the Reverend Mr Thomas Elliot, Minifter of Cavers, con-
taining an Improvement on the Method of correcting the ob-
ferved Diftance of the Moon from the Sun or a Fixed Star.
The paper is publifhed in this volume. [No. VII. *Phyf. Cl.*]

There was likewife read an account, by Dr Andrew Dun-
can, of a cafe of obftinate *fingultus*, in which the beft effects
had been produced by the ufe of vitriolic acid. A gentleman,
in the 73d year of his age, was feized with a violent hiccough,
which continued without intermiffion for feveral hours. Dr
Duncan prefcribed for him a mixture containing a drachm of
acidum vitriolicum tenue, united with four ounces of mint-water,
of which a table-fpoonful was to be taken every half hour.
The firft dofe put a ftop to the *fingultus*. About twelve hours
afterwards, there was a return of the fit; which, however, yield-
ed inftantly to a fecond fpoonful of the mixture; nor was there
afterwards any occafion to repeat the dofe.

Lit. Cl. Dr Gregory read the Introduction to an Effay to-
wards an Inveftigation of the exact Import and Extent of the
common Notion of the Relation of Caufe and Effect in Phyfics,
and of the real Nature of that Relation. Parts of the Effay it-
felf were afterwards read by him at feveral fubfequent meetings
of the Literary Clafs; but he did not incline, that either the

Effay

Essay itself, or any abstract of it, should appear in this volume of the Society's Transactions.

A GENERAL meeting was held for the election of the Office-bearers of the Classes. [See the List subjoined to Part I. of this volume.]

Phys. Cl. Dr WALKER read the concluding part of his paper on the Motion of the Sap in Trees, which is published in this volume. [No. I. *Phys. Cl.*]

THE Reverend Mr PLAYFAIR read a letter from the Reverend Mr THOMAS FLEMING, Minister of Kenmore, giving an Account of an unusual Agitation in the Waters of Loch Tay, on the 12th of September last. The letter is published in this volume. [No. VIII. *Phys. Cl.*]

Mr JOHN ROBISON, General Secretary, informed the Society, that, a few days ago, Mr JAMES RUSSELL, one of the members, had offered to him the perusal of a paper, written by a friend, and containing some thoughts on a method for discovering by observation, whether the centre of the Solar System was in motion; with other interesting matters in astronomy. Mr ROBISON, recollecting that Mr PATRICK WILSON, assistant Professor of Astronomy at Glasgow, had long ago communicated to him in conversation, some curious speculations on this subject, told Mr RUSSELL, that, before perusing his friend's paper, he would write an account of what he could recollect of Mr WILSON's speculation on that subject. This account he now laid before the Society, in order to ascertain the title to originality or priority, in any thing which may have occurred to both of these Gentlemen.

THE sum of this account is, That about the year 1767 or 1768, Mr WILSON entertained an opinion that the aberration

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of the fixed ftars indicated the proportion between the orbital velocity of the earth, and the velocity of light in the vitreous humour of the eye. This opinion foon led him into various difcuffions, and, in particular, made him fuppofe, that the aberration of the fixed ftars, when determined by obfervations made with a telefcope filled with water, would be different from the aberration determined by obfervations made with a common telefcope. Mr WILSON has given an account of fome important and unexpected confequences refulting from thefe fpeculations, in the Philofophical Tranfactions of London. About the year 1775 or 1776, Mr WILSON began to entertain an opinion that the centre of the folar fyftem was in motion, and in 1777, communicated to Mr ROBISON, and others, a paper on this fubject. The water-telefcope was, by this time, become familiar to his thoughts; and it occurred to him, that it might be employed for deciding this queftion, and even for determining the direction and velocity of this motion; by means of the difference between the obferved aberration of the fixed ftars and the aberration which fhould refult from the earth's orbital motion alone. But various objections and difficulties occurred in the profecution of this attempt, and Mr WILSON foon after thought of another method.

IF the earth be carried, with a great velocity, towards a fixed ftar, whofe rays are made to deviate a little by an achromatic prifm, it will follow, that a conftant angle of incidence will give different angles of total deviation, according to the velocity of the motion; and this difference will be both real and apparent. Therefore,

I. LET the telefcope of a meridional quadrant be furnifhed with a prifm, refracting a few degrees in altitude. Search, by meridional obfervations, for fuch ftars as exhibit altitudes inconfiftent with Dr BRADLY's aberrations: The differences will indicate an aberration caufed by a motion of the earth, different from its orbital motion round the fun.

2. FURNISH

2. Furnish a telefcope with a plain mirror, inclined to its axis in an angle of 45°, and a feries of achromatic prifms refracting 90°. Suppofe the telefcope to be directed to a point of the heavens, 90° diftant from a ftar which is viewed through it. Suppofe alfo the earth to be at reft, and the images of this ftar, formed by the refracted and by the reflected light, to coincide. Then fuppofe the earth to be in motion towards this ftar: The images will feparate, both on account of a change in the total deviation of the refracted light, and alfo on account of a tranfverfe aberration, to which the refracted image is liable, by the motion of the telefcope.

3. If a long achromatic telefcope be directed to a fixed ftar, towards which the earth is moving, the focal diftance of the telefcope will be lengthened. The augmentation will indeed be very fmall, but Mr Wilson has fallen upon very ingenious methods of increafing it, fo as to make it become fenfible.

Lit. Cl. Mr Profeffor Dalzel read an Effay towards an Explanation of the Pleafure arifing from certain Scenes, Reprefentations and Defcriptions of Diftrefs: But he did not incline that the Effay, or any account of it, fhould be given in this volume.

Phyf. Cl. The Reverend Mr John Playfair read the fecond part of his Paper, on the Caufes that affect the Accuracy of Barometrical Meafurements, publifhed in this volume. [No. III. *Phyf. Cl.*]

Dr Gregory read a paper communicated by Dr Blane, giving an Account of the Hurricane at Barbadoes on the 10th of October 1780.

There had been nothing that could be called a hurricane felt at Barbadoes for more than a century before 1780, fo that

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the inhabitants began to think themfelves exempt from fuch calamities, and accordingly had no edifices of fufficient ftrength to withftand the force of a hurricane.

On the 9th of October 1780, it began to blow hard at Bar-badoes; but it was not apprehended till next day that there would be any thing more than fuch a gale as often happens at that feafon. But, on the evening of the 10th, the wind rofe to a prodigious degree of violence.

At 8 o'clock it began to make impreffion on the houfes, by tearing off the roofs, and overthrowing fome of the walls. The hurricane was thought to be at its greateft height at mid-night, but did not abate confiderably till 8 o'clock next morning. The ravage made during this night, on every object of nature and art, was complete and dreadful. The inhabitants, without diftinction of age, fex, or condition, were driven from their houfes, for fear of being buried in the ruins of them, and were obliged to pafs the night in the fields, expofed to the impetuous wind, to the cold, which was very re-markable, confidering the climate, to inceffant torrents of rain, and to the terrors of thunder and lightning, which were violent and almoft conftant.

Multitudes perifhed, either by clinging too long to the buildings for fhelter, in attempting to fave what was valuable, or by unavoidable accidents from the falling of walls, roofs, and furniture, the materials of which were projected to great diftances. The number of lives loft was eftimated from returns made to the Governor, at more than 3000; but feveral parifh-es had given no returns.

By the violence of the wind, the bodies of men and cattle were often lifted from the ground, and carried for feveral yards.

All the fruits of the earth then ftanding were deftroyed, moft of the trees on the ifland were torn up by the roots, and many of them were ftripped of their bark.

All

ALL the houfes on the ifland fuffered more or lefs. Many of the private houfes were levelled with the ground, all of them unroofed, and the whole of their carpenter-work and furniture deftroyed. The large elegant church of Bridgetown was reduced to a heap of ruins.

THE fea rofe fo high as to deftroy the Fort, carrying the great guns many yards from their platform, and demolifhing the houfes near the beach. A fhip was driven on fhore againft one of the buildings of the naval hofpital, which, by this fhock, and the impetuofity of the wind and fea, was entirely deftroyed and fwept away. The Mole-head was fwept away, and ridges of coral rock were thrown up, which ftill remain above the furface of the water: But the harbour and road have, upon the whole, been improved, being deepened in fome places fix feet, in others as many fathoms; and the anchoring ground in the road is much better, by the cruft of coral, which had been the growth of ages, being torn up, and leaving a foft oozy bottom. Many fhells and fifh were thrown on fhore, which had been heretofore unknown.

THE fufferings and loffes by fea were alfo great and calamitous. The wind was too violent for any fhip to ride it out, and they all pufhed to fea, where moft of them perifhed by the mere violence of the weather, without being driven any where on fhore. Out of twelve of his Majefty's fhips of war that were expofed to it, five have been totally loft; and out of the crews of thefe, not more than ten or twelve perfons have been faved.

Dr BLANE was fatisfied, both from what he had an opportunity of obferving himfelf, and from the teftimony of thofe who had been prefent during the hurricane, that an earthquake attended it; and he is convinced that it is not a vulgar prejudice or error to fuppofe, that in hurricanes a concuffion of the earth does occur different from what can proceed from the mechanical impetus of the wind. The flags in the floor of the Great Church,

<div align="right">at</div>

at Bridgetown were fet at angles to each other, though they were fheltered from the wind, and nothing had fallen on them that could produce fuch an effect; cafks had changed their pofition in cellars below ground; maffes of rock were removed, which the mere force of air and water did not feem capable of effecting; and there were chafms in the earth, which feemed to indicate fome internal agitation. The inhabitants, both of Barbadoes and St Lucia, felt the earthquake plainly; and at St Lucia the earthquake happened fome hours after the greateft feverity of the gale.

THIS hurricane chiefly affected Barbadoes, (which is in latitude 13°) the middle Caribbee iflands, Martinique, St Lucia, and St Vincent's. It was felt, but very flightly, at Antigua, St Chriftopher's, the Virgin iflands, and at Grenada. At Tobago, they had rough weather at the time, which did no material damage. It is remarkable, that the more northern Weft India iflands, from latitude 17° to the tropic, are feldom exempt from hurricanes, for more than feven or eight years together. At Barbadoes, it has been already obferved, there had been nothing of this kind for above a century.

THE extent of this hurricane, from north to fouth, was pretty well afcertained by the accounts from the different iflands already mentioned. But there were no means of afcertaining, with equal accuracy, how far it extended from eaft to weft. A fhip that arrived at Barbadoes fix days after, had a gale of wind about the time of the hurricane, which was not particularly violent, and was remarkable only for this, that the wind blew all round the compafs; a circumftance which diftinguifhes the hurricane from all other gales within the tropics; the courfe of nature being fo far inverted, that the direction of the trade-winds, at other times conftant, is not then obferved. At Barbadoes, indeed, the greater part of the hurricane was from the N. E.; but an hour or two after midnight, it was, for a little

(E) time,

time, due W. and was more or lefs from all the intermediate points. In places but a few miles diftant, people difagreed in their accounts of its violence and direction at the fame point of time. It was very irregular in thefe refpects at other places; for on the ifland of St Lucia they had it not at any time from the weft; but the Montague and Ajax, the fhips that were driven from that ifland, had it from all points.

THE progrefs of it weftward was very flow, confidering the violence of the wind. This, Dr BLANE thinks, was owing to the various directions in which it blew. At St Vincent and St Lucia, which are not above twenty leagues to leeward of Barbadoes, it was thirteen or fourteen hours later in coming on, and was not near fo violent. At St Domingo they had it in a ftill lefs degree on the 13th and 14th of October. It has fince appeared, that there was in England the moft violent ftorm that has been known for many years, the very day of the hurricane at Barbadoes.

IT was remarked, that the fhips which put before the wind during the hurricane, were not carried with the velocity which might have been expected from the violence of it. A merchant-fhip, with the crew on board, was driven from her anchors at Barbadoes, all the compaffes were broken, and, after toffing about for two days and two nights, the people found themfelves at the mouth of Carlifle bay, the very point whence they fet out, at a time when they might reafonably have fuppofed themfelves 100 leagues from it.

THERE was much lightning during the hurricane, chiefly in large fheets and fteady blazes, and little of the forked and darting kind. At St Lucia, there was much of what the French called *feu de St Elme*, which Dr BLANE fuppofes to be the *ignis fatuus*.

THERE was in the N. E. an Aurora Borealis, an unufual appearance in the Weft Indies.

DURING

DURING the whole night, a rumbling noife was heard in the fky, now and then interrupted by a momentary paufe. There were no obfervations made, either with the thermometer or barometer; but the wind was remarkably cold. Dr BLANE was informed by Dr WARNER of Antigua, that, during another hurricane which happened at that ifland, the barometer, near the level of the fea, fell to $27\frac{2}{10}$. It is known, that, in the Weft Indies, the barometer ftands, with little variation, fomewhere between 29 and 30.

THE influence of the hurricane on peoples health was very remarkable. Inftead of producing ficknefs, it feemed to have the very oppofite effect. There was lefs ficknefs after, than there had been before it; and moft of thofe who were fick at the time of it were benefited by it, except the very old and delicate, who fuffered, either from mechanical violence, or the fubfequent want of fhelter. It had a vifible good effect on the difeafes of the climate, fevers and fluxes. Chronic diarrhœas, the confequence of dyfenteries, were alfo cured by it. But the difeafes on which it operated moft vifibly and fenfibly were pulmonic complaints. Some recent cafes of phthifis, and even the acute ftate of pleurify, were cured by it. Nay, in the more advanced and incurable ftate of phthifis, the hectic fever was, in a great meafure, removed, and a temporary alleviation at leaft procured. Dr BLANE mentioned particularly the cafe of a lady of his acquaintance, who was ill of a pleurify at the time of the hurricane, and paffed more than ten hours in the open air, fitting generally in a plafh of water from the rain that fell; fhe had no more of her complaint, nor any return of it; and Dr BLANE faw her a few weeks after in better looks and in a better general ftate of health than fhe had enjoyed for a great while before. It was a general obfervation, that people had remarkably keen appetites for fome days after the hurricane; and many people, who ufed to be thin and fallow, Dr BLANE faw looking frefh and plump a few weeks after it,

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though the unhealthy rainy feafon was there hardly over. Thefe facts, which appear fo very wonderful, Dr BLANE mentions with confidence, they being confirmed by a concurrence of teftimony, and, in fome meafure, by his own obfervation.

Regifter of the weather at Branxholm.

Dr WALKER prefented and read the title of a paper, communicated by his Grace the Duke of BUCCLEUGH, Prefident of the Society, containing a Regifter of the Quantity of Rain that fell, the height of the Barometer and Thermometer, and the general bearing of the Wind at Branxholm for ten years, ending December 31. 1783. The Regifter is publifhed in this volume. [No. IX. *Phyf. Cl.*]

1785.

Jan. 17.
Mr Frafer-Tytler on the Scandinavian nations.

Lit. Cl. Mr ALEXANDER FRASER-TYTLER read a Differtation on the Character, Manners and Genius of the Ancient Scandinavian Nations. He did not incline that the Differtation, or any abftract of it, fhould be publifhed.

Jan. 24.
Gen. Meeting.

A GENERAL meeting of the Royal Society was held for the election of Members.

Donations.

Dr WALKER laid before the meeting a collection of fpecimens of natural hiftory, and other curiofities, which had been prefented to the Royal Society. Thefe are enumerated in the Lift of Donations, printed at the end of Part I. of this volume.

Feb. 21.
Mr Hill on hiftorical compofition.

Lit. Cl. Mr Profeffor JOHN HILL read the remainder of his Effay on Hiftorical Compofition, publifhed in this volume. [No. IV. and VIII. *Lit. Cl.*]

March 7.
Dr Hutton's theory of the earth.

Phyf. Cl. Dr BLACK, in the abfence of the Author, read the firft part of Dr HUTTON's Theory of the Earth, which is publifhed in this volume. [No. X. *Phyf. Cl.*]

Lit.

Lit. Cl. Dr GREGORY read a second part of his Essay on the general Notion of the Relation of Cause and Effect. [See *supra*, Nov. 15. 1784.]

Phys. Cl. Dr HUTTON read the second part of his Theory of the Earth, published in this volume. [No. X. *Phys. Cl.*]

AT a meeting of a Committee of the Royal Society, Mr ROBISON, General Secretary, presented to the Society from THOMAS HUTCHINS, Esq; his paper on the Congelation of Mercury, and from Dr HUTTON of Woolwich, his Logarithmic Tables.

Lit. Cl. The Reverend Dr MACFARLAN read a Discourse on the Advantages of Manufactures, Commerce and great Towns, to the Population and Prosperity of a Country. The Author having published this Discourse, it becomes unnecessary here to give any account of its contents.

A GENERAL meeting of the Royal Society was held for the election of the Office-bearers for the ensuing year. Those of the preceding year were unanimously continued in office.

Phys. Cl. Dr WALKER read an Essay on the Flowers of Muscous Plants. He did not incline that any account should be given of the Essay in this volume.

AT a meeting of the Council of the Royal Society, Mr Commissioner SMITH informed the members, that he had received a letter from the Count de WINDISCHGRATZ, dated Brussells, May 8. 1785, on the subject of a problem proposed by that nobleman to the learned men of all nations, which has for its object, the diminution of the number of law-suits by some required method, which, at the same time, shall impose no new

restraints

reftraints on natural liberty. The problem, as announced in a printed *programma*, which accompanied the Count's letter to Mr Smith, is as follows:

" Pro omni poffibili inftrumentorum fpecie, quibus quis fe
" obftringere, fuumve dominium in alterum, quibufcunque
" ex motivis, et quibufcunque fub conditionibus transferre
" poteft, formulas tales invenire, quæ omnibus cafibus indivi-
" duis conveniant, atque in quovis cafu fingulis duntaxat termi-
" nis, iifque pervulgatis expleri opus habeant, qui termini,
" æque ac ipfæ formularum expreffiones ejufmodi fint, ut quem-
" admodum in mathefi, nullum dubium, nullum litigium lo-
" cum, habeat."

A prize of a thoufand ducats is offered to any perfon who fhall furnifh a complete folution of this problem. Should there be no complete folution, a prize of five hundred ducats is offer-ed to the author of that fcheme, which fhall be judged to approach the neareft to a folution. The Count propofes, in the printed *programma*, that all writings which fhall be offer-ed in the competition for thefe prizes, fhall be judged of by three of the moft diftinguifhed Literary Academies in Europe. In his letter to Mr Smith, he informs him, that the three learned bodies which he has chofen for that purpofe are: The Royal Academy of Sciences at Paris, the Royal Society of Edin-burgh, and one of the Academies of Germany or Switzerland, which he fhall afterwards name. As a recompence for the trouble they may be put to in this decifion, he offers the fum of 50 *louis d'or* to each of thefe learned bodies, to be affigned by them as a prize for the folution of any queftion which they fhall propofe. Count de Windischgratz intimates, that the Academy of Sciences at Paris has accepted of the office required of them; and he defires that Mr Smith will communicate his requeft to the Royal Society of Edinburgh, and inform him whether that body is willing to undertake the office of deci-

ding

ding in the competition along with the Academy of Sciences, and the other Academy to be yet named.

Mr Smith fignified to the meeting, that although he enter-tained great doubt whether the problem of the Count de Win-dischgratz admitted of any complete and rational folution, yet the views of the propofer being fo highly laudable, and the object itfelf of that nature, that even an approximation to its attainment would be of importance to mankind; he was there-fore of opinion, that the Society ought to agree to the requeft that was made to them. He added, that it was his intention to communicate his fentiments on the fubject to the Count, by a letter, which he would lay before the Council at a fubfe-quent meeting.—The Council were of opinion, That the So-ciety fhould acquiefce in the Count de Windischgratz's pro-pofal, but fhould decline to accept of the recompence offered. The farther confideration, however, of the affair was poftpo-ned, till Mr Smith fhould communicate to the Council the draught of his intended letter to the Count, on the fubject of his problem.

Phyf. Cl. Dr Gregory read a paper communicated by Dr Hope, giving an account of a remarkable cafe, attended with anomalous fymptoms, and terminating fatally; in which, on diffection, the difeafe appeared to have proceeded from a large gall-ftone fticking in the neck of the gall-bladder.

Lit. Cl. Dr Gregory read a continuation of his Effay on Caufe and Effect. [See *fupra*, Nov. 15. 1784.]

Phyf. Cl. Mr William Smellie read an Effay on Inftinct. As this Effay makes a part of a larger work, which the author is preparing to lay before the Public, he did not wifh it fhould ap-pear at full length among the Differtations printed in this vo-lume.

lume. The following abſtract, however, is given of its prin-
cipal contents.

MANY theories have been invented with a view to explain
the inſtinctive actions of animals, but none of them have re-
ceived the general approbation of Philoſophers. This want
of ſuccefs may be referred to different caufes ; to want of at-
tention to the general œconomy and manners of animals ; to
miſtaken notions concerning the dignity of human nature ; and,
above all, to the uniform endeavour of Philoſophers to diſtin-
guiſh inſtinctive from rational motives. Mr SMELLIE endea-
vours to ſhew that no ſuch diſtinction exiſts, and that the rea-
ſoning faculty itſelf is a neceſſary reſult of inſtinct.

HE obſerves, that the proper method of inveſtigating ſub-
jects of this kind, is to collect and arrange the facts which
have been diſcovered, and to conſider whether theſe lead to
any general concluſions. According to this method, he exhi-
bits examples, *Firſt*, of pure inſtincts : *Secondly*, of ſuch inſtincts
as can accommodate themſelves to particular circumſtances and
ſituations : *Thirdly*, of ſuch as are improveable by experience
or obſervation : And, *laſtly*, he draws ſome concluſions.

BY pure inſtincts are meant ſuch as, independently of all in-
ſtruction or experience, inſtantaneouſly produce certain actions,
when particular objects are preſented to animals, or when they
are influenced by peculiar feelings. Such are, in the human
ſpecies, the inſtinct of ſucking, which is exerted by the infant
immediately after birth, the voiding of fæces, the retraction of
the muſcles upon the application of any painful ſtimulus. The
love of light is exhibited by infants, even ſo early as the third
day after birth. The paſſion of fear is diſcoverable in a child
at the age of two months.

AMONG the inferior animals, there are numberleſs pure in-
ſtincts. Caterpillars ſhaken off a tree in every direction, turn
immediately to the trunk, and climb up. Young birds open
their mouths on hearing any noiſe, as well as that of their mo-
ther's

ther's voice. Every species of insect deposits its eggs in the situation most proper for hatching and affording nourishment to its future progeny. Some species of animals look not to future wants ; others, as the bee and the beaver, are endowed with an instinct which has the appearance of foresight. They construct magazines, and fill them with provisions. Bees display various remarkable instincts. They attend and feed the female or queen. When deprived of her, all their labours cease till a new one is obtained. They construct cells of three different dimensions ; for working bees, for drones and for females ; and the queen in depositing her eggs, puts each species into its appropriated cells. They destroy all the females but one, lest the hive should be overstocked. The different instincts of the common bee, of the wood-piercing bee, and of that species which builds cylindrical nests, with rose-leaves, are very remarkable.

EQUALLY singular are the instincts of wasps, and ichneumon flies, which though they feed not themselves upon worms, lay up stores of these animals for the nourishment of their young.

BIRDS build their nests of the same materials, and in the same form and situation, though they inhabit very different climates. They turn and shift their eggs, that they may be equally heated. Geese and ducks cover up their eggs till they return to the nest. The swallow solicits her young to void their excrement over the nest, and assists them in the operation. The spiders, and many insects of the beetle-kind, when put in terror, counterfeit death. This is not, as has been supposed, a convulsion or stupor, but an artifice ; for when the object of terror is removed, they recover immediately.

OF instincts which can accommodate themselves to peculiar circumstances and situations, many instances may be given from the human species ; but these being improveable, fall more properly under the third class.

(F)   THOSE

Those animals are moſt perfect, whoſe ſphere of knowledge extends to the greateſt number of objects. When interrupted in their operations, they know how to reſume their labours, and to accompliſh their purpoſes by different means. Some animals have no other power but that of contracting or extending their bodies. But the falcon, the dog, and the fox, purſue their prey with intelligence and addreſs.

In Senegal, the oſtrich ſits upon her eggs only during the night, leaving them in the day to the heat of the ſun. At the Cape of Good Hope, where the heat is not ſo great, ſhe ſits upon them day and night. Rabbits, when domeſticated, are not inclined to burrow. Bees augment the depth of their cells, and increaſe their number, as occaſion requires. A waſp carrying out a dead companion from the neſt, if he finds it too heavy, cuts off the head, and carries out the load in two portions. In countries infeſted with monkeys, birds, which in other countries build in buſhes or clefts of trees, ſuſpend their neſts at the end of ſlender twigs. The nymphæ of water-moths, which cover themſelves with caſes of ſtraw, gravel, or ſhells, contrive to make their caſes nearly in equilibrium with the water: When too heavy, they add a bit of wood or ſtraw; when too light, a bit of gravel. A cat, when ſhut into a cloſet, has been known to open the latch with its paws.

The third claſs of inſtincts comprehends all thoſe that are improveable by experience and obſervation.

The ſuperiority of man over the other animals, ſeems to depend chiefly on the great number of inſtincts with which he is endowed. Traces of every inſtinct which he poſſeſſes are diſcoverable in the brute-creation, but no particular ſpecies enjoys the whole. On the contrary, moſt animals are limited to a ſmall number. This appears to be the reaſon why the inſtincts of brutes are ſtronger, and more ſteady in their operation than thoſe of man, and their actions more uniform.

Moſt

Most human inftincts receive improvement from experience and obfervation, and are capable of a thoufand modifications. One inftinct counteracts and modifies another, and often extinguifhes the original motive to action. The inftinct of fear is often counteracted by ambition and by refentment. The inftinct of anger, by fear, by fhame, by contempt, by compaffion. Of modified, compounded, and extended inftincts, there are many examples. Devotion is an extenfion of the inftinct of love, to the firft Caufe or Author of the univerfe. Superftition is the inftinct of fear extended to imaginary objects of terror. Hope is the inftinct of love directed to future good. Avarice is the inftinct of love directed to an improper object. Fear is likewife an ingredient of this attachment. Envy is compounded of love, avarice, ambition, and fear. Sympathy is the inftinct of fear transferred to another perfon, and reflected back upon ourfelves. In this manner all the modified, compounded or extended paffions of the human mind, may be traced back to their original inftincts.

The inftincts of brutes are likewife improved by obfervation and experience. Of fuch improvement, the dog, the elephant, the horfe, the camel, afford numerous and ftrong inftances.

From thefe and other examples, given of the different claffes of inftincts, Mr Smellie argues, that inftinct is an original quality of mind, which, in man, as well as in other animals, may be improved, modified, and extended, by experience.

Sensation implies a fentient principle or mind. Whatever feels, therefore, is mind. Of courfe, the loweft fpecies of animals is endowed with mind. But the minds of animals have very different powers; and thefe powers are expreffed by peculiar actions. The ftructure of their bodies is uniformly adapted to the powers of their minds; and no mature animal attempts actions which nature has not enabled it to perform: The inftincts, however, of animals, appear often previoufly to the expanfion of thofe inftruments which nature intended they

fhould

fhould employ. This view of inftinct is fimple: It removes every objection to the exiftence of mind in brutes, and unfolds all their actions by referring them to motives perfectly fimilar to thofe by which man is actuated. There is perhaps a greater difference between the mental powers of fome animals, than between thofe of man and the moft fagacious brutes. Inftincts may be confidered as fo many internal fenfes, of which fome animals have a greater, and others a fmaller number. Thefe fenfes, in different fpecies, are likewife more or lefs ductile; and the animals poffeffing them are, of courfe, more or lefs fufceptible of improving, and of acquiring knowledge.

THE notion that animals are machines, is therefore too abfurd to merit refutation. Though not endowed with mental powers equal to thofe of man, they poffefs, in fome degree, every faculty of the human mind. Senfation, memory, imagination, the principle of imitation, curiofity, cunning, ingenuity, devotion, or refpect for fuperiors, gratitude, are all difcoverable in the brute-creation. Every fpecies too has a language, either of founds or geftures, fufficient for the individuals to communicate their wants to each other; and fome animals underftand in part the language of man. The language of infants is nearly on a par with that of brutes. Brutes, without fome portion of reafon, could never make a proper ufe of their fenfes. But many animals are capable of balancing motives, which is a pretty high degree of reafon. Young animals examine all objects they meet with, and in this inveftigation they employ all their organs. The firft periods of their life are dedicated to ftudy. When they run about and make frolicfome gambols, it is nature fporting with them for their inftruction. Thus they gradually improve their faculties, and acquire an intimate knowledge of the objects that furround them. Men who, from peculiar circumftances, have been prevented from mingling with companions, and engaging in the different amufements and exercifes of youth, are always awkward in their

movements,

movements, cannot ufe their organs with eafe or dexterity, and often continue, during life, ignorant of the moft common objeds.

AT a meeting of the Council of the Royal Society, the fubjeft of the Count de WINDISCHGRATZ's Problem was refumed, and Mr Commiffioner SMITH read to the Meeting the draught of a letter written by him to the Count, ftating objeƈtions to the poffibility of a complete folution of his problem, but intimating, at the fame time, that the Royal Society of Edinburgh had agreed to co-operate with the other two Academies, in deciding on the merit of all Effays or Differtations which fhould appear in the competition for the prizes propofed, though they declined to accept of the recompence offered in the Count's letter. The Council approved of Mr SMITH's letter, a copy of which they requefted of the Author, in order to be preferved among their papers, as he did not incline that it fhould be publifhed in the Tranfaƈtions of the Society.

A P P E N-

APPENDIX.

MEMBERS DECEASED.

SINCE the inſtitution of the Royal Society of Edinburgh, the following Members have died, *viz.*

William Lothian, D. D. *ſenior* Miniſter of Canongate. December 17. 1783.

Sir *George Clerk-Maxwell*, Baronet, of Pennycuik. January 29. 1784.

Matthew Stewart, D. D. Emeritus Profeſſor of Mathematics in the Univerſity of Edinburgh. January 23. 1785.

Andrew Croſbie, Eſq; Vice-Dean of the Faculty of Advocates. February 25. 1785.

Robert Bruce, Eſq; of Kennet, one of the Senators of the College of Juſtice. April 8. 1785.

Sir *Alexander Dick*, Baronet, of Preſtonfield. November 10. 1785.

Alexander Wilſon, M. D. Profeſſor of Practical Aſtronomy in the Univerſity of Glaſgow. October 16. 1786.

John Hope, M. D. King's Botaniſt in Scotland, and Profeſſor of Medicine and Botany in the Univerſity of Edinburgh. November 11. 1786.

Robert Hamilton, D. D. Emeritus Profeſſor of Divinity in the Univerſity of Edinburgh. April 2. 1787.

Sir *James Hunter-Blair*, Baronet, of Dunſkey. July 1. 1787.

William Irvine, M. D. Lecturer on Chemiſtry in the Univerſity of Glaſgow. July 9. 1787.

THE following BIOGRAPHICAL ACCOUNTS of the three firſt of theſe have been read at different meetings of the Claſſes.

I. ACCOUNT

1. Account *of* WILLIAM LOTHIAN, D. D.

[Read by Mr DALZEL, *March* 15. 1784.]

THE cuftom adopted by feveral learned Societies or Acade-demies abroad, which requires, that a profeffed panegyric on every one of the Members, after his death, fhould firft be read before the Academy, and then printed in the hiftory of their tranfactions, has not met with a general approbation, ei-ther in England or in this country. For although characters have frequently appeared in the republic of Letters, whofe fhining talents have, with fufficient propriety, employed the power of eloquence in their praife, every Member of an Aca-demy cannot be deemed the proper fubject of a laboured enco-mium. The Britifh character, naturally fhy and referved, is apt to look with an eye of fufpicion, upon any difcourfe that comes decorated with the pompous title of *Eloge.*

BUT though to write a profeffed panegyric on every deceafed Member of our Society might, with reafon, be thought often-tatious and improper; yet fuch is the merit and juftly acquired literary fame of fome of our number, that, to permit them to fink into the grave, without any public teftimony of our regard, would argue a culpable degree of infenfibility and referve. There are names in our catalogue, whofe praife will be publicly celebrated; and whofe fame will defcend to pofterity, in fpite of the filence which we might think proper to obferve; and as they muft ftand forward in the Biographical Annals of Great Britain, where can an authentic memorial of them be fo pro-perly preferved as in the Regifters of this Society?

It

IT feems proper alfo, that, at the death, even of every one of the Members, a fhort notice of him fhould be inferted in our Records : Mention ought to be made there of his birth and death, of the remarkable incidents of his life, and the claim he had to be inrolled among the Members of the Royal Society of Edinburgh ; fuch a fhort and fimple account having been previoufly read at a meeting of the Clafs to which he more particularly belonged.

BUT whoever has diftinguifhed himfelf in a fuperior degree in the republic of Letters feems to have a claim to higher and more public honours. Nor could the moft faftidious referve be offended, if the memory of fuch a character were celebrated at an affembly of the whole Society.

THESE obfervations have been fuggefted by the recent lofs of a worthy Member of our Literary Department. And as the omiffion of this firft opportunity of introducing a practice, which feems fo laudable, might be afcribed to negligence, or to an imperfect difcharge of that truft with which the Society has honoured its Secretaries, I flatter myfelf the Meeting will hear, with indulgence, the following fhort and fimple account of the perfon to whom I have alluded.

Account of
Dr Lothian.

WILLIAM LOTHIAN, D. D. *fenior* Minifter of Canongate, and Member of this Society, was born in the city of Edinburgh on the 5th of November 1740. Before he was fix years old, he loft his father Mr GEORGE LOTHIAN, a refpectable Surgeon ; and his mother alfo having died when he was an infant, the charge of his education devolved on other relations.

HE had his academical education in the Univerfity of Edinburgh ; and both during the ufual courfe of Literature and Philofophy, and during his application to the ftudy of Theology, he was diftinguifhed for diligence and promifing talents.

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THE ſtudents in that Univerſity have long been accuſtomed to form themſelves into Societies, in which they canvaſs various ſubjects in Literature and Science, with ſuch ardour and liberality of ſentiment, as tend greatly to their improvement, both in knowledge and in public ſpeaking. Into ſeveral of theſe Mr LOTHIAN was admitted, particularly into one which was well known, at that time, by the name of the *Belles-Lettres* Society; and many of the Members, who at preſent make a diſtinguiſhed figure in public life, recollect, that he held an eminent place in their eſtimation.

Mr LOTHIAN was licenſed to preach the Goſpel in October 1762, and ordained Miniſter of Canongate in Auguſt 1764. As a Preacher, his method of inſtruction was ſimple and perſpicuous, his ſentiments rational and manly, and his manner unaffected and perſuaſive.

FOR many years before his death, he was afflicted with an alarming and painful diſeaſe; yet he exerted the activity of his mind and the remaining vigour of his conſtitution with ſuch effect as enabled him to perform all his clerical functions, not only with propriety, but with apparent eaſe. He even found leiſure to write the *Hiſtory of the United Provinces of the Netherlands*, a part of which work he publiſhed in 1780, after having rendered it as perfect as the diſtreſſed habit of his conſtitution would permit. Previous to the appearance of this publication, the Univerſity of Edinburgh had conferred on him the degree of Doctor in Divinity.

IN his laſt illneſs, which was of long duration, and attended with moſt excruciating pain, his patience and fortitude ſupported his ſpirit in an extraordinary degree. He expired on the 17th of December 1783, having only completed the 43d year of his age.

HE was married, in the year 1776, to his couſin Mrs ELIZABETH LOTHIAN, who ſurvives him, by whom he has left four ſons and one daughter.

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As a member of the Church of Scotland, Dr LOTHIAN followed, with firmnefs, that courfe of conduct which feemed to him to be the moft proper. And the appearances which he made in the Ecclefiaftical Courts exhibited fuch marks of found underftanding, and fuch firmnefs of mind, as procured him great refpect. Indeed, his contemporaries and younger brethren, among whom his acquaintance was very extenfive, always repofed the higheft confidence in his judgment, his honour and his integrity, and fpoke in the ftrongeft terms of the fincerity and warmth of his friendfhip.

WHEN this Society was honoured with a Royal Charter of Incorporation, Dr LOTHIAN was naturally thought of as a proper perfon to be inrolled among the number of its Members. But an early death has deprived us of the advantage of his labours.

BESIDES the above mentioned Hiftory, he publifhed two Sermons, which are to be found in the fecond volume of a Collection, entitled, *The Scotch Preacher*, printed at Edinburgh in the year 1776.

II. ACCOUNT

II. ACCOUNT *of Sir* GEORGE CLERK-MAXWELL, *Baronet.*

[*Read by Mr* JOHN CLERK, *junior,* *July* 5. 1784.]

SIR *GEORGE CLERK-MAXWELL* of Pennycuik, Baronet, one of the Prefidents of the Phyfical Clafs of this Society, was born at Edinburgh on the laft day of October 1715. He was the fourth fon of Sir JOHN CLERK of Pennycuik, one of the Barons of Exchequer in Scotland: His mother was a daughter of Sir JAMES INGLIS of Cramond.

HIS more early ftudies were carried on at the Univerfity of Edinburgh, under the eye of his father, who was himfelf a man of letters, and from whom he appears very early to have caught a ftrong tafte for Natural Hiftory, Antiquities and the Theory of Commerce, particularly in fo far as thefe branches of knowledge related to his own country. He afterwards went to Leyden, where he finifhed his ftudies under the immediate infpection of the celebrated BOERHAAVE, who had been the friend of his father; and, before his return home, he vifited feveral parts of France and Germany.

AFTER fettling in his native country, his turn of mind led him to ftudy, with great diligence, the commercial interefts of Scotland, and to be zealous and active in promoting them. He applied himfelf to the introduction and encouragement of various home-manufactures. In particular, he eftablifhed, at a confiderable expence to himfelf, the Linen Manufactory at Dumfries. He likewife fet on foot many different projects for working lead and copper mines. In thefe laudable undertakings, the public advantage outweighed with him every other

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confideration; for his fchemes were profecuted frequently to the detriment of his private fortune.

In 1755, he addreffed *two Letters* to the Truftees for Fifheries, Manufactures and Improvements in Scotland, containing Obfervations on the common mode of treating Wool in this country, and fuggefting a more judicious fcheme of management. Thefe were publifhed, by direction of that Board, in 1756: And the method there recommended having been univerfally followed in practice, has been of real advantage to the public, by improving the quality of Scottifh wool. He likewife, in 1761, wrote a paper on the Advantages of Shallow Plowing, which was read to the *Philofophical Society*, and is publifhed in the third volume of their Effays.

In 1741, Mr Clerk was appointed Lord Treafurer's Remembrancer in Exchequer; and, when the forfeited eftates were put under the management of Commiffioners in 1752, he was fixed on as a proper perfon to fill a place at their Board. In 1760, he was named one of the Truftees for Fifheries, Manufactures and Improvements: And in 1763, Commiffioner of the Cuftoms in Scotland.

His conduct in the difcharge of the public trufts thus committed to him, was fuch as gained him the efteem and confidence of his colleagues. The two Boards of Truftees, in particular, often committed affairs of importance to his fole management; and he never failed to acquit himfelf to their entire fatisfaction. Nor was his ability in their bufinefs more remarkable than his delicacy: For fo fcrupulous was he, that though he had juftly acquired confiderable influence at thofe Boards, he was never fufpected of having once employed it in improper endeavours to ferve his perfonal friends. In the courfe of his duty as a Commiffioner of the Cuftoms, he faithfully improved every opportunity of doing fervice to the Revenue.

One inftance, among many, deferves particular notice, both as being a proof of the confidence repofed in him by the Board of

Cuſtoms, and as a remarkable public event, in which he was, though not oftenſibly, one of the chief actors. For many years before 1764, the Iſle of Man had been a ſource of great hurt to the Revenue, by being under the ſovereignty of the family of Athol; as it was exempted from duties, and conſequently a receptacle for all the ſmugglers who frequented the weſt coaſt of Scotland. In 1764, Mr Grenville, who was then Miniſter, turned his thoughts towards the means of correcting the abuſes occaſioned by the ſituation of the iſland, and applied to the Board of Cuſtoms for ſuch information as was neceſſary towards forming a plan for that purpoſe. Mr Clerk was appointed by the Board to make a ſurvey of the ſouth-weſt coaſt, where the ſmugglers from the Iſle of Man landed their goods. He executed the commiſſion with great accuracy, and was ſoon after ſent for by the Board of Treaſury to make his report. He adviſed, that the ſovereignty of the iſland ſhould be purchaſed, and the ſame laws extended to it by which the reſt of the Britiſh dominions were regulated, as the moſt effectual means of ſuppreſſing the illicit trade. Mr Grenville, from motives of frugality, was at firſt extremely averſe to a purchaſe of the ſovereignty. As the public purſe was then extremely low, and the object of the purchaſe of ſo great a value, he preferred a plan, which, together with ſome other regulations, was to increaſe the number of cruiſers on the ſtation. He had even gone ſo far as to form it into a bill, which he intended to have laid before Parliament, but was at laſt prevailed upon to give it up, after a perſeverance of ſeveral months in the intention; during which time, Mr Clerk, in many converſations with him on the ſubject, laboured to convince him, that, without being adequate to its end, it would have loaded the public with a much greater expence than the ſum neceſſary to purchaſe the ſovereignty. At laſt, Mr Clerk's plan was followed, in almoſt every eſſential particular, by Adminiſtration, and it has been attended with the moſt beneficial conſequences. The

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fmuggling trade, though it ftill fubfifts, is now confined to thofe who are poffeffed of extenfive capitals; whereas, before this act of Parliament, every farmer's fervant who could purchafe half a cafk of fpirits, was engaged for his fhare. The confequence is, that the whole inhabitants on the fouth-weft coaft, who had followed fcarcely any other employment than this pernicious traffic, to the entire neglect of their hufbandry and manufactures, now earn their fubfiftence by a more honeft application of their induftry. The face of the country, which formerly never could raife a fufficient quantity of grain to fupport its own inhabitants, is totally changed, and every year it affords a plentiful fupply to the neighbouring counties.

Mr CLERK was well acquainted with every branch of Natural Hiftory. To Mineralogy he had paid particular attention, from its immediate connection with his mining operations. His knowledge of Geography was fo full and accurate, that he could defcribe, from memory, almoft any city or remarkable place in the known world.

HE was likewife a fkilful engineer and draughtfman, as appears from various roads, bridges, and other public works, in this country, executed under his direction, or on plans which he delineated. Nor were his talents in defigning confined to this more mechanical fpecies of drawing. He could feize and delineate, with uncommon fpirit, every ludicrous expreffion of character; and his drawings in this line are in great requeft with the curious. His mind had likewife a bent to the army; which, however, was never gratified by action, excepting for a few months during the rebellion in 1745. At that time, he joined a military affociation of gentlemen, named *the Yorkfhire Hunters*, who attended the royal army; and he was, on different occafions, employed by the Duke of CUMBERLAND, (who knew him well) and, in particular, to conduct the forces to the proper ground for opening the fiege of Carlifle.

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Mr CLERK had an excellent tafte for the fine arts, and was folicitous to encourage them. As one inftance of this, he had the principal concern in eftablifhing and procuring an endowment for the drawing-fchool in the Univerfity of Edinburgh, where twenty pupils are inftructed *gratis* in the art of defigning. Thefe are felected from among fuch young people, of either fex, as give figns of genius, who are deftined to apply to thofe profeffions in which a fkill in that art is requifite. This inftitution has contributed more than any other circumftance, to the great improvement of ornamental manufactory, which this country has made during the laft twenty years. And whoever recollects the old patterns of carpet, damafk, gauze, and other manufactures of that fort, and compares them with thofe of the prefent day, muft allow the fuperior elegance of defign now exhibited in thofe productions, and which may reafonably be afcribed, in a great meafure, to the happy effects produced by the inftitution we have mentioned.

HE married, at a very early period of life, his coufin-german DOROTHY CLERK-MAXWELL, heirefs of Middlebie in Dumfries-fhire, by whom he had fix fons and feven daughters, of whom only two fons and two daughters furvived him. He fucceeded to his elder brother Sir JAMES CLERK, in the title of Knight Baronet, in the year 1783.

DURING the latter years of his life, his conftitution and fpirits fuffered many fevere fhocks from family misfortunes. He loft, within a fhort time, three fons, a daughter, and a grandfon, all of whom had arrived at years of maturity, and promifed to be the comfort of his old age. Of thefe, his third fon GEORGE, who had been fome years at the Bar, died in 1776. WILLIAM, his fifth, a Lieutenant in the 1ft regiment of foot; ROBERT, his fixth, a Lieutenant in the 56th, and GEORGE CRAIGIE younger of Glendoick, his grandfon, a Captain in the 40th regiment, all perifhed in the fervice of their country, within the period of a few months. The laft mentioned of thefe, in the

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end of 1781, was killed at the ſtorm of New London, juſt as he had mounted the rampart; ROBERT died at Gibraltar, about the ſame time; and WILLIAM was killed at the ſiege of St Chriſtopher's, in the beginning of 1782. Theſe four young gentlemen were all of the moſt promiſing expectations; and it is rarely that one family ſuſtains ſuch accumulated misfortunes. Sir GEORGE's daughter died of grief for the loſs of her brothers and nephew. In addition to theſe calamities, the moſt acute bodily pains gradually waſted his conſtitution. He bore all his diſtreſſes with unſhaken fortitude to the laſt, and attended to the duties of the public Boards of which he was a Member, with his wonted aſſiduity and perſeverance, till within a few days of his death, which happened on the 29th of January 1784. It will be fortunate for his country, if many are left behind him, as ſincerely attached to its welfare, and as active and diſintereſted in promoting it.

III. ACCOUNT

III. Account *of Matthew Stewart,* D. D.

[*Read by Mr John Playfair, April* 3. 1786.]

THE Reverend Dr *MATTHEW STEWART,* late Professor of Mathematics in the Univerfity of Edinburgh, was the fon of the Reverend Mr Dugald Stewart, Minifter of Rothfay in the Ifle of Bute, and was born at that place in the year 1717. After having finifhed his courfe at the grammar-fchool, being intended by his father for the Church, he was fent to the Univerfity of Glafgow, and was entered there as a ftudent in 1734. His academical ftudies were profecuted with diligence and fuccefs; and he was fo happy as to be particularly diftinguifhed by the friendfhip of Dr Hutcheson and Dr Simson. With the latter, indeed, he foon became very intimately connected; for though it is faid, that his predilection for the Mathematics did not inftantly appear on his application to the ftudy of that fcience, yet the particular direction of his talents was probably obferved by his mafter before it was perceived by himfelf. Accordingly, after being the pupil of Dr Simson, he became his friend; and during all the time that he remained at the Univerfity of Glafgow, purfuing the ftudies of Philofophy and Theology, he lived in the clofeft intimacy with that excellent Mathematician, and was inftructed by him in, what might not improperly be called, the *arcana* of the ancient Geometry. That fcience was yet involved in fome degree of myftery; for though the extent of its difcoveries was nearly afcertained, its analyfis, or method of inveftigation, was but imperfectly underftood, and feemed inadequate to the dif-

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coveries which had been made by it. The learning and genius of VIVIANI, FERMAT, HALLEY, and of other excellent Mathematicians, had already been employed in removing this difficulty; but their efforts had not been attended with complete fuccefs. Dr SIMSON was now engaged in perfecting what they had begun, and in refifting the encroachments, which he conceived the modern analyfis to be making upon the ancient. With this view, he had already publifhed a treatife of Conic Sections, and was now preparing a reftoration of the *Loci Plani* of APOLLONIUS, in which that work was to refume its original elegance and fimplicity. To thefe, and other ftudies of the fame kind, he conftantly directed the attention of his young friend, while he was delighted, and aftonifhed at the rapidity of his progrefs.

Mr STEWART's views made it neceffary for him to attend the lectures in the Univerfity of Edinburgh in 1741; and that his mathematical ftudies might fuffer no interruption, he was introduced by Dr SIMSON to Mr MACLAURIN, who was then teaching, with fo much fuccefs, both the Geometry and the Philofophy of NEWTON. Mr STEWART attended his lectures, and made that proficiency which was to be expected from the abilities of fuch a pupil, directed by thofe of fo great a mafter. But the modern analyfis, even when thus powerfully recommended, was not able to withdraw his attention from the ancient Geometry. He kept up a regular correfpondence with Dr SIMSON, giving him an account of his progrefs, and of his difcoveries in Geometry, which were now both numerous and important, and receiving in return many curious communications with refpect to the *Loci Plani*, and the Porifms of EUCLID. Thefe laft formed the moft intricate and paradoxical fubject in the hiftory of the ancient Mathematics. Every thing concerning them, but the name, had perifhed. PAPPUS ALEXANDRINUS has made mention of three books of Porifms written by EUCLID, and has given an account of what they contained; but

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this account has fuffered fo much from the injuries of time, that the fenfe of one propofition only is complete. There was no diagram to direct the Geometer in his refearches, nor any general notion of the fubject, or of the form of the propofitions, to ferve as a rule for his conjectures. The tafk, therefore, of reftoring thefe ancient books, which Dr SIMSON now impofed on himfelf, exceeded infinitely the ordinary labours of the Critic or the Antiquary; and it was only by uniting the learning and diligence of thefe two characters, with the fkill of a profound Geometer, that he was at laft fuccefsful in this difficult undertaking. He had begun it as early as the year 1727, but feems to have communicated the whole progrefs of his difcoveries to Mr STEWART alone.

WHILE the fecond invention of Porifms, to which more genius was perhaps required than to the firft difcovery of them, employed Dr SIMSON, Mr STEWART purfued the fame fubject in a different, and new direction. In doing fo, he was led to the difcovery of thofe curious and interefting propofitions, which were publifhed, under the title of *General Theorems*, in 1746. They were given without the demonftrations; but did not fail to place their Difcoverer at once among the Geometers of the firft rank. They are, for the moft part, Porifms, though Mr STEWART, careful not to anticipate the difcoveries of his friend, gave them no other name than that of Theorems. They are among the moft beautiful, as well as moft general propofitions known in the whole compafs of Geometry, and are perhaps only equalled by the remarkable *Locus* to the circle in the fecond book of APOLLONIUS, or by the celebrated theorem of Mr COTES. The firft demonftration of any confiderable number of them, is that which was lately communicated to this Society *, though I believe there are few Mathematicians, into whofe hands they have fallen, whofe fkill they have not often exercifed. The unity which prevails among them is a proof, that a fingle, though ex-

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tenſive view, guided Mr STEWART in the diſcovery of them
all. It ſeems probable, that, while he aimed at extending Geo-
metry beyond the limits it had reached with the ancients, he
had begun to conſider the *Locus ad quatuor rectas*, beyond which
their analyſis had not reached. With this view, he, no doubt,
thought of extending the hypotheſes of that problem to their
utmoſt generality; that is, to any number of perpendiculars
drawn to an equal number of lines, and to any power what-
ever of theſe perpendiculars. In doing this, he could not fail
to meet with many curious poriſms; for a poriſm is nothing
elſe than that particular caſe, when the data of a problem are ſo
related to one another, as to render it indefinite, or capable
of innumerable ſolutions. Theſe caſes, which rarely occur,
except in the conſtruction of very general and complicated
problems, muſt always intereſt a Geometer, becauſe they trace
out the diviſions of his ſubject, and are uſually diſtinguiſhed
by an elegance and ſimplicity peculiar to themſelves. Such, ac-
cordingly, were the propoſitions which Mr STEWART now com-
municated to the world. He ſuppreſſed his inveſtigations, how-
ever, which were geometrical, and which, if given with all the
preciſion required by the forms of the ancient Geometry,
would probably have occupied ſeveral volumes.

THE hiſtory of theſe geometrical diſcoveries has led us to
neglect the order of time. For Mr STEWART, while engaged
in them, had entered into the Church, and, through the patro-
nage of the Earl of BUTE and the Duke of ARGYLE, had ob-
tained the living of Roſeneath. It was in that retired and ro-
mantic ſituation, that he diſcovered the greater part of the pro-
poſitions that have juſt been mentioned. There, alſo, he uſed
to receive the viſits of his friend Mr MELVIL, whoſe ingenious
obſervations in the *Phyſical and Literary Eſſays*, give us cauſe to
regret that he was ſo early taken from the world of ſcience *.

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* Obſervations on Light and Colours, Phyſ. and Lit. Eſſays, vol. ii. art. 4.

IN the fummer of 1746, the Mathematical Chair in the Univerfity of Edinburgh became vacant by the death of Mr MACLAURIN. The *General Theorems* had not yet appeared ; Mr STEWART was known only to his friends ; and the eyes of the public were naturally turned on Mr STIRLING, who then refided at Leadhills, and who was well known in the mathematical world. He, however, declined appearing as a candidate for the vacant chair ; and feveral others were named, among whom was Mr STEWART. In the end of this year, the *General Theorems* were publifhed, and gave to their Author a decided fuperiority above all the other candidates. He was accordingly elected Profeffor of Mathematics in the Univerfity of Edinburgh, in the beginning of September 1747.

THE duties of this office gave a turn fomewhat different to his mathematical purfuits, and led him to think of the moft fimple and elegant means of explaining thofe difficult propofitions, which were hitherto only acceffible to men deeply verfed in the modern analyfis. In doing this, he was purfuing the object which, of all others, he moft ardently wifhed to attain, *viz.* the application of Geometry to fuch problems as the algebraic calculus alone had been thought able to refolve. His folution of KEPLER's problem was the firft fpecimen of this kind which he gave to the world ; and it was impoffible to have produced one more to the credit of the method he followed, or of the abilities with which he applied it. When the Aftronomer, from whom that problem takes its name, difcovered the elliptical motion of the planets, and their equable defcription of areas round the fun, he reduced the problem, of computing the place of a planet for a given time, to that of drawing a line through the focus of an ellipfe, that fhould divide the area of the femi-ellipfe in a given ratio. It was foon found, that this problem did not admit of an accurate folution ; and that no more was to be expected, than an eafy and exact approximation. In this, ever fince the days of KEPLER, the Mathematicians

ticians of the firſt name had been engaged, and the utmoſt reſources of the integral calculus had been employed. But though many excellent ſolutions had been given, there was none of them at once direct in its method and ſimple in its principles. Mr STEWART was ſo happy as to attain both theſe objects. He founds his ſolution on a general property of curves, which, though very ſimple, had perhaps never been obſerved ; and by a moſt ingenious application of that property, he ſhows how the approximation may be continued to any degree of accuracy, in a ſeries of reſults which converge with prodigious rapidity. Whoever examines this ſolution will be aſtoniſhed to find a problem brought down to the level of elementary Geometry, which had hitherto ſeemed to require the finding of fluents and the reverſion of ſeries ; he will acknowledge the reaſonableneſs of whatever confidence Mr STEWART may be hereafter found to place in thoſe ſimple methods of inveſtigation, which he could conduct with ſo much ingenuity and ſucceſs ; and will be convinced, that the ſolution of a problem, though the moſt elementary, may be the leaſt obvious, and, though the eaſieſt to be underſtood, may be the moſt difficult to be diſcovered.

THIS ſolution appeared in the ſecond volume of the Eſſays of the Philoſophical Society of Edinburgh, for the year 1756. In the firſt volume of the ſame Collection, there are ſome other propoſitions of Mr STEWART's, which are an extenſion of a curious theorem in the fourth book of PAPPUS. They have a relation to the ſubject of poriſms, and one of them forms the 91ſt of Dr SIMSON's Reſtoration. They are beſides very beautiful propoſitions, and are demonſtrated with all the elegance and ſimplicity of the ancient analyſis.

IT has been already mentioned, that Mr STEWART had formed the plan of introducing into the higher parts of mixed Mathematics the ſtrict and ſimple form of ancient demonſtration. The proſecution of this plan produced the *Tracts Phyſical and Mathematical*, which were publiſhed in 1761. In the firſt of
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thefe, Mr STEWART lays down the doctrine of centripetal forces, in a feries of propofitions, demonftrated (if we admit the quadrature of curves) with the utmoft rigour, and requiring no previous knowledge of the Mathematics, except the elements of plain Geometry, and of Conic Sections. The good order of thefe propofitions, added to the clearnefs and fimplicity of the demonftrations, renders this Tract the beft elementary treatife of Phyfical Aftronomy that is any where to be found.

IN the three remaining Tracts, our Author had it in view to determine, by the fame rigorous method, the effect of thofe forces which difturb the motions of a fecondary planet. From this he propofed to deduce, not only a theory of the moon, but a determination of the fun's diftance from the earth. The former is well known to be the moft difficult fubject to which Mathematics have been applied. Though begun by Sir ISAAC NEWTON, and explained, as to its principles, with fingular fuccefs; yet, as to the full detail and particular explanation of each irregularity, it was left by that great Philofopher, lefs perfect than any other of his refearches. Succeeding Mathematicians had been employed about the fame fubject; the problem of the *Three bodies* had been propofed in all its generality, and in as far as regards the motion of the moon, had been refolved by a direct and accurate approximation. But the intricacy and length of thefe calculations rendered them intelligible only to thofe, who were well verfed in the higher parts of the Mathematics. This was what Dr STEWART propofed to remedy, by giving a theory of the moon that might depend, if poffible, on Elementary Geometry alone, or which fhould, at leaft, be the fimpleft that the nature of things would allow. The Tracts were deftined to ferve as the bafis of this inveftigation. We are not, however, to imagine, that Dr STEWART intended to proceed in the fame direct manner that CLAIRAULT, and fome other Geometers, had done. It is not probable, that he believed this to be within

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in the power of pure Geometry. His defign undoubtedly was, to purfue that method of approximation which Sir Isaac Newton had begun, and which Callendrini, Machin and Walmsley had greatly improved; and, by ufing the methods of Geometry, he hoped to reduce the problem to its ultimate fimplicity. Such an undertaking was worthy of a great Geometer, and of a Philofopher, who confidered that one of the chief obftructions to the advancement of knowledge, is the difficulty of fimplifying that knowledge, which has already been acquired. We muft regret, therefore, that the decline of Dr Stewart's health, which began foon after the publication of the Tracts, did not permit him to purfue this inveftigation.

The other object of the Tracts was to determine the diftance of the fun, from his effect in difturbing the motions of the moon. The approach of the tranfit of Venus, which was to happen in 1761, had turned the attention of Mathematicians to the folution of this curious problem. But when it was confidered, of how delicate a nature the obfervations were from which that folution was to be deduced, and to how many accidents they were expofed, it was natural, that fome attempt fhould be made to afcertain the dimenfions of our fyftem, by means lefs fubject to difappointment. Such accordingly was the defign of Dr Stewart; and his enquiries into the lunar irregularities had furnifhed him with the means of accomplifhing it.

The theory of the compofition and refolution of forces enables us to determine what part of the folar force is employed in difturbing the motions of the moon; and, therefore, could we meafure the inftantaneous effect of that force, or the number of feet by which it accelerates or retards the moon's motion in a fecond, we fhould be able to determine how many feet the whole force of the fun would make a body, at the diftance of the moon, or of the earth, defcend in a fecond, and, confequently, how much the earth is, in every inftant,

ſtant turned out of its rectilineal courſe. Thus, the curvature
of the earth's orbit, or, which is the ſame thing, the radius
of that orbit, that is, the diſtance of the ſun from the earth,
would be determined. But the fact is, that the inſtantaneous
effects of the ſun's diſturbing force are too minute to be mea-
ſured; and that it is only the effect of that force, continued
for an entire revolution, or ſome conſiderable portion of a re-
volution, which Aſtronomers are able to obſerve.

THERE is yet a greater difficulty which embarraſſes the ſolution
of this problem. For, as it is only by the difference of the forces
exerted by the ſun on the earth and on the moon, that the mo-
tions of the latter are diſturbed, the farther off the ſun is ſup-
poſed, the leſs will be the force by which he diſturbs the
moon's motions; yet that force will not diminiſh beyond a
fixed limit, and a certain diſturbance would obtain, even if the
diſtance of the ſun were infinite. Now the ſun is actually
placed at ſo great a diſtance, that all the diſturbances, which
he produces on the lunar motions are very near to this
limit, and therefore a ſmall miſtake in eſtimating their quanti-
ty, or in reaſoning about them, may give the diſtance of the
ſun infinite, or even impoſſible. But all this did not deter Dr
STEWART from undertaking the ſolution of the problem, with
no other aſſiſtance than that which Geometry could afford. In-
deed, the idea of ſuch a problem had firſt occurred to Mr MACHIN,
who, in his book on the Laws of the Moon's Motion, has juſt
mentioned it, and given the reſult of a rude calculation, (the
method of which he does not explain) which aſſigns 8″ for
the parallax of the ſun. He made uſe of the motion of
the nodes, but Dr STEWART conſidered the motion of the
apogee, or of the longer axis of the moon's orbit, as the
irregularity beſt adapted to his purpoſe. It is well known,
that the orbit of the moon is not immoveable, but that,
in conſequence of the diſturbing force of the ſun, the long-
er axis of that orbit has an angular motion, by which it

(I)   goes

goes back about three degrees in every lunation, and completes an entire revolution in nine years nearly. This motion, though very remarkable and eafily determined, has the fame fault, in refpect of the prefent problem, that was afcribed to the other irregularities of the moon; for a very fmall part of it only depends on the parallax of the fun; and of this Dr Stewart, as will afterwards appear, feems not to have been perfectly aware.

The propofitions, however, which defined the relation between the fun's diftance and the mean motion of the apogee, were publifhed among the Tracts in 1761. The tranfit of Venus happened in that fame year: the Aftronomers returned, who had viewed that curious phænomenon from the moft diftant ftations; and no very fatisfactory refult was obtained from a comparifon of their obfervations. Dr Stewart then refolved to apply the principles he had already laid down; and, in 1763, he publifhed his effay on the fun's diftance, where the computation being actually made, the parallax of the fun was found to be no more than 6″. 9. and his diftance, of confequence, almoft 29875 femidiameters of the earth *.

A determination of the fun's diftance, that fo far exceeded all former eftimations of it, was received with furprife, and the reafoning on which it was founded was likely to be fubjected to a fevere examination. But, even among Aftronomers, it was not every one who could judge in a matter of fuch difficult difcuffion. Accordingly, it was not till about five years after the publication of the *Sun's Diftance*, that there appeared a pamphlet under the title of *Four Propofitions*, intended to point out certain errors in Dr Stewart's inveftigation, which had given a refult much greater than the truth. A difpute in Geometry was matter of wonder to many, and

perhaps

* About 118,541,428 Englifh miles.

perhaps of fatisfaction to some, who envied that science the certainty of its conclusions. On account of such, it must be observed, that there are problems so extremely difficult, that, in the solution of them, it is possible only to approximate to the truth; and that, as in Arithmetic, we neglect those small fractions, which, though of inconsiderable amount, would exceedingly embarrass our computations; so, in Geometry, it is sometimes necessary to reject those small quantities, which would add little to the accuracy, and much to the difficulty of the investigation. In both cases, however, the same thing may happen; though each quantity thrown out may be inconsiderable in itself, yet the amount of them altogether, and their effect on the last result, may be greater than is apprehended. This was just what had happened in the present case. The problem to be resolved is, in its nature, so complex, and involves the estimation of so many causes, that, to avoid inextricable difficulties, it is necessary to reject some quantities, as being small in comparison of the rest, and to reason as if they had no existence. Dr STEWART, too, it must be confessed, had an additional motive for wishing to simplify his investigation. This was, his resolution, to employ in it no other method than the Geometrical, which, however excellent in other respects, is inferior to Algebra, for the conducting of very complicated reasonings. The skill of this most profound and experienced Geometer, could not remedy that defect; and he was reduced to the necessity of rejecting quantities, which were considerable enough to have a great effect on the last result. An error was thereby introduced, which, had it not been for certain compensations, would have become immediately obvious, by giving the sun's distance near three times as great as that which has been mentioned.

THE Author of the pamphlet, referred to above, was the first who remarked the dangerous nature of these simplifications, and who attempted to estimate the error to which they had

given

given rife. In this laft, however, he has not completely fuc-
ceeded ; and that, too, by committing a miftake fimilar to that
which he cenfured in Dr STEWART, and by rejecting quanti-
ties not lefs than fome which he retained. He obferved, how-
ever, what produced the compenfation that has been taken no-
tice of, *viz.* the immenfe variation of the fun's diftance, which
correfponds to a very fmall variation of the motion of the
moon's apogee. It is doubtful, whether Dr STEWART was
fully apprifed of this circumftance ; becaufe the geometrical
method, elegant and beautiful as it is, rarely prefents a gene-
ral view of the relations, which the magnitudes it treats of
bear to one another ; and many of thefe relations may, there-
fore, efcape the moft profound Geometer, which an Algebraift,
of more ordinary abilities, would not have failed to difcover.

THERE are other of this Author's ftrictures, which we can-
not admit as juft, but which we will not attempt here, either
to enumerate or refute. Yet it were doing great injuftice to
his remarks not to acknowledge, that, befides being juft in the
points already mentioned, they are, every where, ingenious,
and written with much modefty and good temper. The Au-
thor, who concealed his name, and permits it now, for the
firft time, to be publicly mentioned, was Mr DAWSON, a fur-
geon at Sudbury in Yorkfhire ; a man, as it fhould feem, who
might have enjoyed more of the fame, had he been lefs fatis-
fied with the poffeffion of knowledge.

A SECOND attack was foon after this made on the *Sun's Di-*
ftance, by Mr LANDEN ; but by no means with the fame good
temper which has been remarked in the former. He fancied
to himfelf errors in Dr STEWART's inveftigation, which have
no exiftence ; he exaggerated thofe that were real, and feemed
to triumph in the difcovery of them with unbecoming exulta-
tion. If there are any fubjects on which men may be expected
to reafon difpaffionately, they are certainly the properties of
number

number and extenfion ; and whatever pretexts Moralifts or Di-
vines, may have for abufing one another, Mathematicians can
lay claim to no fuch indulgence. The afperity of Mr LAN-
DEN's animadverfions muft not, therefore, pafs uncenfured,
though it be united with found reafoning and accurate difcuf-
fion. The error into which Dr STEWART had fallen, though
before taken notice of by Mr DAWSON, was firft exactly deter-
mined in the work before us *. But Mr LANDEN, in the zeal
of correction, brings many other charges againft Dr STEWART,
the greater part of which feem to have no good foundation.
Such are his objections to the fecond part of the inveftigation,
where Dr STEWART finds the relation between the difturbing
force of the fun, and the motion of the apfides of the lunar
orbit. For this part, inftead of being liable to objection, is de-
ferving of the greateft praife, fince it refolves, by Geometry
alone, a problem which had eluded the efforts of fome of the
ableft Mathematicians, even when they availed themfelves of
the utmoft refources of the integral calculus. Sir ISAAC NEW-
TON, though he affumed the difturbing force very near the
truth, computed the motion of the apfides from thence only at
one half of what it amounts to in reality ; and fo, had he been
required, like Dr STEWART, to invert the problem, he would
have committed an error, not merely of a few thoufandth
parts, as the latter is alleged to have done, but would have
brought out a refult double of the truth †. MACHIN and
CALLENDRINI, when commenting on this part of the *Princi-
pia*, found a like inconfiftency between their theory and obfer-
vation. Three other celebrated Mathematicians, CLAIRAULT,
D'ALEMBERT and EULER, feparately experienced the fame dif-
ficulties,

* IT is but juftice to remark, that Mr LANDEN had probably never feen Mr DAWSON's
Propofitions at the time his own were publifhed, the whole impreffion of them, almoft,
having been burnt by a fire which confumed the warehoufe where they were lodged.

† Prin. Math. lib. 3. prop. 3.

ficulties, and were led into an error of the fame magnitude. It is true, that, on refuming their computations, they found, that they had not carried their approximations to a fufficient length, which when they had, at laft, accomplifhed, their refults agreed exactly with obfervation. Mr WALMSLEY and Dr STEWART were, I think, the firft Mathematicians, who, employing in the folution of this difficult problem, the one the algebraic calculus, and the other the geometrical method, were led immediately to the truth; a circumftance fo much for the honour of both, that it ought, by no means, to be forgotten. It was the bufinefs of an impartial critic, while he examined our Author's reafonings, to have remarked, and to have weighed thefe confiderations.

WE may add, that the accurate meafurement of the fun's diftance, and the complete theory of the moon's motions, with which fcience has been enriched, fince the time to which we now refer, fufficiently vindicate the principle of Dr STEWART's inveftigation, and fhow how much reafon he had to expect, that the former might be inferred from the latter with confiderable exactnefs. M. MAYER, from one of the lunar irregularities, computes the fun's parallax to be 7″. 8, nearly a mean between the parallax already mentioned, and that which has been deduced from the tranfit of Venus in 1769 *.

ON the whole, therefore, while it muft be acknowledged, that Dr STEWART's determination of the fun's diftance is, by no means, free from error, it may fafely be afferted, that it contains a great deal which will always intereft Geometers, and always be admired by them. Few errors in fcience are redeemed by the difplay of fo much ingenuity, and what is more fingular, of fo much found reafoning. The inveftigation is every where elegant, and will, probably, be long regarded as a fpecimen of the moft arduous enquiry which has been attempted by mere Geometry; at the fame time, the miftake into which the geometrical method has betrayed this great Mathematician, will

serve

* Theoria Lunæ, fect. 51.

ferve as a proof that it is not equal to fuch difficult refearches ; and that in thofe cafes, efpecially, where approximation is to be ufed, it is neceffary to facrifice the rigour of the ancient demonftration for the accuracy of the modern analyfis.

THE *Sun's Diftance* was the laft work which Dr STEWART publifhed ; and though he lived to fee the animadverfions made on it, that have been taken notice of above, he declined entering into any controverfy. His difpofition was far from polemical ; and he knew the value of that quiet, which a literary man fhould rarely fuffer his antagonifts to interrupt. He ufed to fay, that the decifion of the point in queftion was now before the public ; that, if his inveftigation was right, it would never be overturned, and that, if it was wrong, it ought not to be defended.

A FEW months before he publifhed the Effay juft mentioned, he gave to the world another work, entitled, *Propofitiones Geometricæ More Veterum Demonftratæ.* This title, I have been told, was given it by Dr SIMSON, who rejoiced in the publication of a work fo well calculated to promote the ftudy of the ancient Geometry. It confifts of a feries of geometrical theorems, for the moft part, new ; inveftigated, firft, by an analyfis, and afterwards fynthetically demonftrated by the inverfion of the fame analyfis. In the former, the propofition to be inveftigated is fuppofed true ; from thence confequences are deduced, and the reafoning is carried on till fome confequence is drawn that is already known to be true. A neceffary connection is thus traced between the propofition that was fuppofed true, and another that is certainly known to be fo ; and, thus, an ingenious method is laid down for making the knowledge of any truth fubfervient to the difcovery of its demonftration. This method made an important part in the analyfis of the ancient Geometers ; but few examples of it have been preferved in their writings, and thofe in the *Propofitiones Geometricæ,* are, on that account, the more valuable.

Dr

Dr STEWART's conſtant uſe of the geometrical analyſis had put him in poſſeſſion of many valuable propoſitions, which did not enter into the plan of any of the works that have been enumerated. Of theſe, not a few have found a place in the writings of Dr SIMSON, where they will for ever remain, to mark the friendſhip of theſe two Mathematicians, and to evince the eſteem which Dr SIMSON entertained for the abilities of his pupil. In the preface to his Conic Sections, in which he acknowledges, that all the theorems, diſtinguiſhed by the letter *x*, were communications from Dr STEWART, he calls him, " egregiæ indolis et " peritiæ virum ;" and in that to his Poriſms, after pointing out many propoſitions that had been ſuggeſted by PAPPUS, and a few that had been adopted from FERMAT, he adds, " Alia " quædam adjecta ſunt quorum præcipua mihi propoſuit, et " aliquorum conſtructionem dedit eximius Geometra MAT- " THÆUS STEWART, a quo materia hæc jam egregie eſt ex- " culta, poſtea, ut ſpero, multum excolenda."

THERE is alſo a theorem of Dr STEWART's publiſhed in Dr SIMSON's edition of EUCLID's *Data,* which I take notice of, chiefly as it affords me an opportunity of paying a tribute to the memory of a man, whoſe high rank did not prevent him from cultivating a ſcience, which it enabled him to patronize. In the note, where Dr SIMSON acknowledges that communication, he mentions another theorem, alſo publiſhed among the *Data* ; " Theſe propoſitions (ſays he) were communicated to me by " two excellent Geometers, the firſt by the Earl STANHOPE, the " ſecond by Dr MATTHEW STEWART."

To this Nobleman, for whoſe abilities and worth Dr STEW- ART entertained the higheſt reſpect, he made a viſit in the courſe of a tour through England, ſoon after the publication of the Eſſay on the Sun's Diſtance, and received from him very ſingular marks of attention. At a later period, when he lamented the loſs of Dr SIMSON, he had the
                                                                    conſolation

confolation to fee a lafting monument raifed to the fame of his friend, by the munificence of Lord STANHOPE, who, by the publication of Dr SIMSON's pofthumous works, has obliged the world with a *reftoration* of the moft curious fragment of the Greek Geometry.

SOON after the publication of the *Sun's Diftance*, Dr STEW-ART's health began to decline, and the duties of his office became burdenfome to him. In the year 1772, he retired to the country, where he afterwards fpent the greater part of his life, and never refumed his labours in the Univerfity. He was, however, fo fortunate as to have a fon, to whom, though very young, he could commit the care of them with the greateft confidence. Mr DUGALD STEWART, having begun to give lectures for his father from the period above mentioned, was elected joint Profeffor with him in 1775, and gave an early fpecimen of thofe abilities, which have not been confined to a fingle fcience.

AFTER mathematical ftudies (on account of the bad ftate of health into which Dr STEWART was now falling) had ceafed to be his bufinefs, they continued to be his amufement. The analogy between the circle and hyperbola had been an early object of his admiration. The extenfive views which that analogy is continually opening; the alternate appearance and difappearance of refemblance in the midft of fo much diffimilitude, make it an object that aftonifhes the experienced, as well as the young Geometer. To the confideration of this analogy, therefore, the mind of Dr STEWART very naturally returned, when difengaged from other fpeculations. His ufual fuccefs ftill attended his inveftigations; and he has left, among his papers, fome curious approximations to the areas, both of the circle and hyperbola. For fome years toward the end of his life, his health fcarcely allowed him to profecute ftudy even as an amufement. He died January 23. 1785, at the age of 68.

THE

The habits of ftudy, in a man of original genius, are objects of curiofity, and deferve to be remembered. Concerning thofe of Dr Stewart, his writings have made it unneceffary to remark, that, from his youth, he had been accuftomed to the moft intenfe, and continued application. In confequence of this application, added to the natural vigour of his mind, he retained the memory of his difcoveries in a manner that will hardly be believed. He rarely wrote down any of his inveftigations, till it became neceffary to do fo for the purpofe of publication. When he difcovered any propofition, he would put down the enunciation with great accuracy, and, on the fame piece of paper, would conftruct very neatly the figure to which it referred. To thefe he trufted for recalling to his mind, at any future period, the demonftration, or the analyfis, however complicated it might be. Experience had taught him, that he might place this confidence in himfelf without any danger of difappointment; and for this fingular power, he was probably more indebted to the activity of his invention, than the mere tenacioufnefs of his memory.

Though he was extremely ftudious, he read few books, and verified the obfervation of M. D'Alembert, that, of all the men of letters, Mathematicians read leaft of the writings of one another. His own inveftigations occupied him fufficiently; and, indeed, the world would have had reafon to regret the mifapplication of his talents, had he employed, in the mere acquifition of knowledge, that time which he could dedicate to works of invention.

It was his cuftom to fpend the fummer at a delightful retreat in Ayrfhire, where, after the academical labours of the winter were ended, he found the leifure neceffary for the profecution of his refearches. In his way thither, he frequently made a vifit to Dr Simson at Glafgow, with whom he had lived from his youth in the moft cordial and uninterrupted friendfhip.

ſhip. It was pleaſing to obſerve, in theſe two profound Mathe-
maticians, the moſt perfect eſteem and affection for each other,
and the moſt entire abſence of jealouſy, though no two men
ever trode more nearly in the ſame path. The ſimilitude of
their purſuits, as it will ever do with men ſuperior to envy,
ſerved only to endear them to one another. Their ſentiments
and views of the ſcience they cultivated were nearly the ſame;
they were both profound Geometers; they equally admired
the ancient Mathematicians, and were equally verſed in their
methods of inveſtigation; and they were both apprehenſive,
that the beauty of their favourite ſcience would be forgotten
for the leſs elegant methods of algebraic computation*. This
innovation they endeavoured to oppoſe; the one, by reviving
thoſe books of the ancient Geometry which were loſt; the
other, by extending that Geometry to the moſt difficult enqui-
ries of the moderns. Dr STEWART, in particular, had remark-
ed the intricacies, in which many of the greateſt of the modern
Mathematicians had involved themſelves in the application of
the calculus, which a little attention to the ancient Geometry
would certainly have enabled them to avoid. He had obſerved,
too, the elegant ſynthetical demonſtrations that, on many oc-
caſions, may be given of the moſt difficult propoſitions, inveſti-
gated by the inverſe method of fluxions. Theſe circumſtances
had, perhaps, made a ſtronger impreſſion than they ought, on
a mind already filled with admiration of the ancient Geometry,
and produced too unfavourable an opinion of the modern ana-
lyſis. But, if it be confeſſed, that Dr STEWART rated, in any
reſpect too high, the merit of the former of theſe ſciences,

(K 2) this

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* ON the reverſe of a miniature picture of Dr SIMSON, now in the poſſeſſion of Mr
Prof. STEWART, is an inſcription, written by Dr MOOR, late Profeſſor of Greek at Glaſ-
gow, an intimate friend of Dr SIMSON, and a great admirer of the ancient Geometry:

GEOMETRIAM, SUB TYRANNO BARBARO SAEVA SERVITUTE DIU SQUALENTEM, IN
LIBERTATEM ET DECUS ANTIQUUM VINDICAVIT UNUS.

this may well be excufed in the man whom it had conducted to the difcovery of the *General Theorems*, to the *folution of* KEP-LER's *Problem*, and to an *accurate* determination of the *Sun's difturbing force*. His great modefty made him afcribe to the method he ufed, that fuccefs which he owed to his own abilities.

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[*N. B.* The numbers refer to the order in which the articles are depofited in the Mufeum of the Univerfity of Edinburgh.]

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A collection of Indian Arms, Apparel and Utenfils, and of Na-
  tural Productions, made in the South Sea iflands, and on the
  weft coaft of America, by Mr *Anderfon,* Surgeon to Captain
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  ental Alabafter.   No. 345.—411.

<div align="right">Thirty</div>

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Two

Two specimens of a large Snake from America.   No. 674. 675.
The Roots of an Oak-tree inosculated.   No. 676.

By Dr *William Cullen.*

LACERTA *Bullaris.*   LIN.   No. 677.
Four species of West India Insects.   No. 678.—681.
Five species of West India Serpents.   No. 682.—687.

By Mr *James Bruce,* Edinburgh.

Two species of Scots Birds preserved.   No. 688. 689.

By *James Boswell,* Efq; of Auchinleck.

A collection of West India Animals:
Insects, nine species.   No. 690.—698.
Lizards, eight species.   No. 699.—707.
Serpents, twelve species.   No. 708.—721.

By Mr *James Dickson,* Bookseller, Edinburgh.

Fourteen Coins of Silver and five of Copper, chiefly Scottish.

By Dr *Samoilowitz* of St Petersburgh.

Memoire sur la Peste qui en 1771 *ravagea l'Empire de Russie: Par
M. De Samoilowitz:* And four other small publications, rela-
tive to the same subject.

By Mr *Thomas Hutchins.*

Experiments for ascertaining the point of Mercurial Congelation.
8vo.   Lond. 1784.

By Dr *Hutton* of Woolwich.

Mathematical Tables.   8vo.   Lond. 1785.
An authentic Narrative of the Dissensions and Debates in the
Royal Society of London.   8vo.   1784.

By

By Dr *Blane.*

Obfervations on the Difeafes of Seamen. 8vo. *Lond.* 1785.

By Dr *Robert Boyd.*

Judicial Proceedings before the High Court of Jufticiary, *&c.* 4to. *Edin.* 1779.

By *H. F. A. De Rouffel,* M. D. and Profeffor of Medi-
cine in the Univerfity of Caen.

Differtatio de variis Herpetum Speciebus, *&c.* 8vo. *Cad.* 1779.
Recherches fur la petite Vérole. 8vo. *A Caen* 1781.

By *Joannes-Francifcus Cofte, &c.*

De Antiqua Medico-Philofophia Orbi novo adaptanda, Oratio
habita in Comitiis Univerfitatis Virginiæ : *Jan.* 12. 1782.

By *M. Dionis du Séjour,* of the Royal Academy of
Sciences of Paris, *&c.*

Traité Analytique des Mouvemens apparens des Corps Céleftes.
Tom. 1. 4to. Paris 1786.

By *M. l'Abbé Treffan, (à Rouen.)*

*Effai fur la Fluide Electrique, par feu M. le Comte de Treffan,
(fon Pere.)* 2 toms. 8vo. *

(L) *LIST*

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* Other Donations have been received, a Lift of which is referved for Vol. II.

January 1. 1788.

L I S T of all the MEMBERS *or* FELLOWS *of the* ROYAL SOCIETY *of Edinburgh.*

I.

MEMBERS upon the Lift at the firft meeting of the PHYSICAL CLASS, Nov. 3. and of the LITERARY CLASS, Nov. 17. 1783.

[*N. B.* * prefixed denotes a Member formerly of the PHILOSOPHICAL SOCIETY, and † a Member now deceafed. *P* added denotes of the PHYSICAL CLASS, and *L* of the LITERARY CLASS.]

1. RESIDENT MEMBERS.

A.

Alexander Abercrombie, Efq; Advocate. *L.*

* *James Anderson,* LL. D. *P.*

B.

* Mr *Benjamin Bell,* Surgeon. *P.*

* *Joseph Black,* M. D. Profeffor of Medicine and Chemiftry in the Univerfity of Edinburgh. *P.*

Hugh Blair, D. D. Emeritus Profeffor of Rhetoric and Belles Lettres in the Univerfity of Edinburgh. *L.*

Robert Blair, Efq; Advocate. *L.*

John Bruce, M. A. Profeffor of Logic in the Univerfity of Edinburgh. *L.*

† *Robert Bruce,* Efq; of Kennet, one of the Senators of the College of Juftice. *P.*

George Buchan-Hepburn, Efq; Advocate. *L.*

(L 2) *Ilay*

C.

Ilay Campbell, Efq; now Lord Advocate.   *L.*

John Campbell, Efq; of Stonefield, one of the Senators of the College of Juftice.   *L.*

* † Sir *George Clerk-Maxwell*, Baronet, of Pennycuik.   *P.*

John Clerk, Efq; now Sir *John Clerk*, Baronet, of Pennycuik. *P.*

John Clerk, Efq; of Eldin.   *P.*

William Craig, Efq; Advocate.   *L.*

* † *Andrew Crofbie*, Efq; Advocate.   *P.*

* *Henry Cullen*, M. D. Phyfician to the Royal Infirmary.   *P.*

Robert Cullen, Efq; Advocate.   *L.*

* *William Cullen*, M. D. Profeffor of the Practice of Phyfic in the Univerfity of Edinburgh.   *P.*

D.

Sir *John Dalrymple*, Baronet, one of the Barons of the Exchequer.   *P.*

Andrew Dalzel, M. A. Profeffor of Greek in the Univerfity of Edinburgh.   *L.*

John Davidfon, Efq; Clerk to the Signet.   *L.*

† Sir *Alexander Dick*, Baronet, of Preftonfield.   *P.*

* *Andrew Duncan*, M. D. Phyfician to his Royal Highnefs the Prince of Wales.

Right Hon. *Henry Dundas*, now Treafurer of the Navy.   *L.*

† Right Hon. *Robert Dundas* of Arnifton, Lord Prefident of the Court of Seffion.   *L.* ‖

Robert Dundas, Efq; Advocate, now his Majefty's Solicitor-General of Scotland.   *L.*

E.

James Edgar, Efq; Commiffioner of the Cuftoms.   *L.*

David Erfkine, Efq; Clerk to the Signet.   *L.*

Colonel *James Edmondftoune*, of Newton.

Adam

‖ Died Dec. 13. 1787, after the Lift of Deceafed Members was printed. See above, p. 46.

F.

* *Adam Ferguson,* LL. D. Emeritus Professor of Philosophy in the University of Edinburgh. *L.*

George Fergusson, Esq; Advocate, one of the Commissaries of Edinburgh. *P.*

James Fergusson, Esq; of Pitfour, Advocate. *L.*

Major-General *John Fletcher-Campbell.* *L.*

Sir *William Forbes,* Baronet, of Pitsligo. *L.*

Major *Andrew Fraser.* *P.*

G.

* *John Gardiner,* M. D. Edinburgh. *P.*

Cosmo Gordon, Esq; one of the Barons of Exchequer. *L.*

* Sir *James Grant,* Baronet, of Grant. *P.*

William Greenfield, M. A. Professor of Rhetoric in the University of Edinburgh. *P.*

* *James Gregory,* M. D. Professor of the Theory of Physic in the University of Edinburgh. *P.*

Right Hon. *John Grieve,* Lord Provost of Edinburgh. *L.*

H.

Alexander Hamilton, M. D. Professor of Midwifery in the University of Edinburgh. *P.*

* *James Hamilton,* M. D. Physician to the Royal Infirmary. *P.*

† *Robert Hamilton,* D. D. Emeritus Professor of Divinity in the University of Edinburgh. *L.*

Robert Henry, D. D. one of the Ministers of Edinburgh. *L.*

John Hill, A. M. now LL. D. Professor of Humanity in the University of Edinburgh. *L.*

* *Francis Home,* M. D. Professor of Medicine and of Materia Medica in the University of Edinburgh. *P.*

George Home, Esq; one of the Clerks of the Court of Session. *L.*

John Home, Esq; of Kilduff. *L.*

John

* † *John Hope*, M. D. F. R. S. Lond. King's Botanist in Scotland, and Profeſſor of Medicine and of Botany in the Univerſity of Edinburgh. *P.*

David Hume, Eſq; Advocate, and now Profeſſor of Scots Law in the Univerſity of Edinburgh. *L.*

Andrew Hunter, D. D. Profeſſor of Divinity in the Univerſity of Edinburgh. *L.*

† *James Hunter-Blair*, Eſq; afterwards Sir *James Hunter-Blair*, Baronet. *L.*

* *James Hutton*, M. D. Edinburgh. *P.*

K.

* *Alexander Keith*, Eſq; Clerk to the Signet. *P.*

L.

† *William Lothian*, D. D. *ſenior* Miniſter of Canongate. *L.*

M.

* *Allan Maconochie*, Eſq; Advocate, Profeſſor of Public Law in the Univerſity of Edinburgh. *L.*

* *John Macgowan*, Eſq; *P.*

John Macfarlan, D. D. Miniſter of Canongate, and Almoner to his Majeſty. *L.*

Henry Mackenzie, Eſq; *L.*

John Maclaurin, Eſq; Advocate; now one of the Senators of the College of Juſtice. *L.*

William Macleod-Bannatyne, Eſq; Advocate. *L.*

Right Hon. *Thomas Miller* of Barſkimming, Lord Juſtice Clerk; now Lord Preſident of the Court of Seſſion. *L.*

* *William Miller*, Eſq; of Glenlee, Advocate. *L.*

Right Hon. *James Montgomery*, Lord Chief Baron of Exchequer. *L.*

* *Alexander Monro*, M. D. Profeſſor of Medicine, and of Anatomy and Surgery in the Univerſity of Edinburgh. *P.*

William

William Morehead, Efq; *L.*

* *John Morthland*, Efq; Advocate. *L.*

N.

William Nairne, Efq; of Dunfinnan, Advocate; now one of the Senators of the College of Juftice. *L.*

Fletcher Norton, Efq; one of the Barons of Exchequer.

P.

* *John Playfair*, M. A. now Profeffor of Mathematics in the Univerfity of Edinburgh. *P.*

John Pringle, Efq; Advocate. *L.*

Mark Pringle, Efq; Advocate. *L.*

R.

David Rae, Efq; of Efkgrove, one of the Senators of the College of Juftice. *L.*

James Robertfon, D. D. Profeffor of Oriental Languages in the Univerfity of Edinburgh. *L.*

William Robertfon, D. D. Principal of the Univerfity of Edinburgh. *L.*

William Robertfon, Efq; Advocate. *L.*

* *John Robifon*, M. A. Profeffor of Natural Philofophy in the Univerfity of Edinburgh. *P.*

Adam Rolland, Efq; Advocate. *L.*

* Mr *James Ruffell*, Surgeon. *P.*

* *John Ruffell*, Efq; Clerk to the Signet. *L.*

* *Daniel Rutherford*, M. D. now King's Botanift in Scotland, and Profeffor of Medicine and of Botany in the Univerfity of Edinburgh. *P.*

S.

* Mr *William Smellie*, Printer in Edinburgh. *P.*

* *Adam Smith*, LL. D. F. R. S. Lond. Commiffioner of the Cuftoms in Scotland. *L.*

John

* *John Steedman*, M. D. Edinburgh.   *L.*

* *Charles Stuart*, M. D.   *P.*

David Stewart-Moncrieff, Efq; one of the Barons of Exchequer.   *P.*

* *Dugald Stewart*, M. A. formerly Profeffor of Mathematics, now of Moral Philofophy, in the Univerfity of Edinburgh.   *P.*

* † *Matthew Stewart*, D. D. Emeritus Profeffor of Mathematics in the Univerfity of Edinburgh.   *P.*

* *Alexander Frafer-Tytler*, Efq; Advocate, Profeffor of Civil Hiftory, and of Greek and Roman Antiquities, in the Univerfity of Edinburgh.   *L.*

William Tytler, Efq; of Woodhoufelee, Clerk to the Signet. *L.*

W.

* *John Walker*, D. D. M. D. Regius Profeffor of Natural Hiftory, and Keeper of the Mufeum in the Univerfity of Edinburgh.   *P.*

George Wallace, Efq; Advocate.   *P.*

* *Andrew Wardrop*, M. D. Edinburgh.   *P.*

V.

James Veitch, Efq; of Elliock, one of the Senators of the College of Juftice.   *L.*

2. NON-RESIDENT MEMBERS.

A.

* *William Alexander*, M. D. London.   *P.*

* *John Amyatt*, Efq; King's Chemift, London.   *P.*

John Anderfon, M. A. F. R. S. LOND. Profeffor of Natural Philofophy in the Univerfity of Glafgow.   *P.*

Mr

* Mr *Thomas Anderson*, Surgeon, Leith.   *P.*

  Archibald Arthur, M. A. Professor of Moral Philosophy in the
     University of Glasgow.   *L.*

B.

  His Grace *Henry* Duke of *Buccleugh*.   *L.*

  Right Hon. *John* Earl of *Bute*.   *P.*

* Mr *William Barron*, Professor of Logic in the University of
     St Andrew's.   *L.*

  James Beattie, LL. D. Professor of Logic and Moral Philoso-
     phy, Marischal College, Aberdeen.   *L.*

* *Gilbert Blane*, M. D. F. R. S. Lond. Physician to St Thomas's
     Hospital, London.   *P.*

  Ebenezer Brownrigg, M. D. Cumberland.   *P.*

* *Patrick Brydone*, Esq; F. R. S. Lond.

* *James Byres*, Esq; Architect at Rome.

C.

  George Campbell, D. D. Principal of Marischal College, Aber-
     deen.   *L.*

  Alexander Carlyle, D. D. Minister of Inveresk, and Chaplain
     in ordinary to his Majesty.   *L.*

  John Chalmers, D. D. Principal of King's College, Aberdeen.   *L.*

  William Chalmers, M. D. Professor of Medicine, King's College,
     Aberdeen.   *P.*

  Mr *John Cook*, Professor of Moral Philosophy in the Univer-
     sity of St Andrew's.   *L.*

  Patrick Copland, M. A. Professor of Mathematics, Marischal
     College, Aberdeen.   *P.*

* Mr *Alexander Cumming*, Watchmaker, London.   *P.*

  Patrick Cummin, M. A. Professor of Oriental Languages in
     the University of Glasgow.   *L.*

D.

Alexander Donaldson, A. M. Professor of Oriental Languages, Marischal College, Aberdeen. *P.*

James Dunbar, LL. D. Professor of Philosophy, King's College, Aberdeen. *L.*

F.

Sir *Adam Fergusson,* of Kilkerran, Baronet, LL. D. *L.*

Robert Findlay, D. D. Professor of Divinity in the University of Glasgow. *L.*

James Flint, M. D. Professor of Medicine in the University of St Andrew's. *P.*

G.

Alexander Gerard, D. D. Professor of Divinity, King's College, Aberdeen. *L.*

James Gillespie, D. D. Principal of New College, St Andrew's. *L.*

Thomas Gordon, A. M. Professor of Philosophy, King's College, Aberdeen. *L.*

Henry Grieve, D. D. Minister of Dalkeith, and Chaplain in ordinary to his Majesty. *L.*

H.

Robert Hamilton, LL. D. Professor of Natural Philosophy, Marischal College, Aberdeen. *P.*

William Hamilton, M. D. Professor of Anatomy in the University of Glasgow. *P.*

George Hill, A. M. now D. D. Professor of Divinity in the University of St Andrew's. *L.*

John Hunter, A. M. Professor of Humanity in the University of St Andrew's. *L.*

George

I.

George Jardine, M. A. Profeffor of Logic in the Univerfity of Glafgow. *L.*

† *William Irvine,* M. D. Lecturer on Chemiftry in the Univerfity of Glafgow. *P.*

L.

John Leflie, A. M. Profeffor of Greek, King's College, Aberdeen. *L.*

* *James Lind,* M. D. Haflar Hofpital. *P.*

* *James Lind,* M. D. Windfor.

Reverend Mr *John Logan,* formerly Minifter of South Leith. *L.*

* *Andrew Lumifden,* Efq;

M.

Jofeph M'Cormick, D. D. Principal of the United College of St Salvator and St Leonard, St Andrew's. *L.*

Hugh M'Leod, D. D. Profeffor of Church Hiftory in the Univerfity of Glafgow. *L.*

Roderick M'Leod, A. M. Sub-Principal of King's College, Aberdeen. *P.*

John Main, D. D. Minifter of Newton. *L.*

* *Donald Monro,* M. D. London. *P.*

* *John Mudie,* M. D. Montrofe. *P.*

O.

William Ogilvie, A. M. Profeffor of Humanity, King's College, Aberdeen. *P.*

R.

William Richardfon, A. M. Profeffor of Humanity in the Univerfity of Glafgow. *L.*

Thomas Reid, D. D. Emeritus Profeffor of Moral Philofophy in the Univerfity of Glafgow. *L.*

Reverend

Reverend Mr *Thomas Robertson*, Minister of Dalmeny.   *L.*

* *John Roebuck*, M. D. Kinneil.   *P.*

John Ross, M. A. Professor of Oriental Languages, King's
　　College, Aberdeen.   *P.*

S.

George Skene, A. M. Professor of Natural History, Marischal
　　College, Aberdeen.   *P.*

Robert Small, D. D. Minister of Dundee.   *P.*

† *Hary Spens*, D. D. Professor of Divinity in the University of
　　St Andrew's.   *L.* ‖

* *Edward Stevens*, M. D. Barbadoes.   *P.*

* *Alexander Stevenson*, M. D. Professor of Medicine in the Uni-
　　versity of Glasgow.   *P.*

* Reverend Mr *John Stewart*, Minister of Luss.   *L.*

George Stuart, LL. D. Emeritus Professor of Humanity in the
　　University of Edinburgh.   *L.*

Right Hon. *James Stuart-Mackenzie*, Lord Privy-Seal.

John Stuart, A. M. Professor of Greek, Marischal College,
　　Aberdeen.   *L.*

T.

* *William Trail*, D. D. Prebendary of Down.   *P.*

V.

Nicholas Vilant, M. A. Professor of Mathematics in the Univer-
　　sity of St Andrew's.   *P.*

W.

James Williamson, D. D. Professor of Mathematics in the Uni-
　　versity of Glasgow.   *P.*

* † *Alexander Wilson*, M. D. Professor of Practical Astronomy in
　　the University of Glasgow.   *P.*

Reverend

‖ Died Nov. 27. 1787, after the List of Deceased Members was printed. See above, p. 46.

Reverend *Charles Wilson,* D. D. Professor of Hebrew in the University of St Andrew's. *L.*

Patrick Wilson, A. M. and now Professor of Practical Astronomy in the University of Glasgow. *P.*

* *William Wright,* M. D. from Jamaica. *P.*

Y.

John Young, A. M. Professor of Greek in the University of Glasgow. *L.*

3. FOREIGN MEMBERS.

Honorary.

* *M. le Comte de Buffon.*

* Father *Giam Batista Beccaria,* Professor of Natural Philosophy in the University of Turin.

* *M. le Comte de Carburi,* first Professor of Medicine in the University of Turin.

* *M. Fougeroux de Bondaroy,* of the Royal Academy of Sciences, Paris, and of the Institute of Bologna.

* *Benjamin Franklin,* Esq; LL. D.

* *William Franklin,* Esq;

* *M. le Comte de Lauraguais.*

* *John Rogerson,* M. D. first Physician to the Empress of Russia.

* *M. Sue, senior,* of the Royal Academy of Surgery at Paris.

Ordinary.

* *P. Camper,* M. D. Holland.

* *Lionel Chalmers,* M. D. South Carolina.

* *Matthew Guthrie,* M. D. St Petersburg.

* *Lorentz Crell,* M. D. Professor of Chemistry at Helmstadt.

* *Alexander Gordon,* M. D. South Carolina.

MEMBERS

II.

MEMBERS chosen since the first Meetings of the Classes.

THE following were elected at the General Meeting of the Society, Jan. 26. 1784, all Ordinary Members:

1. RESIDENT.

Sir *David Carnegie*, of Southesk, Baronet.   *L.*

Sir *James Hall*, of Dunglass, Baronet.   *P.*

John Clerk, Esq; *junior*, of Eldin, Advocate.   *P.*

John Dryfdale, D. D. one of the Ministers of Edinburgh, Principal Clerk of the Church of Scotland, and Chaplain in ordinary to his Majesty.   *L.*

Mr *William Creech*, Bookseller in Edinburgh.   *L.*

2. NON-RESIDENT.

Thomas Hutchins, Esq; Secretary to the Hudson's Bay Company, London.   *P.*

John Moore, M. D. London.   *P.*

Mr *Matthew Boulton*, of Birmingham.   *P.*

Mr *James Watt*, of Birmingham.   *P.*

Robert Fall, Esq; of Dunbar.   *L.*

Right Hon. *Archibald* Earl of *Dundonald*.   *P.*

Nevil Maskelyne, D. D. Astronomer-Royal.   *P.*

James Robertson, M. D. of Oxford.   *L.*

John Grieve, M. D.   *P.*

The Reverend Mr *Archibald Alison*.   *L.*

Sir *John Henderson*, of Fordell, Baronet.   *L.*

3. FOREIGN.

M. *Sue*, *junior*, of the Royal Academy of Surgery, Paris.   *P.*

P. Sim. *Pallas*, M. D. of the Imperial Academy of St Petersburg.   *P.*

M.

M. And. Jo. Lexell, Profeſſor of Aſtronomy at St Peterſburg. *P.*
M. le Clerc de Sept Chênes, Secretary of the Chamber and Cloſet
to his Moſt Chriſtian Majeſty, Paris.   *L.*

THE following were elected at the General Meeting, June 28. *Members choſen, June 28. 1784.*
1784, all Ordinary Members :

1. RESIDENT.

Reverend Mr *Robert Walker*, Miniſter of Canongate.   *L.*
Henry Brougham, Eſq; of Brougham-hall.   *L.*

2. NON-RESIDENT.

Robert Liſton, Eſq; LL. D. his Britannic Majeſty's Miniſter at
the Court of Madrid.   *L.*
Reverend Mr *Matthew Murray*, Miniſter of North-Berwick. *L.*
Right Hon. *Edmund Burke*.   *L.*
Reverend Mr *Walter Young*, Miniſter of Erſkine.   *L.*

THE following were elected at the General Meeting, June 24. *Members choſen, June 24. 1785.*
1785, all Ordinary Members :

1. RESIDENT.

Robert Arbuthnot, Eſq; Secretary to the Board of Truſtees.   *L.*

2. NON-RESIDENT.

Right Hon. *George* Earl of *Morton*.   *P.*
Right Hon. *Dunbar* Earl of *Selkirk*.   *L.*
Right Hon. the Lord *Daer*.   *P.*
The Honourable *Charles Greville*.   *L.*
Sir *William Hamilton*, Knight of the Bath.   *P.*
James Ramſay, Eſq; of Auchtertyre.   *P.*

Benjamin

Benjamin Vaughan, Efq; of London. *P.*

George Young, M. D. Phyfician to the Military Hofpital in the Weft Indies. *P.*

James Hare, M. D. Eaft Indies. *P.*

THE following were elected at the General Meeting, Jan. 23. 1786, all Ordinary Members:

1. RESIDENT.

Robert Blair, M. D. Regius Profeffor of Practical Aftronomy in the Univerfity of Edinburgh. *P.*

Alexander Millar, Efq; Advocate. *L.*

2. NON-RESIDENT.

Right Hon. *James* Earl of *Hopetoun*. *L.*

Right Hon. the Earl of *Ancram*. *L.*

Sir *Robert Murray-Keith*, Knight of the Bath. *L.*

Colonel *William Fullarton* of Fullarton, F. R. S. LOND. *L.*

Thomas Aftle, Efq; F. SS. R. & A. LOND. Keeper of the Records in the Tower of London. *L.*

Charles Hutton, LL. D. F. R. S. LOND. Profeffor of Mathematics in the Military Academy at Woolwich. *P.*

Handyfide Edgar, M. D. Jamaica. *P.*

THE following were elected at the General Meeting, Jan. 22. 1787, all Ordinary Members:

1. RESIDENT.

William Stewart, Efq; Advocate. *L.*

George Brown, Efq; Commiffioner of the Cuftoms. *L.*

James Home, M. D. Edinburgh. *P.*

James

James Finlayson, A. M. Profeffor of Logic in the Univerfity of Edinburgh. *L.*

2. NON-RESIDENT.

James Playfair, D. D. Minifter at Meigle. *L.*

Adair Crawford, M. D. Phyfician to St Thomas's Hofpital, London. *P.*

Thomas Percival, M. D. F. R. S. LOND. at Manchefter. *P.*

John Haygarth, M. B. F. R. S. LOND. at Chefter. *P.*

3. FOREIGN.

M. le Prefident de Virly, Dijon. *P.*

John Baeounin, Efq; of Ruffia. *L.*

OFFICE-BEARERS of the SOCIETY.

General Office-Bearers.

GENERAL OFFICE-BEARERS, elected at the firft and fecond General Meetings, holden June 23. and Auguft 4. 1783.

Prefident.
His Grace the Duke of BUCCLEUGH.

Vice-Prefidents.

Right Hon. *Henry Dundas.* | *Tho. Miller*, Efq; Ld. Juftice-Clerk.

Secretary.	Treafurer.
Mr *John Robifon.*	Mr *Alexander Keith.*

Counfellors.

Dr *Alexander Monro.*	Mr *Baron Gordon.*
Dr *John Hope.*	Lord *Elliock.*
Dr *Jofeph Black.*	Major-Gen. *Fletcher-Campbell.*
Dr *James Hutton.*	Mr Commiffioner *Smith.*
Mr *Dugald Stewart.*	Dr *Adam Fergufon.*
Mr *John Playfair.*	Mr *John Maclaurin.*

Office-Bearers of the Claffes.

OFFICE-BEARERS of the two CLASSES, elected at the Meetings, Nov. 3. and Nov. 17. 1783.

PHYSICAL CLASS.
Prefidents.

Sir *James Grant*, Bart.	Sir *G. Clerk-Maxwell*, Bart. *
Dr *William Cullen.*	Dr *Francis Home.*

Secretaries.

Dr *James Gregory.* | Dr *John Walker.*

LITE-

* March 1. 1784, Dr *Alexander Monro* was elected a Prefident of the Phyfical Clafs in the room of Sir *George Clerk* deceafed.

LITERARY CLASS.

Prefidents.

Ilay Campbell, Efq; Ld. Advocate.	Lord *Elliock.*
Dr *William Robertfon.*	Dr *Hugh Blair.*

Secretaries.

Mr *Alexander Frafer-Tytler.* | Mr *Andrew Dalzel.*

THE fame OFFICE-BEARERS were continued by re-election till Nov. 27. 1786, when, in confequence of a new regulation, all the Office-Bearers were elected on that day, the election to be continued, at a General Meeting annually, upon the laft Monday of November.

OFFICE-BEARERS of the Society, elected for the enfuing year, Nov. 27. 1786, and re-elected Nov. 26. 1787.

Prefident.

His Grace the Duke of BUCCLEUGH.

General Office-Bearers.

Vice-Prefidents.

Right Hon. *Henry Dundas.* | Lord *Dunfinnan.*

Secretary.	Treafurer.
Mr *John Robifon.*	Mr *Alexander Keith.*

Counfellors.

Dr *James Hutton.*	Lord *Elliock.*
Mr *George Ferguffon.*	Major-Gen. *Fletcher-Campbell.*
Mr *Benjamin Bell.*	Mr Commiffioner *Edgar.*
Mr *Dugald Stewart.*	Mr *William Miller.*
Mr *John Playfair.*	Dr *Adam Fergufon.*
Dr *Daniel Rutherford.*	Mr *John Maclaurin.*

PHYSICAL

PHYSICAL CLASS.

Preſidents.

Dr *William Cullen.* | Dr *Alexander Monro.*
Dr *Francis Home.* | Dr *Joſeph Black.*

Secretaries.

Dr *James Gregory.* | Dr *John Walker.*

LITERARY CLASS.

Preſidents.

Mr Baron *Gordon.* | Dr *William Robertſon.*
Mr Commiſſioner *Smith.* | Dr *Hugh Blair.*

Secretaries.

Mr *Alexander Fraſer-Tytler.* | Mr *Andrew Dalzel.*

END OF THE HISTORY.

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I. PART II.

PAPERS READ BEFORE THE SOCIETY.

I.

PAPERS OF THE PHYSICAL CLASS.

I. EXPERIMENTS *on the Motion of the* SAP *in* TREES. *By* JOHN WALKER, *D. D. M. D. F. R. S. EDIN. and Regius Professor of Natural History in the University of* EDINBURGH.

[*Read by the Author, Dec.* 8. 1783, *and Jan.* 5. 1785.]

THE difcovery of the circulation of the blood in animals was foon followed by conjectures concerning the exiftence of a like circulation in the fap of vegetables. Thefe conjectures gave rife to the firft improvements in vegetable phyfiology, which may be dated from the appearance of a fet of queries concerning the motion of the juices of plants, publifhed in the Philofophical Tranfactions, *anno* 1668. Thefe queries immediately engaged Dr BEALE and Dr TONGE, and afterwards Dr GREW, Mr WILLOUGHBY, Mr RAY, and Dr LISTER, to enter upon the fubject; who, in a great variety of obfervations, ftruck out the firft confiderable difcoveries in the vegetable œconomy.

THEIR obfervations, however, fell fhort either of proving or difproving a circulation of the fap: Nor have the difcoveries of a variety of Philofophers, fince that time, been able to demonftrate either fide of the queftion; which ftill remains a controverted and undetermined point in the hiftory of vegetation.

To trace the progrefs of the fap, in the way of experiment, feems to be the only method by which we can expect to arrive

at a fatisfactory folution of this intricate queftion. For this purpofe, thofe trees which are faid to bleed are the moft convenient; or thofe which, at a certain feafon of the year, have fuch an exuberance of fap, that it flows freely from them upon a flight incifion. PLINY * mentions twice the bleeding of the mulberry; but he fpeaks of it as an extraordinary phænomenon, and feems to have been unacquainted with the bleeding of the vine. The trees of this fort are indeed more frequent in the cold than in the warmer climates. Some trees of our own country do not bleed, fuch as the *oak, afh, elm, afpen, hazel,* and *hawthorn.* Of thofe that bleed, the birch and the plane are the moft remarkable; and upon thefe the experiments here related were performed.

IN the laft age, the following important query was propofed on this fubject by Dr LISTER † :

" WHETHER or not does the fap begin to move in all the parts " of a tree at a time?"

FIFTY years afterwards, this queftion, ftill unrefolved, was again refumed by Dr HALES ‡, who, in arguing againft the circulation of the fap, expreffes himfelf thus :

" IF, fays he, early in the fpring, the oak, and feveral other " trees, were to be examined near the top and bottom, when the " fap firft begins to move, fo as to make the bark eafily run or " peel off, I believe it would be found, that the lower bark " would be firft moiftened; whereas the bark of the top-branches " ought firft to be moiftened, if the fap defcends by the bark."

OF late years, M. BONNET, when reafoning in favour of a circulation, and againft this fuppofition of Dr HALES, delivers the following remarks :

" Is it eafy, fays he, exactly to fix the time when the fap " begins to rife in trees? That fluid rifes at firft in very fmall " quantity;

* Nat. Hift. lib. xvi. cap. 38.—Lib. xxiii. cap. 7.
† Philof. Tranf. *anno* 1671, p. 2122.
‡ Vegetable Staticks, vol. i. p. 141.

" quantity; its progrefs is always rapid; it fpeedily reaches the
" tops of the branches, from whence it quickly paffes again to-
" wards the roots *."

But after the doctrine of the circulation of the fap has been
agitated for above a century paft; after fo many obfervations,
and fuch lengthened philofophical difcuffions upon the fubject;
is it not furprifing that this enquiry, firft ftarted by Dr LISTER,
and fince fuggefted by Dr HALES, fhould have been fo much
overlooked, and fhould ftill remain undetermined by experiment,
when it is evidently the previous and leading enquiry on the
fubject?

M. BONNET, indeed, in the above paffage, feems to think,
that the decifion of this queftion by experiment muft be ex-
tremely difficult, if not impracticable. But that this is far from
being the cafe, will appear from the fequel of the prefent paper.

The principal experiment here recorded was therefore made,
in order to know whether all the parts of a tree bleed at once,
or by fucceffion: How far the afcent and diffufion of the fap
depends on the temperature of the air: To trace the route which
it obferves, and to obtain fatisfaction concerning what is called
its *recidivation*, and in feveral other particulars relative to its
movement.

From this experiment alfo, fome light was expected concern-
ing a noted problem in vegetation, Why the terminating buds
of trees are the firft which are difclofed in the fpring.

The tree on which this experiment was made, was a vigorous
young birch, thirty feet high, and its ftem twenty-fix inches in
circumference at the ground.

On the 1ft of February, there was a hole bored in the trunk
of this tree, clofe by the ground, and one of its branches
cut at the extremity, in order to difcover when and where the
running of the fap would firft appear. This was repeated every

second

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* BONNET fur l'Ufage des Feuilles, p. 284.

second day till the 5th of March, during which time the tree at both places was always dry.

<div align="center">MARCH 5.</div>

FAHRENHEIT's Thermometer, at noon, in the shade, 46.; at midnight, 38.

On this day, which had been preceded by the three warmest days since the 1st of February, when an incision was made in the trunk of the birch, just by the ground, I now found a moisture in the wood, not to be perceived before, which made my finger sensibly wet; but there was no more moisture in the bark than formerly. The extremities of the branches were cut, and found likewise dry.

NOTE 1. THIS day, twenty-one triangular and equilateral incisions were cut in the trunk of the tree, on the north side. The base of these triangles was an inch long, and the incision itself an inch deep, both the bark and wood being taken out. These incisions reached from the ground to the height of twenty feet, and were exactly one foot distant from each other.

2. BY *incision*, when not otherwise described in these experiments, is meant a section through the bark into the wood.

3. WHEN an incision does not communicate any sensible moisture to the finger, it is said to be dry; and moist, when it makes the finger sensibly wet. By *bleeding* is meant such a copious flow of the sap as is sufficient to form a drop or stream from an incision.

4. BY the *sap* is meant the lymph, the watery or alimental sap of a tree, and not any peculiar, proper, or venal juice; being the general fluid from which the peculiar milky, gummy, or resinous juices of trees are formed by secretion, and in a way similar to the secretion of the different animal fluids from the general mass of blood.

<div align="right">MARCH</div>

MARCH 8.

Thermometer, at noon, 44.; at midnight, 35.

THE loweſt inciſion upon the tree was moiſt in the wood, as on March 5. but the bark was dry, and no moiſture appeared in any of the upper inciſions.

EXPERIMENT I. This day, I cut the extremities of one of the branches. Both wood and bark were dry as formerly; but the ſap iſſued viſibly between the wood and bark. It ſtood in ſmall globules, but was not ſufficient to form any drop.

COROLLARY I. Here it appears, as it did on ſeveral other occaſions, that the ſap riſes between the wood and the bark to the extremities of the branches, before it reaches thoſe parts either by the wood or the bark; yet it is denied by Dr GREW and M. BONNET, that the ſap ever aſcends at all between the wood and the bark.

MARCH 9.

Thermometer, at noon, 45.; at midnight, 38.

MARCH 10.

Thermometer, at noon, 46.; at midnight, 40.

LITTLE farther change was obſerved on theſe days; only the loweſt inciſion upon the tree was more moiſt than formerly, and the ſecond inciſion, a foot higher, began likewiſe to appear moiſt. The ſap alſo between the wood and the bark in the young branches was ſtill more viſible, while the wood and bark themſelves were dry.

MARCH 11.

Thermometer, at noon, 49.; at midnight, 44.

THIS day, the loweſt inciſion upon the tree at the ground, and the ſecond, a foot above it, did, for the firſt time, begin to bleed. The third inciſion was only moiſt, and all above it were dry, as

formerly,

formerly; only fhewing a little more moifture between the wood and bark.

OBSERVATION I. The fap then on this day, which was the warmeft fince the 1ft of February, with bright fun-fhine, had rifen a foot, or a little more, in the trunk of the tree, fo as to bleed at an incifion.

OBS. 2. At this incifion, a foot from the ground, the fap flowed only from the wood. The bark, which was of a confiderable thicknefs, was quite dry, and not a drop was formed till the wood was penetrated. The moifture between the wood and bark was indeed confiderable, but not fufficient to bleed.

EXP. 2. This day incifions were made upon another birch, which was found to bleed copioufly, both in its trunk and branches. The fap, therefore, in this tree was farther advanced, by feveral days, than in that which was the chief object of our experiments. The latter rofe in one trunk, and ftood in a thin foil and expofed fituation. The former was a younger tree, had a great number of luxuriant fuckers, confequently more vigorous roots, and was placed in a deep rich foil, in a low warm part of the wood. To thefe differences may be attributed the more forward afcent of the fap in this tree above the other.

EXP. 3. A little paft fix o'clock in the evening, when the fun was fet, the two incifions which bled at mid-day were dried up; nor did the fap iffue at a new incifion made a foot from the ground. But an incifion made at that height in the other tree, through which the fap was wholly diffufed, ftill bled.

MARCH 12.

Thermometer, at noon, 49.; at midnight, 41.

THE two loweft incifions bled as on the former day; and the third incifion, two feet from the ground, began to bleed for the firft time; but the fourth incifion, and thofe above it, were ftill dry, as were all the branches.

OBS. 3.

OBS. 3. When the birch is in a bleeding ſtate, no ſap iſſues upon inciſion, till the knife has penetrated through the bark. The ſap then appears in ſuch plenty, between wood and bark, as to run; and runs ſtill more plentifully if the inciſion paſſes into the wood. But not a drop of ſap can be made to iſſue from the bark, whatever way it is cut.

OBS. 4. It appears, that, in the beginning of the bleeding ſeaſon, when the thermometer, at noon, is about 49. or between 46. and 50. and at midnight about 42. or between 40. and 44. that the ſap riſes about one foot in twenty-four hours, in the trunk of the birch, if not formerly raiſed by a greater heat.

BY other trials, it was found, that, in the ſame ſeaſon, when the thermometer, at mid-day, is about 45. and, at midnight, about 38. the ſap then aſcends only about one foot in two days; and that it does not aſcend at all unleſs the mid-day heat is above 40.

MARCH 13.

THE inciſion one foot high bled; but the inciſion two feet high, and all above it, were dry.

Thermometer, at noon, 44.; at midnight, 42.

OBS. 5. It is here obſervable, that the inciſion two feet high was this day dry, although it had bled the day before. The cauſe is obvious from the thermometer. The cold of 41. during the preceding night, had bound up the ſap; and the heat of 44. during the day, was not able to make it bleed at the height to which it had been advanced by the heat of 49. on the preceding day.

MARCH 14.

Thermometer, at noon, 48.; at midnight, 45.

THIS day the fourth inciſion, at the height of three feet, began to bleed; the fifth was moiſt, but all above it were dry as formerly.

B   OBS. 6.

OBS. 6. The incision, one foot from the ground, bled in the evening, more than an hour after the two incisions above it were dried up.

OBS. 7. This day, the bark would not peel off the young branches of the tree; but the *epidermis* separated more freely from the bark than formerly.

MARCH 15.

Thermometer, at noon, 52.; at midnight, 44.

Thermometer, at noon, in the sun, 67.

THE fifth incision, four feet high, bled for the first time; but the sixth incision, and all above it, still refused to bleed; yet the sixth was more moist than formerly, especially between wood and bark.

OBS. 8. It was now found, that the incisions did every day cease to bleed upon the removal of the sun, the uppermost giving over first, and the rest successively downwards. The sap had now risen in the tree to the height of four feet. The fifth incision ceased to bleed this day at three in the afternoon. The four incisions below it gave over bleeding one after another, and were all dry at five o'clock; the sun having become clouded, and the thermometer fallen to 44.

MARCH 16.

Thermometer, at noon, 47.; at midnight, 37.

THE five lowest incisions bled as on the former day; but the sixth still continued dry.

COR. 2. It appears, that the sap will not rise much higher by the heat of 47. than it did on the preceding day by the heat of 52. but will maintain its ascent, and bleed at the same height.

MARCH 17.

Thermometer, at noon, 44. ; at midnight, 42.

THE four lower incifions bled this day. The fifth, which had bled on the two preceding days, was only moift.

COR. 3. When the thermometer falls to 44. the fap cannot run at the fame height at which it ran when the thermometer was at 47.

OBS. 9. It was now obferved, and always found to be the cafe afterwards, that each incifion bled fparingly at firft, and more plentifully as the fap afcended higher. The moft copious flow of the fap was always from the loweft incifions. When the birch tree, therefore, is to be pierced, in order to procure a large quantity of its fap, it will be found proper to make the incifions as near the ground as poffible.

MARCH 18.

Thermometer, at noon, 47. ; at midnight, 42.

THE five lower incifions bled, as on the former days ; but the fixth ftill continued dry.

OBS. 10. The fap, by the temperature of the air, is capable of remaining long ftationary. During the four laft days, it ftood nearly at the height of four feet, without afcending farther. In another experiment, the fap continued ftationary for five days, at the height of two feet, the thermometer, during that time, never being above 43. at noon, nor above 36. at midnight.

MARCH 19.

Thermometer, at noon, 48. ; at midnight, 41.

Thermometer, at noon, in the fun, 65.

THE fixth incifion did this day bleed for the firft time ; the feventh was moift, and the reft dry. But though the incifions in the trunk above the fixth, and fome that were made in the branches, did not bleed ; yet they did all along gradually and vifibly increafe in moifture.

B 2   COR. 4.

Cor. 4. Hence we find, that a tree does not become suddenly replete with sap, as has been generally thought. The sap does not mount into a tree by one, but by several successive tides. The most copious of all these, and the most remarkable, is that which brings on the bleeding. It is this tide, whose progress we trace in the present experiment; but it is evidently preceded by several lesser ones, which communicate a moisture to the tree, though not in such quantity as to bleed.

That a degree of sap ascends in trees immediately upon the falling of their leaves, appears from the vegetation of catkins, during winter, upon the birch, the alder, and the hazel. But in autumn, the trees are left so devoid of sap, by the expence of the former summer and the fall of the leaf, that it is not till spring, and the return of a sufficient degree of heat, that they become so impregnated with sap as to be capable of bleeding.

MARCH 20.

Thermometer, at noon, 44. ; at midnight, 43.

The fifth incision bled, and those below it ; but the sixth, which had bled the day before, and all above it, were dry.

Exp. 4. On this day, and on several other occasions, an incision made on the south side of the tree bled always more plentifully than an incision at the same height on the north side.

Cor. 5. The ligneous circles in the trunks of trees are commonly eccentric, the centre of the circles being placed at a distance from the centre of the tree. M. du Hamel ascribes this eccentricity to the casual insertion of roots, and the irruption of branches, which determines the sap to move in greater abundance on one side of the tree than another. And it is unquestionable that this sometimes happens. But when the centre of these circles stands nearer the north than the south side of the tree, and the circles themselves on the south side are considerably broader than those on the north, which is usually

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the cafe, the eccentricity is to be afcribed to a different and more general caufe, which is pointed out in the above experiment.

For as there is a more copious flow of the fap on the fouth than on the north fide of trees, owing to the one being more in the fun, and the other in the fhade, this muft naturally affect the fhape of their trunks; the fap on the fouth fide being more plentiful, there the growth of the wood muft, of courfe, be more confiderable. And this again fuggefts the reafon, why the wood on the north fide of a large tree is often found harder and more durable than that on the fouth fide; becaufe it is of a flower growth, and confequently of a more compacted fubftance.

<div style="text-align:center">MARCH 21.</div>

Thermometer, at noon, 48.; at midnight, 43.

Thermometer, at noon, in the fun, 60.

The feventh incifion bled to-day for the firft time; the eighth was a little moift, but all above it were ftill dry.

Obs. 11. So far up as the tree bled, which was now fix feet, the bark feparated eafily from the wood, and a great deal of moifture appeared between them. Above this, the fpace between the wood and bark grew gradually drier, and the bark was, with more difficulty, feparable from the wood. Upon many trials, it was found, that, in the birch, the bark feparates from the wood upon the fap's afcent, and not before; nor any higher than where the fap will ftream upon incifion; and that wherever the tree will bleed, there the bark not only parts eafily from the wood, but the *epidermis* feparates readily from the bark, the teguments of the bark from one another, the *alburnum* both from bark and wood, and even the ligneous circles are rendered eafy to be detached from one another.

<div style="text-align:right">Cor. 6.</div>

Cor. 6. As the afcent of the fap thus renders all the ftrata of a tree eafily feparable; and as this is the cafe in the lower parts of the tree, fo far as the fap has afcended, while thefe parts remain firmly attached to one another in the upper parts of the tree, to which the fap has not afcended; it is therefore evident, though contrary to what is generally fuppofed, that this phænomenon is occafioned by the fap in its afcent, and not by any return of the fap downwards from the extremities of the tree.

Cor. 7. As the ligneous circles, during the afcent of the fap, do thus fubfift in a loofe and unconnected ftate, the felling of timber, during that period, ought by all means to be avoided. This period of the fap's afcent varies confiderably in different trees. In the plane, it may be dated from the 25th of December to the 25th of March; in the birch, from the 1ft of March to the 26th of April; in the oak, from the 20th of March to the 1ft of June; and it would be of ufe, were the period of the afcent of the fap afcertained in like manner in the other foreft trees. The oaks, which are cut for their bark in April and May, during the afcent of the fap, afford a foft and perifhable timber, compared to thofe which are cut in the depth of winter. And the fame is the cafe with all the plane-trees cut in the months of January and February, compared to thofe which are cut in the month of November. To obtain timber in its greateft perfection, I believe it cannot be cut too foon after the fall of the leaf, as it is then in its moft faplefs ftate, and the ligneous circles more firmly compacted than at any other feafon.

MARCH 22.

Thermometer, at noon, 45.; at midnight, 40.

THE feven lower incifions bled as on the former day; the eighth was wet, but all the upper ones remained dry.

OBS. 12. On the day an incifion began to bleed, the one imme-
diately above it appeared always moifter than formerly. This
moifture appeared firft, and in greateft quantity, between the
wood and bark, and always fhewed itfelf firft on the loweft
fide of the incifion.

OBS. 13. At whatever height an incifion bled, all the incifions
below it conftantly did fo at the fame time.

MARCH 23.

Thermometer, at noon, 46. ; at midnight, 42.

Thermometer, at noon, in the fun, 68.

THE eighth incifion, which was feven feet high, bled for the
firft time ; the ninth was moift, but all above it dry.

OBS. 14. At $7\frac{1}{2}$ feet high ftood the firft branch upon the tree,
marked A*, which was about three feet long. It was this day
cut at the extremity, and was found very moift, but not fo as
to form a drop. The next branch above it, marked B, was
placed eight feet high, and was eight feet long. This, being
alfo cut at the extremity, was found drier than the former.

MARCH 24.

Thermometer, at noon, 47. ; at midnight, 35.

THIS day the ninth incifion began to bleed ; the tenth was
moift, but thofe above it dry as formerly.

EXP. 5. The fap having now mounted to the juncture of feveral
branches, the branches B and C were cut at the extremity,
but without bleeding. The branch D was alfo cut at the ex-
tremity, and, in like manner, refufed to bleed. But when
this branch was bent down into the perpendicular direction
D E, and kept fo bent by the cord G H, the incifion at the
extremity did then begin to bleed, and in five minutes con-
tinued to drop. Yet the branch below it C, that remained
in its lateral pofition, had its incifion at the extremity ftill dry.

COR. 8.

* *Vide* Plate I. Fig. 1.

Cor. 8. The motion of the fap then is accelerated by the perpendicular pofition of the branches; a leading fact, not only in the motion of the fap, but in the ftructure of the veffels which convey it. And from which at prefent we may thus far conclude, that the motion of the fap of trees is not the fame with that of fluids in capillary tubes, as has been generally thought, but defcends with a greater force than it afcends; and confequently its motion muft depend upon fome different principle.

Cor. 9. From this experiment we may likewife infer, that the fap makes its way fooner, and in greater quantity, to the extremity of pendent than of erect branches. Hence the reafon appears, why the gems upon pendent branches always burft fooner than upon thofe which are in an upright pofition. And it is probably alfo for the fame reafon, that moft fruits are of a brifker growth, and of a larger fize, upon thofe branches which hang down, than upon fuch as are erect.

Obs. 15. In the branches, A, B, C, D, to which the fap had now afcended, we remarked a confiderable alteration in the buds, though very little change had been obferved in them for fix weeks before. They now began to fwell, and their fcales to fhoot from under one another; but the buds upon the fuperior branches, to which the fap had not yet afcended, were not fo fwelled, but compact as formerly.

March 25.

Thermometer, at noon, 42.; at midnight, 34.

Continued fun-fhine all day. Thermometer, in the fun, at noon, 63.

The ninth incifion continued to bleed, but all the fuperior incifions were dry.

Obs. 16. The inverted branch D E continued this day to bleed at the fection E, while the branches B and C, placed below it, but in their natural pofition, were only moift at their extremities.

Obs. 17.

Obs. 17. At five o'clock in the afternoon, the ninth, eighth, and feventh incifions had ceafed to bleed; but ftill the inverted branch, though placed above them, bled at the extremity, and continued to do fo till it was dark, when all the other incifions upon the tree were dried up.

To obferve the effects of an inverted pofition of the branches upon the motion of the fap, the two following experiments were alfo made:

Exp. 6. On the 1ft of March, two branches of a birch, the one placed five, and the other fifteen feet high, were tied down with their extremities pointing directly to the earth. The buds on thefe two inverted branches fwelled larger, broke fooner, and threw out larger leaves, than any other buds upon the tree.

Exp. 7. At the fame time, and in the fame manner, two other branches of a birch were inverted, in every refpect fimilar to each other. All the extremities of the one were cut; but thofe of the other were left entire. That branch whofe extremities were cut, continued to drop at every twig during the whole bleeding feafon; yet the buds upon this branch fwelled larger and broke fooner than thofe upon the other branch, which had been fuffered to remain entire.

Cor. 10. From thefe experiments, I fhall only draw this obvious, though not unimportant conclufion, That wherever the afcending fap moves moft freely, and in the largeft quantity, there, the buds fwell to the largeft fize, and difclofe themfelves fooneft.

Obs. 18. At five this afternoon, the ninth incifion, eight feet high, on the north fide of the tree, was dried up; yet an incifion, at the fame height, on the fouth fide, continued to bleed till funfet, and was bleeding when the incifion, only fix feet high, on the north fide, was become quite dry.

Cor. 11. This obfervation fuggefts a fact, relative to the caufe of the fap's motion, which deferves to be noted: That the motion and bleeding of the fap does not proceed from a force

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communicated to it from the root, but from the action of
heat. The fouth fide of the trunk was this day far more
confiderably heated than the north fide; and therefore, in the
evening, we found it bleed on the fouth fide, at the height of
eight feet, when it refufed to bleed, at the height of fix feet,
on the north fide.

MARCH 26.

Thermometer, at noon, 39.; at midnight, 36.

THE feventh incifion bled; but the eighth and ninth were
dry, though they had bled the two former days.

OBS. 19. On this day, and at all other times, whenever an in-
cifion bled on the trunk of the tree, all the incifions below it
bled likewife.

OBS. 20. In the courfe of this experiment, we have found the
uppermoft incifion fometimes dry, though it had bled the day
before; but here we find the two uppermoft incifions dry,
which had bled the two former days. The caufe is evident
from the thermometer, which this day ftood lower than on
any of the preceding days of obfervation.

AT this feafon, fo like is the fap in a tree, to the fluid in a ther-
mometer, and fo dependent in its motion on the heat and cold
of the atmofphere, that, by looking at the thermometer be-
fore I went abroad, I came now to guefs nearly the height at
which I fhould find the tree bleeding.

OBS. 21. The inverted branch D E bled this day plentifully at
E, though the two incifions below it refufed to bleed; as did
alfo the branches below it, which were in their natural po-
fition.

COR. 12. If at any time we would wifh to obtain a large quan-
tity of the fap of the birch, or of any other bleeding tree, it
would appear, therefore, to be a ufeful practice, to bend the
branches into a perpendicular pofition, and to cut them at
their extremities.

COR. 13.

Cor. 13. We find, that when the parts of a tree are not fully replete with fap, they will bleed with a certain degree of heat, but will refufe to bleed with a fmaller degree : That the more a tree is replenifhed with fap, the lefs degree of heat is neceffary to make it bleed, and *vice verfa.* On the 13th of March, the third incifion refufed to bleed with the heat of 44.; but on this day, the feventh incifion bled with the heat of 39.

March 27.

Thermometer, at noon, 45.; at midnight, 40.

The eighth incifion bled; but the ninth, which had bled formerly, was dry. The inverted branch continued to bleed at its extremity E.

March 28.

Thermometer, at noon, 49.; at midnight, 43.

The eighth incifion bled; but the ninth was dry, as on the preceding day. The inverted branch continued to bleed plentifully at its extremity.

Obs. 22. The buds on the inverted branch were now fwelled to a larger fize, and were evidently more forward than any others upon the tree, though this was only the fifth day fince the branch was placed in that pofture.

Exp. 8. On the 23d inftant, I had cut feven incifions, a foot diftant from each other, upon the branch B. Thefe incifions were cut deep, near to the pith of the branch, perpendicular to the horizon, and were made with a view to folve the two following queries :

1. Whether the fap makes a fwifter progrefs in young than in old wood? And,

2. Whether, at this time, there was any defcending fap to be difcovered in the tree ?

The experiment upon this branch afforded full fatisfaction concerning both thefe queftions.

As

As to the firſt, the ſap had iſſued on the 24th inſtant at the ninth inciſion, which was juſt below the inſertion of this branch, but had been kept from aſcending higher, for three days paſt, by a great degree of cold. During theſe days, I watched every morning to find when the ſap would appear at the loweſt inciſion upon the branch; but the cold was too great to ſuffer it to make any progreſs till this day. Accordingly, all the ſeven inciſions on the branch did this day bleed ſucceſſively, from the bottom to the top, between nine o'clock in the morning and two in the afternoon.

Cor. 14. In anſwer to our firſt enquiry, we therefore find, that the ſap moved in this young branch ſeven feet in one day; but when the thermometer was at the ſame degree of 49. the ſap moved in the trunk of the tree only at the rate of ſeven feet in ſeven days. We may therefore, in general, conclude, that the ſap makes a ſwifter progreſs in young than in old wood; and that, in ſome caſes, the proportional difference is no leſs than ſeven to one.

On the 16th of March, the birch on which this experiment was made, being about thirty feet high and thirty-five years old, bled no higher than four feet above the ground; but a younger birch, ſtanding cloſe by it, being only about fourteen years old, did, on that day, bleed at the top, or fifteen feet high. Many ſuch inſtances might be adduced to ſhew, that the ſap runs more freely, and with a quicker aſcent, in young than in old wood. In conſequence of this, the young trees of every ſpecies, *cæteris paribus*, diſcloſe their leaves in ſpring ſooner than thoſe which are old.

Obs. 23. As to the ſecond enquiry, the firſt bleeding of theſe ſeven inciſions on the branch B was attentively marked, that I might know whether the ſap would firſt appear on the under or upper ſide of each inciſion, or on both at the ſame time. Accordingly, this morning, the ſap made its firſt appearance upon the loweſt ſide of the loweſt inciſion, at h; and ſo ſucceſſively,

cefsively, upon the lower fide of all the other incifions, mark-
ed i, and flowed plentifully, while the upper fide of all the
feven incifions, marked k, remained dry.

Cor. 15. The refult of thefe trials then amounts to this: That
there was at prefent no defcending fap from the branches:
That the whole fap of the tree was in an afcending ftate: That
it had now reached about nine feet high in the trunk; be-
yond which height it was ftill dry, and refufed to bleed.

Being affured of this, I now applied myfelf to examine an
experiment of M. du Hamel, upon which he founds his doc-
trine of a defcending fap in the bleeding feafon.

Exp. 9. This experiment was made, by fawing two inches deep
into the tree, at L, one foot from the ground. Another inci-
fion, of the fame depth, was made three inches below, both
being horizontal; and the wood and bark between the two
were completely extracted. The fap was then perceived to
flow as plentifully from the furface of the upper incifion at
m, as from that of the under incifion at n.

Cor. 16. From this experiment, M. du Hamel* fuppofes, that,
in the bleeding feafon, there is not only an afcending but a
defcending fap. Finding the fap to iffue from both incifions,
he concludes, that it moves at the time in two different
directions, or both upwards and downwards. The facts
which he delivers in the above, and in other experiments,
which I alfo repeated, are certainly true; but this conclufion
which he draws from them is unqueftionably erroneous.

It is evident, from the whole train of our experiment, that,
from the earlieft fpring to the prefent day, the 28th of March,
all the fap which flowed in the birch was in an afcending
ftate, and that there was no defcending fap whatever from
the extremities of the tree towards the root. But when
once any part of a tree comes to be replete with this afcend-
ing

* Phyfique des Arbres, tom. i. p. 66.

ing fap, we find it will run out in any direction, either up-
wards or downwards, wherever an incifion is made.

MARCH 29.

Thermometer, at noon, 46.; at midnight, 42.

THE eighth incifion bled; but the ninth was ftill dry. The
inverted branch bled ftill freely at E. The feven incifions on
the branch B did not bleed.

OBS. 24. Dr TONGE*, in the laft century, firft noticed what he
termed the *recidivation* of the fap, that is, its fubfidence or
defcent in a tree during the cold of the night. This opinion
was alfo adopted by Dr HALES †, who fays, " That the fap
" in all vegetables does probably recede, in fome meafure,
" from the tops of branches, as the fun leaves them." It is
an opinion that has fince been generally admitted, and the
phænomenon itfelf termed the *ocillatory motion* of the fap.

SUCH a motion of the fap, however, appeared very queftion-
able, on feveral occafions, in the courfe of our prefent expe-
riment. Often, when the fap was rifen to a confiderable
height in the tree, the incifions which had formerly bled
would be found dry in a cold morning; but a warm gleam
of the fun would, of a fudden, fet them a-bleeding, not
fucceffively, but all at once. This feems to prove, that the
fap does not defcend when the incifions ceafe to bleed by an
increafe of cold, but is only bound up.

To verify or invalidate this conclufion, the following experi-
ments were made:

EXP. 10. March 28. A luxuriant young birch, two inches in
diameter, was this day cut over, a foot above ground. Be-
ing cut at mid-day, both fections bled for two hours; but
the under one more plentifully than the other. The upper
fection became quite dry on the approach of night. The

<div align="right">tree</div>

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* Philof. Tranf. *anno* 1668. p. 855.

† HALES Staticks, vol. i. p. 145.

tree thus cut, being kept in the fame upright pofition in
which it grew, on the two following days it bled a little
about mid-day; but on each day it became dry, that is,
the fap ceafed to defcend whenever the cold of the evening
began to take place.

Exp. 11. February 10. At four o'clock afternoon, during a keen
froft, two branches, each five feet long, were cut off a plane-
tree. The under fections bled rapidly, and the fap freezing
as it ran, in half an hour there was a long icicle hanging at
each fection. The two feparated branches, being kept per-
pendicular in the open air for half an hour, appeared only
moift at the place where they were cut, but did not bleed.
One of them being brought into a warm room, bled copi-
oufly for an hour. The other having been ftill kept in the
open air, had not feparated a drop during that time; but,
upon being removed into the room, it bled freely like the
former.

Cor. 17. From thefe experiments, we are, therefore, ftill led to
conclude, that the fap does not defcend by cold: That when
a tree ceafes to bleed by an increafe of cold, this effect is not
produced by a fubfiding or defcent of the fap; but that, by
the cold, it feems only to be arrefted and held in a ftate of
ftagnation.

The *recidivation* or *ocillatory motion* of the fap, by the cold of the
night, though long held by philofophers, appears, therefore,
to be an erroneous opinion, which has little or no foundation
in nature.

Cor. 18. In the laft experiment, we have the force of the fap's
motion, and the influence of the cold upon that force,
weighed, the one againft the other. The freezing cold was
not able to prevent the motion of the fap upwards, but was
powerful enough to obftruct its motion downwards. Here,
as it was found in many other cafes, the force of the fap
afcending

afcending at the under fection of the branch, was greatly fu-
perior to its force in defcending at the upper fection.

MARCH 30.

Thermometer, at noon, 50.; at midnight, 43.

THE eighth incifion bled; but the ninth continued dry. The
inverted branch ftill bled freely at E. The under fections of
the feven incifions on the branch B bled; but their upper fec-
tions were as yet dry.

OBS. 25. The ninth incifion ftill refufed to bleed, though the
heat of this day appeared fufficient to elevate the fap to that
height; but between the eighth and ninth incifions, there
were two large young branches, which feem to have led off
the fap fafter than the old wood of the trunk.

OBS. 26. From what has been noticed of the branches D and
B, we find, that a young branch bleeds fooner than an inci-
fion in the trunk, placed even below the infertion of the
branch. This evidently arifes from a quicker and more eafy
flow of the fap in young than in old wood; by which means,
the branch comes to be fooner replete with fap than the ad-
joining part of the ftem.

MARCH 31.

Thermometer, at noon, 62.; at midnight, 40.

THE feventh incifion upon the trunk bled; but thofe above
it were dry. The fection of the inverted branch at E continued
to bleed. All the feven incifions upon the branch B were
dry.

OBS. 27. When I found the thermometer fo much higher this
day than it had been at any time during the feafon, I went
out, expecting to find the tree bleeding at a greater height
than it had hitherto done: But in this I was difappointed;
for all the incifions above the feventh, even the eighth and
ninth, which had formerly bled, were perfectly dry. This
was

was the firſt inſtance of many which afterwards occurred, to ſhew, that, in the early ſpring, a tree bleeds by heat, and, as the ſeaſon advances, by cold.

April 1.

Thermometer, at noon, 50.; at midnight, 34.

No obſervation becauſe of rain.

April 2.

Thermometer, at noon, 46.; at midnight, 39.

The ſeventh inciſion, being the one immediately under the branches, bled; but the eighth, and all the other inciſions above it, upon the trunk, were dry. The inverted branch D E ſtill bled at E, but not in ſuch abundance as formerly.

Obs. 28. It is remarkable, that the eighth and ninth inciſions, which had formerly bled, were dry for ſome days paſt, though the four branches above them bled freely. It appears, that, when the ſap riſes to the juncture of branches, it is there led off rapidly by the younger wood. By this means, the branches become replete with ſap; the adjacent parts of the trunk are drained, and ceaſe to bleed; while the ſap, in the younger wood of the branches, flows plentifully.

Another caſe, analogous to this, was found in the following experiment:

Exp. 12. The grey willow* is a tree which does not bleed; but when the ſap aſcends in ſpring, it riſes viſibly between the wood and bark, though not ſo copiouſly as to bleed; yet wherever it arrives in ſufficient quantity, it makes the bark ſeparate eaſily from the wood, as in the birch, and probably in all other trees.

On the 19th of April, the bark of this tree was found to ſeparate freely from the wood, where the branch was of four years growth. It ſeparated ſtill more freely where the branch

D   was

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* Salix caprea, Lin.

was only of three or two years growth; and moſt readily of all in the laſt year's ſhoots. At the ſame time, the bark refuſed to ſeparate freely in the above branch, where its growth was ſeven years old, and was ſtill more adheſive in the trunk, which was about twenty years growth, and half a foot in diameter.

Cor. 19. Were it not for the light obtained by the former experiments, we might be led to conclude from this trial, that the ſap which appears in ſpring, between wood and bark, deſcends from the extremities of a tree towards the root, and probably in a way of circulation: But we have found, that the ſap which runs in ſpring, between wood and bark, aſcends directly, and in a very gradual manner, from the root. The reſult of this experiment, therefore, coincides exactly with the above obſervation, and ſhews, that the younger wood does powerfully draw off the ſap from the older: That, by draining the trunk, the ſap accumulates in the branches; and that, in young wood, we find a greater quantity of ſap than in the older wood through which it has paſſed in its way from the root.

April 3.

Thermometer, at noon, 49.; at midnight, 44.
No obſervation becauſe of rain.

April 4.

Thermometer, at noon, 53.; at midnight, 44.

The tenth inciſion bled this day, but very ſparingly. The inverted branch D E bled at E. The inciſions on the branch B bled at their under ſections, and alſo at their upper ſections, but in much leſs quantity.

Obs. 29. This laſt appearance ſeems to favour the idea of a circulation, if it might be ſuppoſed, that the ſap, which iſſues from the upper ſections of the inciſions, is the effect of a regular return from the upper extremities of the tree. But it

is

is to be noticed, that, wherever the fap has afcended, the whole body of the wood is replete with it : That, upon incifion, it iffues from the wood downwards, and in every other direction ; and that this happens before any fap has yet arrived at the upper extremities of the tree.

April 5.

Thermometer, at noon, 50. ; at midnight, 41.

April 6.

Thermometer, at noon, 48. ; at midnight, 40.
No obfervation was made on thefe days.

April 7.

Thermometer, at noon, 49. ; at midnight, 42.
The eleventh incifion bled ; and the inverted branch bled at E.

April 8.

Thermometer, at noon, 48. ; at midnight, 40.
The eleventh incifion continued to bleed.

April 9.

Thermometer, at noon, 50. ; at midnight, 44.
The twelfth incifion bled this day.

April 10.

Thermometer, at noon, 53. ; at midnight, 49.
The thirteenth incifion began this day to bleed for the firft time ; but all the incifions above it were ftill dry.   The inverted branch alfo bled at E.
Obs. 30. This day I attended carefully to the iffuing of the fap, both from the upper and under incifions of the branch B, and found, that it flowed in each incifion, both from the ligneous circles, and from between them.   It evidently appeared, how-

ever,

ever, to flow from the veins feparating the circles, before it
iffued from the circles themfelves ; which ferves to fhew, that
the fap runs more freely in the one than in the other, as we
found before, that it runs more freely between the wood and
bark than in the wood itfelf.

Obs. 31. It was alfo this day remarked, that, in all the incifions
upon the branch B, the fap appeared fooner, and flowed
more copioufly from the outer than from the inner circles of
the wood. To be further affured of this, a number of
branches, both of the birch and plane, were cut over, when
the fame appearance conftantly took place ; and which con-
firms the obfervation formerly made, " That the fap is more
" expeditioufly and plentifully conveyed by young than by
" old wood."

During the 11th, 12th and 13th of April, the thermometer,
at noon, ftood at 45. 44. and 43. refpectively ; and, at midnight,
at 36. 35. and 39. Thefe degrees of cold arrefted the fap. It
iffued fparingly at the thirteenth incifion, and at all the under
incifions, but went no higher.

April 14.

Thermometer, at noon, 55. ; at midnight, 46.

The fourteenth incifion bled this day for the firft time ; but
all the incifions above it were ftill dry. The inverted branch
alfo bled.

Obs. 32. It was again carefully obferved, by new incifions on
the branch B, whether, according to M. du Hamel, there
was an afcending fap by the ligneous circles, and a defcending
fap by their veins ; but it was found, as formerly, that the
fap proceeded from both in the fame direction. It iffued, in-
deed, in lefs quantity, from the upper than from the under
fections. When a thin flice of wood was taken off a cica-
trifed or dried fection, the fap iffued from the veins before it
                                                                                made

made its appearance from the circles; and when the place
cicatrifed was only in part cut away, the veins would appear
moiftened with the fap, while the circles themfelves remained
perfectly dry. Thefe appearances, I imagine, made M. Du
Hamel fuppofe, that there was a diftinct defcending fap by
thefe veins. Such appearances do, indeed, at firft fight, very
naturally lead to this fuppofition; but, on farther infpection,
muft be referred to the caufe already eftablifhed, the more eafy
and copious flow of the fap between the circles than in the
circles themfelves.

April 15.

Thermometer, at noon, 49.; at midnight, 48.

THE fourteenth incifion bled as yefterday. The fifteenth was
very moift, but did not bleed.

April 16.

Thermometer, at noon, 56.; at midnight, 50.

THE fifteenth and fixteenth incifions bled this day for the
firft time.

Obs. 33. In the courfe of thefe experiments, this was the firft
inftance in which the fap moved two feet in twenty-four
hours. But the thermometer, in the fhade, ftood higher than
it had hitherto been, and there was bright funfhine during
the whole day.

April 17.

Thermometer, at noon, 51.; at midnight, 47.

April 18.

Thermometer, at noon, 50.; at midnight, 47.

DURING both thefe days the fixteenth incifion bled; but the
feventeenth, though wet, did not bleed. This feemed to be ow-
ing to fome vigorous young branches which led off the fap,
and thereby prevented its rife, for a time, in the ftem.

<div align="right">APRIL.</div>

APRIL 19.

Thermometer, at noon, 54.; at midnight, 50.

THE seventeenth incision did, for the first time, bleed.

OBS. 34. When the tree first began to bleed, the streaming of the sap was confined to two, three or four hours, about the middle of the day; but as the heat of the season advanced, and the tree became more replete with moisture, the running of the sap commenced early in the morning, and continued till very late in the evening. It is likewise to be noticed, that, in the evening, the sap often continued to flow from incisions in the branches, when those upon the trunk were dried up; and that it also run longer from inverted than from upright branches.

APRIL 20.

Thermometer, at noon, 56.; at midnight, 49.

THE eighteenth and nineteenth incisions bled to-day, for the first time. There was warm sunshine during the whole day.

APRIL 21.

Thermometer, at noon, 54.; at midnight, 47.

THIS day the twentieth incision bled.

APRIL 22.

Thermometer, at noon, 52.; at midnight, 45.

THE twenty-first incision, which was made a few days before, and which was the highest that could be made on the tree, did this day bleed for the first time. It was twenty feet from the ground.

APRIL 24.

Thermometer, at noon, 56.; at midnight, 50.

THIS day the tree bled, in all its parts, at every incision upon the trunk, and at every twig cut at the extremities of the branches.

<center>APRIL 30.</center>

Thermometer, at noon, 60. ; at midnight, 52.

THE *vernation*, or budding of the tree, now took place, that is, the young leaves were shot forth so far, as to be of an equal length with the *hybernaculum.*

THIS day all the incisions, in the upper part of the tree, were dry. A little sap still issued from the four incisions upon the trunk, that were next the ground. But fresh incisions being made in different parts of the branches, they all refused to bleed.

<center>MAY 1.</center>

Thermometer, at noon, 58. ; at midnight, 50.

ALL the incisions, both on the trunk and branches, were dry, excepting one, a foot from the ground, which still continued moist, though it did not bleed.

COR. 20. It appears then, that the sap does first cease to flow in the branches ; and that it continues, for some little time, to flow in the lower parts of the trunk, after the upper parts are become dry.

<center>MAY 2.</center>

Thermometer, at noon, 60. ; at midnight, 53.

INCISIONS being now made over the whole tree, from the root to the extremities of the branches, they were all found perfectly dry. The young leaves were now shot forth in length, considerably beyond that of the *hybernaculum.*

OBS. 35. It seemed now natural to conclude, that the tree ceased to bleed, and that the wood was every where become dry, by the evaporation occasioned by the leaves which were now shot forth. The two following experiments, however, shew, that this appearance is owing to a different cause.

EXP. 13. A young birch, $1\frac{1}{2}$ inch in diameter, was cut over at the beginning of the bleeding season, a foot from the ground, and, on the trunk that remained, there was no bud. This
<div align="right">trunk</div>

trunk continued to bleed during the feafon, but it gave over
bleeding at the fame time with the other trees. The wood
became dry, the fap flowed between wood and bark, which
were then eafily feparable from one another, and the bark it-
felf became moift, though it had neither buds nor leaves
upon it.

Exp. 14. All the buds were ftripped off one fide of another
birch tree and all the buds on the other fide, were left en-
tire. Both fides of the tree, however, ceafed to bleed at the
fame time. The wood turned dry, the fap flowed between the
wood and bark, and the bark became moift on that fide of the
tree which was deprived of its buds, in the fame manner,
and at the fame time, in which thefe alterations took place
on the fide of the tree which retained its buds, and whofe
leaves were now confiderably expanded.

Cor. 21. The drying up of the fap, therefore, in the wood of
trees, about the time of their vernation, proceeds not from
the evaporation occafioned by their leaves, but from a general
communication and diffufion of the fap from the wood into
the bark, at that feafon. To this caufe, likewife, and not to
any influence of the leaves, is to be afcribed the running of
the fap between the wood and bark, during the feafon of
vernation.

MAY 10.

Thermometer, at noon 63. ; at midnight, 50.

THE leaves of the tree were now expanded, and the wood was
every where quite dry. The fap flowed between the wood and
the bark, fo as to wet the finger, and bled fenfibly. The bark did
not, in any degree, bleed ; but was every where more moift and
fucculent than when the fap flowed in the wood. The bark
peeled eafily from the wood, the alburnum from both, and its
fibres were more eafily feparated from one another than at any
period while the fap ran in the wood.

CON-

CONCLUSION.

IN the courſe of this paper, many particular obſervations and corollaries have occurred, reſpecting the motions of the ſap and the vegetation of trees ; but there ſtill remain ſome general concluſions to be drawn from the whole train of the experiments. As to the truth of the experiments, I can have little doubt, as they were all twice performed in two different years, and ſome of them repeated on other occaſions ; but the juſtneſs of the concluſions drawn from them muſt be entirely ſubmitted to the determination of the Society.

§ 1.

WHETHER or not all the parts of a tree bleed at once, or by ſucceſſion, is a queſtion that ſeems to be ſolved, in a ſatisfactory manner, by theſe trials.

WE find the bleeding ſap begins firſt to flow at the root, to aſcend ſlowly upwards, and to bleed ſucceſſively as it aſcends, to the very extremities of the tree.

IN the year in which theſe experiments were made, the ſap required forty-three days, from the 11th of March to the 22d of April, to mount twenty feet high in the trunk of the birch ; that is, upon an average, it aſcended nearly ſix inches each day. During another year, however, the ſap was found to riſe twenty feet, in the trunk of the ſame birch, in thirty-three days ; that is, from the 7th of March to the 8th of April, which was about nine inches each twenty-four hours. In another year, the ſame birch did not begin to bleed at the ground till the 27th of March. Such a variation is to be expected, as the ſeaſons vary ; and to this difference in the bleeding of the ſap, is to be aſcribed that remarkable diverſity, in the time of vernation, obſerved by the ſame tree in different years.

E. § 2.

§ 2.

M. du Hamel [*], who beſtows a great deal of attention upon this ſubject, is dubious, whether the ſap of trees, in the bleeding ſeaſon, be in an aſcending or deſcending ſtate, and is ſolicitous that the point ſhould be determined by experiment. In anſwer to this enquiry, it ſeems clear, by the above trials, that, from the 11th of March, when the ſap firſt began to run at the bottom of the trunk, till the 30th of April, when the tree began to un-fold its leaves, the whole ſap of the tree was in a progreſſive ſtate upwards : That it was liable, indeed, to fall back, or to run out, upon inciſion, in any direction ; but that, during the whole bleeding ſeaſon, there was no juſt appearance of any deſcend-ing, returning, or circulatory ſap.

§ 3.

WE may next attend to the tract obſerved by the ſap in its aſcent during the bleeding ſeaſon.

In none of the experiments here related, could any ſap be per-ceived to ariſe, either by the pith or the bark. The whole ſap was conveyed upwards by the wood, and between the wood and bark ; but beyond this canal, no flow of the ſap could be dif-cerned in any exterior part of the tree.

It alſo appears, that the ſap moves both in the ſubſtance of the ligneous circles, and in the veins by which they are ſepa-rated : That, in both, it is in an aſcending ſtate : That it moves more expeditiouſly in theſe veins than in the circles themſelves ; and that it moves more freely in young than in old circles, and, of courſe, more freely in the exterior than in the interior part of every trunk and every branch.

It is aſſerted by Dr Grew [†], and by Meſſrs Bonnet [‡], La Baisse, and Du Hamel, that, in the bleeding ſeaſon, all the

ſap

[*] Phyſique des Arbres, tom. i. p. 66.
[†] Anatomy of Plants, Lond. 1682. fol.
[‡] Bonnet ſur l'Uſage des Feuilles, p. 65.

sap is confined to the wood of the tree, and that no part of it moves between the wood and the bark. In many of the above experiments, I was convinced, that this opinion has arifen from fome miftake. The flow of the fap, between the wood and bark, was daily and evidently perceived ; likewife, that it was there always in an afcending ftate ; and that it even moved more freely, and with greater rapidity, in this channel, than in any part of the fubftance of the wood.

§ 4.

THE caufe of the afcent of the fap in trees, is a curious and important point in the hiftory of vegetation, but ftill involved in obfcurity. Many opinions have been formed on the fubject, but thefe only at random, or, at beft, only from a general view of vegetation. The caufe ftill remains fecret ; nor is it likely that it will ever be brought to light, but by means of minute and accurate experiments.

THE afcent of the fap has been afcribed, by fome, to fermentation *, and, by others, to a certain force communicated to it from the root ; but without any evidence to fhew, that fuch caufes even exift.

THE afcent of the fap by filtration was an opinion rather more plaufible ; but it is oppofed by fome of the principal phænomena. Did the fap afcend like water in a fponge, or in capillary tubes, why fhould its motions be affected, nay even almoft entirely regulated by heat and cold ? Or why, as has been found in thefe experiments, fhould its motion be accelerated by placing a branch in an inverted pofition ?

FROM Dr HALES's experiments, it has been concluded, that the perfpiration of the leaves is the great agent in the motion and elevation of the fap. But, from the experiments here related, it is evident, that the fap afcends with great vigour in trees, even when they are deftitute of leaves.

THE

* HENCKEL. Flora Saturnizans, cap. 4.

The afcent of the fap was afcribed by Ludwig*, to the expan-
fion of the air with which it is impregnated; and, with more
reafon, by others, to the expanfion of the air contained in the
tracheæ, or air-veffels of the plant. As thefe veffels exift only
in the wood, and as it is by the wood chiefly that the afcending
fap is conveyed, this, no doubt, forms a prefumption, that they
contribute, in fome degree, to the elevation of the fap. But,
as we have found, that the fap moves with more force upwards
than in any other direction; and that, in certain circumftances,
it is made to flow and afcend by cold as well as by heat, the
expanfion of air cannot, therefore, be admitted, in any fhape
whatever, as the caufe of its afcent.

The above experiments leave us ftill in the dark, as to the pre-
cife caufe of the afcent of the fap. They fhew, indeed, upon
many occafions, that heat is the prime agent in producing this
effect; and that, probably, by the expanfion of the fap itfelf,
rather than of any air, either contained in it, or in the *tracheæ*.
The incifions upon the birch ran freely in the day-time, efpeci-
ally during funfhine, but dried up regularly, as the cold of the
evening advanced. With a few exceptions, we find the afcent
of the fap conftantly promoted by heat, but retarded and even
arrefted by cold : Yet the precife manner in which heat and cold
produce thefe effects does not appear. It is likely that there are
other caufes which co-operate. Thefe probably are lodged in
the ftructure of the plant, and to difcover them, would require
a more minute examination of that ftructure, than has as yet
been beftowed upon it.

§ 5.

From the preceding experiments, we may now attempt a fo-
lution of that curious queftion in vegetation, why the termina-
ting buds of branches are the firft which difclofe themfelves in
the fpring? This phænomenon has been often imagined, and
particularly

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* Ludwig Inftitutiones Regni vegetabilis, Lipf. 1757, 8vo. p. 183.

particularly by M. Bonnet *, to be a conclusive argument, in favour of a circulation of the sap. It is supposed, that the sap rises from the root, by the wood of a tree, to the extremities of the branches, and that from thence it returns again by the bark to the root, in a circulatory manner. It is therefore concluded, that the bud which terminates a branch must be the first that breaks in the spring, because it receives the first visit of this returning sap. The above experiments, however, enable us to account for this curious appearance in a different manner.

We have had frequent opportunities to remark, that the sap moves with greater rapidity, and in greater plenty, in young than in old wood.

That inverted branches, in which the sap flows more copiously, than in those which are erect, do bud the soonest.

That young trees bud more early than those which are old; and that the sap runs longer in young than in old wood.

All which facts evidently lead to this conclusion, That, as the buds towards the extremities of branches are placed upon the youngest wood, where they receive the most copious flow of the sap, they must, for this reason, swell more early, and disclose themselves sooner than such as are situated upon older wood. From the early breaking of the terminating buds upon branches, no proof can, therefore, be deduced in favour of a supposed circulation.

§ 6.

The subtile and ingenious theory of the generation of plants, given by Linnæus †, which is countenanced by many excellent facts, is further confirmed by these experiments; which strongly insinuate, that the tree is rather destined to support the pith, than the pith the tree; the pith, according to that theory, being essentially necessary, not so much for the vegetation of the plant, as the formation of the seeds.

In

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* Bonnet, p. 285.

† Linnæi Generatio ambigena, Amœn. Acad. vol. 6.

In our experiments, no fap could, at any time, be difcerned either to afcend or defcend by the pith. It is a fubftance quite unqualified for this purpofe. It contains no lymphatics; and, fo far as I know, none of the peculiar fap-veffels of any tree are ever fituated in the pith * ; a fingularity which is not to be found in any of the other parts of a plant.

THE fubftance of the pith very much refembles that of the cellular texture of plants, but is, notwithftanding, of a very different nature †. The cellular texture freely imbibes and tranfmits water; but the fubftance of the pith obftinately repels it. I have often feen coloured liquors rife in the bark and wood of trees, efpecially in the wood of the elder, but not a particle was admitted by the pith, though a fubftance, to appearance, much better adapted for imbibing a fluid. All thefe circumftances lead to fufpect, that the pith has little or no fhare in fupporting the wood, the bark, or the general vegetation of the tree, and that its principal ufe is to aid the formation of the fruit.

ACCORDINGLY, in the numerous fections of trunks and branches made in the foregoing experiments, the buds were conftantly obferved to be connected with, and, in a manner, rooted, in the pith, by means of the *diametral infertions* ‡. It may alfo be every where obferved, that no bud exifts upon any tree, without a connection with the pith; and that buds are always in greater abundance where the pith is moft copious.

IT is fuppofed by LINNÆUS §, that the pith draws the nourifhment from the bark; but the argument he ufes in fupport of this pofition does, by no means, prove it. On the contrary, it rather appears from our experiments, that the pith muft draw its nourifhment from the wood; becaufe, during the whole

spring

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* M. DU HAMEL imagines, that there are in the pith both *vaiffeaux propres*, and *lymphatiques*.

† M. DU HAMEL thinks, that the pith and the *tiffu cellulaire* are the fame fubftance.

‡ THE radiated lines of wood, which extend from the pith to the bark.

§ Amœn. Acad. vol. 6. p. 325.

spring feafon, the wood was replete with fap, while the bark was dry. Befides, when the trunk of a tree, for a certain fpace, is decorticated quite round, the pith, in the decorticated part, lives, and all the parts of the tree above it, fo long as the wood continues green, and conveys fap, which it will do for years. The wood appears to be the great fource of nourifhment to all the parts of the tree. It is probable, that, from this alone, the pith is nourifhed, and that its communication with the bark is not to draw nourifhment from it, but to afford fome important aid to the growth of the buds.

§ 7.

THE important conjecture of Dr HALES, mentioned in the introduction to this paper, and on which he thought the truth or falfehood of the doctrine of a circulation chiefly depended, has been, in the courfe of thefe experiments, completely verified.

WE have found, that, in the early fpring, the fap firft begins to move at the bottom of a tree, and proceeds gradually upwards through all its parts : That the lower bark is firft moiftened, by a fap afcending from the root, and not by a fap defcending from the branches, which was generally fuppofed. And further, that, from the firft movement of the fap in the fpring, till the time of vernation, no defcending fap whatever can be difcerned in the tree.

THESE, indeed, are important points againft the doctrine of a circulation, but I do not think that they completely difprove it. They only prove, that there is no circulating fap in a tree during a certain feafon of the year, that is, from the time the tree begins to bleed till the appearance of the leaves. To decide the matter finally, it is neceffary, that the route of the fap fhould alfo be traced, by accurate experiments, from the time the leaves firft appear, till the defoliation of the tree in autumn. What the refult of fuch an enquiry might be, I cannot determine :

mine: And fhall only obferve, that, from a few trials made with this view, I have been led to fufpect, that, while a tree is in leaf, its fap obferves a very different courfe, and moves by laws very different from thofe, by which it is regulated in the bleeding feafon.
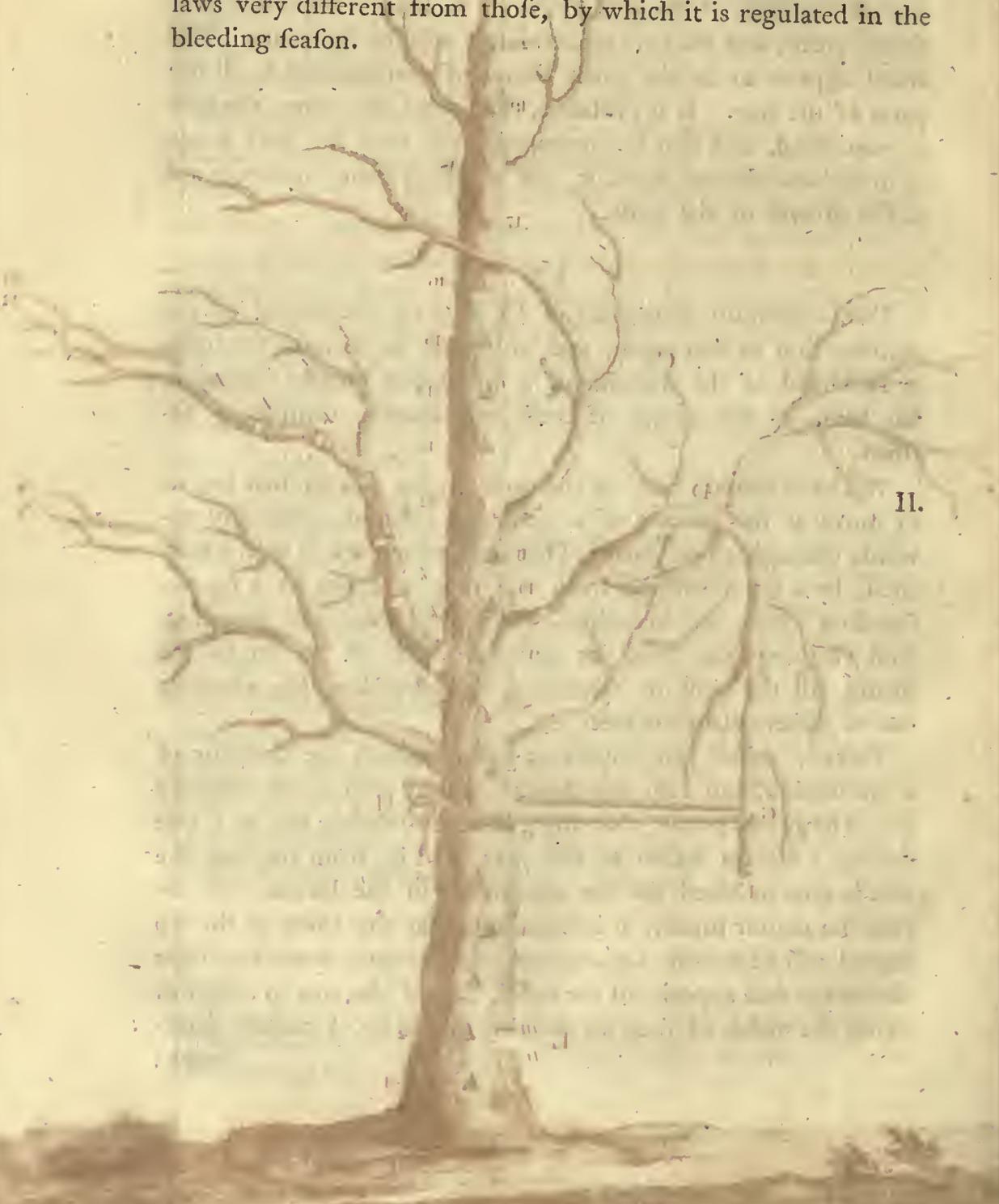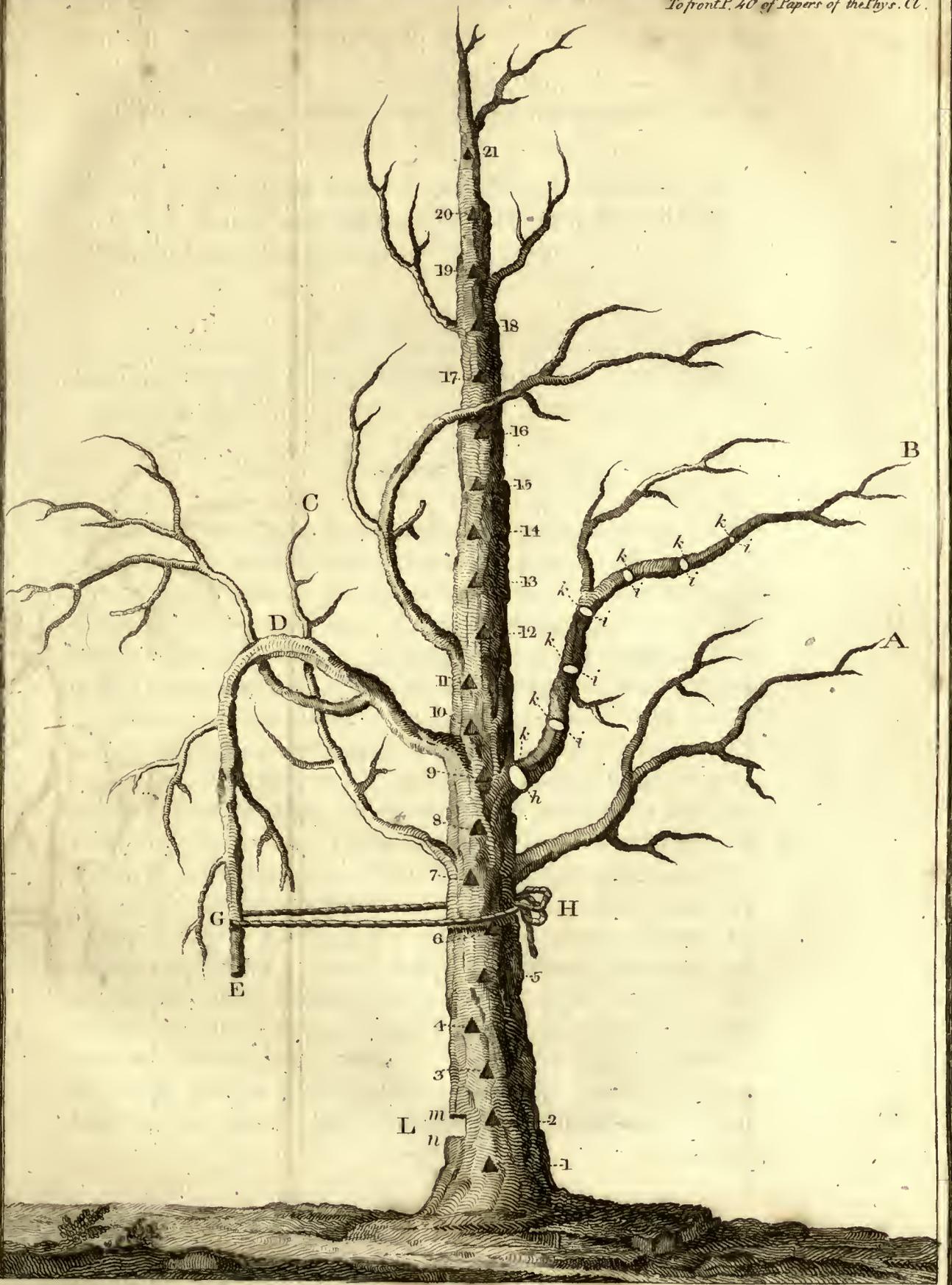
II. *The* Theory *of* Rain. *By* James Hutton, M. D. F. R. S. Edin. *and Member of the* Royal Academy *of* Agriculture *at* Paris.

PART I.

Investigation of the Law of Nature, on which is to be founded a Theory of Rain.

[*Read by the Author, Feb. 2. 1784.*]

THERE is an atmofpherical appearance which is not explained by the known laws of heat and cold. It is the breath of animals becoming vifible, in being expired into an atmofphere which is cold or moift; and the transformation of tranfparent fteam into the ftate of mift, when mixed with air which is of a colder temperature. Natural philofophers have certainly confidered thefe appearances as being explained in the general law by which heat and cold are communicated among contiguous bodies, otherwife they would have endeavoured to point out this particular law, which feems to depart from a more general rule, or does not follow the natural courfe of things obferved on other occafions. The fubject of this paper is to inveftigate a certain rule which, in the cafe now mentioned, may be difcovered as directing the action and effects of heat and cold; and to form a theory of rain upon that inveftigated rule, concerning the evaporation and condenfation of water.

THE air, infpired by an animal, may be confidered as a menftruum diffolving water upon the warm and humid furface of the lungs, and as thus becoming faturated with humidity in this degree of heat. When this folution is again cooled, then,

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according to the known laws of condenſation, water muſt be ſeparated from the menſtruum, and become viſible by reflecting light. In like manner, water may be rendered an inviſible elaſtic fluid, by means of heat alone ; and this fluid, in being cooled, will be condenſed into water, and appear viſible. But it is now to be ſhown, that, when breath or ſteam becomes viſible, in mixing with the atmoſphere, this effect is not produced in conſequence of the general principles of heat and cold : That, for the explanation of this appearance, there is required the knowledge of a particular law ; and that the effects of heat or cold, in relation to air and vapour, proceed not always in ratios which are equally increaſing or diminiſhing.

In order to determine the actual ratio of the diſſolving power of air, in relation to water in different degrees of heat, or the ratio in which the power of heat converts fluid water into elaſtic ſteam, we muſt conſider the ſeveral ratios in which this operation may proceed ; for if, among all the conceivable ways of proceeding, there ſhall be but one with which natural appearances ſhall correſpond, it will then be reaſonable to conclude, that this correſponding ratio is the particular law of nature, and that appearances of this kind are thus to be explained.

The diſſolving power of air, in relation to water, may be ſuppoſed to diminiſh as heat is increaſed ; but this would be inconſiſtent with natural appearances in general. Such a ſuppoſition, therefore, would be now ſuperfluous. This power might alſo be conceived as not affected with the increaſe or diminution of the degree of heat ; and this ſuppoſition is agreeable to the ſolution of ſea-ſalt in water : But, as it is certainly not the caſe with air and vapour, neither is this ſuppoſition to be made. The general rule of diſſolving and evaporating bodies, is to increaſe with heat. This is now to be admitted as the caſe with water evaporating in air, or when, by means of heat alone, it is converted into ſteam ; and it is only the ratio or meaſure of this operation which here is to be made the ſubject of conſideration.

THERE

THERE are juft three different ratios, in which this operation of heat on water may be conceived as proceeding.

1. THE folution may vary at the fame rate with the heat, fo that equal increments of heat fhall be accompanied by equal increments of diffolved vapour.

2. IT may vary at a greater rate, fo that while the heat increafes by equal differences, the quantity of diffolved vapour fhall increafe by differences which are continually augmenting.

3. IT may vary at a lefs rate than the heat, fo that while the heat increafes by equal differences, the quantity of diffolved vapour fhall increafe by differences which are continually diminifhing.

THESE three rates of evaporation, or folution of water in air, may be reprefented geometrically, thus: Let the ftraight line *C H* reprefent the fcale of the thermometer. Let the perpendicular or-

dinates, *a m*, *b r*, be taken in the proportion of the quantity of water, which can be held in folution, by a given quantity of air, of the temperatures *a* and *b*. Draw the ftraight line *m r*. Draw alfo the curve *m d e f r*, having its convexity turned towards *C H*; and the curve *m g k l r*, having its concavity turned towards *C H*. It is evident, that the ordinates to the line *m r* will mark the progrefs of heat, and alfo of a folution, varying at the fame rate with the heat. In like manner, the ordinates to the curve *m d e f r*, will mark the progrefs of folution, varying at a greater rate than the heat; and the ordinates to the curve *m g k l r*, will mark the progrefs of folution, varying at a lefs rate than the heat: For thefe ordinates are taken in the proportion of the quantity of water diffolved in
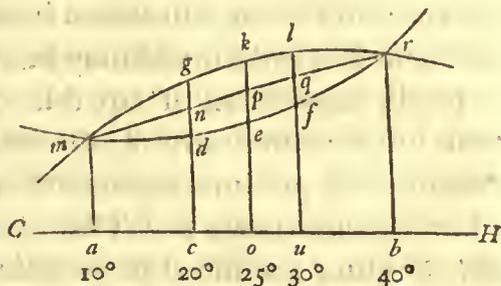
air,

air, of the different temperatures, indicated by the points of the line *C H*, from which they are drawn.

LET us now confider thefe three rates of aqueous folution, with a view to know the effect of mixing together faturated portions of the atmofphere of different temperatures. For this purpofe, let it be obferved, that the ordinates to the line *m r*, drawn from the point of *C H*, which denotes the temperature of the mixture, will always reprefent the quantity of water contained (whether diffolved or not) in an unit of the mixture ; for the ordinates *m a*, *r b*, were taken in the proportion of the quantities contained in an unit of air of the temperatures *a* and *b* ; and it is to be prefumed, that, upon mixture, the heat, and alfo the water, are uniformly diffolved ; and, therefore, both the heat and water, contained in an unit of the mixture, vary in the fame proportion, and may be expreffed by the fame meafure.

IN the fuppofition of equable folution, let us mix equal portions of faturated air, of the temperatures 10. and 40. the mixture will produce a temperature 25. which will be reprefented by the ordinate *o p*. This ordinate alfo reprefents the quantity of water contained in an unit of the mixture. But it alfo reprefents (in the prefent fuppofition) the quantity of water, held in folution by an unit of air of the temperature 25.

INSTEAD of equal portions, let two parts of a faturated folution, of the temperature 40. be mixed with one part of a faturated folution, of the temperature 10. the temperature produced will be 30. and will be expreffed by *u q;* which will alfo exprefs both the water contained in an unit of the mixture, and the quantity of water held in folution by the unit.

IN like manner, two parts of the temperature 10. mixed with one part of the temperature 40. produces a mean temperature 20. ; and the ordinate *c n* expreffes the heat, mixture, and folution of the unit.

EVERY mixture, therefore, that can be made of this folution will be found equally faturated, as are its conftituent parts, and
<div align="right">will</div>

will have neither excefs nor deficiency of the diffolved fubftance. This, however, is not the cafe in the other two rates of folution; for, as in thofe two cafes the ordinates of heat and folution are not the fame, the medium of heat will not exprefs a folution faturated with humidity, or a mixture in which there is not fuperfluity of the diffolved fubftance. Let us now confider thefe more particularly.

In the curve *m d e f r*, which reprefents the increafing rate of folution, let equal portions of the folution in 40. and in 10. be mixed, then the medium of heat in 25. will have for the ordinate of mixture, that is to fay, the quantity of water contained in this mixture *o p*, whilft *o e* is the ordinate of folution, that is to fay, the quantity of water that may be diffolved in this degree of heat, confequently, *e p* is the quantity of water that cannot be retained in folution, in this medium temperature produced by the mixture.

If two parts of the folution in 40. be mixed with one of that in 10. the medium temperature will be 30. ; and, if two parts of the laft be mixed with one of the other, the medium temperature produced will be 20. In thofe two cafes, *f q* and *d n* are the quantities which will be feparated from the folution.

In like manner, may be found the effect of any mixture of two portions in different temperatures, and the quantity of water that would be feparated on thefe occafions afcertained, if the actual curve of evaporation were known, or that rate in which the folution of water in air proceeded.

The progrefs of folution, inftead of being in an increafing rate, may be in one that decreafes, in relation to the progrefs of heat. In that cafe, the mixture of two portions of the folution in different degrees of heat, inftead of producing a feparation of fuperfluous moifture in the medium temperature, by reafon of the fuperfaturation, as in the former cafe, will be followed by an increafed power for the evaporation of water, by having an underfaturation in the mixed mafs.

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THIS propofition will be illuftrated in the curve *m g k l r*, which reprefents the decreafing rate of folution. Let equal portions in 40. and 10. be mixed, and let the ordinate be raifed in the medium degree of heat 25. *o k* will then be the whole power of folution, or the quantity of water that air is capable of diffolving in this degree of heat ; but *o p* is the quantity of water that is actually in this mixture ; confequently, the air is here underfaturated with humidity by the quantity *p k*.

IF two parts of 40. fhall be mixed with one in 10. or two of 10. with one in 40. the quantities of underfaturation will be changed, and *q l* and *n g* will exprefs thofe quantities, in relation to the mixtures in the medium temperatures.

THUS, in every mixture of folution in this decreafing rate of folution, there will be found an underfaturation of the air, with regard to the diffolved moifture, inftead of a fuperfaturation, which is found in all the mixtures of the folution in the increafing rate.

LET us recapitulate :

IF the folution of water in air increafes with heat in an equal rate, no mixture can be made of portions, in different degrees of heat, that will produce either fuper or underfaturation ; but the mixture, like the conftituent portions, will be always faturated without fuperfluity.

IF the folution of water in air increafes with heat in a decreafing rate, the mixture of two faturated portions, in different degrees of heat, will produce no condenfation of humidity, but, on the contrary, will be capable of diffolving more aqueous fubftance.

IF, on the other hand, the folution of water in air increafes with heat in an increafing rate, the mixture of two faturated portions, in different degrees of heat, will produce a condenfation of humidity, as being fuperfaturated in the medium temperature of heat.

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THIS laſt caſe properly applies to the phænomena of breath and ſteam, which have been rendered viſible, in mixing with air that is colder than themſelves ; and it explains the various appearances that may occur, in mixing together ſeveral portions of air, more or leſs ſaturated with humidity, and in different temperatures of heat and cold : For

IT is not every mixture of the atmoſpheric fluid, in different temperatures, that ſhould, according to the theory, form a viſible condenſation ; this effect requiring, in that atmoſphere, a ſufficient degree of ſaturation with humidity. Neither is it neceſſary, for this effect, that the two portions to be mixed ſhould each be ſaturated with humidity up to the temperature in which it then is found ; it is ſufficient, that the difference in the temperatures of thoſe portions to be mixed ſhould more than compenſate the defect in point of ſaturation. But, if a mixture ſhall be made of two portions of the atmoſphere, both fully ſaturated with humidity, then, however ſmall may be the difference of their temperatures, there is reaſon to believe, that a condenſation, proportionate to this difference, will take place.

HAVING thus explained the atmoſpherical appearance of viſible miſt, produced in the mixture of inviſible fluids, we may now apply this rule of condenſation as a principle for the theory of rain.

RAIN is the diſtillation of water, which had been firſt diſſolved in the atmoſphere, and then condenſed from that ſtate of vapour or ſolution. It is the explanation of this condenſation that muſt form the theory of rain. So far, therefore, as the condenſation of aqueous vapour has been explained, and ſo far as the evaporation of water from the ſurface of the globe is underſtood, we have a theory for the general appearance of rain.

WATER, indeed, is condenſed in a cloud equally as in rain, and yet clouds may ſubſiſt without rain. But, it is evident, that, without condenſation of aqueous vapour in the atmoſphere, no rain could be produced ; and that, however different cauſes

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may influence water condenfed in the atmofphere, and operate varioufly, in either retaining it longer in a fufpended ftate, or bringing it fooner to the ground, the condenfation of the water is properly the caufe of rain. We may now endeavour to confirm this theory of rain, in having again recourfe to natural appearances.

THE moft convincing experiment, in confirmation of the theory, would be, to have rain or fnow produced by a mixture of portions of the atmofphere, properly conditioned for the condenfation of the contained vapour. But fuch an experiment as this we alfo have. M. DE MAUPERTUIS, in his *Difcours fur la méfure de la terre*, fays, That, at Tornea, upon the opening of a door, the external air immediately converts the warm vapour of the chamber into fnow, which then appears in what he calls "de gros tourbillons blancs." A fimilar appearance happened at St Peterfburgh, *anno* 1773. I have it from Profeffor Robison, who faw it. It was in a crowded affembly, the company fuffering from the clofenefs of the room, a gentleman broke a window for relief. The cold air rufhing in, formed a vifible circumgiration of a fnowy fubftance.

THE law of nature, on which this theory of rain is founded, may be now confidered in relation to its final caufe ; or how far it may appear to be conceived in wifdom for the purpofe of this world, as affording a proper climate for plants and animals.

HAD the law, refpecting aqueous evaporation in the atmofphere, been conceived in any other manner than that which has been now found eftablifhed in nature, the fummer's heat, which is the caufe of vegetation, could never have been attended, as at prefent, with refrefhing fhowers of rain. By the circulation of the fluid atmofphere, the heat of torrid regions is carried away, and the cold of frigid regions is brought to temperate the exceffive heat that is excited upon the furface of the earth in the fummer folftice ; but, if no condenfation of humidity in the atmofphere could be produced by the mixture of

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its parts, however faturated with aqueous vapour, and in different degrees of heat, the natural cold of the polar regions, and the contingent cold of fnows, accumulated, during winter, upon the higher countries, however tranfported to warmer regions, would be altogether ineffectual for the purpofe of forming clouds and condenfing rain.

THE prefent fyftem of the atmofphere is fo calculated as that every mixture of different portions of that fluid, unequal in their degrees of heat, and faturated with humidity, muft procure a condenfation of water. This fyftem, therefore, of the atmofphere, with this particular law in relation to heat and cold, is calculated to produce rain, by the continual mixture of its parts, which are in different temperatures.

IN this fyftem, we fhall fee, that the cold regions of the polar circles are not ufelefs and inactive in the operations of this world. In like manner, the frozen regions of the Alpine fituations of the Continent, ferve a purpofe, in the conftitution of this earth, by preferving, in the accumulated fnows, a ftore of the winter cold for the fummer feafon; and thus preparing cold portions of the atmofphere to be mixed with the warmer portions, faturated with humidity, and ready to produce rain*.

WHILE the atmofphere is thus tempered, by tranfporting the heat and cold of diftant regions, the regions of the earth moft diftant from the fea, may be fupplied with fhowers of rain at every feafon of the year, or at any feafon, according to the arrival of thofe ftreams of the atmofphere which are in the proper conditions for producing, by their mixture, a medium degree of heat, and a fuperfaturation or condenfation of aqueous vapour. This wife fyftem of things, or this ufeful purpofe in the œconomy of the world, could not have been accomplifhed without that particular law of nature refpecting aqueous condenfation; for, if the mixing together of the atmofpheric ftreams produced no condenfation, the fummer hemifphere of

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* THE explanation of this propofition depends upon Dr BLACK's theory of latent heat.

the globe would be parched with drought; and the winter hemifphere deluged with rain.

To fee this, let us confider the fummer hemifphere of the globe, warmed by the influence of the afcending fun. From the laws of hydroftatics, it will appear, that there fhould be formed, on this occafion, two oppofite currents in the atmofphere above this half of the globe, the one moving along the furface of the earth, from the polar region towards the equator, the other flowing above, in a contrary direction. This circulation, therefore, being fuppofed, let us fee what follows, according to the actual conftitution of things. On the one hand, the evaporation of the winter's moifture from the furface of the continent, warmed by the fummer fun, muft tend to faturate with humidity the polar atmofphere, as it acquires an evaporating power from its increafing heat ; on the other hand, the progrefs of the upper current, from the tropic towards the pole, in having its degree of heat diminifhed by the general cooling caufe, will naturally bring the mafs to a point of faturation with the aqueous vapour which it had received. In this ftate of things, the two oppofite currents in the atmofphere, while feparate, might pafs on without condenfing humidity fufficient to produce rain ; but the moment that fufficient portions of thofe faturated ftreams fhall mix, not only cloud, but fhowers will be produced ; becaufe the fudden formation of a mean degree of heat, in the mixture of two portions in different temperatures, muft condenfe a quantity of vapour fufficient to form rain.

Rain having fallen in a place, in confequence of the mixture in the atmofphere above, this will naturally be followed by clearnefs in the fky and funfhine, which is fo neceffary for warming the furface of the earth, and for giving health and vigour to growing plants.

But, without the particular law now inveftigated, refpecting evaporation and condenfation of vapour, neither rain nor dew could

could be produced upon the fummer hemifphere of the globe, nor perhaps ever in tropical latitudes ; evaporation would every where take place, more or lefs ; the general tendency would be to faturate the atmofphere with water, or fill it with vapour in its greateft heat ; and the mixture of the different parts of the atmofphere would only conduce to temper the faturation, without producing any condenfation of vapour in the mean degrees of heat. But when, in confequence of the declining fun, the influence of the general cooling caufe fhould prevail, the atmofphere would gradually become clouded, and be darkened. This cloudinefs would increafe to a general diftillation of the condenfed vapour ; and this diftillation would be uniformly continued, until the returning fummer fhould change the ftate of condenfation to that of evaporation.

Such a fyftem as this, of fix months rain and fix months drought, conftantly fucceeding, would not have prefented us with all that variety of beautiful objects which we now behold ; nor would it, like the prefent conftitution of this world, appear calculated with all that wifdom of defign which we may perceive to be in the poffibility of things ; for fuch an uniform excefs of cloud and condenfation, on the one hand, and of funfhine and evaporation, on the other, would not appear to fulfil the intention of providing fuftenance and fatisfaction, as far as poffible, for every living thing ; whereas, in the actual fyftem, now under contemplation, while both the extremes of drought and of wetnefs are fo wifely avoided, temperate drought and moifture, rain and funfhine, fo beneficial to the œconomy of this world, are every where beftowed with the moft provident attention, but not without a variety of different degrees ; which moft evidently marks out perfection in the defign, where fuch a multitude of different beings, dependent on the various temperament of thofe oppofite elements, are to be provided with the neceffary conditions for their life, for the maturity of the individual, and for the continuation of the race.

PART II.

The Theory of Rain applied to natural Appearances.

[*Read by the Author, April 12. 1784.*]

HAVING formed a theory of rain, founded upon a general law refpecting the condenfation of aqueous vapour contained in the air, it is now propofed to make fome application of this theory to natural events, in confidering the meteorological obfervations of the globe, and endeavouring, either to explain appearances that are not otherwife underftood, or, from thofe appearances that are evident in themfelves, to draw conclufions in confirmation of the theory.

UPON this occafion, where there is an indefinite variety in a feries of particular obfervations, it is neceffary to inveftigate fome order in thofe events, and to form a generality among phænomena, which will then be phyfical truths, and may be compared with the theory.

1*ft*, IT may be required to fhow fome reafon why, on all the furface of the earth in general, there are always feafons of rain, whether regular or irregular. Here the fubject of enquiry will properly refpect the generality of rain.

2*dly*, IT will be proper to confider fuch regular periodical rains, as may be found with the circumftances attending their production, which then would ferve to try the theory, or to illuftrate it. Here the regularity of rain will be the object in view, and not its generality.

3*dly*, IT will be neceffary to examine the apparent exceptions from the doctrine founded on the theory, or thofe appearances of irregularity in nature that do not flow from the theory, although they may be in perfect confiftence with it, and might be explained, had we the peculiar circumftances which are the

occafion

occasion of the event. Here, again, the subject to be dif-
cussed will be the apparent exception from the generality of
rain.

4thly, THE proportional quantities of rain falling in the dif-
ferent situations of the earth may be made an object of our at-
tention, in order to illustrate the theory, as well as to explain
appearances. Here a comparative estimate will be made of cli-
mates in relation to rain.

5thly, and *lastly*, HAVING thus considered the particular ap-
pearances of the globe in general, so far as our imperfect know-
ledge of them reaches, we may next examine a particular place,
such as is best known, in relation to the appearances in general
of rain. The meteorological observations of our own climate
will here be the proper object of examination, with a view to
confirm the theory, and to form general rules, which may be
occasionally applied, either to any particular meteorological re-
gister, or to every observation of change in our weather, that
is, such as shall be attended with circumstances proper for judg-
ing of the principle.

1. *Of the Generality of Rain.*

LET us suppose the surface of this earth wholly covered
with water, and that the sun were stationary, being always ver-
tical in one place, then, from the laws of heat and rarefaction,
there would be formed a circulation in the atmosphere, flowing
from the dark and cold hemisphere to the heated and illumi-
nated place, and returning above, from the heated place, in
all directions, towards the place of greatest cold.

As there is, for the atmosphere of this earth, a constant cool-
ing cause, this fluid body could only arrive at a certain degree
of heat ; and this would be regularly decreasing from the cen-
tre of illumination to the opposite point of the globe, most di-
stant from the light and heat. Between those two regions of
extreme heat and cold, there would, in every place, be found

two

two ftreams of air, flowing in oppofite directions. If thofe
ftreams of air, therefore, fhall be fuppofed as both fufficiently
faturated with humidity, then, as they are of different tem-
peratures, there would be formed a continual condenfation of
aqueous vapour, in fome middle region of the atmofphere, by
the commixtion of part of thofe two oppofite ftreams.

HENCE there is reafon to believe, that, in this fuppofed
cafe, there would be formed, upon the furface of the globe,
three different regions, the torrid region, the temperate, and the
frigid. Thefe three regions would continue ftationary ; and
the operations of each would be continual. In the torrid re-
gion, nothing but evaporation and heat would take place ; no
cloud could be formed, becaufe, in changing the tranfparency
of the atmofphere to opacity, it would be heated immediately
by the operation of light ; and thus the condenfed water would
be again evaporated. But this power of the fun would have a
termination ; and it is there that would begin the region of
temperate heat, and of continual rain. It is not probable, that
this region of temperance would reach far beyond the region of
light ; and, in the hemifphere of darknefs, there would be
found a region of extreme cold and perfect drynefs.

LET us now fuppofe the earth as turning on its axis, in the
equinoctial fituation. The torrid region would thus be changed
into a zone, in which there would be night and day ; confe-
quently here would be much temperance, compared with the tor-
rid region now confidered ; and here perhaps there would be
formed periodical condenfation and evaporation of humidity,
correfponding to the feafons of night and day. As temperance
would thus be introduced into the torrid extremity, fo would
the effect of this change be felt over all the globe, every part of
which would be now illuminated, confequently heated in fome
degree. Thus we would have a line of great heat and evapora-
tion, graduating each way into a point of great cold and con-
gelation. Between thefe two extremes of heat and cold, there
would

would be found, in each hemifphere, a region of much tem-
perance, in relation to heat, but of much humidity in the at-
mofphere, perhaps of continual rain and condenfation.

THE fuppofition now formed muft appear extremely unfit for
making this globe a habitable world, in every part; but, ha-
ving thus feen the effect of night and day, in temperating the
extremities of heat and cold in every place, we are now pre-
pared to contemplate the effects of fuppofing this globe to re-
volve around the fun, with a certain inclination of its axis. By
this beautiful contrivance, that comparatively uninhabitable
globe is now divided into two hemifpheres, each of which is
thus provided with a fummer and a winter feafon. But our
prefent view is limited to the evaporation and condenfation of
humidity; and, in this contrivance of the feafons, there muft
appear an ample provifion for thofe alternate operations in every
part; for, as the place of the vertical fun is moved alternately
from the one tropic to the other, heat and cold, the original
caufes of evaporation and condenfation muft be carried over all
the globe, producing either annual feafons of rain, or diurnal
feafons of condenfation and evaporation, or both thofe feafons,
more or lefs, that is, in fome degree.

THE original caufe of motion in the atmofphere is the influ-
ence of the fun heating the furface of the earth, expofed to that
luminary. We have now fuppofed that furface to be of one
uniform fhape, and fimilar fubftance; from whence it has fol-
lowed, that the annual progrefs of the fun, perhaps alfo the di-
urnal progrefs, would produce a regular condenfation of rain
in certain regions, and the evaporation of humidity in others;
and this would have a regular progrefs in certain determined
feafons, which would not vary. But nothing can be more di-
ftant from this fuppofition than is the natural conftitution of
the earth; for the globe is compofed of fea and land, in no re-
gular fhape or mixture, while the furface of the land is alfo ir-
regular, with refpect to its elevations and depreffions, and vari-
ous;

ous, with regard to the humidity and drynefs of that furface which is expofed to heat as the caufe of evaporation. Hence a fource of the moft variable motions in the fluid atmofphere, always affected with the heat of each particular part of the furface with which it comes in contact; hence a tendency to faturate every part of the atmofphere with aqueous vapour, more or lefs, fo far as other natural operations will admit; and hence a fource of the moft irregular commixture of the feveral parts of this elaftic fluid, whether faturated or not with aqueous vapour.

ACCORDING to the theory, nothing is required for the production of rain befides the mixture of portions of the atmofphere, fufficiently faturated with humidity, and in different degrees of heat. But we have feen the caufes of faturating every portion of the atmofphere with humidity, and of mixing the parts that are in different degrees of heat. Confequently, over all the furface of the globe, there fhould happen occafionally rain and evaporation, more or lefs; and alfo, in every place, thofe viciffitudes fhould be obferved to take place, with fome tendency to regularity, which, however, may be fo difturbed as to be hardly diftinguifhable upon many occafions. Variable winds, and variable rains, fhould be found in proportion as each place is fituated in an irregular mixture of land and water; whereas regular winds fhould be found in proportion to the uniformity of the furface; and regular rains, in proportion to the regular changes of thofe winds, by which the mixture of the atmofphere neceffary to rain may be produced. But, as it will be acknowledged, that this is the cafe in almoft all this earth, where rain appears according to the conditions here fpecified, the theory is thus found to be in conformity with nature, and natural appearances are thus explained by the theory.

2. *Of*

2. *Of the Regularities of Rain.*

THE variable rains and falls of fnow, which happen irregularly in moft places, having been explained from the natural conftitution of this globe, from the proper difpofition of its folid and its fluid parts, and from the periodical influence of heat and cold, occafioned by the motion and pofition of this globe, in relation to the fun, we fhall find it eafy to underftand the more regular periodical appearances, with regard to rain, which happen in a few places of the earth.

IN looking for a regular periodical caufe for the mixture of portions of the atmofphere, in different degrees of heat, and fufficiently faturated with humidity, nothing appears fo promifing as the trade-winds in the Indian fea, blowing one half of the year in one direction, and, during the other half, in a contrary direction; for, as thefe ftreams of atmofphere are limited, they muft fomewhere produce a mixture of different portions of that fluid mafs; and, in finding rain to be the confequence of thefe regulated events, or as correfponding to thefe probable caufes, we fhall have reafon to conclude, that thofe mixed portions of the atmofphere have been fufficiently faturated with humidity, and in different temperatures, in relation to heat. But this is actually the cafe; we find, in this place, regular appearances, with regard to rain, which correfpond to the regular caufes now affigned, for the commixtion of the atmofphere. This correfpondency, therefore, while it explains thofe natural appearances, confirms the theory.

THE iflands which are placed under the line, in the middle of the Indian ocean, feem to form for themfelves conditions of periodical condenfation, that correfpond to the diurnal influence of the fun, and to the nocturnal motions in the atmofphere. It is not here pretended to explain, *a priori*, how, in fuch places, either always, or at certain feafons, there fhould be daily periods of rain. It is enough to find that fuch is the fact, and that

it can be explained by no other theory but this, in which
we find a diurnal caufe of mixing together the different parts
of the atmofphere, by means of heating the mountains, and
furface of the earth, by the great illumination of the fun, thus
rarefying fome parts of the atmofphere, and producing com-
motions in the fluid mafs of air which furrounds the ifland.

THESE periodical commotions in the atmofphere of iflands in
tropical fituations muft not be confidered as a thing doubtful in
its nature, or a matter merely conjectural. The fact is well af-
certained in the fea and land breezes that are felt regularly
blowing every day in thofe oppofite directions. This is the
fact; and that rain fhould accompany thefe commotions follows
from the theory provifionally; that is, in cafe of the proper
conditions for the condenfation of vapour being found in the
atmofphere thus mixed. Now, thefe conditions are not always
found where we find the breezes. But, in the iflands now un-
der confideration, fituated under the line, and in a fea that muft
be hotter than any other upon the globe; a fea, either confined
conftantly between the tropics, or continually fupplied from the
tropical region of the Pacific ocean, it is not unreafonable to
fuppofe that fufficient faturation with aqueous vapour may be
found in the atmofphere; nor that, in the diurnal commotions
of this fluid, there may be portions of it mixed in different de-
grees of heat.

IT is, in like manner, that the periodical rains which happen
regularly upon the different coafts of the peninfula of India
muft be explained. The regular monfoons in thofe feas occafion
the tranfportation of air, faturated with aqueous vapour, which
has flowed along the furface of the fea, here to be elevated and
mixed with thofe portions which, having loft their heat to a
fufficient degree, are in a condition to produce, by their com-
mixture, a condenfation of water upon the land. Nothing can
better illuftrate this explanation than the great annual and periodi-
cal rains which happen upon this continent, and which are ex-
hibited

hibited upon fo large a fcale, that it is almoft impoffible to have them explained in any other manner. Let us examine thofe circumftances which cannot be miftaken, and which may be fufficient for deciding in this queftion.

FROM the eaft to the weft of this great tropical continent of Afia and Africa, the rivers inform us, that it rains in the feafon of the fummer folftice; and that, on the contrary, fair weather is here produced by the removal of the heating caufe. We cannot fuppofe, that heat is an immediate caufe for the condenfation of aqueous vapour; nor can we fuppofe that this effect fhould not be produced by cold; for this would be no lefs than to fuppofe in nature an inconfiftency, which never has appeared. While, therefore, we allow the laws of nature to be fteady, the effect of the fummer fun, in this continental fituation, muft be, to elevate the heated air, and to have its place fupplied by that which has come, fraught with aqueous vapour, from the neighbouring feas: But being arrived here, upon this heated continent, this humid air muft be elevated into the higher regions of the atmofphere, and either be tranfported from thence towards the polar regions, there to be gradually condenfed, as the cooling caufe takes place, or it muft here fall in rain, by finding a caufe for its condenfation. Upon the firft fuppofition, no rain fhould be found here during the fummer feafon; or the rivers, by which we are to judge of this event, fhould be at the loweft after fummer. But, as the oppofite of this is true, the rivers being then in their fwelled ftate, it neceffarily follows, that the humid atmofphere, tranfported from the fea, muft have its water condenfed upon this heated continent in the fummer folftice; and there is not, at prefent, any other principle known, by which this operation might take place, or any other theory by which thofe natural appearances of periodical rain might be explained.

THE fummer fun, which proves a caufe of rain in certain regions, where feas, affording great evaporation from their heat,

are in the neighbourhood, proves, on the contrary, a caufe of drought in other regions, where the fource of water, or evaporation, is more fcanty, or at a diftance. A winter continent, heated by the elevation of the fummer fun, fhould be more difpofed to have drought than rain, during the period of its heat, unlefs fome tranfient ftreams of atmofphere, proper for the purpofe, fhould reach this place, and happen to meet : There would thus be occafioned fhowers of rain, of great importance to the vegetation of the place, but not to be confidered as a general feafon of rain.

But the cafe is altered, upon the declining of the fummer fun. The atmofphere, upon this continent, then becoming either faturated to its degree of heat, or cooled to its degree of faturation, is difpofed to produce rain, with every mixture which is in a different temperature. Hence a fource of autumnal rains and winter fnows, which may fall with all the regularity of the tropical rains ; and of this we alfo have information, from the regular covering of thofe northern continental regions, with a permanent fnow ; an event that happens with great conftancy, and may be confidered as a regular periodical rain.

Having thus found rain as being properly caufed, upon two oppofite principles, a vertical or highly elevated fun, and the removal of that caufe of heat, no place fhould be found, upon the furface of this earth, where rain may not happen, more or lefs, from the one or other of thofe caufes. But there are places where it is faid never to rain : And now the queftion is, how far thefe appearances may be confiftent with the theory of general rain which has been given.

3. *Of apparent Exceptions from the Generality of Rain.*

The argument for the generality of rain has been founded upon thefe two principles, *firft*, That mixed portions of the atmofphere are, by means of a certain law of nature, qualified

for

for the production of rain; and, 2*dly*, That there is, in the conftitution of this terraqueous globe, caufes for mixing the different parts of the atmofphere, particularly, during fummer, or by the influence of the fun. Had the rule, eftablished by nature, for the evaporation of water and condenfation of vapour, followed any other ratio than that which has been inveftigated in the theory, no mixture of the atmofphere could have produced either mift or rain, and the regions of condenfation muft have been limited to the regions of cold, where, in all probability, there muft have been continual rain, with no other variation, perhaps, than a little change in the limits of the condenfing regions, each of thefe two regions increafing and diminifhing alternately, with the feafons of winter and fummer.

In the actual fyftem of the globe, the cafe is different, and there is ample provifion made, in general, for rain; but, in the theory which has been given with regard to a certain part of that fyftem, there is required, for the production of rain, certain circumftances and conditions which do not flow immediately from the heating and cooling caufes exerted every where upon the globe. If thofe conditions, therefore, are not obferved in certain places, no rain fhould there appear, notwithftanding the nature and fituation of fuch places fhould be fimilar to thofe of other places where abundant rain is found. But, if it be reafonable to conclude, that, in fome particular fituations, there fhould not be found the proper conditions for mixing together portions of the atmofphere, fufficiently faturated with humidity, and in different degrees of heat, or that thefe fhould occur but feldom, then, in finding upon the whole earth precifely fuch a fpot or two, in which feldom or very rarely it is found to rain, we might be allowed to fuppofe a failure in the conditions proper for rain in thofe places; and to conclude this from the effect, where it is not poffible to fee farther into the caufe.

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THE lower Egypt, and a narrow fpot upon the coaft of Peru, are the only examples that we have of this fingular occurrence. It would have been impoffible, *a priori*, to have concluded, that, of all the places upon the earth, thefe two fhould have been thofe in which rain fhould not happen ; the knowledge of man, in tracing future effects from known caufes, will ever be, perhaps, too imperfect for fuch an undertaking, where it is neceffary, not only to value every condition neceffary in the data, but alfo every quantity and degree in thofe different conditions ; but, though we may not form that judgment *a priori*, yet, finding that thefe are the only places in which rain does not fall, we may be allowed to conclude, that fuch is the natural ftate of the winds about thofe places, as to prevent the proper conditions for producing rain.

This conclufion is alfo, in fome meafure, confirmed from ULLOA's obfervations with regard to the wind, which appears to blow fo fteadily upon the coaft of Peru, that either continual rain might be here expected, or no rain at all, upon this coaft. In this laft cafe, we would have reafon to conclude, that the vapours from the fea were carried over the coaft to be condenfed, by mixing with other ftreams of cold atmofphere in the mountainous regions of the Andes, where it rains fo abundantly for moft part of the year.

IF, on the one hand, we fuppofe the wind blowing continually from the fea, without mixing with a ftream of air proper to condenfe humidity, it muft pafs over this heated coaft, without letting fall a drop of rain. If, on the other hand, we fhall fuppofe the trade-wind, which has come over the Atlantic, to be continued over the ridge of the Andes, weftward, after having depofited much rain in this hilly region, there would be alfo no reafon to fuppofe, that this current of atmofphere, paffing over the heated coaft, fhould there find conditions proper for condenfing its humidity.

BUT

BUT the queſtion is not, if, in any ſituation upon the ſur-
face of the earth, a judgment might be formed, *a priori*, of no
rain happening, during a certain courſe of time, which to us
ſeems endleſs; the contrary is the reſult of reaſoning from the
theory of aqueous condenſation, and from the natural conſti-
tution of the globe. But here are two little ſpots upon the
earth where it almoſt never rains, contrary to a concluſion of a
generality in the phænomenon of rain. It muſt, however, be con-
ſidered, that this generality was not a thing abſolute in the
concluſion, and neceſſary in the univerſal of the caſe. It was
only abſolutely neceſſary in ſome places; and it was, from the
indefinite variety of caſe, in all probability, moſt general. But
this generality will admit of ſuch an exception as may be con-
ſiſtent with the theory.

Now it is nowiſe inconſiſtent with the theory to ſuppoſe,
that there ſhould be, upon the globe, a few places, in which the
concurrence of the various conditions neceſſary for producing
rain ſhould not be found: That the greater part of the earth
ſhould be found without rain, would certainly be inconſiſtent
with the theory; but that a particular ſpot or two, containing
no diverſity of climate or of country, no variation of moun-
tain and of valley, ſhould be found without rain, inſtead of
tranſgreſſing the neceſſary concluſion of a generality with re-
gard to rain, confirms the theory, in preſuming the neceſſity
for the concurrence of certain circumſtances or conditions,
which are required in order to condenſe humidity in air.

THE cauſe of rain, though often exerted, will not be al-
ways ſufficient to produce the full effect; for a ſcanty con-
denſation of aqueous vapour will not deſcend in rain, but re-
main ſuſpended in a viſible form, and thus produce miſt upon
the ſurface of the earth, and clouds in the atmoſphere above.
There are alſo ſome ſituations in which the effect of the ſum-
mer ſun is, to form a certain haze, that diminiſhes very much

<div align="right">the</div>

the intenſity of heat which the direct rays of that luminary would produce.

Thus there are an indefinite variety of appearances to be produced from this ſimple principle of aqueous condenſation; for, in taking the gradation from the one extreme of tranſparent atmoſphere to the other of the denſeſt cloud, and from the falling of the gentleſt miſt and dew to the heavieſt rain, hail and ſnow, we have an indefinite variety of appearances, all flowing from one ſimple principle.

4. *Comparative Eſtimate of Climates in relation to Rain.*

It has been now obſerved, that the places in which it ſeldom or never rains are, in a manner, as nothing, and ought only to be conſidered, upon the globe, as a point or two, where rain, ſo variable in its quantity, appears to ceaſe. Here, therefore, may be conſidered as placed the leaſt quantity; and from this to the greateſt quantity, there is a conſiderable latitude, and an indefinite gradation.

It will be neceſſary to reduce theſe particular obſervations to a generality, and thus to have ſome facts to which the theory may be applicable. But, in order to have the theory tried by thoſe appearances, it will be neceſſary to ſtate the principles upon which, according to the theory, the differences in the quantity of rain in each place ſhould depend. We may thus form ſome general principles, by which the natural appearances, with regard to the quantities of rain, may be compared.

In each place of the earth, the general quantity of rain depends upon two ſeparate principles, which may be variouſly compounded. The firſt principle upon which the formation of rain depends, according to the theory, being the mixture of different ſtreams of the atmoſphere, the quantity of rain muſt depend, in the firſt place, upon circumſtances favourable to this mixture, or this meeting of different winds.

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THE meeting together of different ftreams of air is not fuffi-
cient for the production of rain ; it is alfo required, that thofe
ftreams of air be in degrees of heat fufficiently different to pro-
duce a proper condenfation ; but as every place, except the
poles themfelves, may be confidered as fituated between two
different regions, the one hotter and the other colder than it-
felf, any place in which circumftances are found favourable for
the commixtion of different winds, may be confidered as having
alfo this condition favourable for the condenfation of rain ;
and thus thefe two conditions, the mixture of winds, and the
proper temperatures of thofe winds, may be comprehended
under this firft principle.

THE fecond principle to be now confidered, is the quantity of
humidity contained in the ftreams of air which are mixed for
the production of rain. · Here is a diftinct principle, which is
perfectly different from the firft ; and, according to the theory,
the quantity of rain in any place, *cæteris paribus*, will neceffa-
rily depend upon this principle. There being thus two different
principles for determining the quantity of rain, we muft al-
ways have an eye to each of thofe principles, in comparing na-
tural appearances with the theory. With this view, it will be
proper to confider feparately thefe two principles as the caufe of
rain ; and it will be eafy to underftand the compounded effect
of both, after afcertaining what fhare of operation may belong
to each.

WERE the furface of this globe uniform, or a perfect fphe-
rical form, whether of fea or land, it does not appear how
there fhould be produced any wind, or ftreams of air, but what
were regular, in being determined by the influence of the fun
and motion of the earth, by which the different parts of that
furface would come varioufly, but regularly, to be affected by
the influence of this luminary. But the furface of this globe
is compofed of fea and land ; and this diverfification is various
and irregular. Here is, therefore, a fource of variable winds,

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or different ftreams of air, which may mix for the production
of rain.   The furface of the earth is alfo diverfified with plains
and mountains, woods and barren defarts ; and here is fixed
another fource of variation ; firft, for the various heating of that
furface ; fecondly, for the production and mixture of different
ftreams of air ; and, laftly, for the influencing or determining
the quantities of rain in each place.

MOUNTAINS, in general, may be confidered as conducing
much to the mixing of different ftreams of air ; for, by the
heating of the fides of thofe mountains, more directly expofed
to the rays of the fun, there are neceffarily formed partial
ftreams, or occafional currents, in that fluid mafs of atmofphere ;
and thefe currents muft tend to mix its different parts.   Moun-
tains, alfo, in oppofing the more general ftreams or currents of
the atmofphere, muft deflect thofe currents in their courfe, and
form a fource for the meeting together of currents coming
from the different fides of thofe ridges, and from the oppo-
fite quarters of the fame fide.   Therefore, mountains and
their neighbourhood may be confidered as being, *cæteris pa-
ribus*, more favourable to the production of rain than plains
and low countries little above the level of the fea.   But, as this
conclufion is found, in general, to be verified from experience,
the theory here receives frefh confirmation from natural appear-
ances.

THUS, it will appear, that the effects commonly afcribed
to mountains, *viz.* breaking the clouds by their mechanical
operation, and attracting them by their electric quality, and
fuch like operations, are erroneous, or unneceffary for explain-
ing the general appearance of mountainous fituations having
more rain and thunder than the plains.   Neither is the cold,
natural to the tops of mountains, to be confidered as productive
of rain, in cooling and condenfing the atmofphere ; for the
cold upon the top of a mountain is the effect of the atmofphere ;
this

this place being no colder, in general, than any other in the neighbouring atmofphere at the fame height.

ACCORDING to this principle, there fhould be more rain upon the land than upon the fea, which, being a plane, and homogeneous in its nature, has neither the fame power to produce ftreams of air, nor to mix together thofe which it may produce. We find this alfo confiftent with experience. There is lefs rain, in general, upon the fea than upon the land, fo far as we may judge from all that we know. In the conftant trade-winds, there is very little rain; but, in the variable winds adjoining to the trade-winds, rain falls in abundance, which is ftrictly agreeable to the theory. So certain alfo is this general principle, that the moft experienced feamen and beft obfervators have made the remark, that, in thofe great oceans, the appearance of a cloud at a diftance was an indication of an ifland, which they feldom failed to find from that indication.

THE fecond principle in the caufe of rain is the different degrees of humidity that may happen to be in the ftreams of air which are mixed. Here we fhall alfo find a great fource of variation as to the quantity of rain to be produced in equal circumftances, *i. e.* with a perfect fimilarity in the other requifite conditions. It is not, however, fo eafy to exemplify the reality of this principle from actual obfervation, as it is with regard to the other, which had been fo evident as to have been received into a general opinion. We fhall, therefore, be obliged to look out for fome appearances, by which the theory may be confirmed, in proving the two following general propofitions:

1ft, THAT the place where the greateft quantity of rain fhould fall, *cæteris paribus*, is in the land contiguous to a great fea in a tropical fituation.

2dly, THAT the place where the leaft quantity of rain fhould fall upon the earth, *cæteris paribus*, is the moft inland part of the continent of Europe and Afia, in a cool or temperate latitude.

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IF these two propositions be true, the theory, so far as depends upon this principle of condensation, will be confirmed. It is, therefore, now proposed to give an example in each of those propositions, from the comparison of which examples with the observations made in other places, we may arrive at the truth, and find the propositions proved.

THE first of these is with regard to the greatest quantity of rain. Nobody will doubt of the East Indies being a place properly corresponding to the terms of the proposition ; and it has been found, that 104 inches of rain have there fallen in one place in a season ; which is at least three times the quantity which generally falls in the regions subject to our observations.

WITH regard to the second case, I know of no meteorological register to consult, by which the comparative dryness of the region, specified in the proposition, might be determined ; but there are some notorious facts from which this conclusion may be formed, by taking a proper compass in our reasoning.

THE Caspian sea, so far as it remains stationary, in neither increasing nor diminishing, affords a measure of the evaporation from the surface of that sea, in relation to the rain that falls upon the country, which is drained by the rivers running into it ; conversely, it affords a measure of the quantity of that rain, in relation to this evaporation. But this country is in the very place which we would observe, with respect to the quantity of rain, as being near the centre of the greatest continent. If, therefore, we could find a similar example in a different situation of the globe, we should then, in making a comparison, find data for drawing some conclusion concerning the quantities of rain which fall upon those different places. The lakes in North America will afford this comparison. The medium latitude of these lakes is about 45°. ; and this is nearly that of the Caspian sea ; consequently, *cæteris paribus*, there should be, in those instances, an equal evaporation from equal surfaces.

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WE may next compare the two extents of land which fupply with water thofe two compared evaporating furfaces. If, in thofe two cafes, the furfaces of land, collecting rain, be equally proportioned to the furfaces from which that water is to be evaporated ; and, if we fhall fuppofe, that the quantity of rain which falls upon thofe two furfaces of land, is equal in proportion to their fpaces ; in that cafe, we fhould conclude, that all the water received into thofe lakes might be evaporated, as it is in the Cafpian fea. If, on the contrary, an immenfe quantity of water iffues annually from thofe lakes, while there is reafon to conclude, from the comparifon of the Cafpian, that all the received water fhould be evaporated, we fhall then have reafon to conclude, that there falls much more rain upon this inland place of North America, than upon a fimilar fituation in the great continent of Europe and Afia. The fact is, that the Cafpian receives its water from a furface of land, larger, in proportion, than that from whence the lakes of America are fupplied ; confequently, there fhould no water iffue from the lakes, but all evaporate, according to this rule.

IN this calculation, the evaporation has been fuppofed to be equal, from equal fpaces, on the furface of the Cafpian and the lakes. But it may be alleged, that the evaporation from the lakes may be lefs than that from the Cafpian ; confequently, there might appear to be a redundancy of water, in this cafe, from the lakes, although the proportion of rain might be no greater. This argument, upon another occafion, might be conclufive ; but, in this cafe, where a greater power of evaporating water muft attend the leffer quantity of condenfed vapour, as flowing neceffarily from the fame caufe, *viz.* the great diftance from the fea, to allege a greater evaporating power upon the furface of the Cafpian than on that of the lakes, is evidently to give up the argument ; unlefs the greater evaporation fhall be fuppofed to arife from a different caufe ; and here the only caufe of

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this kind that occurs is a greater degree of heat; which may be now confidered.

THERE is no doubt that there would appear to be lefs heat in the climate of North America than in that of Europe, comparing equal latitudes; but, unlefs this greater cold arifes from fome other caufe than that which produces the greater quantity of condenfed vapour, this argument from the temperatures, in relation to heat and cold, would be no more conclufive than that from the drynefs of the climate. Now, it muft be evident, that, upon a continent where there is a greater quantity of condenfed vapour, there muft be more clouds to intercept the heat of the fun, or its influence in heating the furface of the earth; and alfo, there muft be more of that heat loft, in relation to our fenfation, by being employed in evaporating the greater humidity from the furface of that earth. The proper conclufion is, that the greater cold, in the climate of North America, compared with the climate of the Cafpian, arifes from the fame caufe which produces the greater quantity of rain; at leaft, that this is the cafe in a great meafure, and that we have no rule for valuing the effect of any other caufe.

HAVING thus found, that a greater quantity of rain falls upon a given furface in the fmaller continent of the new world, than upon a fimilar one in the greater continent of the old, the theory is fo far confirmed; as, according to this theory, there fhould be found more favourable circumftances, or conditions, for the condenfation of aqueous vapour in the atmofphere, and the production of rain in the fmaller than in the greater continent.

5. *The Theory applied to Meteorological Obfervations.*

HAVING compared the general appearances of the globe, in relation to rain, with the theory, and having found that perfect correfpondency betwixt them, which is neceffarily required in phyfical truths, we may now confider the general appearances

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of a particular place upon the globe, such as the island which we inhabit. Because, having the opportunity of making meteorological observations for this place, we ought to find, in those observations, a certain confirmation of the theory, if it is just; and we should also be able to form a certain explanation of those natural appearances, so far as the theory shall be admitted.

In such an island as this of Great Britain, situated in a region of variable winds and temperate heat, more or less influenced, on the one side, with the most extensive continent of the earth; on the other, with the Atlantic ocean, there is reason to conclude, that showers will often happen, without extreme quantities of rain falling at any one time; and that the climate of this country, with respect to drought and moisture, will incline towards the latter. This is also found to be the case, comparing Britain with the drier regions of the continent. But what is most interesting at present, will be to observe what are the concomitant circumstances of those frequent showers which fall in this variable climate; for here the best opportunity may be afforded of having the doctrine confirmed, in finding the conditions required in the theory for the observed effect.

Before entering on this subject, where latent causes are to be concluded from observed effects, it will be necessary to mention some circumstances which, from the nature of things, render these observations of phænomena less conclusive, on many particular occasions, although nowise deficient, on the whole, for ascertaining truth, if properly considered.

In considering the meteorological observations of this country, with a view to illustrate and confirm the theory, three things occur, as requiring separate attention: 1*st*, The motion of the wind, or the quarter from whence it comes. 2*dly*, The degree of heat, or indication of the thermometer placed in the atmosphere. *Lastly*, The changed weight of the atmosphere, or indication of the barometer. These three variable things

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are to be confidered in relation to the perceived effects, rain or drought, which are fuppofed to happen in confequence of one or more of thofe three caufes; that thus we may endeavour to difcover which of thefe is to be efteemed the proper caufe, and which to be confidered as only a concomitant appearance.

NOTHING appears to us fo diftinct as the motion and direction of the wind, yet nothing is fo fallacious as the reafoning from this appearance, confidered as a caufe in the changes to be produced in the atmofphere, and as explaining thofe effects of change which we perceive. In making our obfervations on the wind, we are limited to a fpot, which may be confidered as a point in the line of the wind's direction; and, from our obfervations in this fpot, we are apt to conclude with regard to operations which include a great extent. When, for example, the wind blows from the weft, in our obfervation, we fay, it has come along the Atlantic; when, from the eaft, that it has come from the continent of Europe; yet, unlefs we fuppofe the wind, in moving, to preferve a ftraight line, or direct courfe, it muft be evident, that, in thofe two cafes, the wind, inftead of coming, as we imagine, from the eaft or weft, may truly have come from the north or fouth. Now, to any one who confiders attentively the nature of motions in the fluid atmofphere, it muft appear, that a ftraight line is that, of all others, which there is the leaft reafon to conclude fhould take place in the variable winds of the globe; but thefe are the winds only with which we are now concerned.

IT will likewife be evident how great a difference there is between a weft or eaft wind and a fouth wind, on the one hand, or a north wind, on the other. Now, what a confufion, in our reafoning, muft fometimes follow this prefumption of our principles? For, if we may confound a fouth wind, in our obfervations, with a wind coming to us directly from the weft, we muft alfo be fubject to miftake a north wind upon a like occafion, *i. e.* in taking it for a weft wind. Thus, therefore, in

reafoning

reafoning from our obfervations, a fouth wind and a north wind, things as different in their qualities as oppofite in their directions, will fometimes be confounded.

THE practical obfervation to be now made from this is, that we fhould always allow the appearance, with regard to the direction of the wind, or place from whence it came, to be corrected by thofe concerning the temperature of this fluid, in relation to heat and cold, fo far as there is reafon to conclude that this indication of the thermometer is a thing of greater certainty than that of the wind's direction.

THERMOMETRICAL obfervations, with regard to the temperature of the atmofphere, are, from their nature, variable. The furface of this earth is heated by the influence of the fun; and the atmofphere, in contact with this furface, is heated by communication of temperature: Or, in like manner, it is cooled, upon another occafion, when it happens to be warmer than the furface of the earth. But, whatever may be the temperature of the atmofphere, there is, in general, a certain allowance to be made for the diurnal influence of the fun; and this is found out, by experience, both with regard to its quantity upon the fcale of the thermometer, and to the time of its periodical appearance in the rotation of the earth.

HAVING thus learned to make allowance for the diurnal variation of the thermometer, its variable temperature, as an indication in our meteorological journal, is next to be confidered, and the caufes of that change. It muft be evident, that nothing can contribute fo much to change the temperature of the atmofphere, as change in the direction of the wind, fuppofing, that, in our obfervation, it gives no falfe indication. It is impoffible, that the fouthern atmofphere fhould be tranfported over this ifland, without giving heat above the mean temperature of the feafon at which the obfervation is made; or that the wind fhould come directly from the north, without producing the oppofite effect. Therefore, we are obliged to eftablifh this

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principle, that whatever degree of heat or cold is felt exceeding
the mean temperature, or that which is proper to the feafon of the
obfervation, muft be attributed to the motion of the atmofphere
from the fouth or north, although the direction of the wind,
upon the little fpot of our obfervation, may have given another
indication.

THE atmofphere moving from the eaftern or weftern regions
is not neceffarily either warmer or colder than the place of our
obfervation; but it may be occafionally either the one or the
other; and, from the known nature and circumftances of fuch
places, there are alfo rules to be formed for judging of thefe
occurrences. It would, however, be foreign to our prefent
view to enquire into thefe rules; and it is only neceffary to ob-
ferve, upon the whole, that there is no fteady caufe for either
heat or cold, in general, being tranfported to us, in the cafe of
the atmofphere being moved directly from the eaft or weft.

HENCE will appear the truth of that general rule which was
propofed for judging of the region from whence the atmofphe-
ric ftream has moved to us, *viz.* that we fhould afcribe more to
the heat and cold of that fluid, compared with our mean tem-
perature for the feafon, than to the direction in which the ftream
paffes over our head. The obfervations which relate to the ba-
rometer may now be confidered.

THE barometer is as juft a meafure of the weight or com-
preffion of our atmofphere, as is the thermometer of its degree
of heat or cold. But natural philofophers, obferving the con-
nection of changes in the barometer, with the difpofition of the
atmofphere to rain, have judged, that one of thofe things ftood
in relation of a caufe to the other; and, finding, that often the
mercury in the barometer fell from its ftationary place before
the change from fair to rainy weather, they have concluded,
that rarity in the atmofphere was an immediate caufe of rain.
If fuch a conclufion as this could be admitted upon found prin-
ciples, the theory now given, with regard to the phænomenon of
rain,

rain, would be ufelefs or uncertain; but, that fuppofition with regard to the effect of rarity in the atmofphere, fo far from being fupported by the truth of obfervation, or from phyfical principles, is deftitute of every confirmation.

WHATEVER fhall be fuppofed the caufe of rain, one thing is evident, that the neceffary confequence of the falling of rain from the atmofphere is to make that atmofphere more light, proportionally to the quantity of water which, after being feparated from the air, is fupported by the earth on which it falls. But there do not fall fuch quantities of rain in thefe regions, as to explain the quantity of loft preffure, indicated by the barometer upon thefe occafions; therefore we are obliged to reject the confideration of the appearance of the barometer, either as the caufe or the effect of rain; although, inafmuch as they are connected with the caufes of rain, the indications of the barometer are found, from experience, to be of fome ufe in the prognoftication of that event.

THOSE great changes in the atmofphere, which occafion the remarkable rifings and fallings of the barometer, are not partial, as happening to a narrow fpot around the place of obfervation, but are of great extent. This appears from the comparifon of different regifters; for, at the diftance of 400 miles, and perhaps much more, two barometers proceed nearly in the fame manner, rifing and falling, in general, almoft in the fame ratio; but, within that diftance, rainy weather often happens in one place, while it is fair weather in another; confequently, in fuppofing either the levity of the atmofphere, or its gravity, to occafion rain, we fhould be led into abfurdity, by concluding the fame caufe as producing contrary effects, or a caufe exifting without its proper effect.

INSTEAD of fuppofing the changed compreffion of the atmofphere to be an immediate caufe of rain, let us fuppofe this change to be the confequence of fome great emotion produced in that fluid body; then, as different parts of the atmofphere

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come naturally to be mixed on thofe occafions of inteſtine mo-
tion, we ſhould have, according to the theory, an immediate
cauſe ſomewhere, in all probability, for the condenſation of
humidity, or production of rain. It does not, however, ap-
pear why the falling barometer ſhould indicate rain any more
than the riſe of the mercury; at the ſame time, it may be
made to appear how, in general, the gradual riſe of the ba-
rometer, to its greateſt ordinary height, and its continuation in
this growing ſtate, ſhould naturally indicate fair weather, or
much fair weather, in the quarter of the globe concerned with
thoſe obſervations.

In order to perceive this, let us ſuppoſe ſuch fair weather to
take place, and that there is an undiſturbed atmoſphere in this
quarter of the earth; then it will appear, that the neceſſary eva-
poration from the ſurface of the globe muſt gradually increaſe the
weight of the atmoſphere, or its height, or both. But, in this
caſe, the mercury in the barometer muſt riſe with a gradual
progreſs, while there is no motion in this quarter of the atmo-
ſphere, ſufficient to cauſe a general rain, or to make a change in
this natural ſtate of the barometer. Thus, though, perhaps,
there is not any condition of the barometer that poſitively indi-
cates rain, we have, from the obſervations of that inſtrument, a
poſitive indication of fair weather.

But, though this indication of fair weather be poſitive in
its nature, as being founded on principle, and not on ſuppoſi-
tion; yet it is only true conditionally; that is, providing no
other cauſe interferes, or that the ſtationary place of the mer-
cury be not occaſioned by the contrary operation of different
changes. This deceitful occurrence, however, though often
happening in ſmall degrees, will rarely prevail to ſuch an ex-
tent as might render doubtful, in general, the poſitive indica-
tion of the barometer, in relation to fair weather.

Having thus obtained a poſitive indication of what may be cal-
led the fair-weather ſeaſons, and the rainy ſeaſons, requiring com-
motions

motions of the atmosphere, which may naturally occasion the mercury to fall, we shall, in this manner, have explained the indications of the barometer, so far as connected with the cause of rain : At the same time, it is not pretended to explain, upon this principle, why the falling of the barometer should, in general, be a necessary indication of rain, any more than the sudden rising of the mercury in that instrument.

In the temperate regions of the earth, there are great changes of the barometer, compared with those which happen in the torrid region between the tropics, where they are but small. This also should be the case, according to the nature of things ; that is to say, in considering heat and cold, upon the surface of the earth, as the causes of motion in the portions of the atmosphere which come more immediately within the compass of our observations. The torrid region, however greatly affected by the diurnal motion of the earth, or influence of the sun, is but little affected by the annual progress, which, to all the rest of the earth, from the 40th degree of latitude, is so extremely interesting. This region of perpetual summer, having, on each side, a temperate region, can never have the tranquillity of its atmosphere molested with extreme rarefaction and condensation, like the temperate zone, bounded, on the one side, with this torrid region, and, on the other, with a region that experiences such an extreme vicissitude in its temperature. The changes from summer to winter, and from winter to summer, necessarily produce great motions in the atmosphere ; but it is only in the atmosphere of the temperate regions that the effect of those motions is felt upon the barometer.

The tranquillity of the barometer, in the equinoctial situation, does not arise from the want of a moving cause to actuate the atmosphere in that region ; for there the sun, which may be considered as the prime mover of the machine, is at all times powerful. But this tranquillity arises from defect in the joint conspiring

spiring together of all thofe caufes, which, in the temperate zone, excite to fo great changes in the preffure of the impending at-mofphere. This moving caufe in the equinoctial region is more equable than it is any where elfe, except perhaps at the poles ; and it is always exerted nearly in the fame direction, in forming a motion from eaft to weft. When it is otherwife, that is, when fome cafual change interrupts the equable progreffion of the atmofphere, the moft violent effects may appear, in particu-lar places, for a fhort fpace of time, without much change in the general quantity of the atmofphere in this region, by which the ftation of the mercury in the barometer is determined ; confequently, the barometer, which is much . affected by the motions of the atmofphere in the temperate regions, fhould be but little affected with thofe motions in the middle region.

To conclude, the barometer is an inftrument neceffarily con-nected with motions in the atmofphere ; but it is not equally affected with every motion in that fluid body. The barometer is chiefly affected by thofe motions by which there are produced accumulations and abftractions of this fluid, in places or regions of fufficient extent to affect the preffure of the atmofphere upon the furface of the earth. But as every commotion in the atmo-fphere may, under proper conditions, be a caufe for rain, and as the want of commotion in the atmofphere is naturally a caufe of fair weather, this inftrument may be made of great importance for the purpofe of meteorological obfervations, al-though not in the certain and more fimple manner in which it has been, with the increafe of fcience, fo fuccefsfully applied to the meafuring of heights.

HAVING thus eftablifhed this principle, that the barometer is but little affected with the fall of rain, we may now employ fome general obfervations of this inftrument, to difcover or illu-ftrate certain operations in the atmofphere, which are more im-mediately connected with the caufe of rain in the region now confidered.

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It is found, that, in the tropical or equinoctial region, the variation of the barometer is small, compared with that in the temperate zone, notwithstanding there may be greater falls of rain in the first than in the last. But, if the power for evaporating water, and of condensing vapour, increases in a higher ratio than the equable progress of heat and cold, it must appear, that, to produce the same quantity of aqueous condensation in a hot region, in which the atmosphere is saturated with vapour, a smaller quantity of the atmosphere, of different temperatures, to be mixed for that purpose, will be required; and, conversely, a greater quantity of the atmospheric streams must concur for producing the same quantity of rain in the temperate regions, not equally saturated with vapour; consequently, greater temporary accumulations and local abstractions of the atmosphere, in the one region than in the other. Hence, a greater rise and fall of the barometer, accompanying the changes of the weather, in relation to rain and drought in the temperate than in the tropical region.

Thus, certain natural appearances, which are perfectly inconsistent with the levity of the atmosphere being the immediate cause of rain, find an easy explanation in the present theory, which requires the mixture of several portions of the atmosphere in different temperatures of heat. We may now proceed to consider the natural appearances which generally attend rain in this island, with a view to recommend the theory, in showing that such mixtures actually take place.

1. If the mixing together of different streams of the atmosphere be the cause of rain, calmness, or steady breezes, should be the attendants of fair weather; but this, in general, is the case. The converse of this is also true; for partial showers never happen without wind, although general rains, or such as are produced in the higher regions of the atmosphere, may be attended with a calm, or fall without disturbance, in the place of our observation. Now, the truth of the proposition is manifested

fefted in this, that, by people who reafon from the immediate obfervation alone, wind is attributed to the fhower as an effect, when it may more truly be confidered as ftanding in the relation of a caufe.

2. WHEN, in calm weather, rain begins, it is reafonable to expect that this fhould be followed by wind; and, in like manner, if in windy weather it begins to rain, it may be reafonable to expect that the wind fhould calm, after a certain period, with the rain. Thefe undoubtedly are the general appearances; and thefe appearances are explained upon this principle, that wind is the caufe of rain, and that, in the oppofition of winds, a calm may be produced.

3. DURING a calm and clear fky, fhowers never happen; but, with fqualls of wind, fudden fhowers appear. In calm weather, before it rains, the heaven is all overclouded, and the rain becomes general, equable, and not in fpots: But, when attended with wind, the rain is unfteady; one while, the fpot around us is involved in the thickeft cloud and heavy rain; another while, it is under the cleareft fky; and thefe alternate operations in the atmofphere of thickening and clearing continue during the fqually weather.

4. THESE facts are from my own obfervation; and they neceffarily imply the mixture of hot and cold ftreams of air for the production of rain. But fometimes this operation is a thing vifible in itfelf; for when, by means of the motion of the clouds, the atmofphere is perceived to be moved in oppofite directions, here, it is evident, nothing is required befides the proper conditions, in thofe mixing ftreams, for the condenfation of rain. Now, I have had it from experienced feamen, men of great knowledge and obfervation, that, in our channel, they had often occafion to remark this oppofition in the winds, or the clouds going againft the wind, as being a fure mark of heavy rain to follow.

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5. THE changes in the temperature of our atmosphere attend the alterations of rain and fair weather, no less evidently than those changes happen, in consequence of changes in the streams of wind. If the wind has blown from the southern and warmer regions, replete with humidity, it brings warm weather, and this may continue to be fair; but, when rain succeeds, it is generally found, that a change of wind succeeds the rain, and then the air becomes more cold. In like manner, if a cold north wind prevails, it may continue fair; but, when rain succeeds, there is commonly a change in the wind, and also in the temperature of the atmosphere. And, in general, as many alterations as shall happen in the prevalencies of those different winds, or streams of hot and cold atmosphere, so many repetitions have we of the rain.

UPON the coast of Hudson's bay, while the thermometer is at 90°. with calmness and a sky perfectly serene, it is common for a sudden gust of wind to come from the north-west, with such violence as to threaten oversetting every thing; and along with the blast, there comes a shower of snow or hail. This lasts only a very short space of time; it clears up, grows calm and serene, as before; but the temperature of the air has much changed; from 90°. the thermometer will fall to 50°. for a short space of time, and then it gradually rises to the ordinary heat. This observation, which I have from my friend Mr GRÆME, a gentleman of great accuracy, who lived long in that country, points out clearly the agitation of the atmosphere as being the cause of rain, and not its consequence. It also demonstrates the sudden mixture, in the atmosphere, of air which, for the season, is extremely cold, compared with the general temperature of the atmosphere upon this continent.

BUT, in the application of these general rules to particular cases of observation, it must always be considered, that though intestine commotion, or mixture of the atmosphere, be necessarily required in order to produce rain, it is not every mixture

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or commotion in the atmofphere that will be followed by this effect ; for though mixture of the atmofphere be a neceffary condition in the caufe of rain, it is not the only condition.; and, therefore, the fame appearances, in relation to the winds, and to the different temperatures of the atmofphere, may be obferved, while rain, as the effect, may either follow or not; according as the third condition may or may not take place : That is, that the mixed atmofphere be fufficiently faturated with vapour or humidity ; which is a thing that cannot perhaps be made the fubject of our obfervation.

6. RAIN happens in the hotteft weather, and in every degree of temperature, down to the freezing point ; it requires, therefore, much attention to obferve the changes of temperature in the atmofphere that ufually attend the production of rain, in all this range of the thermometer from 80°. to 32°. But, about the freezing point, the effects of heat and cold are fo manifeft, in the fluidity and congelation of water, that a perfon can hardly avoid making obfervations which will tend to confirm the theory.

WHEN, after fettled froft, it begins to fnow, the cold is always found to relent, and the thermometer to rife to the freezing point, or nearly, however low it may have been before. But after the fnow has fallen, and the fky becomes clear, the cold increafes, until it again refumes its former intenfity, or even proceeds to a greater degree. This is an appearance which is eafily explained in the theory ; and it is an appearance which every perfon, who can make an obfervation, has it frequently in his power to verify.

7. THE climate which we inhabit has, for character, temperance in extreme ; our winters and our fummers differ but little from each other in their mean temperatures. There is, in this ifland, but little fteady determination for the wind, which, in general, is extremely variable. The variable nature of our winds cannot be the effect of the temperance of our climate ;

but

but the temperance of our climate may, in some meafure, be produced in confequence of the variable nature of our winds. So far as this is the cafe, that the mixture of different ftreams of the atmofphere temperates the heat and cold of our air, this operation fhould be attended with proportionate condenfation of aqueous vapour. Here the theory is brought to the teft of obfervation. But, before deciding the point in queftion, let us underftand what it is which, in obfervation, fhould be decifive with refpect to the theory.

It is not the quantity of rain which falls during the year, nor in any portion of it, that affords a principle by which to form a judgment in relation to the prefent queftion; for it is the continuance of rain, and not the quantity, that is the object of enquiry. The number of days and hours, throughout the year, in which it rains, is, no doubt, a proper fubject for our obfervation, in order to form an eftimate with regard to the point in queftion; but it is not itfelf that point in queftion. The point is the condenfation of aqueous vapour in the atmo-fphere; and though no rain can fall without the condenfation of aqueous vapour, there may be much condenfation of that vapour, without rain, as a teftimony of that event. Thus we are led to direct our obfervation to other phænomena befides rain; appearances which may be equally conclufive, in relation to the point to be decided, with rain itfelf. Now, thefe appear-ances, in which the condenfation of aqueous vapour is equally demonftrated with that of rain, are no other than cloudinefs in our atmofphere.

The queftion refpecting the theory being now brought to this iffue, with regard to obfervation, it may be demanded, what is the proportion of ferene fky and cloudinefs in the at-mofphere that properly belongs to this climate? Here is a que-ftion propofed, that requires not extreme exactnefs in its anfwer. I believe every body, from their recollection, will allow, that, for one day or hour of clear funfhine, there are two or three of

     cloudinefs

cloudinefs in the atmofphere; and this is fufficient for deter-
mining the queftion, whether or not the condenfation of aque-
ous vapour be prevalent in the climate of this ifland?

8. CLOUDINESS in the fky being a demonftration of aque-
ous condenfation in the atmofphere, in like manner as is the
cafe with rain, this appearance may now be examined with re-
gard to the temperature of the air, in relation to heat and cold,
that commonly attends on this occafion. Let us begin with
fummer; and fuppofe the weather to be warm; that is, precife-
ly in the natural temperature of the feafon. There is no que-
ftion with regard to the effect of a clear fky, or continued
funfhine: Heat is certainly the effect of funfhine; and this
heat is accumulated in the earth, *cæteris paribus,* in proportion
to the intenfity of the light and the duration of the illumina-
tion. The queftion now to be examined is this, what fhould
be the effect of condenfation of aqueous vapour in the atmo-
fphere at this feafon, and in this fummer temperature; that is
to fay, whether fhould heat or cold be the confequence of this
operation?

NOTHING is fo eafy as the anfwer to this queftion. We fup-
pofe the atmofphere in the mean temperature of the fummer-
feafon, and that a condenfation of aqueous vapour is produced
by the admixture of a current of atmofphere in a different tem-
perature. Now, as this effect may be produced by the admix-
ture of air, either hotter or colder than our atmofphere, which
is fuppofed to be quite ferene, the effect muft be a change of
the temperature of our atmofphere, either to a greater or a lefs
degree of heat than its mean temperature for the feafon, accord-
ing as the fupervening atmofphere, producing cloudinefs in our
fky, fhall be either hotter or colder, in its temperature, than
that in which we had been involved immediately before.

FROM this conclufion, we will now draw a practical obferva-
tion, which may be of fome utility in trying the theory and
explaining appearances. If the heat of the atmofphere be,

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at any time, above its mean temperature for the feafon, and a change fhall happen from a ferene fky to cloudinefs, we have reafon to expect, that the extreme heat will be temperated, and the atmofphere confequently cooled. But, if the temperature of our atmofphere be below its mean heat for the feafon, then, from the change of clearnefs for a cloudy fky, we have reafon to look for a change from cold to hot.

FROM this alfo we have a proper explanation of a general appearance, with regard to the ferenity of the fky, in every climate, and in the oppofite feafons of fummer and winter; for this ferene fky, or clear atmofphere, is perfectly confiftent with the two extremities of temperature; that is, with that of heat, upon the one hand, and of cold, upon the other. It is only a mixture of thofe two extremes, that is to fay, of hot and cold atmofphere, which produces, at the fame time, cloudinefs to the fight, and temperance in relation to the fenfe of heat and cold. Thus will be explained a common obfervation, with regard to the weather of this country, that the air is always cold, below its mean temperature for the feafon, when the fky is clear. The country people allege that it is then froft, even in the midft of fummer. They probably find hoar-froft early in the morning, efpecially in the higher parts of the country; and furely the making of ice in Bengal juftifies that obfervation.

9. THE formation of hail is evidently upon the fame principle as that of fnow. The one is, therefore, equally with the other, explained by the theory. There are, however, peculiarities in the production of hail, which do not take place in that of fnow; but thefe peculiar circumftances are to us, perhaps, unknown; and as there is nothing in the appearance of hail that is, in any refpect, inconfiftent with the theory, the confounding of fnow and hail brings no error into our fcience, nor affects the doctrine with the leaft uncertainty. Hail is evidently formed by the collection of fmaller molecules, which ultimately are of the

nature

nature of fnow ; and it is probably by means of electrical at-
traction, that this collection is performed.

10. THERE is one appearance more, that often attends rain,
and, therefore, fhould be confidered ; this is thunder, which fo
frequently accompanies violent and fudden rain. But, as we
are ignorant of any principle upon which electricity fhould be
the caufe of condenfing aqueous vapour in the atmofphere, this
is not the place for examining what may be the effects of elec-
tricity, with regard to aqueous vapour condenfed from its ela-
ftic ftate, farther than that it is moft reafonable, and alfo con-
fiftent with appearances, to fuppofe a more fudden attraction of
the condenfed particles of water, than what happens upon other
occafions, where even a degree of electrical repulfion may pre-
ferve them from immediate contact, and protract the fall of
rain, by fufpending the condenfed vapour in form of mift.

III.

III. On the CAUSES which affect the ACCURACY of BAROMETRICAL MEASUREMENTS. By JOHN PLAYFAIR, A. M. F. R. S. EDIN. and Professor of Mathematics in the University of EDINBURGH.

[Read by the Author, March 1. 1784. and Jan. 10. 1785.]

THOUGH the labours of M. DE LUC, and of the excellent observers who followed him, have brought the barometrical measurement of heights to very great exactness, they have not yet given to it the utmost perfection it can attain. Some causes of inaccuracy are still involved in it; of which we ought, at least, to estimate the effects, if we cannot correct them altogether. The allowance made on account of the temperature of the air, implies in it a hypothesis that has not been examined, nor even expressed; and many other circumstances that affect the density of the atmosphere, have either been wholly omitted, or improperly introduced. The object of the present paper is to correct the errors that arise from these causes, or, where that cannot be done, to assign the limits within which those errors are contained.

1. THE most important correction introduced by M. DE LUC, is that which depends on the temperature of the air. His observations led him to conclude, that, at a certain temperature, marked nearly by $69°\frac{1}{4}$ of FAHRENHEIT, the difference of the logarithms of the heights of the mercury in the barometer, at the upper and the lower stations, gave the height of the former of those stations above the latter in 1000ths of a French toise; but that at every other temperature above or below $69°\frac{1}{4}$, a correction of .00223 of the whole was to be added or

subtracted

subtracted for every degree of the thermometer. By observations still more accurate, it has been found, that the temperature at which the difference of the logarithms gives the height in English fathoms, is 32°; and that the correction at other temperatures is .00243 of that difference, for every degree of the thermometer *. The manner of estimating the temperature of the air, adopted in all these observations, was the same; an arithmetical mean was taken between the heights of the thermometers, at the upper and lower stations, and was supposed to be uniformly diffused through the column of air intercepted between them. M. DE LUC, however, was sensible that this supposition was inaccurate; and General ROY, too, has observed, that " one of the chief causes of error in barome-
" trical computations proceeds from the mode of estimating
" the temperature of the column of air from that of its extre-
" mities, which must be faulty in proportion as the height and
" difference of temperature are great †." It will appear, however, that this estimation, though adopted merely on account of its simplicity, and probably on no other principle than the general one of taking a mean between two observations, which, taken singly, are inaccurate, comes nearer to the truth than there was any reason to expect.

2. IT is certain, that the atmosphere does not derive its heat from the immediate action of the solar rays. These rays, in traversing that subtle and transparent medium, are but slightly refracted, and, meeting with little obstruction, neither lose nor communicate much of their influence. We are assured of this by many experiments; and we know, that air, in the focus of a burning glass, is never heated till some solid body be introduced.

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* General ROY makes the fixed temperature 32°, = .00245, at a medium. Sir G. SHUCKBURGH makes the fixed temperature 31°¼, and the expansion, as here assigned, *viz.* .00243. *Phil. Transf.* 1777. It is sufficient for us at present to know these numbers nearly. According to the formula laid down hereafter, they will all require to be corrected.

† *Phil. Transf.* 1777.

troduced. The atmofphere, therefore, is warmed by the earth, from the furface of which a quantity of heat is continually flowing off, and afcending through the different ftrata of the air into the regions of vacuity, or of æther. But this afcent, on the whole, is uniform ; becaufe there is a certain temperature which, though varied by periodical viciffitudes, remains under every parallel the fame, as to its mean quantity. Every ftratum, therefore, of the atmofphere, whatever be its height, gives out, at a medium, the fame quantity of heat that it receives ; in other words, its mean temperature is conftant, and neither increafes nor decreafes, on the whole.

3. Let there be three ftrata, then, of the atmofphere of the fame thicknefs $\dot{x}$, and contiguous to one another ; fo that, if x be the diftance of the firft from the furface of the earth, that of the fecond may be $x + \dot{x}$, and of the third $x + 2\dot{x}$. Let b, b', b'', be the heats of the ftrata, and Δ, Δ', Δ'', their denfities refpectively : Then, fince the quantity of heat, communicated in an inftant from one ftratum of a fluid to a contiguous ftratum, muft be, as the difference of their temperatures, multiplied into the denfity of the colder, and divided by the denfity of the warmer, the heat communicated, in an inftant, from the firft ftratum to the fecond, $= (b - b')\frac{\Delta'}{\Delta}$; and that communicated by the fecond to the third, $= (b' - b'')\frac{\Delta''}{\Delta'}$. But, fince the difference of Δ and Δ'' is indefinitely fmall, as alfo that of Δ' and Δ'', we have $\frac{\Delta'}{\Delta} = 1$, and $\frac{\Delta''}{\Delta'} = 1$; fo that the heat gained by the middle ftratum is $= b - b'$, and that loft by it $= b' - b''$. Now, thefe two quantities muft be equal, in order that the temperature of the ftratum may remain uniform, that is, $b - b' = b' - b''$; or, in other words, the heat of the firft ftratum exceeds the heat of the fecond, as much as the heat of the fecond exceeds the heat of the third. Therefore, the heat of the fucceffive ftrata muft decreafe, by equal differences, as we afcend through equal

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fpaces,

spaces, into the atmosphere ; and, in general, the differences of temperature must be proportional to the differences of elevation.

It is to be understood, however, that this law is subject to certain anomalies, both annual and diurnal, and those intermixed with other accidental irregularities, which it would be difficult, perhaps impossible, to ascertain. All that can be said of it is, that it is the law which nature tends to observe, and that the sum of the deviations from it, on the one side, is probably equal to the sum of those on the other. In an effect that is perpetually subject to the action of accidental and unknown causes, the discovery of a mean, from which the departures on the opposite sides are equal, is all that we can reasonably expect ; and it is sufficient for us to know, that, though any particular conclusion may involve an error, yet, if a multitude of instances be taken, the errors will certainly correct one another.

4. If, therefore, H be the heat at the surface of the earth, and h the heat at any given height a, above the surface, the heat, at any other height, as x, will be $H - \dfrac{(H-h)x}{a}$. At a medium, it is found, that FAHRENHEIT's thermometer falls a degree for every 300 feet that we ascend into the atmosphere ; so that, if x is expressed in fathoms, the heat, at that height, is $= H - \dfrac{x}{50}$.

5. But though we are thus led to conclude, that the decrease of heat in the superior strata of the atmosphere is proportional to their elevation, there is no reason to suppose, that the condensation produced by that decrease is also uniform. Indeed, the experiments of General Roy have placed it beyond all doubt, that the variations in bulk of a given quantity of air are, by no means, proportional to its variations of temperature. Those experiments, though very numerous, are too few to ascertain

exactly

exactly the law which connects these variations, and we must have recourse to reasoning, in order to supply this defect. Let us suppose that air of a given temperature, for instance, of 32°, by the loss of one degree of heat, is contracted $\frac{1}{411}$ or the part m of its whole bulk; its bulk, therefore, when of the temperature 31°, will be $1-m$. By the loss of another degree of heat, its temperature will be reduced to 30°, and its contraction will not be m, as before, but $m(1-m)$, which, subtracted from $1-m$, its bulk, when of the temperature 31°, will give its bulk when of the temperature 30°, $=1-2m+m^2=(1-m)^2$. In like manner, after the loss of 3° of heat, the bulk of the same given quantity of air is shewn to be $(1-m)^3$; and, in general, its bulk is as that power of $1-m$, which is denoted by the difference between 32° and the given temperature. If, therefore, b be the heat of a given quantity of air, $(1-m)^{32-b}$ will be the space occupied by that air, supposing always that the compressing force is given.

6. This formula assigns a finite magnitude to the air as long as the diminution of its heat is less than infinite; for as $1-m$ is less than unity, when b becomes negative and infinite, $(1-m)^{32-b}$ becomes then, and not till then, $=0$. When b is affirmative, and greater than 32, $(1-m)^{32-b}$ becomes greater than 1, and increases continually, being infinite when b is infinite. When $32-b$ is not very great, then $(1-m)^{32-b}=1+(b-32)m$ nearly, which agrees with the hypothesis of uniform contraction and dilatation in moderate temperatures.

This formula also represents, with tolerable exactness, the experiments which General Roy made with the manometer, ex-

cepting

cepting in one circumftance ; for the formula makes the expan-
fion increafe with the heat continually, though not uniform-
ly ; whereas the experiments give the greateft expanfion be-
tween the temperatures of 60° and 70°. But this feems to
be fo anomalous a fact, that it looks more like fome accidental
effect, produced from the particular manner of making the
experiments, than a part of that law of nature, which connects
the variations of bulk in bodies with their variations of tem-
perature.

7. BUT this is not the only irregularity to which the ex-
panfion of air by heat, and its contraction by cold, appear to
be fubject. We learn from the manometrical experiments of
the fame excellent obferver, that a given variation of tempera-
ture is accompanied with more or lefs variation of bulk, accord-
ing as the air is compreffed by a greater or a lefs force. Air,
for inftance, compreffed by the weight of an entire atmofphere,
was expanded by the 180 degrees from freezing to boiling, no
lefs than 484 of thofe parts, whereof, at the temperature 32°,
it occupied 1000. But the fame air, when compreffed only by
$\frac{1}{5}$ of an atmofphere, was, by the fame difference of heat, ex-
panded no more than 141 parts ; and that though the heat of
boiling water was applied to it for an hour together. It is not
eafy either to affign the caufe, or to determine the law of this
inequality. General ROY has, indeed, conftructed a table of the
correction to be made on account of it ; which proceeds on
the fuppofition, that the expanfion, for one degree of heat, de-
creafes in the fame proportion that the column of mercury in
the barometer exceeds a given length. This given length is
nearly $= 4.5$ inches ; fo that if b be the length of the column of
mercury in the barometer, and .00252 the expanfion for one de-
gree of heat, when the barometer is at 30 inches, and the tem-
perature of the air 32°, then $\frac{b-4.5}{25.5} \times .00252$, will be the expanfion
of air of the fame temperature, for the fame change of heat,
<div align="right">when</div>

when the mercury in the barometer ftands at the height *b*. But this formula cannot be juft, otherwife air, compreffed by no greater a force than that of 4.5 inches of mercury, would be incapable of dilatation by heat, or contraction by cold.

8. It will agree equally well with the experiments, and will involve no contradiction, even in the extreme cafes, to fuppofe, that the expanfion for a certain degree of heat is as a certain power of the compreffing force. If this power be called μ, *m* being the expanfion for 1 degree of heat, when the mercury in the barometer is of the height *b*, the expanfion for any other height of the mercury, as β, will be $\dfrac{\beta^\mu}{b^\mu}m$; and combining this with the former formula for expanfion (§ 5.), we have the fpace which air occupies, as far as it depends on temperature,

$$= (1 - \frac{m\beta^\mu}{b^\mu})^{\frac{32-h}{}}$$. From a comparifon of General Roy's expe-

riments *, μ appears to be between $\frac{1}{2}$ and $\frac{1}{3}$; and it muft be confeffed, that it is very difficult to affign its value within nearer limits. The form of the correction, however, if not its abfolute quantity, may be found from what is here determined. The laft of thefe muft be afcertained by future experiments.

9. These inequalities belong to the temperature of the air ; there is another that depends wholly on the compreffion. In deducing the rule for the meafurement of heights by the barometer, it has hitherto been fuppofed, agreeably to the experiments of Mr Boyle and M. Mariotte, that the denfity of the air, while its temperature remains the fame, is exactly as the force that compreffes it. But the experiments referred to were not accurate enough to eftablifh this law with abfolute precifion ; and they left room to fufpect a deviation from it, either when the compreffing force is very great or very fmall. Accordingly, from experiments defcribed in the 9th vol. of the Mem. of Berlin, it appears that the elafticity of air of the tempera-
ture.

* Tab. 2. and 3. p. 701. 703. Tranf. 1777. part 2.

ture $55°$, or the compreſſing force, increaſes more ſlowly than the denſity ; ſo that, if the compreſſing force be doubled, the denſity will exceed the double by about a tenth part, &c. The law of this variation is expreſſed with tolerable exactneſs, by ſuppoſing, that if D be the denſity of the air, and F the force compreſſing it, then $D = F^{1+n}$, n being a very ſmall fraction, nearly $.0015$.

10. I⊤ muſt be acknowledged, that new experiments are neceſſary to aſcertain the law of this inequality with preciſion. But as the formula $D = F^{1+n}$ is very general, and might be rendered ſtill more ſo, without affecting the method of integration that is to be employed, the reſult of that integration may be uſeful when our phyſical knowledge becomes more accurate. In the mean time, it may not be improper to remark, that the preciſe knowledge of the law which connects the compreſſing force with the denſity of elaſtic fluids, is an object well deſerving the attention of natural philoſophers. The determination of that law may go far to decide the queſtion, whether the particles of ſuch fluids are in contact or not ; that is, whether the elaſticity of each particle be a force that extends beyond the neareſt particles, like the forces of magnetiſm and gravitation ; or one which, like that of a ſpring, extends only to the bodies which are next it. It is an enquiry, therefore, of no leſs importance in general phyſics than in that particular ſubject which we have here undertaken to examine.

11. THERE is one other correction to be applied to the height of a mountain, as it is uſually found from obſervations of the barometer. This ariſes from the diminution of gravity, whether we aſcend or deſcend from the ſurface of the earth. The effect of that diminution is to produce a twofold error ; becauſe, on the ſuppoſition of uniform gravity, the weight of each particle of air is computed too great, and the weight of the column of mercury in the barometer, that is not on the ſurface, is

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alfo reckoned too great. The effect of both thefe errors is of the fame kind, tending to make the height lefs than it is in reality; yet it is only the firft of them, and that too the leaft confiderable, which has hitherto been taken into account.

12. IT were to be wifhed, that, to the caufes here enumerated, and that are to be introduced into the computation, we could add the operation of moifture, in altering the weight and elafticity of the air. But the law of that operation has not yet been difcovered; and it will be fufficient to point out, in the conclufion of this paper, a method by which it may be determined from obfervations of the barometer itfelf.

BEFORE proceeding to the inveftigation of the effect which all thefe inequalities together muft produce, it is proper to remark, that the two inequalities in the expanfion of air, taken notice of (§ 5. and 7.), after having been difcovered by General ROY, were applied by him to correct the height of mountains, meafured by the barometer; but that it is, by no means, certain, that he has given to thofe corrections the precife form which they ought to have. This, indeed, cannot be known, unlefs the effect of each inequality, on a fingle ftratum, be firft introduced into the differential equation between the denfity of the air and the height above the furface, and the amount of its effect on a whole column of air be deduced from thence by integration.

13. LET y, then, be the denfity of the air, at any height x above the furface of the earth, the heat at the furface being $= H$, expreffed in degrees of FAHRENHEIT's thermometer. If alfo λ be fuch a number, that λx gives the degrees by which the thermometer ftands lower at the height x than at the furface (§ 4.), the temperature at the height x will be $= H - \lambda x$; and, if the expanfion of a given quantity of air, which occupies the fpace 1, and is of the temperature 32°, for 1° of heat, be called m, then, abftracting at prefent from that inequality of

<div align="right">expanfion</div>

expanfion which depends on preffure, we have the fpace occu-
pied by that fame quantity of air, when it is of the temperature
$H-\lambda x$, equal to $(1-m)^{32-H+\lambda x}$: Or, making $32-H=\tau$, we have
the required fpace $= (1-m)^{\tau+\lambda x}$.

Now, if the given quantity of air, of which the bulk has
been fuppofed $= 1$, and the temperature $= 32°$, be compreffed
by a column of air of the fame denfity and temperature with
itfelf, but of the height p, and if its denfity, in this cafe, be
alfo called 1 ; then, in the cafe of its having any other tempe-
rature, as $H-\lambda x$, and being compreffed by any other force, as
$-\int y\dot{x}$, or the weight of the fuperincumbent air at the height x,
we have $1 \;\; : \;\; y \;\; : : \;\; p \;\; : \;\; \dfrac{-\int y\dot{x}}{(1-m)^{\tau+\lambda x}}$, and likewife

$$y = \frac{-\int y\dot{x}}{p(1-m)^{\tau+\lambda x}}.$$

No account is here taken of the diminution of gravity, any
more than of the departure of the law of the elafticity of air
from direct proportionality to the denfity (§ 8.), becaufe it is
convenient to confider the problem at firft under the more fim-
ple view, where only the two firft inequalities are intro-
duced.

13. Since $y = \dfrac{-\int y\dot{x}}{p(1-m)^{\tau+\lambda x}}$, we have

$$py(1-m)^{\tau+\lambda x} = -\int y\dot{x}, \;\; \text{and}$$

$$p\dot{y}(1-m)^{\tau+\lambda x} + p\lambda y(log.\;1-m)(1-m)^{\tau+\lambda x}\;\dot{x} = -y\dot{x},$$

Or, $\;\; \dfrac{p\dot{y}}{y} + p\lambda \, log.\,(1-m)\dot{x} = -\dfrac{\dot{x}}{(1-m)^{\tau+\lambda x}}.$

<div align="right">Hence</div>

Hence, making $log.(1-m) = g$,

$$\frac{p\dot{y}}{y} = -p\lambda g\dot{x} - \frac{\dot{x}}{(1-m)^{\tau+\lambda x}}, \text{ and}$$

$$p\,log.\,y + p\,log.\,C = -p\lambda gx + \frac{1}{\lambda g(1-m)^{\tau+\lambda x}}.$$

If D denote the denfity of the air at the furface of the earth, D will be the value of y, when $x = 0$, and fo

$$p\,(log.\,D + log.\,C) = \frac{1}{\lambda g(1-m)^{\tau}}. \quad \text{Therefore}$$

$$p\,log.\,C = \frac{1}{\lambda g(1-m)^{\tau}} - p\,log.\,D; \text{ and fo by fubftituting for}$$

$p\,log.\,C$, $p\,(log.\,y - log.\,D) + \dfrac{1}{\lambda g(1-m)^{\tau}} = -p\lambda gx + \dfrac{1}{\lambda g(1-m)^{\tau+\lambda x}};$

or changing the figns,

$$p\,(log.\,D - log.\,y) - \frac{1}{\lambda g(1-m)^{\tau}} = p\lambda gx - \frac{1}{\lambda g(1-m)^{\tau+\lambda x}}.$$

This equation exhibits, in general, the relation between the denfity of any ftratum of air, and the height of that ftratum above the furface of the earth, on the fuppofitions that the heat of the atmofphere decreafes uniformly as we afcend, and that the contraction produced in air by cold, obferves the law defcribed in § 5. It might be confidered as an equation to a curve, of which the abfciffæ reprefented the height of the different ftrata of the atmofphere, and the ordinates, the denfities of thofe ftrata: This curve would evidently be different from the logarithmic, but would be found to have certain relations to it not uninterefting, and not difficult to trace, if we had leifure for fuch a digreffion.

N   14. Let

14. LET us now suppose that z is the whole height to be measured, and that Δ is the density at that height, the temperature there being also found $= b$, by observation. If then x become $= z$, and $y = \Delta$, we will also have $\lambda z = H - b$, and $\tau + \lambda z = 32 - H + H - b = 32 - b = r - b$, making $r = 32$. Also $\lambda = \dfrac{H - b}{z}$. Therefore, by substituting these values of y, x, λ, and $\tau + \lambda z$, in the preceding equation, we have,

$$p\,(log.\,D - log.\,\Delta) - \cfrac{z}{g\,(H - b)\,(1 - m)} =$$

$$pg\,(H - b) - \cfrac{z}{g\,(H - b)\,(1 - m)^{r-b}}.$$

Hence, by transposition, &c.

$$gp\,(H - b)\,(log.\,D - log.\,\Delta - (H - b)\,g) = z\left((1 - m)^{H-r} - (1 - m)^{b-r}\right);$$

$$\text{and } x = \frac{gp\,(H - b)\,(log.\,D - log.\,\Delta - (H - b)g)}{(1 - m)^{H-r} - (1 - m)^{b-r}}.$$

THUS the height of any column of air is expressed in terms of the density, and of the temperature at the top and bottom of it; the equation for the height, though an exponential one in its general form, admitting of an easy resolution, from the circumstance of λz being given by the observations of the thermometer.

15. THAT this formula may be applied to the measurement of heights, it is necessary to introduce into it the lengths of the columns of mercury in the barometer, instead of the densities of the air, at the lower and upper stations. Let b be the height at which the mercury stands in the lower barometer, and β that at which it stands in the higher barometer; then, since b is the compressing force at the surface of the earth, we have

$$D =$$

$D = \dfrac{b}{(1-m)^{r-H}}$; and, for a like reafon, $\Delta = \dfrac{\beta}{(1-m)^{r-b}}$. There-

fore, $log.D = log.b - (r-H)g$, and $-log.\Delta = -log.\beta + (r-b)g$. Hence $log.D - log.\Delta = log.b - log.\beta + (H-b)g$, and fubftituting for $log.D - log.\Delta$ in the formula of the laft fection,

$$z = \frac{gp(H-b)(log.b - log.\beta)}{(1-m)^{H-r} - (1-m)^{b-r}}.$$

16. This is the exact value of z, or of the whole height to be meafured, on the fuppofition that the heat of the atmofphere decreafes uniformly as the height increafes ; and that the contraction for a given difference of heat decreafes according to the law defcribed in § 5. But, in order that it may be more convenient for computation, and may be more eafily compared with the formula now in ufe, the quantity $\dfrac{1}{(1-m)^{H-r} - (1-m)^{b-r}}$

muft be reduced into a feries. Now $\dfrac{1}{(1-m)^{H-r} - (1-m)^{b-r}} =$

$\dfrac{(1-m)^{r}}{(1-m)^{H} - (1-m)^{b}}$. But from the nature of logarithms, (g being, as before, the logarithm of $1-m$)

$$(1-m)^{H} = 1 + Hg + \frac{H^2 g^2}{2} + \frac{H^3 g^3}{6} + \&c. \quad \text{And}$$

$$-(1-m)^{b} = -1 - bg - \frac{b^2 g^2}{2} - \frac{b^3 g^3}{6} - \&c. \quad \text{Therefore}$$

$$\frac{(1-m)^{r}}{(1-m)^{H} - (1-m)^{b}} = \frac{1 + rg + \frac{r^2}{2}g^2 + \frac{r^3}{6}g^3 + \&c.}{(H-b)g + \frac{H^2 - b^2}{2}g^2 + \frac{H^3 - b^3}{6}g^3 + \&c.} ;$$

and

and $\dfrac{g(H-b)(1-m)^r}{H}$ $\dfrac{}{(1-m)-(1-m)^b}$ $=$ $\dfrac{1+rg+\dfrac{r^2}{2}g^2+\dfrac{r^3}{6}g^3+\&c.}{1+\dfrac{H+b}{2}g+\dfrac{H^2+Hb+b^2}{6}g^2+\&c.}$.

Hence $z = p(log.b-log.\beta)\left(\dfrac{1+rg+\dfrac{r^2}{2}g^2+\dfrac{r^3}{6}g^3+\&c.}{1+\dfrac{H+b}{2}g+\dfrac{H^2+Hb+b^2}{6}g^2+\&c.}\right)$.

17. THESE feries will not converge faft, unlefs rg, Hg, and hg, be all of them quantities much lefs than unity. Now, as m, or the expanfion of air of the temperature r, for 1° of heat, is, in fact, very fmall, being nearly $= .00245$, and as g, or the loga-rithm of $1-m$, muft, of confequence, be nearly $= -m = -.00245$, it is plain, that, in all moderate temperatures, thefe feries will converge with great rapidity; though, in extreme cafes, where z is fuppofed vaftly great, and where b may be ne-gative, and alfo great, the feries in the denominator may con-verge fo flowly that recourfe muft be had to the formula in § 15. from which no quantities are rejected.

WHEN m, and, of confequence, g, are very fmall, and when H and b do not differ much from r, the preceding formula, agreeably to a remark in § 6. will comprehend the cafe of uni-form expanfion, and will give the fame expreffion for the height, that would be derived from confidering only the equable de-creafe of heat as we afcend in the atmofphere. Now, as in the cafe fuppofed, we may reject all the powers of g but the firft, and may alfo fuppofe $g = -m$, we have

$$z = p(log.b-log.\beta)\left(\dfrac{1-rm}{1-\dfrac{H+b}{2}m}\right), \text{ or}$$

$$z = p(1+\left(\dfrac{H+b}{2}-r\right)m)(log.b-log.\beta).$$

18. THIS

18. THIS last is precisely the formula of M. DE LUC, if we give to p, r, and m, the proper values *. It was discovered by that ingenious and indefatigable observer, without any enquiry into the propagation of heat through the atmosphere, the principle on which it depends; and, that so near an approximation to the truth should have been thus obtained, is to be considered as a singular instance of sagacity or of good fortune. For if the heat of the air diminished, not in the simple ratio of the increase of the height, but in that of any power of it, so as to be expressed by $H-\lambda x^n$, then, by computing as has been done above, we should find $z = p(1+m(\frac{nH+b}{n+1}-r)) log. \frac{b}{\beta}$. Here the temperature from which r, or the fixt temperature, is to be subtracted, is not $\frac{H+b}{2}$, but $\frac{nH+b}{n+1}$; and this is a formula which conjecture or experiment alone would scarcely have discovered.

IT is farther to be remarked of the formula $z = p(1+m(\frac{H+b}{2}-r)) log. \frac{b}{\beta}$, that it is rigorously just, if we suppose the temperature $\frac{H+b}{2}$ to be uniformly diffused through the column of air, of which the height is to be measured, as is done by Dr HORSLEY in his theory of M. DE LUC's rules †; but that, on a supposition, more conformable to nature, of the heat diminishing in the same proportion as the height increases, it is only an approximation to the truth, or the first term of a series, whereof the other terms are rejected as inconsiderable.

19. THE

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* If we take M. DE LUC's rule, as improved by the later observations of General ROY and Sir GEORGE SHUCKBURGH, $p = 4342.9448 =$ the modulus of the tabular logarithms multiplied by 10000 : $r = 32°$ and $m = .00245$ nearly. It is unnecessary to remark, that the logarithms understood in all these formulas are hyperbolic logarithms, and that the multiplication of them by p is saved, by using the tabular logarithms, and making the first four places of them, excluding the index, integers.

† Phil. Transf. vol. 64. part 1.

19. THE amount of the terms which are thus rejected comes now to be considered; and it will be ascertained with sufficient accuracy, if we compute the second term of the series, or that which involves in it m^2.   Now;

$$\frac{1+rg+\dfrac{r^2}{2}g^2+\&c.}{1+\dfrac{H+b}{2}g+\dfrac{H^2+Hb+b^2}{6}g^2+\&c.}=$$

$$1+\left(r-\frac{H+b}{2}\right)g+\left(\frac{r^2-r(H+b)}{2}+\frac{H^2+4Hb+b^2}{12}\right)g^2;$$

and $g = log.(1-m) = -m+\dfrac{m^2}{2}-\&c.$

so that $g^2 =$ $m^2-\&c.$

Therefore, by substitution, $\dfrac{1+rg+\dfrac{r^2}{2}g^2}{1+\dfrac{H+b}{2}g+\dfrac{H^2+Hb+b^2}{6}g^2}=$

$$1+\left(\frac{H+b}{2}-r\right)m+\left(\frac{r}{2}-\frac{H+b}{4}+\frac{r^2-r(H+b)}{2}+\frac{H^2+4Hb+b^2}{12}\right)m^2.$$

THIS is the coefficient of $p\,log.\dfrac{b}{\beta}$, which gives z, corrected both for the temperature of the air and the first inequality of expansion, (§ 5). The term $\left(\dfrac{H+b}{2}-r\right)m$, is M. DE LUC's correction, as has been already observed, the third term, *viz.* $\left(\dfrac{r}{2}-\dfrac{H+b}{4}+\dfrac{r^2-r(H+b)}{2}+\dfrac{H^2+4Hb+b^2}{12}\right)m^2$, contains not only a part which depends on the equable decrease of heat as we ascend in the atmosphere, but also one which arises from the above mentioned inequality of expansion.

20. THE

20. THE term involving m^2, that has now been computed, will rarely amount to any thing confiderable. The coefficient of it vanifhes when both H and b are equal to r, but increafes as thefe two quantities recede from r on either fide. In no inftance where the barometer is to be applied to actual meafurement, will the correction probably be found greater than in determining the height of Coraçon above the level of the South Sea, where H, or the height of the thermometer at that level, was $84°\frac{1}{2}$, and b, or the height of the thermometer at the top of the mountain, $43°\frac{1}{2}$; the coefficient of m^2 comes out, in this cafe $+426$, and m^2 being $= .000006 = (.00245)^2$, the correction $= .00259$, or nearly $\frac{1}{400}$ of the height of the mountain, as found before any correction was applied, or $= 40$ feet nearly. It is to be remarked, too, that, for every value of H, or of the temperature at the lower ftation, there are two values of b, or the temperature at the upper ftation, that make the coefficient, $\frac{r}{2} - \frac{H+b}{4} + \frac{r(r-H-b)}{2} + \frac{H^2+4Hb+b^2}{12}$, and, of confequence, the correction depending on it equal to nothing. This is evident from the nature of the coefficient; but, as the law by which this laft increafes and decreafes is, by no means, fimple, it were convenient to have it reduced into a table, for the different values that might be affigned to H and b, from which it would be immediately obvious in what cafes it was to be taken into account, and when it might fafely be omitted.

BUT though this correction may fometimes be of confequence enough to be included in the meafurement of heights, it is certain that it may be fafely neglected in the computation of the other corrections. For the error thereby committed in the eftimation of a new correction, will be nearly the fame part of the former correction, that the new one is of the whole height. If, for inftance, the new correction be $\frac{1}{100}$ of the

whole

whole height, the error committed in eftimating it will be but $\frac{1}{100}$ of the former correction; and, if that did not exceed $\frac{1}{400}$, the error in queftion will not exceed $\frac{1}{40000}$ of the whole height.

21. In computing the effect of the fecond inequality of expanfion, defcribed § 8. we may, therefore, abftract from the laft inequality, and may even fuppofe, with M. De Luc, that the temperature, which is a mean between thofe of the extremities of a column of air, is uniformly diffufed through that column. Let the excefs of that mean, above the temperature r, or $\frac{H+b}{2} - r = f$; and let β, the height of the mercury in the uppermoft barometer, be confidered as variable. Then taking the formula of § 8. and fuppofing m to be the expanfion for 1° of heat, when the mercury in the barometer is of a given height, which we fhall here call γ *, (to avoid the confufion that would arife from naming it, as in the art. above referred to) and retaining all the other denominations as before, we have

$$y = \frac{-\int y \dot{x}}{p\left(1 + \frac{fm}{\gamma^{\mu}}\beta^{\mu}\right)}.$$

Hence $py\left(1 + \frac{fm\beta^{\mu}}{\gamma^{\mu}}\right) = -\int y\dot{x}$, fo that, taking the fluxions,

$$p\dot{y}$$

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* According to the experiments of General Roy, above quoted, the expanfion of air, for 1° of heat, at the temperature 32°, is .00245 nearly, that air being compreffed at the fame time by the weight of a column of mercury 29.5 inches high. As we have fuppofed m, in the preceding computations, to be .00245, we muft fuppofe $\gamma = 29.5$. The formula fuppofed here to give the fpace occupied by the air, fo far as heat is concerned, *viz.* $1 + \frac{fm}{\gamma^{\mu}}\beta^{\mu}$, is changed from the exponential expreffion of § 8. in confequence of what has been juft obferved about the effect of neglecting one inequality in the computation of another.

$$p\dot{y}+\frac{pfm\beta^{\mu}\dot{y}}{\gamma^{\mu}}+\frac{pfm\mu y\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}=-y\dot{x}, \text{ and, dividing by } y,$$

$$\dot{x}=-\frac{p\dot{y}}{y}-\frac{fmp\beta^{\mu}\dot{y}}{\gamma^{\mu}y}-\frac{\mu fmp\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}.$$

To exterminate from this equation y and $\dot{y}$, it is to be re-marked, that $y=\dfrac{\beta}{p\left(1+\dfrac{fm}{\gamma^{\mu}}\beta^{\mu}\right)}$, and that therefore

$$\frac{\dot{y}}{y}=\frac{\dot{\beta}}{\beta}-\frac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}+fm\beta^{\mu}}. \quad \text{Hence, by fubftitution, } \dot{x}=$$

$$p\left(-\frac{\dot{\beta}}{\beta}+\frac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}+fm\beta^{\mu}}-\frac{(1+\mu)fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}+\frac{\mu^{2}f^{2}m^{2}\beta^{2\mu-1}\dot{\beta}}{\gamma^{\mu}\left(\gamma^{\mu}+fm\beta^{\mu}\right)}\right).$$

But $\dfrac{\mu^{2}f^{2}m^{2}\beta^{2\mu-1}\dot{\beta}}{\gamma^{\mu}\left(\gamma^{\mu}+fm\beta^{\mu}\right)}=\dfrac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}-\dfrac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}+fm\beta^{\mu}};$

therefore $\dot{x}=p\left(-\dfrac{\dot{\beta}}{\beta}-\dfrac{fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}\right)$, the other terms deftroying

one another. By integration, then, $x=p\left(-log.\beta-\dfrac{fm\beta^{\mu}}{\mu\gamma^{\mu}}+C\right).$

If C be taken fuch that x may vanifh when $\beta=b$, the height of the mercury in the lower barometer, we will have

$$x=p\left(log.\frac{b}{\beta}+\frac{fm(b^{\mu}-\beta^{\mu})}{\mu\gamma^{\mu}}\right).$$

O

22: THAT

22. THAT it may appear wherein this formula differs from the ordinary one, instead of b^μ and β^μ, we muſt introduce *log. b*, and *log. β*, which, when b and β are not very unequal, may be done without difficulty.   For we have

$$\frac{b^\mu}{\gamma^\mu} = 1 + \mu \, log. \frac{b}{\gamma} + \frac{\mu^2}{2} \left(log. \frac{b}{\gamma} \right)^2 + \frac{\mu^3}{6} \left(log. \frac{b}{\gamma} \right)^3 + \&c. \; ; \; \text{alſo}$$

$$\frac{\beta^\mu}{\gamma^\mu} = 1 + \mu \, log. \frac{\beta}{\gamma} + \frac{\mu^2}{2} \left(log. \frac{\beta}{\gamma} \right)^2 + \frac{\mu^3}{6} \left(log. \frac{\beta}{\gamma} \right)^3 + \&c. \quad \text{Therefore}$$

$$\frac{b^\mu - \beta^\mu}{\gamma^\mu} = \mu \left(log. \frac{b}{\gamma} - log. \frac{\beta}{\gamma} \right) + \frac{\mu^2}{2} \left(\left(log. \frac{b}{\gamma} \right)^2 - \left(log. \frac{\beta}{\gamma} \right)^2 \right) + \&c.$$

That is, $\dfrac{b^\mu - \beta^\mu}{\gamma^\mu} = \mu \, log. \dfrac{b}{\beta} + \dfrac{\mu^2}{2} log. \dfrac{b\beta}{\gamma^2} \times log. \dfrac{b}{\beta}$, rejecting all the

terms which involve powers, of $log. \dfrac{b}{\gamma}$, of $log. \dfrac{\beta}{\gamma}$, and of μ, higher than the ſquare.   Hence alſo,

$$\frac{fm \left(b^\mu - \beta^\mu \right)}{\mu \gamma^\mu} = fm \, log. \frac{b}{\beta} + \frac{\mu fm}{2} log. \frac{b\beta}{\gamma^2} \times log. \frac{b}{\beta} \, , \; \text{and}$$

$$x = p \left(log. \frac{b}{\beta} + \frac{fm \left(b^\mu - \beta^\mu \right)}{\mu \gamma^\mu} \right) =$$

$$p \left(log. \frac{b}{\beta} + fm \, log. \frac{b}{\beta} + \frac{\mu fm}{2} log. \frac{b\beta}{\gamma^2} \times log. \frac{b}{\beta} \right) ; \; \text{or} \; x =$$

$$p \, log. \frac{b}{\beta} \left(1 + fm + \frac{\mu fm}{2} log. \frac{b\beta}{\gamma^2} \right) .$$

23. THIS

23. This formula includes the correction to be made for that inequality of the expanſion of air by heat which depends on its compreſſion, and which was deſcribed at the 7th and 8th articles. The firſt term of the formula, *viz.* $p \, log. \frac{b}{\beta}$, is the difference of the tabular logarithms of b and β. The ſecond, *viz.* $fmp \, log. \frac{b}{\beta}$, is M. DE LUC's correction, and the ſame that was already inveſtigated, § 17. The third, *viz.* $\frac{\mu fm}{2} log. \frac{b\beta}{\gamma^2} \times p \, log. \frac{b}{\beta}$ is the correction for the above mentioned inequality of·expanſion. It is of a form very convenient for computation; for the former correction being $=$ $fmp \, log. \frac{b}{\beta}$, we need only multiply it by $\frac{\mu}{2} log. \frac{b\beta}{\gamma^2}$ to have the third term of the formula, or the correction required. It muſt be remembered, that $log. \frac{b\beta}{\gamma^2}$ ſignifies the hyperbolic logarithm of $\frac{b\beta}{\gamma^2}$.

THE exact amount of this correction cannot be known, till μ be defined by experiments on the expanſibility of air under different degrees of compreſſion; thoſe which General ROY has made, though excellent, not being perfectly ſufficient for that purpoſe. If we ſuppoſe $\mu = \frac{1}{2}$, and if, as an example, we take $b = 29$ inches, and $\beta = 24$, γ being $= 29.5$, then we will find $log. \frac{b\beta}{\gamma^2} = - .22$ nearly, which, multiplied into $\frac{\mu}{2}$, or into $\frac{1}{4}$, is $- \frac{1}{16}$ nearly, and this multiplied into M. DE LUC's correction, gives the correction for the compreſſion. The former is, therefore, to be diminiſhed by $\frac{1}{16}$, before it be applied

to

to the difference of the tabular logarithms, to give the true
height of the one barometer above the other. In other cafes,
the proportional part, to be added or fubtracted, will be greater
as β becomes lefs, or as the height becomes greater : It will be
$= 0$, when $b\beta = \gamma^2$; affirmative, when $b\beta$ is greater than γ^2;
and negative when it is lefs.

24. THERE remain to be confidered the two corrections that
depend, one, on the relation between the denfity of the air and
the force comprefing it ; the other, on the diminution of gra-
vity as we afcend from the furface of the earth. It was ob-
ferved (§ 9.), that, if D denote the denfity of the air, and F
the comprefing force, $D = F^{1+n}$. But the force, comprefing
a ftratum of the atmofphere at the height x above the furface
of the earth, and of the denfity y, which, on the fuppofition
of uniform gravity, is denoted by $-\int y\dot{x}$, on that of gravity
decreafing as the ν power of the diftance from the centre of the

earth, is denoted by $-\int \dfrac{s}{(s+x)^\nu} y\dot{x}$; where s is the femidiame-

ter of the earth. This is evident, becaufe the weight of each
ftratum of air is proportional to its denfity, multiplied into the
accelerating force which draws the particles of it toward the
earth. Now, let q be the length of fuch a column of mercury,
that air, comprefed by it, would be of the fame denfity with
the mercury itfelf, which denfity, in all the preceding invefti-
gations, is underftood to be conftant, and to be $= 1$ * ;

then,

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* THE mercury in the barometers is fuppofed to be reduced to a fixed temperature, by
the application of a correction on account of the thermometers attached to them, after the
manner of M. DE LUC, or of General ROY ; the latter reduces the mercury always to the
temperature of 32°. When the difference of temperature is not very great in the two
barometers, the correction of their heights may be made according to the very ingenious
remark of the aftronomer royal. *Phil. Tranf. vol.* 64. *part* 1. *p.* 164.

then, $\quad 1 \;:\; y \;::\; q^{1+n} \;:\; \dfrac{\left(-\int \dfrac{s'}{(s+x)}\, y\dot{x}\right)^{1+n}}{(1-m)^{\tau+\lambda x}}$, and

$$y = \dfrac{\left(-\int \dfrac{s'}{(s+x)}\, y\dot{x}\right)^{1+n}}{q^{1+n}(1-m)^{\tau+\lambda x}}, \quad \text{or } y^{\frac{1}{1+n}} = \dfrac{-\int \dfrac{s'}{(s+x)}\, y\dot{x}}{q(1-m)^{\frac{\tau+\lambda x}{1+n}}}.$$

In which formula, all the inequalities that have been enumerated are expreſſed, except that which was conſidered in the two preceding articles. Hence, multiplying by $q(r-m)^{\tau+\lambda x}$, and taking the fluxions, there comes out,

$$q\left(\dfrac{1}{1+n}y^{\frac{1}{1+n}-1}\dot{y}(1-m)^{\frac{\tau+\lambda x}{1+n}} + \dfrac{\lambda g}{1+n}y^{\frac{1}{1+n}}(1-m)^{\frac{\tau+\lambda x}{1+n}}\dot{x}\right) = -\dfrac{s'y\dot{x}}{(s+x)},$$

Dividing therefore by y,

$$q\left(\dfrac{1}{1+n}y^{\frac{1}{1+n}-2}\dot{y}(1-m)^{\frac{\tau+\lambda x}{1+n}} + \dfrac{\lambda g}{1+n}y^{\frac{1}{1+n}-1}(1-m)^{\frac{\tau+\lambda x}{1+n}}\dot{x}\right) =$$

$$-\dfrac{s'\dot{x}}{(s+x)}\text{ ; and making } y^{\frac{1}{1+n}-1} = v \text{, and, conſequently,}$$

$$\dfrac{-n}{1+n}y^{\frac{1}{1+n}-2}\dot{y} = \dot{v}, \text{ we have}$$

$$\dot{v}(1-m)^{\frac{\tau+\lambda x}{1+n}} - \dfrac{n\lambda g}{1+n}v(1-m)^{\frac{\tau+\lambda x}{1+n}}\dot{x} = \dfrac{ns'\dot{x}}{q(s+x)}.$$

This

This equation will become integrable if it be multiplied by $(1-m)^{-\lambda x}$, for it is then

$$\dot{v}(1-m)^{\frac{\tau-n\lambda x}{1+n}} - \frac{n\lambda g}{1+n} v(1-m)^{\frac{\tau-n\lambda x}{1+n}}\dot{x} = \frac{ns'\dot{x}}{q(s+x)'(1-m)^{\lambda x}};$$

and fo $v(1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{ns'}{q}\int\frac{\dot{x}}{(s+x)'(1-m)^{\lambda x}}.$

But $v = y^{\frac{1}{1+n}-1} = y^{-\frac{n}{1+n}}$, therefore,

$$y^{-\frac{n}{1+n}}(1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{ns'}{q}\int\frac{\dot{x}}{(s+x)'(1-m)^{\lambda x}}.$$

25. It is neceffary to introduce β into this formula, by fub-

ftituting for y, its value, $= \dfrac{\left(\dfrac{s'}{(s+x)'}\beta\right)^{1+n}}{q^{1+n}(1-m)^{\tau+\lambda x}}$; and, therefore, as

$$y^{\frac{n}{1+n}} = \frac{s^{n\prime}\beta^{n}}{q^{n}(s+x)^{n\prime}(1-m)^{\frac{n(\tau+\lambda x)}{1+n}}}, \text{ we have}$$

$$\frac{q^{n}(s+x)^{\prime n}(1-m)^{\frac{n(\tau+\lambda x)}{1+n}}}{s^{\prime n}\beta^{n}} \times (1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{ns'}{q}\int\frac{\dot{x}}{(s+x)'(1-m)^{\lambda x}},$$

            or

$$\text{or,} \quad \frac{q\,(s+x)^{\overset{n}{}}\,(1-m)^{\overset{vn}{}}}{s^{\overset{vn}{}}\beta^{\overset{n}{}}} + C = \frac{ns^{\overset{v}{}}}{q}\int \frac{\dot{x}}{(s+x)^{\overset{v}{}}\,(1-m)^{\lambda x}}.$$

26. In the cafes which actually take place in nature, v is either equal to $+2$, or to -1. It is equal to $+2$, when the barometer is raifed above the furface of the earth, and to -1, when it is depreffed below it. When $v = +2$, the laft equation becomes

$$\frac{q\,(s+x)^{\overset{n}{}}\,(1-m)^{\overset{2n}{}}}{s^{\overset{2n}{}}\beta^{\overset{n}{}}} + C = \frac{ns^{\overset{2}{}}}{q}\int \frac{\dot{x}}{(s+x)^{\overset{2}{}}\,(1-m)^{\lambda x}}.$$

When x is fuppofed very fmall in comparifon of s, the fluent $\int \dfrac{\dot{x}}{(s+x)^{2}\,(1-m)^{\lambda x}}$ may be expreffed by a feries, converging with fuch rapidity, that the two firft terms will be fufficient for the prefent purpofe. Now, as $\dfrac{1}{(s+x)^{2}} = \dfrac{1}{s^{2}\left(1+\dfrac{x}{s}\right)^{2}} =$

$\dfrac{1}{s^{2}}\left(1-\dfrac{2x}{s}\right)$ nearly, $\dfrac{ns^{2}}{q}\int \dfrac{\dot{x}}{(s+x)^{2}\,(1-m)^{\lambda x}}$ becomes

$$= \frac{n}{q}\int \overline{(1-m)^{-\lambda x}\,\dot{x}\left(1-\frac{2x}{s}\right)} = \frac{n}{q\,(1-m)^{\lambda x}}\left(-\frac{1}{\lambda g}+\frac{2x}{\lambda g s}+\frac{2}{\lambda^{2}g^{2}s}\right).$$

Therefore, $\dfrac{q\,(s+x)^{\overset{n}{}}\,(1-m)^{\overset{2n}{}}}{s^{\overset{2n}{}}\beta^{\overset{n}{}}} + C =$

$\dfrac{n}{q\,(1-m)^{\lambda x}}\left(-\dfrac{1}{\lambda g}+\dfrac{2x}{\lambda g s}+\dfrac{2}{\lambda^{2}g^{2}s}\right).$ To define C, x muft be put $= 0$,

$= o$, and $\beta = b$, so that

$$\frac{q^n(1-m)^\tau}{b^n} + C = \frac{n}{q}\left(-\frac{1}{\lambda g} + \frac{2}{\lambda^2 g^2 s}\right), \text{ and } C =$$

$$-\frac{q^n(1-m)^\tau}{b^n} + \frac{n}{q}\left(-\frac{1}{\lambda g} + \frac{2}{\lambda^2 g^2 s}\right). \quad \text{If this value be substituted for}$$

C, and if all the terms be divided by $(1-m)^\tau$, we shall have

$$\frac{q^n(s+x)^{2n}}{s^{2n}\beta^n} - \frac{q^n}{b^n} = \frac{n}{q\lambda g}\left(\frac{1}{(1-m)^\tau} - \frac{1}{(1-m)^{\tau+\lambda x}} + \frac{2x}{s(1-m)^{\tau+\lambda x}} - \right.$$

$$\left. \frac{2}{\lambda gs(1-m)^\tau} + \frac{2}{\lambda gs(1-m)^{\tau+\lambda x}} \right).$$

THE approximation which has been used here for finding the fluent $\int\dfrac{\dot{x}}{(s+x)^2(1-m)^{\lambda x}}$, is sufficiently exact, because no terms have been rejected but such as are divided by s^2, and which, of consequence, are extremely small in respect of the rest.

27. WE are now to suppose, that x becomes equal to z, or to the whole height that is to be measured; then also,

$$\tau+\lambda x = r-b, \quad \lambda = \frac{H-b}{z}, \text{ and } \tau = r-H, \text{ as in § 14.;}$$

and so by substitution, $\dfrac{q^n(s+z)^{2n}}{s^{2n}\beta^n} - \dfrac{q^n}{b^n} =$

$$\frac{nz}{qg(H-b)(1-m)^{H-b}}$$

$$\frac{nz}{qg\,(H-b)\,(1-m)^{r-H}}\left(1-\frac{1}{(1-m)^{H-b}}-\frac{2z}{gs(H-b)}+\right.$$

$$\left.\frac{2z}{s(1-m)^{H-b}}+\frac{2z}{gs(H-b)\,(1-m)^{H-b}}\right)=\frac{nz}{qg(H-b)}\left((1-m)^{H-r}-\right.$$

$$(1-m)^{b-r}-\frac{2z}{gs(H-b)}(1-m)^{H-r}+\frac{2z}{s}(1-m)^{b-r}+$$

$$\left.\frac{2z}{gs\,(H-b)}\,(1-m)^{b-r}\right).$$

THE value of z is to be found from this equation; and as the firſt ſtep in the approximation, we may ſuppoſe s ſo great in reſpect of z, that $s+z=s$, nearly; and, alſo, that all the terms divided by s vaniſh; which, in fact, is the ſame thing with ſuppoſing the force of gravity to be uniform. We have, then,

$$\frac{q^n}{\beta^n}-\frac{q^n}{b^n}=\frac{nz}{qg\,(H-b)}\left((1-m)^{H-r}-(1-m)^{b-r}\right),\ \text{or},$$

$$z=\frac{\frac{1}{n}q^{1+n}g\,(H-b)\left(\frac{1}{\beta^n}-\frac{1}{b^n}\right)}{(1-m)^{H-r}-(1-m)^{b-r}}.$$

28. THIS is the exact value of z, on the ſuppoſition that gravity is uniform, and that the elaſticity of the air is not ſimply as its denſity, but as the power of it denoted by $\frac{1}{1+n}$. But if we content ourſelves with an approximation, which the ſmallneſs of n renders eaſy, the logarithms of b and β may be

P   introduced,

introduced, and the formula will become fimilar to that which was formerly invefligated.   For $\dfrac{1}{\beta^n}$, or

$$\beta^{-n} = 1 - n\,log.\,\beta + \frac{n^2}{2}\,(log.\,b)^2 - \frac{n^3}{6}\,(log.\,b)^3 + \&c.$$ When n is very fmall, as in the prefent cafe, this feries converges with extreme rapidity; and the terms involving n^3, &c. may fafely be rejected.   Therefore,

$$\frac{1}{\beta^n} - \frac{1}{b^n} = 1 - n\,log.\,\beta + \frac{n^2}{2}\,(log.\,\beta)^2 - 1 + n\,log.\,b - \frac{n^2}{2}\,(log.\,b)^2 =$$

$$n\,(log.\,b - log.\,\beta) - \frac{n^2}{2}\Big((log.\,b)^2 - (log.\,\beta)^2\Big)\;.$$

Hence, $z = \dfrac{q^{1+n}\,g\,(H-b)\Big(log.\,b - log.\,\beta - \dfrac{n}{2}\,(log.\,b)^2 + \dfrac{n}{2}\,(log.\,\beta)^2\Big)}{(1-m)^{H-r} - (1-m)^{b-r}}$

29. WHEN n vanifhes altogether, the value of z, affigned by this formula, coincides, as it ought to do, with that which was invefligated, on the fuppofition of the denfity being precifely as the compreffion; for by applying the reduction of art. 17. we have,

$$z = q\Big(1 + m(\frac{H+b}{2} - r)\Big)\,log.\,\frac{b}{\beta}\;.$$

But when n, though very fmall, does not vanifh altogether, by the fame reduction,

$$z = q^{1+n}\Big(1 + m(\frac{H+b}{2} - r)\Big)\,log.\,\frac{b}{\beta}\Big(1 - \frac{n}{2}\,log.\,b\beta\Big)\;.$$

If, therefore, we fuppofe q^{1+n} to be equal to p, or to 4.343 fathoms,

fathoms, which must be nearly true; and, if we call A the height, or the value of z, computed from the formula $z = p\left(1+m(\frac{H+b}{2}-r)\right) log. \frac{b}{\beta}$, the correction to be applied on account of n; will be $-\frac{n}{2}A\, log.b\beta.$

30. It is not, however, now a matter of indifference in what measure the lengths of the columns of mercury in the barometers are expressed, as it was, when only the ratios of these columns entered into the computation. They must be expressed in terms of the same measure, wherein the height of the mountain is required, and wherein q has been already determined. For, if we take the exact expression for the height, *viz.*

$$z = \frac{\frac{1}{n}q^{\frac{1+n}{n}} \cdot g\,(H-b)\left(\frac{1}{\beta^{\frac{1}{n}}} - \frac{1}{b^{\frac{1}{n}}}\right)}{(1-m)\frac{H-r}{} - (1-m)\frac{b-r}{}}, \text{ or that to which it may be re-}$$

duced, $z = q\left(1+m(\frac{H+b}{2}-r)\right)\left(\frac{q^{\frac{n}{n}}}{n\beta^{\frac{1}{n}}} - \frac{q^{\frac{n}{n}}}{nb^{\frac{1}{n}}}\right)$, it is evident,

that $\dfrac{q^{\frac{n}{n}}}{n\beta^{\frac{1}{n}}} - \dfrac{q^{\frac{n}{n}}}{nb^{\frac{1}{n}}}$ can have no definite signification, unless b, β, and q be all expressed in terms of the same measure. As the conveniency of computation requires that p or $q^{\frac{1+n}{}}$ should be expressed in fathoms, so b and β must also be expressed in parts of a fathom. The same is true of the logarithmic expression, $\frac{n}{2} log.b\beta$, to which the preceding one is reduced. Thus, if

$b = 30$ inches, and $\beta = 20$ inches, we must make $b = \dfrac{5}{12}$,

and

and $\beta = \frac{5}{18}$, fo that $b\beta = \frac{5 \times 5}{12 \times 6 \times 3}$, half the hyperbolic logarithm

of which, or that of $\frac{5}{6\sqrt{6}}$, is $= -1.0782$, and this multiplied

into $-n$, fuppofing $n = .0015$, gives $+.0016$ to be multiplied

into A, or the height as already approximated. The correction

here is, therefore, about $\frac{1}{637}$ of A. In other cafes, it will ex-

ceed this proportion as $b\beta$ diminifhes, but (becaufe $b\beta$ will rare-

ly be greater than $\frac{25}{144}$), its minimum will be about $\frac{1}{.770}$. In

the meafurement of great heights, therefore, this equation may

deferve to be confidered.

31. WE come now to find the correction which muft be made
on the ordinary rule, on account of the diminution of gravity
as we afcend from the furface of the earth. By § 27. we have,

$$\frac{q^{1+n}\left(1 + \frac{z}{s}\right)^{n}}{\beta} - \frac{q^{1+n}}{b^{n}} =$$

$$\frac{nz}{g(H-b)}\left((1-m)^{H-r} - (1-m)^{b-r}\right) - \frac{2z}{gs(H-b)}(1-m)^{H-r} +$$

$$\frac{2z}{s}(1-m)^{b-r} + \frac{2z}{gs(H-b)}(1-m)^{b-r}\right); \text{ and fince we know al-}$$

ready, that $z = \dfrac{\frac{1}{n}q^{1+n}g(H-b)\left(\frac{1}{\beta}^{n} - \frac{1}{b}^{n}\right)}{(1-m)^{H-r} - (1-m)^{b-r}}$ nearly, if we fub-

ftitute this value of z, or rather that which was before derived

<div align="right">from</div>

from it, *viz.* $z = q\left(1 + m(\frac{H+b}{2} - r)\right)\left(\frac{q^n}{n\beta^n} - \frac{q^n}{nb^n}\right)$, in all the

terms of this equation, into which *s* enters as a divifor, we fhall have a new and more accurate value of *z*, and, by a like procefs, might from thence obtain one ftill more accurate, if it were neceffary.

Now, if this be done, and if the correction depending on *n* be fuppofed fufficiently determined by the computations of the two preceding articles, fo that it may now be neglected altogether ; and if *m* alfo be fo fmall, that all the powers of it, higher than the firft, may be neglected, we obtain,

$$z = p\left(1 + m(\frac{H+b}{2} - r)\right) \log.\frac{b}{\beta} + \frac{2p^2}{s}\left(1 + m(\frac{H+b}{2} - r)\right)^2 \log.\frac{b}{\beta}$$

$$+ \frac{p^2}{s}\left(1 + m(\frac{H+b}{2} - r)\right)^2 \left(\log.\frac{b}{\beta}\right)^2.$$

32. THE firft term of the preceding equation is the height corrected by M. DE LUC's method ; the fecond term, *viz.* $\frac{2p^2}{s}\left(1 + m(\frac{H+b}{2} - r)\right)^2 \log.\frac{b}{\beta}$, is the correction for the diminution of the weight of the quickfilver in the uppermoft barometer; and the third term, or $\frac{p^2}{s}\left(1 + m(\frac{H+b}{2} - r)\right)^2 \left(\log.\frac{b}{\beta}\right)^2$, is the correction for the gradual diminution of the weight of the air in the different ftrata between the lower and the upper ftaftion. The laft of thefe two corrections, which, in all ordinary cafes, is alfo the leaft, is the only one of them to which, it would feem, that any attention has hitherto been paid. The other, or the effect of the diminution of the gravity of the quickfilver, was included in this inveftigation, when, at § 25. we fubftituted for

y,

v its value, $\dfrac{\left(\dfrac{s'}{(s+x)}\,\beta\right)^{1+n}}{\dfrac{1+n}{q}\,(1+m)^{\tau+\lambda x}}$. It is found by making as s to

$p\left(1+m(\dfrac{H+b}{2}-r)\right)$; so twice the height, computed by the ordinary method, to a fourth proportional, which is to be added to that height.

THE correction for the diminished gravity of the air is a third proportional to the semi-diameter of the earth, and the height, as computed by the ordinary rule. For different mountains, therefore, this correction is in the duplicate ratio of their heights.

THESE corrections are both additive, and for such a mountain as Coraçon may be equal, the first to 42, and the second to 12 feet.

33. IN the measurement of depths below the surface of the earth, β is greater than b, and $v = -1$, so that the compressing force, at any depth x below the surface, is $= \left(\int\dfrac{s-x}{s}y\dot{x}\right)^{1+n}$;

where the fluent is affirmative, not negative, as in all the preceding instances, because the air which, by its weight, compresses the stratum at the depth x, is on the same side of that stratum with x, whereas it was before on the opposite side.

Making, therefore, $y = \dfrac{+\left(\int\dfrac{s-x}{x}y\dot{x}\right)^{1+n}}{p(1-m)^{\tau+\lambda x}}$, we have;

by proceeding as above,

$$z = p\left(1+m(\dfrac{H+b}{2}-r)\right)log.\dfrac{\beta}{b} - \dfrac{p^2}{s}\left(1+m(\dfrac{H+b}{2}-r)\right)log.\dfrac{\beta}{b}$$

$$+ \dfrac{p^2}{2s}\left(1+m(\dfrac{H+b}{2}-r)\right)^2\left(log.\dfrac{\beta}{b}\right)^2.$$

In

In this formula, the fecond term, *viz.* $- \frac{p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)log.\frac{\beta}{b}$ is juft half the correfponding term in the preceding formula, (§ 31.) with a contrary fign, fo that the correction for the diminution of the gravity of the quickfilver takes away from a depth, as it adds to an elevation. The correction $\frac{p^2}{2s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\left(log.\frac{\beta}{b}\right)^2$ retains the fame fign in both cafes, but in this is only half of what it was in the former. That thefe laft corrections fhould be each half of the correfponding one in the preceding cafe, might have been concluded from this, that, by any fmall afcent above the furface of the earth, the force of gravity is twice as much diminifhed as by an equal defcent below it. The reafon of the change of the figns in the fecond term is alfo fufficiently obvious.

34. Though thefe corrections fuppofe that z is fmall in refpect of s, yet they would afford a fufficient approximation to the truth, were we to reafon concerning much greater depths under the furface of the earth than any to which man can penetrate. For example, on a fuppofition that the atmofphere was continued downwards within the earth, its denfity being always as its compreffion, and its temperature every where the fame, (and, for the greater cafe of computation equal to r), let it be required to find, at what depth its denfity would become equal to that of mercury. To refolve this problem, it muft be remembered, that the denfity of mercury, throughout all this computation, has been fuppofed $= 1$, and p equal to the height of a column of mercury, which, gravitating every where with the fame force as at the furface, would, by its preffure, give to air the denfity 1. If a barometer, therefore, were carried down to the depth at which air was as denfe as mercury, the mercury in it would rife to the height p, or to 4343 fathoms nearly, fuppofing, at the fame time, that its own gravity were not diminifhed. Now, on this fuppofition, (by § 33.)

<div align="right">any</div>

any depreſſion below the ſurface, as, $z = p\,log.\dfrac{\beta}{b} + \dfrac{p^2}{2s}\left(log.\dfrac{\beta}{b}\right)^2$,

the temperature being ſuppoſed $= r$, and the term

$-\dfrac{p^2}{s}\,log.\dfrac{\beta}{b}$ being left out, as relating only to the diminution of

the weight of the quickſilver in the lower barometer. If, then, b, or the column of mercury in the barometer at the ſurface, be 30 inches, or $\dfrac{5}{12}$ of a fathom, and $\beta = 4343$, we find $p\,log.\dfrac{\beta}{b} =$

10000 × *tabular log.* 10423 = 40180 fathoms = 45.6 miles near-

ly. The ſecond term, $\dfrac{p^2}{2s}\left(log.\dfrac{\beta}{b}\right)^2$, (or the ſquare of the for-

mer divided by the diameter of the earth), $= +.25$ of a mile, ſo that $z = 45.85$ miles nearly. The approximation might be carried to much greater exactneſs if it were neceſſary; but this is ſufficient to ſhew, that, at a leſs depth under the ſurface than 46 miles, the denſity of air would become equal to that of quickſilver; and if this concluſion appear, in any degree, pa-radoxical, it need only be conſidered, that, abſtracting from any diminution of the power of gravitation, the denſity of air would be nearly doubled by every $3\frac{1}{2}$ miles of deſcent below the ſurface of the earth.

35. If, again, we would form any concluſion concerning the limit to which our atmoſphere may extend upwards, we muſt

reſume the formula, $y = \dfrac{\left(-\displaystyle\int \dfrac{s'}{(s+x)}\,y\dot{x}\right)^{1+n}}{q^{1+n}\,(1-m)^{\tau+\lambda x}}$;

and, if we would abſtract from the effect of the cold in the higher regions to reduce the atmoſphere within narrower limits than thoſe to which it would otherwiſe extend,

we

we may suppose the temperature $r+f$ to be uniformly diffused through it, and so for $(1-m)^{\frac{\tau+\lambda x}{}}$ we may substitute $1+fm$. Putting also $a = q(1+fm)^{\frac{1}{1+n}}$, and making $s+x$, or the distance from the centre, $= v$, $ay^{\frac{1}{1+n}} = -\int s'v^{-\prime}y\dot{v}$; wherefore, taking the fluxions, dividing by y, and integrating,

$$-\frac{a}{n}y^{-\frac{n}{1+n}} + C = (\nu-1)s'v^{1-\prime}.$$

To define C, suppose that $y = D$ when $x = 0$, or when $v = s$;

then, $C = \dfrac{a}{n}D^{-\frac{n}{1+n}} + (\nu-1)s$; and so,

$$\frac{a}{n}\left(D^{-\frac{n}{1+n}} - y^{-\frac{n}{1+n}}\right) = (\nu-1)(s'v^{1-\prime} - s);$$

and making $\nu = 2$, $\dfrac{a}{n}\left(D^{-\frac{n}{1+n}} - y^{-\frac{n}{1+n}}\right) = s\left(\dfrac{s}{v} - 1\right).$

36. Now, if n be affirmative, as has been supposed, this formula, because of the negative exponent of y, gives s infinite, when $y = 0$. The atmosphere, therefore, on this supposition, admits of no limit. But, if we suppose n to be negative, that is, if we suppose the density to be as the power $1-n$ of the compression, instead of $1+n$, the formula of the last article becomes

$$\frac{a}{n}\left(D^{\frac{n}{1-n}} - y^{\frac{n}{1-n}}\right) = s\left(1 - \frac{s}{v}\right).$$

Q

And

And if we now suppose the atmosphere to terminate, or y to become $= 0$, then $\dfrac{aD^{\frac{n}{1-n}}}{n} = s\left(1 - \dfrac{s}{v}\right)$, and the entire height of the atmosphere, or $v = \dfrac{s^2}{s - \dfrac{a}{n}D^{\frac{n}{1-n}}}$.

THIS value of v may either be finite, infinite, or negative, according to the different magnitudes assigned to n and D. If these be such that s is equal to $\dfrac{a}{n}D^{\frac{n}{1-n}}$, it is obvious that v is infinite; but if s be greater than $\dfrac{a}{n}D^{\frac{n}{1-n}}$, v must be finite and affirmative. If s be less than $\dfrac{a}{n}D^{\frac{n}{1-n}}$, then v is negative; by which we are to understand, that the height of the atmosphere is, as it were, more than infinite, or that its density is finite, even at an infinite distance. It must be remarked, too, that, when n is very small, as it must be in the case of the earth's atmosphere, $D^{\frac{n}{1-n}}$ being nearly $= 1$, we have $v = \dfrac{s^2}{s - \dfrac{a}{n}}$.

As $a = 4343$ fathoms, (on the supposition that the temperature of the atmosphere is 32^{c},) and as $s = 3491840$, it follows, from this formula, that, according as n is greater than .00125, equal to it, or less, the density of the atmosphere will vanish at a finite, an infinite, or not even at an infinite distance.

37. BUT to return to what is the more immediate object of this paper, it will now be proper to bring into one view the

the different corrections that have been inveſtigated. We muſt, therefore, recollect, that the coefficient p is the length of a column of mercury, which, preſſing on air of the temperature r, would give to it the denſity of mercury, (which is denoted by unity), ſuppoſing, at the ſame time, that the denſity of air is as the force compreſſing it. Hence p is likewiſe the height of a homogeneous column of air, of any denſity whatever, which, by its preſſure, would make air of the ſame denſity with itſelf; or it is the height to which the atmoſphere would extend above the ſurface of the earth, if it were reduced to the ſame denſity throughout, which it has at the ſurface of the earth, when it is of the temperature r. It has been found by experiment, that, when $r = 32°$, p is nearly equal to 4342.948 fathoms, which number is the modulus of the tabular logarithms multiplied by 10000. This determination, however, is only to be conſidered as approaching to the truth, if we are to have regard to the following corrections. Inſtead of p, in ſome of theſe inveſtigations, we have uſed q to denote the height of a column of mercury, which, ſuppoſing the condenſation of air to be as the power $1+n$ of the compreſſing force, would, by its preſſure, give to air the denſity of mercury, or the denſity 1; q^{1+n} cannot differ much from p, but its preciſe length is to be determined only by experiment. In what follows, p is put for the numeral coefficient, whatever it may be, by which the formula muſt be multiplied to give the height in fathoms, or in any known meaſure.

The expanſion of air for one degree of heat, the temperature being 32°, and the height of the barometer 29.5 inches, is $= m = .00245$ nearly. μ is the exponent of a power ſuch that 29.5 being denoted by γ, $\dfrac{\beta^{\mu}}{\gamma^{\mu}} \times m =$ the expanſion for one degree of heat, when the mercury in the barometer ſtands at β. The value of μ is not certainly known; it is probably be-

tween

tween 1 and $\frac{1}{3}$. n is a number such, that the density of air is as the power $1+n$ of the compressing force; it is supposed $= .0015$.

THE heights of the mercury in the barometers, at the lower and upper stations, are b and β; H and h are the temperatures, marked by FAHRENHEIT's thermometer at those stations respectively, and $\frac{H+h}{2} - r$ is put $= f$.

39. THEN, the first approximation to the height, without any correction, is, $z = p \, log. \frac{b}{\beta}$.

1*mo.* The first correction, M. DE LUC's, (§ 17.) =

$$+ m \left(\frac{H+h}{2} - r \right) p \, log. \frac{b}{\beta}.$$

2*do.* THE correction for the decrease of heat in the superior strata of the atmosphere, and for the first inequality of expansion, (§ 19.) =

$$+ m^2 \left(\frac{r}{2} - \frac{H+h}{4} + \frac{r(r-H-h)}{2} + \frac{H^2 + 4Hb + b^2}{12} \right) p \, log. \frac{b}{\beta}.$$

3*tio.* THE correction for the second inequality of expansion, or for its variation by a given change of temperature, according to the pressure, (§ 22.) = $\quad + \frac{\mu m}{2} \left(\frac{H+h}{2} - r \right) p \, log. \frac{b}{\beta} \times log. \frac{b\beta}{\gamma^2}$; or, if E be put for M. DE LUC's, or the first equation, this last $=$ $+ \frac{\mu E}{2} log. \frac{b\beta}{\gamma^2}$.   But as μ does not appear to be very small, it will be more accurate to compute $\frac{pfm (b^\mu - \beta^\mu)}{\mu \gamma^\mu}$, which includes in it both the first and third corrections (§ 21.).

4*to.*

4*to.* THE correction on account of the departure of the law of the elasticity of air, from that of the direct ratio of the density, (§ 29.)

$$= -\frac{n}{2}p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta} \times log. b\beta.$$

In this equation, b and β must be expressed in the same measure with p, that is, in fathoms.

5*to.* FOR the diminution of the weight of the quickfilver in the upper barometer, there is an equation to be applied =

$$+ \frac{2p^2}{s}\left(1+m(\frac{H+b}{2}-r)\right)^2 log.\frac{b}{\beta}.$$

6*to.* ON account of the diminished gravity of the air in a-scending from the surface of the earth, there is a sixth correction

$$= +\frac{p^2}{s}\left(1+m(\frac{H+b}{2}-r)\right)^2\left(log.\frac{b}{\beta}\right)^2.$$

WHEN a depth below the surface is to be measured, the fifth equation becomes negative and loses the multiplier 2 ; the sixth remains affirmative, but is divided by 2.

40. THESE equations, even exclusive of the first, may, in the measurement of great heights, amount to a considerable proportion of the whole. In the instance of Coraçon, 15833 feet above the level of the sea, the greatest height to which the barometer has ever been carried, the first equation exceeds 1100 feet, and the third appears not to be less than — 300. The remaining corrections are, indeed, less considerable ; but, being all affirmative, they must not be entirely neglected. And, on the whole, it is certain, that, though the first equation alone will give the height sufficiently exact, while it does not exceed five or six thousand feet, yet, at greater elevations, the corrections that have now been enumerated must all be taken into account. To facilitate the computation by means of them, they ought to be reduced into tables adjusted to their proper arguments, after the values of p, m and r are accurately determined,

mined, by comparing the formula that has been given here with obfervations. But this would lead into difquifitions far exceeding the bounds of the prefent inquiry, the object of which is, to afcertain the form, rather than the abfolute quantity of thefe corrections.

41. It is evident, that, in the preceding inveftigation, as well as in all the other methods of meafuring heights by the barometer, it is fuppofed, either that the one of the barometers is vertical to the other, or that a perfect æquilibrium prevails through that part of the atmofphere intercepted between them. The determination of the conftant quantity in the fore-going integrations, by fuppofing that $b = \beta$ when $x = o$, or that the mercury in the two barometers ftands at the fame height in them, when they are at the fame diftance from the furface of the earth, obvioufly involves in it either the one or the other of thefe conditions. But the laft of them, the æquilibrium of the atmofphere, never takes place ; and, therefore, it is neceffa-ry, in order that barometrical meafurements be perfectly accu-rate, that the one barometer be immediately above the other, or, at leaft, that the horizontal diftance between them be very fmall. If this be not the cafe, the unequal diftribution of the heat through the different parts of the fame ftratum of air will render it impoffible to deduce the difference of the heights of the barometers from a comparifon of the columns of mercury contained in them.

For inftance, let there be three barometers ; the *firft* at the furface of the earth, the *fecond* raifed up into the air per-pendicularly above the *firft*, and the *third* removed into a colder climate, but raifed up alfo into the air, fo as to have in it a co-lumn of mercury of the fame length with that in the *fecond*. Thefe two laft, when compared together by M. de Luc's, or by the preceding rules, will appear to be at the fame height above the furface, or above the firft barometer. But, if each of them be compared with the *firft*, the *fecond* will appear

more

more elevated above it than the *third*, becaufe of the greater cold fuppofed to prevail in the region where this laft barometer is placed. Here, therefore, are two different determinations of the height of the third ftation above the firft, neither of which has any claim to be preferred to the other. It is evident, therefore, that, in barometrical meafurements, there is always a degree of uncertainty introduced by the horizontal diftance between the two ftations, and that, befide thofe accidental errors, which are of the lefs confequence, that, in a number of obfervations, they may nearly compenfate for one another.

It muft be confeffed, too, that we have not at prefent the means of removing this uncertainty, nor even of afcertaining its limits with tolerable exactnefs. Thefe depend on a problem which is no longer to be refolved by the principles of ftaticks, but requires the *motions* of an elaftic fluid, under various degrees of compreffion and rarefaction, to be determined. The folution, therefore, is extremely difficult; and no refult, fufficiently fimple to be of ufe in thefe computations, is ever likely to be obtained from it.

It would, however, be of confequence to determine, by obfervation, the mean height of the barometer at the level of the fea in the different regions of the earth. That mean height is not every where the fame. Under the line, it appears, from the obfervations of M. BOUGUER, to be 29.852 inches, reducing the mercury to the temperature of 55°; and in Britain, it is 30.04, reducing the mercury to the fame temperature. The mean temperature of the air, as well as its mean weight in different climates, will alfo require to be determined before the art of levelling extenfive tracts by the barometer can be brought to perfection.

42. THERE is another caufe of error which, had the effects of it been fufficiently known, ought, no doubt, to have entered into this inveftigation. Moifture, when chemically united to air, or diffolved in it, fo as to compofe a part of the fame homogeneous

mogeneous and invifible fluid, appears to have a powerful effect to encreafe the elafticity of the air, and its expanfion for every additional degree of heat which it receives. In experiments with the manometer *, it has been obferved, that, till the moifture was diffolved in the air, it had no fenfible effect on its elafticity; but that, as foon as it began to diffolve, the expanfion, for one degree of heat, was encreafed, and continued to be fo, for every fucceffive addition of heat, from thence to the boiling point, where it became nine times that of dry air. From this, too, it probably proceeded, that, at Spitzbergen, within ten degrees of the pole, a place where the circle of perpetual congelation in the atmofphere, approaches near to the furface of the earth, and where the air may naturally be fuppofed to be very dry, the ufual rule for the meafurement of heights was found to err greatly in excefs, and it appeared, that the denfity of the air was greater than could have been inferred from its compreffion and its temperature.

43. THOUGH the judicious and accurate experiments of General ROY have afcertained this effect of humidity, and have even gone far to determine the law of its operation, yet, for want of a meafure of the quantity of it, contained, at any given time, in the air, it is impoffible to make any application of this knowledge to the object under our confideration. While I was reflecting on this difficulty, it occurred, that the barometer itfelf might become a meafure of the humidity of the air, and that the error committed in the meafuring of a known height, if all other circumftances were taken in, would determine the quantity of that humidity. For, if we fuppofe, that the formula $z = p\left(1 + m\left(\dfrac{H+h}{2} - r\right)\right)log.\dfrac{b}{\beta}$ gives the true height between the ftations at which two barometers have been obferved, when the moifture diffolved in the air is of its medium quantity, (which we may call unity), then, if that

moifture

* See General Roy's experiments, fection 2. Phil. Tranf. vol. 67. part 2.

moisture be either increased or diminished, the expression $p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta}$ will no longer be equal to the true height, but must be multiplied into $1\pm\pi$ in order that it may be equal to z. Now, this fraction $\pm\pi$ represents the excess or defect of the moisture dissolved in the air above or below its mean quantity; or, more exactly, it is proportional to the increase or diminution of the elasticity of the air arising from that cause. When $p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta}$ is less than the true height, the fraction π must be affirmative, and indicates an increase of elasticity, and, consequently, of moisture in the air. The contrary happens when $p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta}$ is greater than the true height. To determine π, since $z =$

$$(1+\pi)\,p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta}, \quad 1+\pi = \frac{z}{p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta}}.$$

Or if the error, that is $z - p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta} = e,$

then $\pi = \dfrac{+e}{p\left(1+m(\frac{H+b}{2}-r)\right)log.\frac{b}{\beta}}$, or $\pi = \dfrac{+e}{z-e}$.

44. To apply the barometer, therefore, for the purposes of hygrometry, let there be two barometers fixed, the one at the top, and the other at the bottom of a high tower, or hill of moderate elevation, and let them be observed at the same instant, together with their corresponding thermometers. If the difference of their heights, computed from thence, be equal precisely to the true difference, then is the moisture dissolved in the air no way different from its mean quantity; but if the difference of the heights so computed be greater or less than the truth, then π, as above determined, will give the quantity by which the actual moisture in the air is less or greater than the mean quantity. The height at which the one barometer should be placed above the other, ought not to be so small that

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the unavoidable errors of obfervation, (which may amount to five feet), may be confiderable in refpect of the whole; nor fo great as to introduce error from other caufes. It ought not, therefore, to be lefs than 100, nor much greater than 500 feet.

45. In this manner, we fhall have a meafure, not indeed of the abfolute quantity of humidity diffolved in the air at a given time, but of the differences of the humidity diffolved in it at different times. Our hygrometer, therefore, will afford a fcale for the meafuring of moifture, not unlike that which the thermometer affords for the meafuring of heat; and both deduced from the changes produced on the bulk, or the fpecific gravity of certain bodies. The beginning, or zero, of this fcale may alfo be fixed by a certain and invariable rule, if we affume m, in the preceding formula, (or the expanfion of air for one degree of heat), of a given magnitude, as, for inftance, .00245, and conceive the fcale to begin when $\pi = 0$, or when the formula, thus adjufted, gives the true height.

The hygrometer with which we will be thus furnifhed, feems well adapted to the purpofes of aftronomy. For it meafures the humidity chemically united with the air, and not merely the difpofition of the air to depofit that humidity, which, though much connected with the changes of the weather, has little to do with the aftronomical refraction. It is true, that the fractions π may not be directly proportional to the differences of the humidity of the air, nor to the changes of refracting power, which thofe differences of humidity may produce; but they are probably connected with thefe laft, by fome fixed and invariable law, which future experiments may be able to afcertain. Nor can this application of the barometer fail of leading to fome ufeful conclufion; for if, on trial, it fhall be found, that the operation of humidity in changing the fpecific gravity of the air, is over-ruled or concealed by the action of more powerful caufes, the difcovery, even of this fact, will give a value to the obfervations.

IV.

IV. *On the* USE *of* NEGATIVE QUANTITIES *in the* SOLUTION *of* PROBLEMS *by* ALGEBRAIC EQUATIONS. *By* WILLIAM GREENFIELD, M. A. F. R. S. EDIN. *Minister of St Andrew's Church, and Professor of Rhetoric in the University, of* EDINBURGH.

[*Read by the Author, April* 12. 1784.]

BY the introduction of letters into algebra, to denote all the quantities, both known and unknown, involved in an equation, this very important advantage was gained, that the final equation exhibited both a general rule for the solution of all similar problems, and also the limitations within which such problems were possible.

THIS, however, could not be understood universally, if the signs + and — were not used in that extensive sense in which they are now taken. For there are innumerable problems, which require us to consider some of the quantities, as capable of existing in two opposite situations. Thus the distance of a star from the horizon, may include both its elevation at one time, and its depression at another. Hence, in the general investigation of this distance, two different cases arise, which may seem to require two different equations.

MATHEMATICIANS, however, came naturally to consider such opposite situations as analogous to addition and subtraction. And, upon this ground, they made the equation to which the problem was reduced in the one case, serve also for the other, in the following manner: If it was one of the unknown quantities which had changed its situation, they took a negative root; if it was one of the known quantities, they

changed

changed its fign in the equation.   It is evident how vaft an ac-
ceffion was thus gained to the elegance and univerfality of al-
gebraical folutions.

ALBERT GIRARD appears to have been the firft who obferved
this ufe of negative roots.   In his work, publifhed in the year
1629, entitled, *Invention nouvelle en Algebre*, he mentions it with
great diftinctnefs, and as a matter unknown before *.

MONTUCLA, who acknowledges that he never faw the work
of GIRARD, infifts very ftrenuoufly that DES CARTES was the
perfon, to whom we owe our knowledge of the nature and ufe
of negative roots ; that it was he, who firft introduced them
into geometry and algebra †.   But without derogating from
the very extraordinary merit of that philofopher, we muft beg
leave, in this matter, to differ fomewhat from MONTUCLA.
For, according to his own account, the work of GIRARD
was publifhed in 1629, whereas the *Geometry* of DES CARTES
was not publifhed till feven or eight years afterwards, in
1637 ‡.

WE may, perhaps, go farther, and add, that although DES
CARTES indeed obferved, that the fhifting of a line or point
from one fide of a given line or point to the other, made no
change in the equation, except in the figns + and —, yet he
did not fee, in its full extent, all the advantage to be derived
from the ufe of negative quantities. This will appear not altoge-
ther improbable from the following circumftances : In the third

<div align="right">book</div>

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* I HAVE not been able to procure the book ; but the following paffage, quoted by Dr
HORSELEY, feems to warrant what has been afferted : " Jufques icy nous n'avons encore
" expliqué à quoy fervent *les folutions par moins*, quand il y en a. La folution par
" moins s'explique en geometrie en retrogradant, et le moins recule là où le + avance."
And, after giving an inftance, he adds ; " Et ainfi faudra-t-il entendre de toutes folu-
" tions par moins ; qui eft une chofe de confequence en geometrie incognue aupara-
" vant." HORSELEY'S NEWTON, *vol. 1. p. 171. note (u)*.

† MONTUCLA Hift. de Math. vol. 2. p. 85.

‡ MONTUCLA Hift. de Math. vol. 2. p. 82. & 84.

book of his *Geometry*, where he treats exprefsly of the nature
of equations, he takes no notice of thofe which have all their
roots negative ; and, in the fecond book, where he mentions
his new method of confidering curves, he fays nothing of ne-
gative abfciffæ and ordinates, although the analyfis of curves
is, of all the parts of mathematics, that which moft obvioufly
fuggefts and requires the ufe of the negative roots.

IN fact, the ufe of negative quantities appears not to have
been, either at this time, or for fome time afterwards, familiar
to mathematicians. This is evident from the *Elementa Cur-
varum* of JOHN DE WITT, a work, at that time, of fome me-
rit, but which will be confidered, rather as affording a curi-
ous piece of information in the life of that great man, than as
adding to a fame, which is fo far fuperior to all literary emi-
nence. In this work, which is publifhed by SCHOOTEN at the
end of his edition of DES CARTES's *Geometry*, no notice is
taken of negative abfciffæ and ordinates : So that the author is
obliged to confider feparately two or more equations, which
every mathematician at prefent, from the view of negative
quantities, which is now become familiar, would confider as
one fingle equation, denoting for one and the fame line refer-
red to the fame axis, the relation between the abfciffæ and or-
dinates, through all the different cafes of their fituation with re-
fpect to each other, that is, through all the angles of the co-
ordinates. Thus, in his fecond book, where he confiders the
lines of the firft and fecond order, beyond which he does not
go, he demonftrates, in the four firft theorems, that the four

following equations belong to ftraight lines : 1. $y = \dfrac{bx}{a}$;

2. $y = \dfrac{bx}{a} + c$; 3. $y = \dfrac{bx}{a} - c$; 4. $y = -\dfrac{bx}{a} + c$. But he does

not fhow, either in this or any other part of the work, that
each of thefe equations, by changing the figns of y or x, gives
the relation between the abfcifs and ordinate, when the one or

the

the other is taken in an oppofite fituation ; and that the fecond and fourth equation ought to be confidered as one, and as belonging to the fame ftraight line referred to the fame axis.

Even long after this time, we find, that Dr Wallis, although, in his *Algebra*, he confiders at fome length the meaning and ufe of negative quantities, yet, in his *Arithmetic of Infinites*, falls into a ftrange miftake, which leads us to fufpect, that his notions on this fubject were not perfectly clear. For, obferving that his general expreffion for hyperbolic areas would, in certain cafes, be a fraction with a negative denominator, he did not perceive, that this expreffed the area on the other fide of the ordinate, inftead of the area fought ; but he contents himfelf with faying, that the denominator of the fraction being lefs than nothing, denoted the area to be more than infinite.

That even fome time afterwards, the ufe of negative quantities had not become familiar, appears from the aftonifhment which Dr Halley expreffes at his own difcovery of a formula, which, by the mere change of the figns, gave the focus both of converging and diverging rays, whether reflected or refracted by convex or concave fpecula or lenfes. And Mr Molyneux fpeaks of the univerfality of Halley's formula as fomewhat that refembled magic.

Thus it appears to have been long, before mathematicians ventured to employ negative quantities fo freely, as we now perceive them to be employed. The reafon of which probably was, that no fatisfactory account had been given of the grounds upon which the conclufions drawn from them are founded. But the confiftency of thefe conclufions, with all the moft indifputable truths of the mathematical fciences, and the great beauty and advantage, derived from the very general folutions which are thus obtained, gradually eftablifhed their ufe.

Still, however, a complaint remains, which appears to be too well founded, that the Method of negative quantities, as has been the cafe with fome other rules of the art, is supported,

ed, rather by induction and analogy, than by mathematical de-
monftration. But fomething more than this is to be expected
from mathematicians; and their knowledge of algebra will ftill
be confidered as imperfect, if there be any of its operations
which they cannot, in every letter and fign of it, explain as a
feries of juft reafoning, capable of being expreffed in common
language. Now, it does not appear that our inftructors in ma-
thematics have enabled us to do this in the cafes to which we
allude, that is, where negative quantities are found, without
any intimation of the quantities from which they are fubtract-
ed. In confidering the abftract operations of addition, fub-
traction, multiplication, &c. we may indeed take negative
quantities by themfelves: For here the meaning is obvious; we
are examining, in what manner fuch operations will affect thofe
quantities, which are fubtracted from other quantities. But
when we come to apply thefe operations to the bufinefs of al-
gebra, the refolution of equations, it is not fo eafy to perceive,
nor does it appear to have been fufficiently explained, in what
light we are to confider negative quantities, or how mathemati-
cians are to be juftified in the ufe which they make of them.
The very vague and unfatisfactory, and often myfterious ac-
counts of the matter, which are given even by writers of the
greateft eminence, ferve only to fhew, that although they are
fatisfied of the certainty of the method, yet they perceive that
fomething ftill remains which ought to be explained, and of
which no good explanation has been given.

Mr Baron MASERES, indeed, has publifhed a large work,
which he entitles, " A Differtation, on the ufe of the negative
" fign in algebra; containing a demonftration of the rules ufu-
" ally given concerning it, and fhewing how quadratic and
" cubic equations may be explained, without the confideration
" of negative roots." But this differtation contributes little to
remove the difficulties complained of. For even allowing the
author to be right in his notion, that it would be better " if ne-
                                                    " gative

" gative roots had never been admitted into algebra, or were
" again difcarded from it * ;" yet ftill he has carried us to the
length only of cubic equations.   The truth is, that the whole
bufinefs of algebra might be carried on without the confidera-
tion of the negative roots. The difference between fuch a fyftem
and the prefent, is precifely this ; that wherever a problem re-
quired us to confider any of the quantities, as exifting in oppo-
fite fituations ; wherever, for inftance, a line or a point was to be
confidered, as fituated firft on the right hand, and then on the
left ; it would be neceffary, to find and to refolve a feparate equa-
tion for each of thefe cafes.   Thus, in the analyfis of any par-
ticular curve, it would be neceffary to have a feparate equation
for each of the four angles of the co-ordinates ; except, indeed,
the axes were fo chofen, as to make us certain that there were
fome of thefe angles, in which no part of the curve was to be
found.   Since, therefore, the ufe of negative quantities frees us
from this inconvenience, which, in many cafes, particularly in
the analyfis of curves, would be exceedingly perplexing ; and
fince it evidently affords fo great elegance and univerfality to
algebraical folutions ; to find our author gravely declaring that
he can fee no advantage in it, is perfectly aftonifhing : As it is
to be lamented, that he did not exert his induftry and ingenui-
ty, rather to confirm than to deftroy ; rather to demonftrate, how
far we might rely on the method of negative quantities, than
to overturn at once fo great a part of the labours of the modern
algebraifts.

. WHAT follows is an attempt to explain this fubject, without
confidering the negative fign in any other light, than as the fign
of fubtraction ; and without propofing any alteration in the
received fyftem of algebra.

* Differt. on the Neg. Sign, p. 34.

I. *Of*

I. *Of the Negative Roots of Equations.*

1. *Of Determinate Equations.*

IN the folution of problems by means of equations, the analyft fixes upon one or more quantities, by the determination of which all that is required may be known or performed. We fhall at prefent fuppofe that there is only one quantity to be determined. The problem fhews the conditions which are required of this quantity ; and thefe conditions, as far as they can be fo exprefled, are reduced to an equation of the common form,

$$L \ldots a + bx + cx^2 + \&c. = 0.$$

Here, according to the common method in the general notation of equations, the fign $+$ denotes, at pleafure, either the addition or fubtraction of the terms to which it is prefixed.

IN many cafes, nothing elfe is required, but to determine the *magnitude* of the quantity fought. There the pofitive roots alone can determine the magnitude ; fo that if the equation has no pofitive roots, or none which come within the limits of the problem, then the problem is impoffible.

BUT let the problem require us to determine, not only the different magnitudes of the line AB (x), but alfo, with refpect to each of thefe magnitudes, whether it lies on the right or left of the given point A. Here we fuppofe the problem to be fuch, that whether we reduce it to an equation, upon the fuppofition that AB lies to the right, or upon the fuppofition that it lies to the left, there is no circumftance, except only the oppofite fituation of AB, to make any difference in thefe equations.

IN this cafe, we make either fuppofition at pleafure ; as, for inftance, that it lies to the right ; and, on this fuppofition,

S   we

we exprefs the conditions required of AB in an equation, as,

$$L \ldots a + bx + cx^2 + \&c. = 0.$$

Then, in determining the magnitude of AB in this direction, the pofitive roots are to be employed.

Now, on the other fide of A, take MA, which we fhall denote by X; and let it be of any magnitude, not lefs than any of the negative roots of L. It is evident that L may be reduced to the form

$$M \ldots \left\{ \begin{array}{c} A \\ + BX + Bx \\ + CX^2 + 2CXx + Cx^2 \\ + \&c. \end{array} \right\} = 0.$$

And this again may be reduced to the form

$$N \ldots A + B(X+x) + C(X+x)^2 + \&c. = 0.$$

THE equation N, therefore, is another expreffion of the conditions required of x, upon the fuppofition that it lies to the right of A.

BUT if we make the contrary fuppofition, that AB lies to the left of A; then fince this is the only alteration in the conditions which the equation N requires of x; therefore, the conditions required of it, when it lies to the left of A, will be expreffed in the equation

$$N' \ldots A + B(X-x) + C(X-x)^2 + \&c. = 0.$$

Now, this equation may be reduced to the form

$$M' \ldots \left\{ \begin{array}{c} A \\ + BX - Bx \\ + CX^2 - 2CXx + Cx^2 \\ + \&c. \end{array} \right\} = 0.$$

By

By comparing this equation with *M* and *L*, it will be evident that it may be reduced to the form

$$L' \ldots a - bx + cx^2 - \&c. = 0.$$

This equation *L'*, therefore, expreſſes the conditions required of *AB*, when it lies to the left of *A* ; and, conſequently, the poſitive roots of *L'* determine the different magnitudes of *AB* in that ſituation.

But *L'* differs from *L*, only by having changed the ſigns of the terms involving the odd powers of *x*. Therefore *L* and *L'* have the ſame roots, except only that the poſitive roots of the one are the negative roots of the other.

Therefore, the negative roots of the equation *L*, to which the problem is reduced, upon the ſuppoſition that *AB* lies to the right of *A*, are the poſitive roots of the equation to which it would be reduced, upon the ſuppoſition that *AB* lies to the left of *A*. Therefore, theſe negative roots are the determinations of *AB* in this laſt ſituation.

Again : Let it be required to determine, not only the *diſtance* of time between a certain event and a given inſtant ; but alſo, whether the event happened *after* or *before* the given inſtant. Then reduce the problem to an equation, *L*, upon either ſuppoſition, as, for inſtance, that it happened after ; and by aſſuming *X*, a period of time immediately before the given inſtant, we can ſhew, as above, that the negative roots of *L* will be the determination of the epoch, when it happened before the given inſtant.

In like manner, let it be required to determine, not only the *momentum* of the force which acts in the right line *AB*, but alſo, whether it acts in the *direction AB*, $A \underline{\hspace{3cm}} B$ or in the direction *BA*. Then, if we reduce the problem to an equation, upon the ſuppoſition that it acts in the direction *AB*, we are to aſſume *X*, an additional force acting in the ſame direction.

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In like manner, let it be required to determine, not only the *value* of a certain fum of money, but alſo, whether it is part of a certain perſon's *ſtock*, or whether it is part of his *debts*. Then, if we reduce the problem to an equation, upon the ſuppoſition that it is part of his ſtock; we are to aſſume *X* a ſuppoſed additional quantity of ſtock.

There are caſes, therefore, where the quantity ſought is to be conſidered in two different ſituations, which may be repreſented by addition and ſubtraction from another aſſignable quantity of the ſame kind; and where there is nothing in the problem, except only this oppoſite ſituation, which can produce any difference in the equations to which it is reducible upon each ſuppoſition. From the preceding obſervations it will appear what may be underſtood by the negative roots, and how mathematicians are juſtified in the concluſions which they draw from them in ſuch caſes.

The negative roots are ſometimes alſo uſeful in the ſolution of problems relating to abſtract quantities. For the equation

$$L \ldots a + bx + cx^2 + \&c. = 0$$

has the ſame roots with the equation

$$L' \ldots a - bx + cx^2 - \&c. = 0;$$

except only that the negative roots of the one are the poſitive roots of the other. Wherever, therefore, any problem producing the equation *L*, is ſo connected with any other problem producing the equation *L'*, that they may be conſidered as different caſes of the ſame problem, or that the conſideration of the one ſuggeſts the other; there it is evident, that the negative roots will be uſeful, by affording, from either of theſe equations, the ſolution of both problems. Thus, the equation $x^2 + x = a$, gives us, not only the number, which, added to its ſquare, makes a ſum equal to *a*; but alſo, by the negative root, the

the number which, fubtracted from its fquare, leaves a remainder equal to *a*.

Wʜᴀᴛ has been faid is eafily applicable to thofe problems, where more than one quantity is to be determined.

2. *Of Indeterminate Equations.*

Iɴ problems which are folved by indeterminate equations, there is often nothing elfe required, but to determine the different *magnitudes* of one or more of the variable quantities, correfponding to any given magnitudes of the remaining variable quantities. There the pofitive roots alone can determine thefe correfponding magnitudes ; fo that if there be no pofitive roots, or none which come within the limits of the problem, then the problem is impoffible.

Bᴜᴛ let the problem require us to determine, not only the different correfponding magnitudes of the lines *AB* (*x*) and *BC* (*y*) ; but alfo, with refpect to each of the values of *x*, whether it lies to the *right* or *left* of the given point *A* ; and with refpect to each of the correfponding values of *y*, whether it is to be taken *above* or *below* the line *AB*. Here we fuppofe that, whether *AB* lies to the right or left, and whether the correfponding line *BC* is to be taken upwards or downwards, there is nothing, except only thefe oppofite fituations of *AB* and *BC*, to make any difference in the equations, to which the problem would be reduced upon each of thefe fuppofitions. Then, we make any of thefe fuppofitions at pleafure ; as for inftance, that *AB* lies to the right, and that *BC* lies above *AB* ; and on this fuppofition, we exprefs the conditions
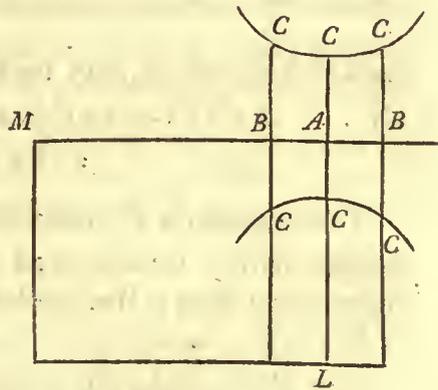
ditions required of thefe quantities in an equation of the common form, as,

$$L \ldots a + bx + cy + dx^2 + exy + fy^2 + \&c. = 0.$$

Then, in determining the correfponding magnitudes of AB and BC in thefe directions, the pofitive roots are to be employed.

Now, on the other fide of A, in the line AB, take MA, which we fhall denote by X, not lefs than any of the negative values of x; and in the line AC, below AB, take AL, which we fhall denote by Y, not lefs than any of the negative values of y. It is evident, that the equation L may be reduced to the form

$$M \ldots \left\{ \begin{array}{l} A \\ + BX \quad + Bx \\ + CY \quad + \ldots + Cy \\ + DX^2 + 2DXx + \ldots + Dx^2 \\ + EXY + EYx \quad + EXy + \ldots + Exy \\ + FY^2 \quad + \ldots + 2FYy + \ldots + \ldots + Fy^2 \\ \qquad\qquad\qquad\qquad + \&c. \end{array} \right\} = 0.$$

And this equation may be reduced to the form

$$N \ldots A + B(X+x) + C(Y+y) + D(X+x)^2 + E(X+x)(Y+y) + F(Y+y)^2 + \&c. = 0.$$

THIS equation N, therefore, is another expreffion of the conditions which are required of the variable quantities, upon the fuppofition that x lies to the right of A, and that y lies above AB.

BUT if we make the fuppofition that x lies ftill to the right of A, but that y lies below AB; then, fince this is the only alteration in the conditions which the equation N requires of x and y; therefore the conditions required of them, upon this new fuppofition, will be expreffed in the equation

$$N' \ldots A + B(X+x) + C(Y-y) + D(X+x)^2 + E(X+x)(Y-y) + F(Y-y)^2 + \&c. = 0.$$

Now,

Now, by reducing this equation to the form of M, and comparing it with L, it will be evident, that it is the same with the following equation ;

$$L' \ldots a + bx - cy + dx^2 - exy + fy^2 + \&c. = 0.$$

This equation L', therefore, expresses the conditions required of the variable quantities, when x lies to the right of A, and when y lies below AB. And, consequently, the corresponding positive roots of L' are the determinations of the corresponding magnitudes of AB and BC in this situation.

But L' differs from L, only by having changed the signs of the terms involving the odd powers of y. Therefore, L' and L have the same roots, except only that the positive values of y in the one, are its negative values in the other.

Therefore, in the equation L, the positive values of x, and the corresponding negative values of y, are the determinations of the corresponding magnitudes of AB and BC, when AB lies to the right of A, and when BC lies below AB.

In the same manner, it may be shewn, that the negative values of x, and the corresponding positive values of y, are the determinations of AB, BC, when AB lies to the left, and BC lies above AB.

And, *lastly*, That the corresponding negative values of x and y, are the determinations of AB, BC, when AB lies to the left, and BC lies below AB.

The observations which have been made under the head of determinate equations, are equally applicable to those which are indeterminate. And the foregoing demonstration may be easily extended to any number of indeterminate quantities.

II. *Of*

II. *Of the Negative Quantities which are not the Roots of the Equation.*

BESIDES the roots of the equation, or the quantities to be determined, problems frequently occur, which require us to confider fome of the *given* quantities, as capable, confiftently with the conditions of the problem, of exifting in one or other of two oppofite fituations, which may be reprefented by addition and fubtraction.

SUPPOSE, for inftance, that the given lines $AB = a$, $AC = b$, may be taken either on the right or left of the given point A; and let the problem be reduced to an equation, upon the fuppofition that they are each taken to the right. This equation, when ordered according to the powers of a and b, will be reprefented by the following general formula:
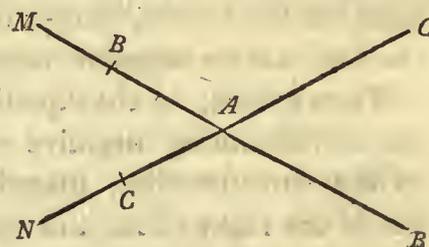
$$L \ldots p + qa + rb + sa^2 + tab + vb^2 + \&c. = 0.$$

IN the lines AB, AC, and on the left of the point A, take $AM = A$, $AN = B$, of any magnitudes, not lefs refpectively than a, b.

THEN the equation L may be reduced to the form,

$$M \ldots \left\{ \begin{array}{lllll} P & & & & \\ + QA & + Qa & & & \\ + RB & + \ldots & + Rb & & \\ + SA^2 & + 2SAa + & \ldots & + Sa^2 & \\ + TAB & + TBa & + TAb & + \ldots + Tab & \\ + VB^2 & + \ldots & + 2VBb + & \ldots + & \ldots + Vb^2 \\ & & & + \&c. & \end{array} \right\} = 0.$$

And

And this again is reducible to the form,

$$N \ldots P + \mathcal{Q}(A+a) + R(B+b) + S(A+a)^2 + T(A+a)(B+b) + V(B+b)^2 + \&c. = 0.$$

THIS equation, therefore, is another expreſſion of the conditions of the problem, upon the ſuppoſition that *AB*, *AC* are taken to the right of *A*.

Now, by reaſoning in the very ſame manner as before, it is evident, that when *AB* or *AC* is taken to the left, the conditions of the problem will ſtill be expreſſed by an equation, which will, in all reſpects, be the ſame with *L*, except only, that the quantity which has changed its ſituation, will change its ſign.

FROM the whole, the two following concluſions ſeem to be demonſtrated.

1. WHERE the problem allows us to conſider *x*, any of the unknown or indeterminate quantities, as capable of exiſting in two oppoſite ſituations, which may be repreſented by addition and ſubtraction ; then the equation, which expreſſes the conditions required of *x* in one of theſe ſituations, and whoſe poſitive roots determine the magnitudes of *x* in thât ſituation ; the ſame equation, by its negative roots, will determine the magnitudes of *x* in the oppoſite ſituation.

2. WHERE the problem allows us to conſider *a*, any of the given quantities, as capable of exiſting in two ſuch oppoſite ſituations ; then the equation which expreſſes the conditions of the problem, upon the ſuppoſition that *a* is in one of theſe ſituations, will be reduced to the equation expreſſing the conditions of the problem on the contrary ſuppoſition ; by ſimply changing the ſign of *a*, or, in other words, the ſign of the terms involving the odd powers of *a*.

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V.

V. Experiments *and* Observations *upon a* Remark-able Cold *which accompanies the* Separation *of* Hoar-Frost *from a* Clear Air. *By* Patrick Wilson, *M. A. F. R. S.* Edin. *and Professor of Astronomy in the University of* Glasgow.

[*Communicated by* Dr Black; *and read by* Dr Walker, *Secretary,* July 5. 1784.]

SECT. I.

Macfarlane *Observatory, Glasgow College, Feb.* 14. 1784.

IN the seventieth and seventy-first volumes of the London Philosophical Transactions, the reader will find an account of some Experiments and Observations made here upon cold in the years 1780 and 1781.

Though, at first, I had no other view but that of keeping a register of the very cold weather which set in on the 13th January 1780, yet I was soon led to extend the plan of my observations, upon meeting with a new phænomenon, which appeared to me to deserve some attention. This phænomenon consisted in a constant difference of temperature of the snow which, at that time, covered the fields, and that of the air at a few feet above: the snow being the coldest.

Having, by careful and repeated trials, fully assured myself of the fact, I was insensibly drawn to form some conjectures as to the cause. The most obvious suggestion was, that such an excess of cold depended upon an evaporation from the snow; especially when it was considered, that this substance, from its

spongy

spongy and flaky contexture, muft expofe a vaft quantity of fur-face to the action of the external air.

This view of the matter appeared to me ftill more probable, from having formerly been witnefs to a very quick evaporation of icy films from the furface of polifhed metal at very low tem-peratures ; and from other experiments, demonftrating the ac-tual evaporation of ice, of which I had read an account in the French Memoirs.

Having always been a great admirer of Dr Black's Philo-fophy, in regard to heat and cold, and confidering the prefent phænomenon as an immediate confequence of his law of eva-poration, I refolved to attend to it further, in all its circum-ftances, from a defire of extending a little the boundaries of that induction which, in his hands, has been fo fertile in gene-ral principles of fo much importance.

In the two papers above quoted may be feen by what fteps, as opportunities offered, I followed out this defign, and how very early I was perplexed by facts which feemed ftrongly to evince, that no evaporation whatever was going on when the excefs of cold, at the furface of the fnow, was perceivable. On the contrary, the further the experiments were pufhed, the ftronger were the prefumptions, that the air, fo far from ab-forbing from the fnow, or wafting it by evaporation, was all the while depofiting hoar-froft profufely upon its furface, as well as upon all other bodies with which it had a free commu-nication.

The following extract from the paper of the year 1780, will fet this in a ftrong light, and will fhow, how far my firft im-preffions were obliged to yield to the authority of facts.

" On Sunday night, January 23. 1780, feveral things were " laid out at the Obfervatory, fuch as fheets of brown paper, " pieces of boards, plates of metal, glaffes of feveral kinds, " &c. which all began to attract hoar-froft, feemingly as foon " as they had time to cool down to the temperature of the air.

T 2   " The

" The fheets of paper, being thin and eafily cooled, acquired
" it fooneft, and, when beheld by candle-light, were beauti-
" fully fpangled over by innumerable reflexions from the mi-
" nute cryftals of hoar-froft which had parted from the air.

" Evident fymptoms of the fame difpofition of the air to
" depofit hoar-froft occurred on all the former nights of ob-
" ferving, and the tubes of the thermometers were fo much
" crufted with it, that it required fome attention to keep that
" part which correfponded to the fcale quite free." At the end
of faid paper is the following fcholium :

" These experiments, indeed, rather favour the opinion of
" the excefs of cold at prefent treated of, depending upon a
" principle the very reverfe of evaporation. But till opportu-
" nities offer, in this, or in a colder climate, of making more
" experiments, it will be too early to fay any thing very de-
" cided concerning the nature and extent of a cooling procefs
" which has fo recently come under obfervation. All that can at
" prefent be affirmed is, that, in certain circumftances, fuch a
" procefs takes place ; and that it depends probably upon fome
" principles different from evaporation. At the fame time, fome
" of the experiments fhow, that a free communication betwixt
" the fnow and external air, perhaps whilft in motion, is ne-
" ceffary ; but in what manner this promotes the refrigeration
" does not as yet appear."

The experiments gone through this firft feafon, rendering it
fo difficult to account for the phænomenon by an evaporation
from the fnow, the next ftep was, to comprehend, if poffible,
by what other means fuch a cooling procefs could be maintain-
ed, confiftently with thofe general principles which were al-
ready known to have a real exiftence ; and to this point, I con-
fefs, I frequently turned my thoughts, from a fufpicion of there
being fomething fingular and undifcovered at bottom.

Accordingly, before the return of the fucceeding winter,
feveral views occurred, concerning which it was propofed to
make

make an appeal to experiment as foon as the froft fhould afford an opportunity.

FIRST of all, it did not feem impoffible, that the air, in fuch low temperatures, might impart fome faline ingredient to the fnow, along with the hoar-froft it fo freely depofited ; and, by that means, produce a conftant liquefaction at the furface, which, though very inconfiderable, might be fufficient to prevent the fnow from acquiring the warmth of the higher air. I was led to this random fufpicion, by having obferved that fnow, after lying for fome time on the ground, acquired a certain degree of firmnefs at the furface, as if the parts there had caked together by the gradual intervention of fome fluid medium ; and this, too, in cafes where fuch an effect feemed not to depend upon the influence of the fun in the day-time.

IT was imagined alfo, that, in fevere froft, the fnow fpread abroad upon the face of a country might poffefs a power of depurating the atmofphere from any phlogiftic taint ; and thus, according to fome late difcoveries of my very ingenious friend Dr CRAWFORD, there would be a conftant production of cold, by the air in contact with the fnow, abforbing fenfible heat, as it was gradually fo purified.

THAT property of ice, mentioned by MAIRAN, of expanding in volume whilft expofed to the action of a fharp and increafing froft, joined to the prefumption from analogy, that bodies, when fo expanding, muft become colder by an increafed capacity for heat, feemed alfo, in fome meafure, applicable to the prefent difficulty.

ONE other conjecture was, that the hoar-froft, in the act of feparating from the air, and forming upon the fnow, might affume fome particular arrangement, favourable to a fudden increafe of its capacity for retaining heat, and thereby give rife to a continual abforption of it ; and, of courfe, to a cooling procefs.

THESE,

THESE, and such like, were the surmises which offered themselves previous to my entering upon the subject for the second time, and which I was desirous to bring to the test of experiment, not without some hopes of being able to account for the phænomenon in question, by principles already known and familiar to us. This attempt, however, ended very unsuccessfully, as may be seen by the account given in my paper for the year 1781. Indeed, neither the weather, nor other hinderances, then admitted of pursuing the experiments far; though still enough was accomplished to show something anomalous and obscure in regard to the cause sought after.

IN this state, the subject lay by till the commencement of the late rigorous season, when, having occasion to be frequently at the Observatory at late hours, on account of the approach of the Georgium Sidus to its opposition, I was again led to resume the experiments upon cold.

IN order to proceed with more certainty and expedition, I had now ready a set of ticklish thermometers, with naked balls and slender ivory scales, and all very nearly agreeing, as to their dimensions and distance betwixt the fixed points. These thermometers, upon which I set a high value, were the last my father ever constructed; and for which he selected very exact capillary tubes, having their bores, according to his improved method, so much of a flattened oval form, as to present a very obvious broad pillar of quicksilver upon the scale, notwithstanding the smallness of the balls; a property highly convenient, especially when nice experiments are to be carried on by candle-light, and in the open frosty air.

MY father's state of health not permitting him to encounter the inclemency of the weather in such night-observations, my first object was, a repetition of several of the experiments formerly made, before proceeding to others, which, by this time, had been planned with a view of carrying forward the enquiry.

DECEMBER

DECEMBER 28. 1783.

ACCORDINGLY, this night, betwixt ten and eleven o'clock, one of the thermometers was expofed to the free air in the Obfervatory-park, four feet from the ground, and at a confiderable diftance to windward of the houfe. To an arm which projected from a flender frame of wood, the thermometer was fo applied, as to prefent itfelf floping, not far from a horizontal pofition, for the greater convenience of quickly reading off the degrees. Near by the frame, another thermometer was laid down upon the furface of the fnow, which covered the ground to a confiderable depth. At this time, the heavens were very clear all around, and the motion of the air from the eaft, fo foft as only to bend a little the flame of the candle, when fteadily held out.

AT eleven o'clock, the thermometer in air pointed to + 5, and the one upon the fnow to — 7, the difference being twelve degrees. Half an hour after, they pointed to + 4 and — 7 ; and every thing wore the appearance of a fine fettled frofty night.

I NOW returned to the Obfervatory to attend to fome aftronomical bufinefs. After lighting up the tranfit-room, I fet the meridian telefcope to the altitude of a ftar, which preceded the planet in right afcenfion, and which was very foon to pafs the mid wire at a certain fecond by the clock. When the time drew near, I looked for it in the field of view without finding it. Having glanced at the index to be certain that the inftrument was rightly directed, I looked for the ftar again, but could perceive nothing. Stepping now forward, and turning my back towards the candles, the better to behold the heavens through the tranfverfe flit in the roof, I immediately difcovered, that the ftar-light there was wholly gone. This was quite unexpected, as about five or fix minutes before, the heavens,

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when feen through the fame opening, promifed a very good ob-
fervation.

UPON going abroad, I found the face of things entirely
changed, the heavens being now overcaft, not however by
clouds, but by a thick uniform haze or fogginefs above, which
obfcured even the ftars of the firft magnitude. Being now
out of doors, I thought of vifiting the thermometers; and,
upon approaching them with fome caution, I found, not with-
out furprife, that the excefs of cold, at the furface of the fnow,
had almoft quite vanifhed. The thermometer in air pointed to
+6, two degrees higher than before, and the one upon the
fnow to + 4 : This was at fifty minutes paft eleven. Till half
paft twelve the fogginefs above continued rather to increafe,
when both thermometers pointed exactly to the fame degree
+ 7 ; which, at fo low a temperature, and from the fuddennefs
of the change, I could not help regarding as very remarkable,
efpecially as nothing fimilar to this had occurred in my former
obfervations.

By half an hour after one in the morning, the ftars be-
gan again to fhine out; when now I was amufed to find the
excefs of cold at the furface of the fnow returning. The air,
by this time, was + 8, and the fnow + 4. As the morning ad-
vanced, the atmofphere turned more and more ferene, and the
thermometers came to differ no lefs than eight degrees. The
obfervations made at this time are fet down in the following
regifter :

DECEMBER

DECEMBER 28. 1783, at night.			Air.	Snow upon the ground.
11		o'clock, Quite clear, -	+ 5	— 7
11	3'0	Ditto, - -	+ 4	— 7
11	5'0	Overcaft, -	+ 6	+ 4
12	3'0	More overcaft, -	+ 7	+ 7
		Morning.		
1	3'0	Turning a good deal clearer,	+ 8	+ 4
1	4'5	Still more fo, -	+ 8	+ 2
2	2'0	Clear every where, except an ill defined cloud in N. E.	+ 9	+ 4
3		Ditto, except a fmall ill defined cloud near zenith, -	+11	+ 3
3	4'5	Very clear, except fome better defined clouds near horizon, from N. to N. E. -	+12	+ 4

DECEMBER 29. 1783.

FROM fun-fetting till paft ten o'clock this night, the heavens were fometimes clear and fometimes overcaft, which induced me to go to the Obfervatory in hopes of feeing the planet, and of tracing farther the effects of fuch a fluctuation of the atmofphere upon the thermometers. On my way, I was overtaken by a low fog or mift, and the thermometers being immediately expofed, as before pointed, as follows :

DECEMBER 29. 1783, at night.			Air.	Snow upon the ground.
11	2'0	- - -	+11	+ 3
11	3'0	Mift increafing, and very thick,	+12	+ 9
11	4'5	Ditto, - - -	+12	+10
12	1'0	Ditto, - -	+12	+10
12	1'5	Still very thick, -	+12	+12

U   DECEMBER

DECEMBER 30. 1783.

THIS night the thermometers were affected ſtill more remarkably by the viciſſitudes of the atmoſphere, the ſnow not only acquiring the ſame temperature as the air, when the heavens were overcaſt, but thereupon becoming conſiderably warmer. This ſingular reverſe will be found in the following regiſter:

		DECEMBER 30. 1783, at night.	AIR.	SNOW upon the ground.
7		o'clock, Clear all over, -	— 1	— 9
9		Ditto, wind gentle E. -	— 4	— 12
10		Ditto, - -	— 4	— 12
11	2′0	Wind a little before this ſhifted from E. and E. by N. to S. and now ſome clouds in S. W.	— 1	— 8
11	3′5	Cloudy all over, wind S. S. W. blowing out the candles,	0	+ 4
12		Ditto, -	0	+ 4
12	3′0	No intervals of ſky, but a general uniform cloudineſs which hid all the ſtars, -	+ 1	+ 4
		Morning.		
1	3′0	Ditto, - -	+ 3	+ 9
2		Particles of ſnow beginning to fall, -	+ 6	+ 10
2	3′0	Ditto, - -	+ 6	+ 10
3	3′0	More ſnow falling than before,	+ 10	+ 14

THE ſnow ſcale, expoſed from nine o'clock till eleven o'clock and twenty minutes, gained two-tenths of an ounce of weight. THE ſame, when expoſed from the time laſt mentioned till half paſt one in the morning, loſt .07 of an ounce.

WITH

WITH a view to some more exact statical experiments than those made in the year 1781, I had now prepared a flat circular scale, made of white iron, two feet in diameter, and turned up at the circumference about half an inch. In place of cords for hanging it to the balance, it was found more commodious to substitute pretty strong wires, by which the scale could be lifted up and set down, and carried backwards and forwards, without ever interfering with the snow upon its surface, as sometimes was the case when cords were used on former occasions. This scale was covered with snow quite to the brim, and, when cooled in the open air, it was applied to a good balance, and exactly counterpoised, by adding at last to the opposite scale very small drops of lead-shot. That no part of the external surface of the scale might communicate with the air, it was placed upon a round board, which had in it a circular space, just deep enough to receive the scale up to the brim. In this state, where nothing, therefore, but the snow which covered it communicated with the air, it was exposed abroad four feet from the ground upon a small table, at nine o'clock.

NOT only by repeated trials of the weight of this scale, but also by close inspection by candle-light, I wanted to determine at what times the air was depositing hoar-frost, or taking the same up in the way of evaporation; and particularly to mark the connection betwixt these contrary states of the air in the lower regions and a serene or clouded atmosphere, upon which last the variable temperature at the surface of the snow seemed so immediately to depend.

FOR this purpose, besides the snow-scale, there were exposed a variety of bodies, such as glass, metal plates, sheets of dark coloured paper, a plank of wood, china, &c.

UPON frequently examining all these bodies by candle-light, from nine o'clock till twenty minutes past eleven, it was quite manifest, that they were drawing hoar-frost from the air, and in the same order as is mentioned in the quotation from the ex-

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periments

periments made in the year 1780, except in one inftance, which fhall be particularly taken notice of in the fequel. Agreeably to this, it was found alfo, that the fnow-fcale was all the while gaining weight, as marked in the foregoing regifter. From the regifter alfo, it is manifeft, that this depofition of hoar-froft took place whilft the air was ferene, and whilft there was an excefs of cold at the furface of the fnow.

FROM twenty minutes after eleven till half an hour paft one in the morning, there were very plain indications of all thefe fubftances furrendering to the air, though indeed flowly, the hoar-froft which had been before imparted to them ; whilft the fnow-fcale, as is marked in the regifter, was lofing weight. From the regifter it alfo appears, that all this happened when the heavens were overcaft, and when the fnow upon the ground was of a higher temperature than the air.

DURING moft part of the winter, the atmofphere was extremely liable to change from a ferene to a foggy or clouded ftate, and *vice verfa*. Thefe alternations affecting the cooling procefs at the furface of the fnow, in fo particular a manner, I was frequently led to repeat the obfervations and ftatical experiments which have juft now been defcribed, without meeting with any difference in the circumftances worthy of being mentioned. The phænomena of the nights of December 28. and 30. occurred frequently afterwards in the fame order, but particularly in the night of January 25. when the heavens were overcaft three times, and turned twice clear in the fpace of fix hours.

R E M A R K S.

FROM the foregoing regifters, obfervations, and experiments; as alfo from thofe of the years 1780 and 1781, it feems evident, that the fnow continued colder than the air four feet above it, only fo long as it was attracting hoar-froft at its furface ; and that whenever this attraction ceafed, and even when it was fol-

lowed

lowed by a flow evaporation, the snow turned quickly as warm and sometimes warmer than the air.

How difficult soever it may be, upon known principles, to account for the connection between the excess of cold at the surface of the snow and its attracting hoar-frost, it is yet easy to understand how the snow may become as warm or warmer than the air above, notwithstanding an evaporation takes place. For though, from Dr_ Black's general laws, a certain waste or absorption of sensible heat must thereby infallibly ensue, it is evident, that a much drier state of the air, and a much more rapid evaporation, may be necessary to prevent the uppermost stratum of snow from being heated by the much warmer snow immediately beneath : For, on December 30. when the frost was very intense, the snow was so warm as + 24, at a little more than three inches below the surface. And this I take to be the reason why the excess of cold, at the surface of the snow, so readily disappears when the attraction of hoar-frost is suspended, and, along with it, that active cooling process which seems, some how or other, to be its concomitant.

When the atmosphere, after having been, for some time, very serene, becomes suddenly clouded, it is certain also, that this change must be attended with the extrication of much sensible heat in the higher regions, where those vapours are congregated. A store of heat, so produced, must soon affect the mass of air which lies below. It is well known also, that the lower air, thus rising in its temperature, will be less disposed than before to give out any matter in the form of hoar-frost, or may be even enabled to absorb this from the surface of the snow, and of other bodies, in the way of evaporation. Hence may be understood, how, upon the sudden formation of clouds or fog, the thermometer, exposed to the air, always rose some degrees ; and how, in consequence of this increase of temperature, the snow-scale, and other bodies, no longer attracted any hoar-frost ; and, finally, how the excess of cold at the sur-

face

face of the fnow, confidered as a phænomenon, either wholly or in a great meafure depending upon a conftant attraction of hoar-froft, always vanifhed when the heavens were overcaft, or when any fog or hazinefs interrupted the clearnefs of the lower air.

THERE is, however, one circumftance to be found in the regifter of December 28. which feems repugnant to the explanations that have now been attempted. From midnight till near four o'clock that morning, the air continued to rife in its temperature, and at fuch a rate as feems incompatible with the conftant giving out of hoar-froft, and with the correfponding excefs of cold, which took place at the furface of the fnow, unlefs we fuppofe, that the warmer air, which fucceffively arrived at the place of obfervation, was, at the fame time, more and more charged with vapours, for which, it muft be confeffed, we have very little or no evidence.

A DIFFICULTY of this kind coming in the way of our general reafonings upon fuch phænomena, rather leads to a fufpicion of there being fome other principles concerned, which as yet may have altogether efcaped obfervation. I have been the more inclined to harbour fuch a fufpicion, fince reading lately in the Berlin Memoirs for 1780, a Differtation by M. ACHARD upon the difpofition of the air to fhed night-dew, in which there are fome curious remarks. It is much to our purpofe here to take notice, that this author mentions particularly the fudden overcafting of a ferene fky, as having frequently come under his obfervation; and that it was always accompanied with moft fenfible and defultory changes in the electricity of the lower air. The fcope of M. ACHARD's Memoir, is, to fhow how much electricity is concerned in the phænomena of the atmofphere, and how neceffary it is, in all our meteorological refearches, to have refpect to the operations and effects of fuch a principle. According to this author, the different difpofitions of the air, as to giving out and taking in moifture,

moisture, depend much upon its state of electricity. It might, therefore, be much worth while to examine experimentally, how far the same principles may co-operate with the more general causes above assigned, in regulating the affinity betwixt the air and the hoar-frost dissolved in it; and how far the like phænomenon of cold may take place upon the separation of night-dew from a clear air in milder seasons.

If the watery principle, when united to the air in a warm as well as in a very cold temperature, existed in the state of vapour, or under any other form and constitution similar in both cases, one should expect some difference in the phænomena, when, in the first case, it is yielded to bodies in the form of moisture, and, in the last, in the form of hoar-frost; because we are certain, from Dr BLACK's discoveries, that the same quantity of the same kind of matter under the one and the other of these two forms, contains a very different quantity of absolute heat.

UPON the present supposition, therefore, if it should be found, that the cold produced when bodies attract moisture from the air, is no greater than what is produced when they attract hoar-frost, this would amount to a proof, that the cooling process is much more active in the last case than in the first; or, in other words, that the waste of sensible heat, effected by the unknown cause, is much greater, in the act of separation, when the air deposits hoar-frost, than when it deposits moisture.

S E C T. II.

HAVING now been assured, by so many arguments drawn from experiment, that the excess of cold at the snow had a constant dependence upon its attracting hoar-frost from the air, I was next desirous of learning, whether an equal degree of cold would obtain when the hoar-frost was attracted by substances of a similar loose contexture.

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THE iſſue of experiments, made with this view, ſeemed to offer an alternative, according to which any farther reſearches might be conducted to greater advantage: For as yet, I was uncertain, whether ſo anomalous a phænomenon originated from ſome property of ſnow in relation to the air at the time of giving out its hoar-froſt, or whether it depended upon the mere ſeparation of hoar-froſt from the air, by that affinity which bodies in general have to hoar-froſt. I accordingly began with the following trial:

JANUARY 24. 1784.

THIS night, the heavens being very ſerene, and the wind coming gently from the eaſt, and every thing without doors greedily attracting hoar-froſt, the ſnow-ſcale, formerly mentioned, was expoſed upon a long frame, four feet high. Towards the other end of the frame, I placed a circular board, of the ſame diameter, covered with fine flinty ſand, free of duſt, much like that made uſe of for ſand-glaſſes. A thermometer was laid upon the ſnow in the ſcale, and another upon the ſand, with their naked balls, within a few inches of the moſt leeward ſide. A foot to windward, and at an equal diſtance from the ſcale and board, and even with their ſurface, another thermometer was expoſed to the air. After waiting a conſiderable time, with ſome curioſity, to know the iſſue of this experiment, I returned to view the apparatus at half an hour after ten o'clock, when, at once, I found reaſon entirely to relinquiſh all my former conjectures, by which, I thought, I might poſſibly account for the phænomenon, by ſome properties peculiar to ſnow: For now I ſaw diſtinctly, that the exceſs of cold was moſt remarkable at the ſurface of the ſand. At this time, the thermometer expoſed to the air, which afterwards ſweeped the apparatus, pointed to + 14, whilſt the one upon the ſnow pointed to + 10, and that upon the ſand to + 8. I continued to obſerve till half an hour after one in the morning; and

and that upon the fand to + 8. I continued to obferve till half an hour after one in the morning; and the following regifter fhows how the thermometers pointed according to their feveral fituations:

Jan. 24. 1784, at night.	Air.	Snow-fcale.	Sand-board.	Snow upon the ground.
10 30′ o'clock,	+14	+10	+8	
11 15′ -	13	10	8	
11 20′ - -	11	8½	6½	+5
11 40′ -	12	8½	7	
11 55′ - -	10	7½	6	6
12 45′ -	12	9	7	
1 30′ - -	12	10	8	6

By examining the thermometers fo frequently I had occafion to remark, that the balls and ftems of the two which lay upon the fnow and fand were crufted with hoar-froft much fooner than the other which was to windward in the air. The one upon the fand contracted hoar-froft the fooneft, and, what at the time I thought ftrange, more early than the fourth thermometer which I had laid down upon the fnow at the ground. In regard to the thermometer in air, I fhould rather think it attracted no hoar-froft whatever, properly fpeaking, and that what was difcernible upon it proceeded from accidental minute floating particles which clung to the glafs, and afterwards entangled more of the fame kind: For the ball of this thermometer was not, like the one belonging to the fand, crufted over with an uniform dead filver whitenefs, but was befet with a number of fmall tufts or prickles of the hoar-froft, whilft the intervals of glafs between them were entirely clear.

With a view to a repetition of the ftatical experiment, I had carefully afcertained the weight of the fnow-fcale and fand-

X   board

board immediately before I firſt ſet them out; and after they
had remained abroad from forty-five minutes paſt nine till near
two o'clock in the morning, they were again weighed, when
the ſand had gained four-tenths of an ounce, and the ſnow
very nearly three-tenths.

A LITTLE after midnight, a thin circular board, which had
been previouſly cooled, was put over the ſand, and ſupported
at the diſtance of about an inch and a half above the ſurface.
After ſeventeen minutes, it was removed, when the thermome-
ter on the ſand pointed lower than the one in air by only two
degrees; and probably, for the greateſt part of this interval,
the cooling proceſs had abated.

IN a letter with which I had been favoured this day from Dr
BLACK, by whoſe correſpondence upon this ſubject I think
myſelf highly honoured and obliged, there was ſuggeſted an
experiment with gauze to be laid over the thermometer, which
was accordingly tried. For this purpoſe, I faſtened with pack-
thread a piece of open gauze to a hoop of eight inches diameter
and an inch deep; and, when the thermometers were ſheltered
in this manner, the quickſilver commonly roſe nearly two
degrees.

JANUARY 26. 1784.

HAVING now found, that the ſand was more efficacious than
the ſnow in promoting this ſingular kind of refrigeration, I
this night repeated the laſt experiment with fine powder of
wood charcoal, the looſe ſhavings of braſs gathered from a
turner's lath, a friable amalgam of quickſilver and tin, the
ſand and the ſnow, to ſee if there would be any remarkable
difference in the cold produced by ſubſtances differing ſo much
in their nature and denſity. The apparatus conſiſted of circu-
lar boards, two feet in diameter, which I ranged in order upon
a long ſlender frame, ſet at right angles to the direction of any
air that was ſtirring. I then covered them with the various

materials

materials I had collected, and laid a thermometer upon each, near the leeward fide, as ufual.

THE refult was, that all, except the fnow, kept nearly of the fame temperature, full fix degrees below that of the air, at the fame height, and immediately to windward, which then was + 12. The fand feemed rather the coldeft, and the fnow obvioufly neareft to the heat of the air.

IN the mean time, the feparation of hoar-froft from the air was very manifeft. It was moft difcernible to the fight upon the fand and charcoal duft, though the manner of attaching itfelf to thefe fubftances was very different. On the fand, it fhowed itfelf by making the furface all over fparkle with an infinity of minute bright points, whilft, on the charcoal duft, it fettled without fuch contiguity, and formed into many broken filaments, of a dull hue, which here and there lay cluftered as if aiming at fome ftellated arrangement.

THE prefent experiment was made about midnight, when the heavens were very clear, and the wind at eaft and one point fouth, and fo brifk as to trail horizontally the flame of the candle till it fometimes went out. Now and then this gentle current came fuddenly ftraight downwards for a few feconds, as was apparent from the manner in which it affected the flame of the candle.

So long as I was employed abroad at this time, there was no fluctuation in the ftate of the atmofphere, nor any alternation in the cooling procefs. Laft night, however, the cafe was very different, as has been already mentioned. The experiments then made were chiefly with the fnow-fcale and fand-board. When the heavens were overcaft, both foon acquired the temperature of the air, which then was very ftill. It was found, too, by ftatical experiments, that the fand acquired an addition to its weight, when it happened to be for fome length of time colder than the air; but when the cooling procefs was interrupted, and the fand continued for fome time of the fame tem-

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perature

perature as the air, the scale gradually became lighter, though in a small degree.

R E M A R K S.

In estimating the degree of refrigeration at the surfaces of the various substances upon the board, the thermometers were always laid down at the leeward side, as has been so frequently mentioned. This was soon found to be a necessary precaution; for, when exposed in any other situation, the cold shown was less considerable. I was, indeed, led very early to suspect such a result, upon considering, that this very cold air, though prone to give out hoar-frost, might not all at once be disposed to part with what was redundant, though solicited by bodies capable of receiving it. The consequence of this seemed to be, that any given portion of this very cold air, in flitting slowly over the sand, &c. would part with more and more hoar-frost, and, on that account, become colder and colder, so as to be coldest of all near the leeward side ; or, in other words, would be thrown into a *fit of continual refrigeration* in its passage over the boards, which circumstance was found to be agreeable to experience.

This fact, therefore, seems very consonant to all the rest, as indicating, in another way, the relation between the separation of hoar-frost from the air, and the apparent waste of sensible heat. Having brought this topic into view, it may perhaps be worth while to pursue it, for a moment, a little farther.

It has been already observed, that the thermometer upon the sand-scale was much sooner crusted over with hoar-frost than the one in air to windward. This, indeed, is what might have been expected, on account of the last of these two situations being the warmest. But as the thermometer upon the snow at the ground was always colder, than that upon the sand, it does not so readily appear, how this last should have attracted hoar-frost sooner than the first. This fact seems to show, that any

portion

portion of air, by being thrown into a fit of continual refrige-
ration, by the action of the furface over which it travels, is,
upon its arrival at the leeward fide, and during the fit, difpofed
to part with a greater quantity of hoar-froft in a given time,
than what otherwife it would do, even though equally cold.
According to this idea, were the furface fo much extended as
to bring the fit of refrigeration to a maximum, and fo put an
end to it, before the arrival of the air at the leeward fide, a
body at this leeward fide would acquire hoar-froft more flowly
than another lying fomewhat more to windward, to which the
air can reach whilft in the fit of cooling. Thus, therefore, in
regard to the greater part of the air, which fweeps the endlefs
continuous furface of the fnow upon the ground, we may con-
ceive the fit of refrigeration as confummated; on which ac-
count, it will be lefs difpofed than that which croffes the fand
upon the fcale to give out its hoar-froft: And, in this way, the
fact under confideration may be accounted for.

FROM a defire of making fome more formal experiments
upon the air whilft in this progrefs of cooling, by the action
of furfaces expofed to it, I provided a wooden canal, fifteen feet
long, a foot wide, and fifteen inches deep. This canal, open
at both ends, and with its bottom covered with the fine fand,
I intended to have expofed on fome favourable night for the
frofty air to glide along it; and by thermometers placed at cer-
tain intervals, as well as plates of metal, &c. which I could
bring to the teft of a balance, to have determined the greateft
degree of cold, and the rate of cooling, and of giving out hoar-
froft, from the windward to the leeward end: But before I
could conveniently enter upon this experiment, I was ftopped
by the thaw. Perhaps a platform of deals laid clofe to one
another, and covered with fand, would be a much better appa-
ratus; as the more a furface, defigned for fuch a purpofe, is ex-
tended in breadth, the warmer air would the lefs readily flow
in fidewife, fo as to mar the effect produced by the flow cur-
rent:

rent advancing to leeward. It would not be wonderful, though fomewhere upon an elevated and detached platform of this kind, we fhould find an *artificial cold* greater than what prevails at the fame time on the fnow at the ground; as the warmer fnow, which lies immediately beneath, at leaft for the moft part, muft more or lefs counteract the cooling procefs kept up there.

But to return from this digreffion, I now come to relate the moft ftriking experiment I had an opportunity of making this winter, during the time I was occupied in fuch cold vigils.

In fome of the fereneft and ftilleft nights, having frequently amufed myfelf by attending to the capricious arrangement of the hoar-froft as it fettled upon different bodies, I was led to remark, that quickfilver was a long while of attracting any, and even at laft fparingly, and chiefly at thofe places of its furface which were fullied by a dufty film. This naturally fuggefted a comparifon of quickfilver and the fand, as to their powers of contributing to the cooling procefs at their furface.

For the apparatus, I borrowed from a cabinet-maker two mahogany tea-trays, of an oval form, twenty-two inches by feventeen, and near an inch deep, infide meafure.

January 29. 1784.

About nine o'clock at night, I placed them out in the park upon a flight plane-tree table, about a foot afunder, and with their longer axes pointing to windward. After levelling one of the trays, its bottom was completely flooded over with quickfilver, to the amount of twenty-four pounds weight, which Meffrs Hill and Monteath, furgeons and druggifts here, moft obligingly lent me for that purpofe. The bottom of the other tray was covered to the depth of a quarter of an inch with the fine flinty fand. Upon each of the furfaces of the fand and of the quickfilver, I laid down a thermometer, with the ball near to the leeward end as ufual, and expofed a third

to

to the air, about a foot to windward, and even with the trays.
I then left them for an hour to cool; after which I continued
to obferve them now and then for two hours more. During all
this time, I found, that the thermometer placed upon the
quickfilver continually pointed higher than the other upon the
fand, as fet down in the following regifter:

Jan. 29. 1784. at night.	Air.	Tray with quickfilver.	Tray with fand.	Excefs of cold on the quickfilver.	Ditto on the fand.
10. o'clock,	+4	+3	— 1	1	5
10 30′ -	+3	+2	— 1	1	4
11 -	+3	+2	— $1\frac{1}{2}$	1	$4\frac{1}{2}$
11 30′ -	+3	+ $1\frac{1}{2}$	— $1\frac{1}{2}$	$1\frac{1}{2}$	$4\frac{1}{2}$
12 -	+4	+2	0	2	4

To make fure of every thing in this experiment, efpecially
as the extremes of temperature were but inconfiderable, I fome-
times changed the thermometers, and fhifted the fand-tray
from the right to the left fide of the other, without at all alter-
ing the report. Whilft this experiment was going forward, I
difcerned plainly all the common fymptoms of the hoar-froft
joining the fand, and fettling upon the infide and outfide wood
of both trays. Though at length, fome made its appearance
upon the face of the quickfilver, yet I am apt to think, that
the cold generated all around by the hoar-froft which attached
itfelf to the wood, was the chief caufe of the quickfilver keep-
ing below the temperature of the air to windward.

IT afterwards occurred to me, that, in this experiment, it
would have been proper to have filled the tray with quickfilver
to the very brim, and to have defended the outfide wood from
the air by fome rare fubftance. Had things been fo managed,
and the other tray completely filled alfo with fand, and defended
in the fame manner, I am perfuaded the refult would have been
more remarkable; and that the quickfilver, thus expofed with
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an unfullied face, would have kept as warm as the air to wind-ward, how much foever the fand might have been colder.

BUT taking the refult of this experiment as we found it, we may fafely regard it as an inftance of what may be called the fame volume of air in one part, laying down its vapour in the form of hoar-froft, and in another, paffing away without fuch a decompofition taking place. In the former cafe, we accordingly found the correfponding cold produced, but very fmall indications of any fuch thing in the latter.

As quickfilver thus refifts the hoar-froft, fo may fome other fubftances; and, on the contrary, there may be fome much more fitted than others to promote this fort of decompofition of the air in low temperatures. But this fuggefts a variety of experiments which I have had no opportunity of purfuing. Certain late appearances have made me think of trying a broad furface, made up of a combination of wool-cards, having obferved fomething like a preference of fharp points in the fettling of hoar-froft.

THOUGH it would require many more experiments than our opportunities have allowed of, to underftand fully feveral points belonging to this Enquiry; fuch as, the fits of refrigeration of the air, and the correfponding aptitude to part with its hoar-froft, yet the foregoing experiments, regifters, and obfervations, when attentively confidered and compared with one another, and with thofe narrated in the two papers publifhed in the London Philofophical Tranfactions, feem to confpire in fupport of the following

GENERAL CONCLUSIONS:

That when bodies attract hoar-froft from a clear air, there is a cold produced at their furfaces; and that this cold does not originate from any peculiar qualities of bodies upon which the hoar-froft fettles, any farther than as fome bodies are capable of attracting from the air more or lefs of it in a given time:

That

That the difpofition of the air of thus parting with hoar-froft, and the cold which accompanies that feparation, has a conftant dependence upon the general ferenity of the atmofphere, and is always interrupted upon the fky being overcaft with clouds or fogginefs, efpecially near to the place of obfervation.

The analyfis which has now been detailed, though imperfect in many refpects, feems, however, to demand our affent to thefe general propofitions, how anomalous foever they may appear.

The nature or effence of the thing we call HEAT is fo far removed beyond the immediate reach of our fenfes, that we need not wonder though new facts relating to it come into view, and even though they cannot immediately be traced up to any general laws hitherto eftablifhed. If, upon mature reflection, the prefent phænomena cannot be accounted for in this way, they ought, on that very account, to challenge our attention the more, as opening to us the neceffity of enlarging our ftock of principles, and inviting us forward to fo defirable a work.

In the *firft* propofition above laid down, it is afferted, that the cold produced is in proportion to the quantity of hoar-froft feparated from the air in a given time. This, however, muft be underftood with fome limitation, and may not perhaps hold true, if we compare together the degrees of cold and quantities of hoar-froft feparated in different ftates of the air.

The import of the propofition only is, " That, at any given " time, the more hoar-froft the air imparts to bodies over " which it paffes in a clear ftate, the greater is the cold then " produced." For it is very conceivable, that, according to the different ftates of the air, in different feafons, or in different nights of the fame feafon, arifing from its being more or lefs charged with vapour, or perhaps with electricity, or fome other

Y   latent

latent principles, the quantity of hoar-froft given out, compared with the corresponding cold, may be very different.

In the paper of the year 1781, it is said, " That last year " there was a much more copious giving out of hoar-froft at " times when the difference of temperature was not more re- " markable ;" and, from this fact, I was then disposed to conclude, that the cooling procefs had no immediate dependence upon the feparation of hoar-froft. But, from the facts which have been afcertained this winter, it feems neceffary to correct this opinion in the extent above explained. It ought alfo to be confidered, that the comparifon above quoted between the years 1780 and 1781, had refpect to the temperature of the fnow upon the ground only ; and it is evident, that this may, *cæteris paribus*, differ more or lefs from that of the air, according as the fnow has fallen more or lefs recently, or is more or lefs deep, upon warm or upon frozen ground.

It may alfo be proper here to take notice of what may be called a fpurious kind of hoar-froft, which is attended with no cold whatever at fettling upon bodies. I mean that which trees and buildings are fo apt to be decorated with during a mift in frofty weather ; in which cafe it is obvious, that the hoar-froft was previoufly formed in the air, and floated in it, and was not formed in the act of being depofited upon the body.

S E C T.   III.

Though the night-obfervations of this and the former winters afforded fo many examples of cold thus depending upon the feparation of hoar-froft from the air, I come now to mention one, and the only one inftance wherein, during the night, this condition of things was totally reverfed, and when the fame phænomenon, of an excefs of cold at the furface of the fnow, took its rife from a moft manifeft evaporation.

JANUARY 28. 1784.

ABOUT nine o'clock this night, the excefs of cold was four, five, and fometimes fix degrees. The circumftances of the weather, indeed, were now very particular. With the air fo warm as + 27, the fky was quite clear, whilft a ftrong wind blew directly from the north. At the fame time, too, the heavens were illumined with a moft vivid difplay of the Aurora Borealis, which fhooted from the north, round by the eaft, and up beyond the zenith towards the fouth, where the wandering irradiations all converged, fo as to form an imperfect crown.

DURING this play of the elements, there were no longer to be found the fmalleft traces of that hoar-froft about which I had fo often been employed in calmer and in colder times. Early in the afternoon, I had laid out a parcel of things, which might fhow me the ftate of the air when night fhould come. But neither upon them, nor upon the wooden fpars of the wicket which opens from the foffe round the Obfervatory to the park, nor upon its fide-ftones, nor the hedge, nor the thorn-tree near by, was there to be feen the fmalleft particle. Every thing around was entirely ftripped of hoar-froft by this dry and devouring gale.

THE fand-board and fnow-fcale, fet out as formerly, gave now a very different report. The thermometer on the fand never cooled a fraction of a degree below the temperature of the air, whilft the fweeping wind cooled down the fnow feveral degrees. Evaporation in all this was fo evidently concerned, that it would have been abfurd to have tried if the fand had loft weight in that way. But, at any rate, fuch an attempt would have been difficult, as the fand was fo liable to be difperfed by the wind, that I was obliged to lay it very thick upon the fcale, and to fhelter it a little under the lee of the hedge. Being, however, defirous to know, at what rate the fnow wafted by evaporation in this fituation, I got the white iron fcale, with

fnow

ſnow compreſſed upon it, muffled from the wind by a piece of open gauze. In this ſtate, when expoſed for two hours, it loſt ſix-tenths of an ounce. Now and then I looked to ſee if any of the ſnow was drifting away through the gauze, but could perceive none traverſing the beams of the candle, when the lantern was held in the moſt favourable poſition for detect-ing ſuch a thing; and I rather think that the whole waſte was owing to evaporation.

SINCE the above date, I have ſometimes, in the courſe of obſervations, made commonly from nine o'clock in the morning till mid-day, found the like exceſs of cold upon the ground ſnow, proceeding from actual evaporation; and this too when the weather was much more calm. But, on all theſe occaſions, it was evident, that the air was riſing quickly in its tempera-ture, as the ſun approached the meridian. On this account, may it not be ſuppoſed, That the air was acquiring, not only a power of keeping diſſolved what, during the night, it would have depoſited as hoar-froſt, but of cauſing ſuch an evaporation from the ſnow, as to produce an obſervable cold by that pro-ceſs? Whatever there may be in this ſuppoſition, the fact is certain as above ſtated.

WHEN the air is not very froſty, I am inclined to think, from the above obſervations, that a cold, in conſequence of evaporation in the day-time, takes place not unfrequently, and that this may be one cauſe of that profuſe giving out of hoar-froſt which night brings along with it, when the work of refri-geration is ſtill continued by that other proceſs which has been the ſubject of this Eſſay.

THE following I have always found to be a characteriſtical diſtinction between the two proceſſes, beſides the others already mentioned. A thermometer freely expoſed, with its ball en-vironed with a ſmall maſs of ſnow, falls ſenſibly below the temperature of the air which meets it, when evaporation goes on. But in the moſt active ſtate of the other proceſs, I never

observed

obferved fuch a thermometer in air point fenfibly below another befide it, whofe ball was perfectly clear. In fhort, the whole features of the one procefs, compared to thofe of the other, are fo diffimilar, as to fhew evidently they depend upon principles of a very different nature.

In the profecution of fo dark a fubject, we have proceeded hitherto entirely in the way of analyfis, and have been careful to prevent any fuppofition or conjecture from mixing with, or affecting our conclufions. But having now arrived at what appears to be a general and leading fact, and of fo anomalous a kind, the fituation obliges us, more or lefs, to take up with furmifes, as guides to farther experiments; in the view of finally reconciling the prefent phænomena with what we already know concerning the nature and properties of heat.

When fuch a cold is produced, as that which has been confidered at fo much length, the queftion is, What becomes of the fenfible heat which thus conftantly difappears?

From the experiments mentioned in the paper of 1781, we are difpofed to think, that this heat does not enter into the compofition of the hoar-froft which is given out by the air.

If, however, it fhould be found, that the air itfelf, at the moment the decompofition takes place, has its capacity for retaining heat much increafed, fuch a circumftance would immediately folve the difficulty. For, by this means, the air, when parting with any given portion of hoar-froft, might abforb, not only the whole heat, which, according to Dr Black's law, ferved to keep the hoar-froft diffolved, but alfo, it might abforb a portion of the fenfible heat belonging to the body or furface upon which the hoar-froft fettles; and thus occafion a diminution of fenfible temperature, or the cold in queftion.

But regarding the air, in thefe extreme colds, and whilft the hoar-froft is diffolved in it, as a chemical mixt, it may be demanded, What reafon is there for fuppofing that the capacity of the air for heat fhould increafe at the moment it gives out its

hoar-

hoar-frost to bodies attracting it ? To this it may be answered, since we are confessedly dealing in surmises and conjectures, that, possibly, in the mixed subject we are now contemplating, there may be a third ingredient, of an electrical or phlogistic kind, and which is necessarily separated from the air along with the hoar-frost.

ACCORDING to this view, with the help of Dr CRAWFORD's general fact mentioned above, we could account for the cooling process, by saying, that it depends upon the increased capacity of the air for heat, in consequence of its being dephlogisticated by the mediation of a third substance, namely, the hoar-frost, which, by a predominant affinity, in certain cases, is made to part from the air, and unite itself to the attracting substance.

IT would require, however, many nice and well ordered experiments, before the merits of a suggestion, so arbitrary as this is, could be determined.

BUT how much soever we may be at a loss to understand in what manner cold is produced by the separation of hoar-frost from a clear air, or what becomes of the sensible heat which, in that process, constantly disappears, yet, by regarding the thing itself as a general fact, now demonstrated by a competent induction, it seems already to offer us some assistance in explaining, by the synthetical method, certain phænomena connected with our subject. Of this, what has been mentioned of the two thermometers, page 172. may serve as an example.

IN the first case, we know so much of the nature of evaporation as to be certain, that any portion of air, relatively dry, at meeting the small mass of snow surrounding the ball, must produce cold, more or less, even by the most transient contact. By a constant succession, therefore, of such evaporating air, the mercury in the thermometer will be made to sink very sensibly below that of another exposed to the same current, having no snow round its ball.

BUT

But when the air is in a contrary ſtate, and diſpoſed to give out hoar-froſt, the ball, with the ſnow round it, may be con- ſidered, according to the new ideas we have acquired, as not affording ſurface enough for the extrication of hoar-froſt from any portion of air, during ſo momentary a contact, in paſſing to leeward. For, from ſeveral phænomena already inſiſted upon, it ſeems evident, that an action, continued for ſome length of time, is neceſſary for unlocking the hoar-froſt from the air, and conveying it to the attracting ſurface. Hence the thermometer with the ſnow round the ball, in the circumſtances ſuppoſed, ſhould not be cooled more than the current of air in which it is placed; and thus this characteriſtical diſtinction betwixt the two proceſſes may be accounted for.

In like manner, may be underſtood, how it is in the cleareſt and ſtilleſt nights only, that the cold at the ſurface of the boards was obſerved to be moſt remarkable. For, according to what has been juſt now mentioned, any very rapid motion of the air acroſs theſe ſurfaces, ſeems inconſiſtent with the extrication of hoar-froſt, upon which the refrigeration depends.

Further, in the paper of the year 1780, an account is given of an experiment, which conſiſted in blowing the ambient cold air upon the ſnow where the thermometer lay, and of fanning the ſame briſkly with a piece of ſtiff paper faſtened to the end of a long ſtick, in expectation that the thermometer would point lower by an increaſed evaporation. This experiment was made pretty early, and whilſt I was in the perſuaſion, that the obſerved exceſs of cold depended entirely upon evaporation. The reſult, however, was, that the thermometer, inſtead of pointing lower by ſuch means, always roſe ſeveral degrees. Though this circumſtance was thought odd and unaccountable at the time, yet the true reaſon of it ſeems now to offer itſelf very plainly. For, from the explanations attempted in the two foregoing paragraphs, it would appear, that, by the operations with the bellows and fan, we had all the while been diſturbing

that

that more leifurely and intimate communion betwixt the air and the fnow, which is neceffary to the extrication of hoar-froft; and that accordingly the thermometer approached confiderably nearer to the temperature of the air.

" THAT the extrication of hoar-froft requires an action con-
" tinued for fome length of time, upon a given portion of
" air,"

is a propofition of fome moment, becaufe, taken along with the other general fact, it enables us fo eafily to explain certain collateral phænomena which fo much characterife this kind of cooling procefs; fome examples of which have now been produced. On that account, it might be worth while to eftablifh the propofition farther, by more direct experiments. For this purpofe, a fimple apparatus might be conftructed for making the air, in night-obfervations, to pafs with different rates of velocity over the cooling furfaces, in order to difcover how much the extrication of hoar-froft, and the cold produced at the leeward fide, depends upon an undifturbed and leifurely communication between the air and the fubftances expofed. As to the iffue, I am already almoft entirely convinced, that, were the natural flow paffage of the air over the furfaces changed fuddenly, by machinery, into a rapid current, the thermometers at the leeward fide would very foon rife, if not to the fame, at leaft nearly to the fame temperature as the air to windward.

IT might alfo be proper to try how far, and for what length of time, a confiderable quantity of cold air, when fhut up on all fides from the external atmofphere, would, by a leifurely and fucceffive application of all its parts to a furface of fand, &c. keep up a cooling procefs; and even for this experiment, it would be no difficult matter to contrive a proper apparatus.

IT is now full time that we relieve the reader, who may have followed us fo far in a difcuffion which has fwelled to a much greater extent than originally was intended, and where fo perpetual a recurrence of the fame phrafeology, how neceffary fo-

ever

ever to the illuftration of fo new a fubject, muft doubtlefs have
been felt as tedious. We fhall, therefore, conclude with ob-
ferving, that experiments of this kind fall moft properly under
the province of thofe philofophers who live in climates where
the winter is of longer continuance, and attended with more
rigour, and a more permanent ferenity of the atmofphere.
Here, in this latitude, the opportunities are fo rare, and, when
they do occur, fo tranfient, that our progrefs in fuch an expe-
rimental enquiry muft advance only by flow fteps. To thofe,
therefore, more favoured by fituation, would we humbly re-
commend a farther profecution of a fubject, which, befides its
entire novelty, feems, upon feveral other accounts, to have a
claim to fome attention.

Z   VI.

VI. *An* Account *of the Method of making a* Wine, *called by
the* Tartars *KOUMISS; with Observations on its Ufe
in Medicine. By* John Grieve, *M. D. F. R. S.* Edin.
and late Phyfician to the Ruffian Army.

IN an age like the prefent, when few things in nature feem
to have eluded the refearches of philofophy, when the com-
munications of learning are as well eftablifhed as thofe of com-
merce, it may appear fomewhat furprifing, that one of the
moft important productions of milk fhould ftill remain, in a
great meafure, unknown to the moft enlightened parts of Eu-
rope.

THE production I mean is the vinous liquor which is pro-
cured by fermentation from mares milk. And it was fcarcely
to be expected, that, after it had efcaped the obfervation of
men the moft fkilled in chemiftry, it fhould be taught us by a
horde of Tartars, whofe rank in fociety is not above that of
Barbarians.

EVEN in Ruffia itfelf, it was with difficulty I could learn the
particulars of the preparation ; and though it has been ufed,
for fome ages, by feveral tribes of people who belong to that
empire, yet, in the year 1781, when I firft began to think of
employing it in medicine, it was as little known in what may
be called *Ruffia proper*, as it is now in Great Britain. If the
academicians of St Peterfburgh gave fome accounts of it, thefe
accounts have never excited the attention of the phyficians of
Ruffia.

THIS neglect is moft probably to be afcribed, partly to the
obfcure relations of travellers, and partly to the pride of fyftem,

which

which men of learning are too often apt to indulge, in rejecting as incredible whatever does not coincide with their own preconceived opinions.

ON consulting the authors who have made mention of this subject, I find, that they give little satisfactory information concerning it. They all agree, that a vinous liquor, from mares milk, was used by some of the Tartar nations, under the name of *KOUMISS*; but none of them enter into a detail of the process by which that wine was prepared, much less does any one of them point out the purposes, either in œconomy or medicine, to which it may be applied.

MARCUS PAULUS VENETUS gives some account of it in his History of the Eastern Nations*, which was published as long ago as the thirteenth century. He says, it was used by the Tartars as their common beverage, but makes no mention of the method of preparing it.

STRAHLENBERG, in his description of the Russian empire †, relates some circumstances of the preparation ; but his method, if followed, could not be attended with success; for he mentions, that the *Kalmucks* take off the thick substance, which, in consequence of souring, rises to the top of the milk, and employ this in their food, while they use the remaining liquor either for drink or distillation. Now, this is not only contrary to the usage of that people, when they wish to obtain a fermented liquor of any strength ; but experience proves, that no perfect fermentation can be produced, unless all the parts of the milk be left united in their natural proportion.

GMELIN, in his History of a tour which he made through Siberia ‡, pays more attention to the Tartar method of distilling a spirit from the wine of milk, than to the fermenting process by which that wine is procured.

Z. 2.   THE

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* De Region. Oriental. lib. 1. cap. 57.

† Beschreibung des Russichen Reichs, p. 319.

‡ GMELIN's Reisse durch Siberien, t. 1. p. 273.

THE lateft writer that I find mentioning *Koumifs*, is the celebrated profeffor of natural hiftory in St Peterfburgh, Dr PALLAS *. His account is as circumftantial as could well be expected from a traveller, whofe object was natural hiftory in general; yet the principles on which the fermentation depends, as well as the mode of conducting the procefs, are not fufficiently explained in his work.

THESE accounts, however imperfect, might have led philofophers, long before this time, to a difcovery of the true method of fermenting milk, had not the writings of NEWMAN ‡, an eminent German chemift, contributed to deceive them. He was himfelf impofed upon by one LUCAS, a Dominican monk, who afcribed its fermentation to the flour of millet and the grains of barley, which, he faid, the Tartars added to it, and to the wine-cafk in which the operation was performed. NEWMAN, it would feem, was unwilling to admit of the fermentability of milk, becaufe it was contrary to the ideas he had entertained of an animal liquor; and, therefore, adopting the oppofite opinion, he feems glad to have an authority, however weak, to fupport it.

VOLTELEN ‡, too, a chemift of Holland, affords a ftriking example, how eafily men are mifled, even in matters of fcience, by their own prejudices. He had no doubt of the exiftence of a fermentable principle in milk, inafmuch as it contained a certain quantity of a faccharine fubftance. He knew alfo, that the whey contained the fugar in folution; it was on it, therefore, that he inftituted his experiments; he added even more fugar to the whey than the natural proportion; but no vinous fermentation could, by any means, be produced in it. Nor did even his want of fuccefs undeceive him. He never once imagined, that the butyraceous and cafeous parts of the milk were no lefs neceffary to its fermentation than the faccharine and ferous.

Even

* Phyficalifh. Reife durch einig. provintz. des Ruffifch. Reichs, t. 1. p. 316.
† NEWMAN, Chem. experimental. t. 1. part 2. p. 18.
‡ Obfervat. de lacte humano cum afinino et ovillo comparato, p. 54.

Even MACQUER, in his Chemical Dictionary *, has fallen into an error of the same kind. Speaking of whey, he says, " In " whey is contained diffolved, a confiderable quantity of ex- " tractive fubftance, of the nature of the faccharine juices, and " it is accordingly fufceptible of the fpirituous fermentation. " The Tartars certainly make from it a fpirituous drink, or " kind of wine." From this it appears he had not made the experiment.

THE following method of making *Koumiſs*, is that which I adopted in my own practice with fuccefs. It is common among the *Baſchkir Tartars*, who inhabit that part of the government of *Orenbourg* which lies between the rivers *Kama* and *Volga*. It was communicated to me by a Ruffian nobleman, in whofe cafe I was confulted, and who was the firft who made ufe of it by my advice. He went into that country on purpofe to drink it; and, as he refided for fome time there, he could not be miftaken with refpect to the procefs.

TAKE of frefh mares milk, of one day, any quantity ; add to it a fixth part of water, and pour the mixture into a wooden veffel ; ufe then, as a ferment, an eighth part of the foureft cows milk that can be got ; but, at any future preparation, a fmall portion of old *Koumiſs* will better anfwer the purpofe of fouring ; cover the veffel with a thick cloth, and fet it in a place of moderate warmth ; leave it at reft twenty-four hours, at the end of which time, the milk will have become four, and a thick fubftance will be gathered on the top ; then, with a ftick, made at the lower end in the manner of a churnftaff, beat it, till the thick fubftance above mentioned be blended intimately with the fubjacent fluid : In this fituation, leave it again at reft for twenty-four hours more ; after which, pour it into a higher and narrower veffel, refembling a churn, where the agitation muft be repeated, as before, till the liquor appear to be perfectly homogeneous; and, in this ftate, it is called *Koumiſs* ;

of

* MACQUER Dictionary of Chemift. p. 432.

of which the taſte ought to be a pleaſant mixture of ſweet and
ſour.   Agitation muſt be employed every time before it be uſed.

To this detail of the proceſs, he ſubjoined, that, in order to
obtain milk in ſufficient quantity, the Tartars have a cuſtom
of ſeparating the foal from the mare during the day, and al-
lowing it to ſuck during the night.   And, when the milk is to
be taken from the mare, which is generally about five times
a-day, they always produce the foal, on the ſuppoſition, that ſhe
yields her milk more copiouſly when it is preſent.

To the above method of making *Koumiſs*, which I have
tranſlated as literally as poſſible from the original Ruſſian manu-
ſcript now in my poſſeſſion, I will add ſome particulars, taken
from other communications with which I was favoured by Tar-
tars themſelves.   For though I think no addition neceſſary to
render it either more ſimple or more intelligible, yet I think it
my duty to with-hold nothing which may, in any wiſe, throw
light on ſo eſſential a part of my ſubject.

ACCORDING to the account of a Tartar who lived to the
ſouth-eaſt of *Orenbourg*, the proportion of milk and ſouring
ought to be the ſame as above; only, to prevent changing the
veſſel, the milk may be put at once into a pretty high and nar-
row veſſel; and, in order to accelerate the fermentation, ſome
warm milk may be added to it, and, if neceſſary, more ſouring.

FROM a Tartar whom I met with at the fair of *Macarieff* upon
the Volga, and from whom I purchaſed one of the leathern bags *
                                                                    which

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* THIS bag was made of a horſe's hide undreſſed, and,
by having been ſmoked, had acquired a great degree of
hardneſs.   Its ſhape was conical, like the figure in the
margin, but was, at the ſame time, ſomewhat triangular,
from being compoſed of three different pieces, ſet in a
circular baſe of the ſame hide.   The ſutures, which
were made with tendons, were ſecured by a covering on
the outſide, with a doubling of the ſame ſkin, very cloſe-
ly ſecured.   It had a dirty appearance, and a very diſ-
agreeable ſmell.   On being aſked the reaſon of this, he
said, "The remains of the old Koumiſs were left, in order to ſupply a ferment to the
" new milk."

which are ufed by the Kalmucks for the preparation and car-
riage of their *Koumifs*, I learned, that the procefs may be much
fhortened by heating the milk before the fouring be added to
it, and as foon as the parts begin to feparate, and a thick fub-
ftance to rife to the top, by agitating it every hour, or oftener.
In this way, he made fome in my prefence in the fpace of
twelve hours. I learned alfo, that it was common, among
fome Tartars, to prepare it in one day during fummer, and that
with only two or three agitations; but that in winter, when,
from a deficiency of mares milk, they are obliged to add a
great proportion of that of cows, more agitation and more time
are neceffary. And though it is commonly ufed within a few
days after the preparation, yet, when well fecured in clofe
veffels, and kept in a cold place, that it may be preferved for
three months, or even more, without any injury to its qualities.

HE faid farther, that the acid fermentation might be pro-
duced by four milk, as above, by a four pafte of rye-flour, by
the rennet of a lamb's ftomach, or, what is more common, by
a portion of old *Koumifs*; and that, in fome places, they faved
much time, by adding the new milk to a quantity of that al-
ready fermented, on being mixed with which, it very foon un-
dergoes the vinous change. It was according to the firft pro-
cefs, however, that all the *Koumifs* which I have employed in
medicine was prepared.

FROM all thefe accounts, it appears, that three things are ef-
fential to the vinous fermentation of milk. Thefe are *heat,*
fouring, and *agitation.* Heat is neceffary to every fpecies of fer-
mentation, and fouring is perhaps not lefs fo, though not in fo
fenfible a degree as in the prefent cafe; but the chief art of fer-
menting milk confifts in *agitation.* This laft circumftance has
wholly efcaped the attention of chemifts, notwithftanding it
appears to be confonant to the operations of nature in other fpe-
cies of fermentation. In fermenting vegetable juices and in-
fufions, nature has no need of the affiftance of art; the in-
teftine

teftine motion which accompanies the fermentation is fufficient to produce the degree of agitation which feems neceffary to keep the parts of the fluid in mutual contact, or to fit them for mutual action. Milk, on the contrary, is no fooner foured than a feparation of its parts takes place; the cream rifes to the top, while the cheefe either falls to the bottom, or is fufpended in the whey. When thefe parts are brought, however, into clofe contact with one another, by agitation, and this repeated at proper intervals, a vinous liquor is produced; of the medical virtues of which I fhall now treat.

FROM the time I had heard of *Koumifs*, I had conceived an opinion of its importance in the cure of certain difeafes. I judged, that a preparation of milk, which could not be curdled by the juices of the ftomach, while, at the fame time, it poffeffed all its nutritive qualities, with the fuperaddition of a fermented fpirit, might be of effential fervice in all thofe diforders where the body is defective either in nourifhment or ftrength.

THE cafe of the above mentioned nobleman, who communicated to me the firft procefs, gave me an opportunity of trying, how far my conjectures were well founded. He was in that ftate which feemed to me ftrongly to indicate the ufe of fuch a medicine as *Koumifs*. I accordingly advifed him to it.

AT twenty-fix years of age, he laboured under a complication of chronic complaints. A confirmed *lues venerea*, injudicioufly treated, with three fucceffive falivations by mercury, added to bad management of himfelf under thefe, had given rife to his difeafe. His body was much emaciated; his face was of a livid yellow colour; his eyes were funk, and round his eye-lids there was a dark fhade; he felt a fevere pain in his breaft, and that was accompanied with a confiderable cough and mucous expectoration; his appetite and digeftion were greatly impaired; he had frequent tremblings and faintings; he began to feel the fymptoms of hectic fever. In a word, his whole appearance was confumptive, and he was fo weak that
he

he required affiftance to get into the carriage in which he was to be conveyed into Tartary.

AFTER drinking *Koumifs* fix weeks only, he returned perfectly free from all the above fymptoms, and was become fo plump and frefh-coloured, that, at firft fight, it was with difficulty his friends could recognife him. As he did not come immediately to *Nifchne-Novogorod*, where I then was, he wrote me a letter, the fubftance of which, as far as it related to this fubject, I fhall give here.

AFTER telling me the fudden and remarkable change the *Koumifs* had produced, during the firft few days; that he ceafed to be difturbed in his fleep; that his nervous and dyfpeptic fymptoms left him; that he felt as if his veffels had been diftended with a frefh cooling liquor; that he became cheerful; that it ferved him both for food and drink; that though he ufed it to the quantity of a gallon and a half, and fometimes even more, in the twenty-four hours, yet he always drank it with pleafure, and without intoxication; that his body, during its ufe, was regularly open; but that his urine was fo much increafed, that he was ufually excited to make water every hour: He proceeded to exprefs himfelf in the following ftrong terms, which ferves to fhow how much he had profited by it.

" I AM difpofed to confider *Koumifs*, (fays he) with all defe-
" rence to you, as an univerfal medicine, which will cure every
" difeafe, if you do not chufe to except fever; for I am per-
" fuaded, that the moft fkilful phyfician, with all the drugs of
" the fhop, could not have reftored me to the health I now en-
" joy."

THE next cafe in which it was employed, though not fo defperate as the former, gave fufficient proofs of its nutritive and ftrengthening qualities. A lady, who had been witnefs to its uncommon efficacy in the nobleman's cafe above mentioned, was encouraged to try it in her own. It was not convenient for

<div align="center">A a</div>

<div align="right">her</div>

her to go herfelf to Tartary, and therefore fhe had it fent to her, well fecured in cafks, during the autumn.

She had been long fubject to a train of nervous diforders. By thefe, fhe was much extenuated, and reduced to a ftate of extreme weaknefs and irritability. She ufed it for about a month, at the end of which time, the functions of her nervous fyftem were reftored, and, with health and vigour, fhe acquired a plumpnefs and frefh complexion.

The following year, I refolved to try it at *Nifchne-Novogorod* under my own eye. As mares milk could not be obtained in fufficient quantity in town, it was made at the feat of a nobleman, not far diftant, from which it was occafionally tranfported. The feafon was far advanced, however, before a cafe was prefented, in which its efficacy might be tried. At laft, about the middle of Auguft 1782, I was confulted by the General Governor's nephew. He had all the fymptoms of incipient phthifis; pain of breaft, dry cough, occafional hæmoptyfis, and great emaciation; he was not, however, become hectic. His two elder brothers had died of true pulmonary confumptions. He had taken much medicine, in a different part of the country, and had obferved a very ftrict antiphlogiftic regimen; but though milk had conftituted the greateft part of his diet, yet there were no figns of recovery. He drank *Koumifs* for about two months only, and that in rather an unfavourable feafon; but the confequence was, that all the above fymptoms difappeared, and his flefh and ftrength returned; nor was there any reafon to apprehend a relapfe, at the time I left that country.

About the fame time, I advifed its ufe to another young nobleman, who had laboured under an abfcefs in the left fide, about the region of the twelfth rib. As he had then refided in a remote part of the country, no attention had been paid to it; on the contrary, by improper applications, the fides of the ulcer were become hard. He had loft his flefh and ftrength; he had occafional faintings; and there were all the appearances of
incipient

incipient hectic. By the use of *Koumiss* for about six weeks, proper chirurgical dressings being at the same time applied, his health was perfectly re-established.

THERE were some other cases in which I employed it with equal success; but of which, as being less important, I omit the detail.

ALL those who drank it agreed in saying, that, during its use, they had little appetite for food; that they drank it in very large quantities, not only without disgust, but with pleasure; that it rendered their veins turgid, without producing languor; that, on the contrary, they soon acquired from it an uncommon degree of sprightliness and vivacity; that even in cases of some excess, it was not followed by indigestion, headach, or any of the symptoms which usually attend the abuse of other fermented liquors. To this may be added, that the Baschkir Tartars, who, towards the end of winter, are much emaciated, no sooner return in summer to the use of *Koumiss*, than they become strong and fat *.

FROM all these circumstances, I think myself entitled to infer, that this wine of mares milk may be applied to many of the purposes of medicine. From the mild acid which it contains, may it not be considered as a cooling antiseptic? From its vinous spirit, may it not become an useful stimulant, cordial, and tonic? And, from its oily and mucilaginous parts, may it not prove a valuable article of nourishment? If chronic diseases, as is generally allowed, depend on a debility of the solids; and if they are difficult of cure, because the organs, which ought to supply the body with nourishment and strength, do not only themselves partake of the general weakness, but are too often, by the indigestible nature of the food with which

<div align="center">A a 2</div> <div align="right">they</div>

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* THE author of a historical description of all the nations which compose the Russian empire, says, speaking of Koumiss, " Elle est fort nourissante, et peut tenir lieu de tout " autre aliment. Les Baschkirs s'en trouvent très bien, elle les rend bienportans et " gais; elle leur donne de l'embonpoint, et de bonnes couleurs." *Descrip. de tout. les Nat. de l'Emp. Russ. t.* 2. *p.* 118.

they are overcharged, ſtill more debilitated; may not a ſub-
ſtance of eaſy digeſtion, which at once ſtrengthens the ſtomach
and nouriſhes the body, become a powerful remedy in all ſuch
caſes?

AND if acute diſeaſes, eſpecially of the febrile kind, are fre-
quently attended with ſymptoms of weakneſs and putridity,
may it not be found, from its antiſeptic and tonic powers, to
be an uſeful corrector of the one, and reſtorative from the
other?

MAY not the ſudden change it produced, in the *firſt* caſe, in
the ſtate of the patient's feelings, and eſpecially of his ſleep,
point it out as of uſe in all caſes of exceſſive irritability?

MAY not the effect it had in reſtoring his ſtomach to its
functions, recommend it in dyſpepſia? And may not the vi-
gour and plumpneſs which enſued from its uſe, indicate it in
caſes even of confirmed atrophy?

HAVE we not reaſon to believe, that it may be uſed to ad-
vantage in the cure of nervous diſorders in general, from the
manner in which it operated in the *ſecond* caſe? And in the in-
cipient, perhaps even in the advanced ſtages of phthiſis, from
the rapid and effectual change it occaſioned in the pulmonary
ſymptoms of the *third?*

AND may not its efficacy in the *fourth* caſe, encourage us to
employ it in all caſes of ſuppuration or ulcer, in which the bo-
dy is threatened with hectic fever?

WHETHER all theſe queſtions can be anſwered in the af-
firmative, muſt be determined by future experience; and, if
they ſhould, perhaps the ſcarcity of mares milk in this coun-
try would greatly circumſcribe its utility.

HENCE enquiries will naturally be made, whether other ſpe-
cies of milk admit of a ſimilar vinous fermentation, and what
proportion of ſpirit they contain. As theſe have never been the
object, however, of my attention, I will here give the ſubſtance
                                                          of

what I have been able to learn from others refpecting that which is the moft common, the milk of cows.

Dr PALLAS *, in the work above quoted, fays, that cows milk is alfo fufceptible of the vinous fermentation, and that the Tartars prepare a wine from it in winter, when mares milk fails them ; that the wine prepared from cows milk, they call *Airen* ; but that they always prefer *Koumifs* when it can be got, as it is more agreeable, and contains a greater quantity of fpirit ; that *Koumifs* on diftillation yields of a weak fpirit one third, but that *Airen* yields only two ninth parts of its whole quantity ; which fpirit they call *Arika*.

THIS account is confirmed by OSERETSKOWSKY, a Ruffian †, who accompanied LEPECHIN, and other academicians, in their travels through Siberia and Tartary. He publifhed lately a Differtation on the ardent fpirit to be obtained from cows milk.

FROM his experiments, it appears, that cows milk may be fermented with, or even without, fouring, provided fufficient time and agitation be employed ; that no fpirit could be produced from any one of its conftituent parts taken feparately, nor from any two of them, unlefs inafmuch as they were mixed with fome part of the third ; that the milk, with all its parts in their natural proportion, was the moft productive of it ; that the clofer it was kept, or, which is the fame thing, the more difficultly the fixed air is allowed to efcape during the fermentation, (care being taken, however, that we do not endanger the burfting of the veffel), the more fpirit is obtained. He alfo informs us, that it had a fourer fmell before than after agitation ; that the quantity of fpirit was increafed, by allowing the fermented liquor to repofe for fome time before diftillation ; that from fix pints of milk, fermented in a clofe veffel, and thus fet to repofe, he obtained three ounces of ardent fpirit, of which one was

consumed

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* Phyficalifch. Reife durch verfchied. provintz. des Ruffifch. Reichs, t. 1. p. 316. et 317.

† Specim. inaug. de Spir. Ardent. ex lact. Bub. Argentorat. 1778.

confumed in burning; but that from the fame quantity of the fame milk, fermented in an open veffel, he could fcarcely obtain one ounce.

THESE particulars of the fermentation of mares and cows milk are an interefting addition to the facts concerning fermentation in general; a fubject fo very obfcure and imperfectly under-ftood, that I fhall not hazard any remarks on it. My princi-pal intention was, to point out to phyficians what appears to me a powerful means which may be employed by them on ma-ny occafions in the cure of difeafes.

VII.

VII. *An* IMPROVEMENT *of the Method of correcting the* OB-SERVED DISTANCE *of the* MOON *from the* SUN *or a* FIXED STAR. *By the Rev. Mr* THOMAS ELLIOT, *Mini-ster of the Gospel at Cavers.*

PROBLEM.

HAVING the apparent diftance of the Moon's centre from a fixed Star, or from the centre of the Sun, together with the apparent altitudes of their centres, to find the true diftance.

SOLUTION.

THE difference between the apparent and true altitudes, and the angles which the Moon and Star make with the zenith and each other, muft be known before the feveral corrections of di-ftance are computed.

THE difference between the apparent and true altitude of a Star is the refraction in altitude, given p. 2. of *Tables requi-fite to be ufed with the nautical ephemeris.* If the diftance was taken from the Sun in place of a Star, his refraction may be corrected by fubtracting from it his parallax in altitude, given at the end of the *requifite tables,* and the difference ufed inftead of the re-fraction of a Star ; and, if great accuracy is required, the mean refractions may be corrected by the barometer and thermome-ter, according to Dr BRADLEY's rule, p. 130. *requifite tables.*

To find the difference between the apparent and true altitude of the Moon, the horizontal parallax, given in the ephemeris for the preceding noon or midnight, muft be reduced to the time of obfervation, according to the inftructions in the *requi-fite*

fite tables. Then to the arithmetical complement of the logarithmic cofine of the moon's altitude, add the proportional logarithm of the reduced horizontal parallax, the fum will be the proportional logarithm of the parallax in altitude; from the parallax in altitude fubtract the refraction in altitude, and the remainder will be the difference between the apparent and true altitude of the moon; which call the corrected parallax.

If, at the time of obfervation, the moon and ftar are in the fame vertical, which may fometimes happen in low latitudes, no angles are to be found. They will be in the fame vertical, and on the fame fide of the zenith, if the apparent diftance and leffer altitude together are equal to the greater altitude. In which cafe, the fum of the corrected parallax and ftar's refraction, added to the apparent diftance when the moon's altitude is greateft, or fubtracted from it when the moon's altitude is leaft, will give the true diftance. They will alfo be on the fame vertical, but on oppofite fides of the zenith, if the apparent diftance, added to the fum of the altitudes, is equal to 180°. In this cafe, the difference of the corrected parallax and ftar's refraction, *fubtracted* from the apparent, will give the true diftance; except when the moon is fo near the zenith, that the corrected parallax becomes lefs than the ftar's refraction, in which cafe the difference muft be *added* to the apparent diftance.

If the apparent altitudes are equal, the angles at the moon and ftar will alfo be equal, and may both be found at once, by adding the logarithmic tangent of the common altitude to the logarithmic tangent of half the apparent diftance, the fum, rejecting radius, will be the logarithmic cofine of each of the angles at the moon and ftar, and each of them will be acute, or lefs than 90°.

When the altitudes are unequal, the angles may be found by the following method:

To

To the logarithmic cotangent of half the fum of the apparent altitudes add the logarithmic tangent of half their difference, and from the fum fubtract the logarithmic tangent of half the apparent diftance, the remainder will be the logarithmic tangent of a 1ft arc.

THE fum of arc 1ft and half the apparent diftance, will be a 2d arc.

THE difference of arc 1ft and half the apparent diftance, will be a 3d arc.

To the log. tangent of arc 3d add the log. tangent of the greater altitude, the fum, rejecting radius, will be the log. cofine, either of the angle itfelf at the higher object, between the other object and the zenith, or of its fupplement to 180°, as arc 1ft is lefs or greater than the half diftance. As the application of the *firft* and *third* corrections depends on the quality of the angles, it muft be obferved, that, if arc 1ft is lefs than the half diftance, the angle *itfelf* will be found, and will be acute; but if arc 1ft is greater than the half diftance, the angle found will be the *fupplement* of the angle at the higher object to 180°, and the angle itfelf will be obtufe, or greater than 90°. Neverthelefs, if the greater altitude is that of the Moon, the cofine thus found is to be ufed in computing the *firft* correction of diftance.

To the log. tangent of arc 2d add the log. tangent of the leffer altitude, the fum, rejecting radius, will be the log. cofine of the angle at the lower object, between the other object and the zenith, and will always be acute.

THESE two angles being known, the feveral corrections of diftance will be found as follows:

1. To the arithmetical complement of the log. cofine of the angle at the Moon, add the proportional logarithm of the corrected parallax, the fum will be the proportional logarithm of the *firft* correction, which is to be added to the apparent di-

ftance

ftance if the angle at the Moon is obtufe, and fubtracted if acute.

2. ADD together the proportional logarithms of the fum and difference of the corrected parallax and *firft* correction of diftance, and take their fum, which, for diftinction, call the rectangle logarithm. To the rectangle logarithm, add the conftant logarithm 1.5819, and the log. tangent of the diftance *once* corrected, the fum of thefe three logarithms, rejecting ten from the index, will be the proportional logarithm of the *fecond* correction of diftance, which is always to be added, except the diftance is more than 90°, in which cafe it is to be fubtracted.

To half the rectangle logarithm add the log. fine of the diftance *twice* corrected, the fum, rejecting ten from the index, will be the proportional logarithm of a correction, to be fubtracted from the angle at the Star, or to be added to its fupplement.

3. To the arithmetical complement of the log. cofine of the corrected angle at the Star, add the proportional logarithm of the Star's refraction, the fum will be the proportional logarithm of the *third* correction, which (contrary to the *firft*) is to be fubtracted from the diftance, if the angle at the Star is obtufe, and added if acute.

THESE three corrections, applied as above directed, will give the true diftance of the Moon from the Sun or a fixed Star.

THERE is, indeed, a *fecond* correction for the Star's refraction, fimilar to the *fecond* correction for parallax; but in moft cafes it will not amount to 1″; and even when the Star's altitude is only 5°, and the diftance only 20°, it will not exceed 2″½ : It may, therefore, generally be omitted. But, if it is defired, this correction may be found in the fame manner as the *fecond*.

4. ADD together the proportional logarithms of the fum and difference of the Star's refraction and *third* correction of diftance, the conftant logarithm 1.5819, and the log. tangent of the diftance *thrice* corrected, the fum of thefe four logarithms,
rejecting

rejecting ten from the index, will be the proportional logarithm of a *fourth* correction, which, added to the distance, thrice corrected, will give the true distance.

THE following method of finding the angles at the Moon and Star will perhaps be more familiar to some; as it is the same with the method commonly used to find the apparent time from the angle at the pole between the meridian and the Sun or a fixed Star; and though it is not quite so concise as the former, it has this advantage, that it gives both the angles without any ambiguity. When this *second* method is used, the logarithms should be taken to at least five places of figures, besides the index.

1. *To find the Angle at the Moon.*

ADD together the apparent zenith distance of the Star, the apparent zenith distance of the Moon, and the apparent distance of the Star from the Moon's centre; take their sum, half their sum, and the difference between the half sum and the zenith distance of the Star; then add together the arithmetical complements of the log. sines of the Moon's zenith distance and the apparent distance of the objects, and the log. sines of the half sum, and the difference between the half sum and the zenith distance of the Star. Half the sum of these four logarithms will be the log. cosine of half the angle required, which being doubled, will give the angle at the Moon between the zenith and the Star.

2. *To find the Angle at the Star.*

ADD together the zenith distances of the Moon and Star, and the apparent distance, and take their sum and half sum as before; but now take the difference between the half sum and the zenith distance of the Moon; then add together the arithmetical complements of the log. sines of the Star's zenith distance and the distance of the objects, and the log. sines of the

half

half fum and the difference between the half fum and the zenith diftance of the Moon. Half the fum of thefe four logarithms will be the log. cofine of half the angle, which, being doubled, will give the angle at the Star between the zenith and the Moon.

THE angles being found, the feveral corrections of diftance are to be computed and applied according to the rules already given.

INVESTIGATION.

IN the fpherical triangle *MZS*, let *Z* reprefent the zenith, *M* the apparent place of the Moon, *S* the apparent place of the Star, and *MS* the apparent diftance of the Star from the Moon's centre. Let *Zp* be a perpendicular arc let fall from *Z* upon *MS*, produced if neceffary, and let *m* be the middle of the bafe, fo that *Mm* or *Sm* be equal to half the diftance of the objects. If the zenith diftances *MZ* and *SZ* are equal, the triangle will be ifofceles, and the angles *ZMS* and *ZSM* will alfo be equal, and *Zp* will fall upon *MS* in *m*; but if *MZ* and *SZ* are unequal, *Zp* will fall upon *MS* at fome diftance from *m*, either within or without the triangle, and the angles *ZMS* and *ZSM* will alfo be unequal. Then (by cafe 11. *obliq. fpher. triang.*) *pm* will be the *firft* arc, equal to the diftance between the perpendicular and the middle of the bafe; half the bafe added to *pm* will be the *fecond* arc, equal to the diftance of the perpendicular from the lower object; and the difference between half the bafe and *pm* will be arc *third*, equal to the diftance of the perpendicular from the higher object. It is evident that, when *pm* is lefs than half the bafe, the perpendicular muft fall within the triangle, and the angles, both at *M* and *S* muft be acute; on the contrary, when *pm* is greater than half the bafe, the perpendicular muft fall without the triangle, and the angle at that object which is next the perpendicular will be obtufe; and

ZSp

ZSp (fig. 1.) will be the fupplement of *ZSM*, and *ZMP* (fig. 2.) will be the fupplement of *ZMS* to 180°.

Zp being perpendicular to *MS*, the two triangles *ZpM* and *ZpS* will both be right-angled at *p*. The hypothenufes *MZ* and *SZ* are the zenith diftances of the objects, or the complements of their apparent altitudes, and the legs *MP* or *SP* are the *fecond* or *third* arches. Then (by cafe 6. *right ang. fpher. triang.*) the cotangent of the hypothenufe, or, which is the fame, the tangent of the altitude, multiplied by the tangent of the leg, and divided by radius, gives the cofine of the angle between the hypothenufe and that leg; by which the angles *ZMS* and *ZSM* will be found.

THE other method of finding the angles is prop. 17. *fpher. triangles*, prefixed to SHERWIN's Tables, revifed by CLARK; and is the fame with that given in the *requifite tables* for finding the horary angle.

THE fine of the horizontal parallax being to the fine of the parallax in altitude, as radius to the fine of the zenith diftance, (KEIL's *Aftron. lect.* 21.) the fine of the horizontal parallax, multiplied by the fine of the zenith diftance, or, which is equal to it, by the cofine of the altitude, and divided by radius, will give the fine of the parallax in altitude.

LET *Lq* reprefent the parallax in altitude, and *Mq* the refraction in altitude, then *Mq* fubtracted from *Lq* will leave *LM* the corrected parallax, equal to the difference between the apparent and true altitude of the Moon. Let *SR* be equal to the Star's refraction; then *L* will be the true place of the Moon, and *R* the true place of the Star, and *LR* the true diftance. Let *La* be a perpendicular arc from *L*, falling upon *MS*, produced if neceffary, and let *Rc* be a perpendicular arc from *R*, falling upon *LS*, produced if neceffary with the diftance *LS* draw *Lb*, and with the diftance *LR* draw *Rd*; then *LR* and *Ld* being radii from the fame centre, or rather arches from *L*, as a pole, to the fame parallel, will be equal to one another; and,

for

for the fame reafon, *SL* and *Sb* will be equal to one another: Then the feveral corrections and corrected diftances will be as follows :

1*ft* correction *Ma*, diftance once corrected *Sa*.

2*d* correction *ab*, diftance twice corrected *Sb*, equal to *SL*.

3*d* correction *Sc*, diftance thrice corrected *Lc*.

4*th* correction *cd*, diftance four times corrected *Ld*, equal to *LR* the true diftance. Radius 1.

THE *firft* correction *Ma* is equal *ML* multiplied by the co-fine of *LMS*.

THE arc *La* being perpendicular to *MS*, the two triangles *MaL* and *SaL* will both be right-angled at *a*. It has been proved, that *SL* and *Sb* are equal ; therefore *ab*, which is the *fecond* correction, will be the difference between *SL* and *Sa ;* and is found by the following proportion : The rectangle under the tangents of half the fum, and half the difference of *LM*, the hypothenufe, and *aM*, one of the legs, is equal to the fquare tangent of half *La*, the other leg ; and the rectangle, under the tangents of half the fum and half the difference of *SL* and *Sa*, is alfo equal to the fquare tangent of half *La*, (HEATH's *Aftron. p.* 330.) Hence the fquare tangent of half *La*, divided by the tangent of half the fum of *SL* and *Sa*, will be equal to the tangent of half the difference of *SL* and *Sa*, that is, to the tangent of half *ab* ; and twice the fquare tangent of half *La*, divided by the tangent of half the fum of *SL* and *Sa*, will be equal to the tangent of *ab*. The proper divifor, therefore, for finding this *fecond* correction juftly, is the tangent of *Sa* increafed by half *ab*. But, as this will not make the correction $\frac{1}{4}''$ lefs than when *Sa* is made the divifor, fuppofing the diftance not under 20°, it was thought needlefs to mention it in the precepts.

IN fuch a fmall triangle, where the corrected parallax is the hypothenufe, which can never exceed $56'\frac{1}{2}$, the difference between the arcs themfelves and their fines or tangents is fo very inconfiderable, that they may be taken indifferently for one ano-

ther

ther, without any fenfible error; and, by this means, the calcu-
lator may avail himfelf of that convenient and ufeful table of
the proportional logarithms, and fave a great deal of trouble in
making proportions for feconds. When the arcs themfelves
are taken inftead of the tangents of the arcs, it will fhorten
the operation, and the refult will be the fame, if half the rec-
tangle under the fum and difference of LM and aM is fubfti-
tuted for twice the rectangle under half the fum and half the
difference of LM and aM; each of them is equal to half the
fquare of La, or twice the fquare of half La, and half the fquare
of La, divided by the tangent of half the fum of SL, and Sa is
equal to ab.

WHAT is called the rectangle logarithm is the proportional
logarithm of the fquare of La; its half is the proportional lo-
garithm of La, and La, divided by the fine of LS, is equal to
the angle LSa, which being fubtracted from ZSM, leaves
ZSL, equal to the oppofite angle dSR, fig. 2.; or, when the an-
gle at the Star is obtufe, as in fig. 1. the angle pSi, equal to the
oppofite angle LSa, being added to the fupplement of the angle
at the Star, makes the angle ZSi equal to the oppofite angle
LSR or dSR, whence the remaining corrections are found in
parts of the arc Ld.

THE *third* correction Sc is equal to SR, multiplied by the co-
fine of cSR.

THE *fourth* correction cd is the difference between Lc and LR,
and Rc being perpendicular to Ld, makes the triangles ScR and
LcR right-angled at c, fo that cd is found by the fame propor-
tion as ab.

VIII.

VIII. Account *of a* Remarkable Agitation *of the Waters of* Loch Tay: *In a Letter from the Reverend Mr* Thomas Fleming, *Minister of Kenmore, to the Reverend* John Playfair, *M. A. F. R. S.* Edin. *and now Professor of Mathematics in the University of* Edinburgh.

[*Read by Mr* Playfair, *Dec.* 6. 1784.]

Dear Sir,   *Kenmore Manse, Nov.* 4. 1784.

I DID not return from the excursion on which I was when I had the pleasure to see you at Dundee till last Tuesday night. On my arrival, I found your letter respecting the phænomenon that lately happened in this neighbourhood. Although ill qualified to give you satisfaction upon this subject, I shall, however, comply with your desire, and give you the most accurate account of that phænomenon which I have been able to obtain.

On Sunday the 12th of September, about nine o'clock in the morning, an unusual agitation was observed in Loch Tay, near the village of Kenmore. That village stands at the east end of the lake, having the river, which there issues from the lake, on the north side, and a bay, about 160 yards in length and 200 yards in breadth, on the south. The greater part of this bay is very shallow, being generally no more than two or three feet deep; but before it joins the body of the lake, it becomes suddenly very deep. At the extremity of this bay, the water was observed to retire about five yards within its ordinary boundary, and in four or five minutes to flow out again. In this manner, it ebbed and flowed successively three or four times during the space of a quarter of an hour, when, all at once, the water

rushed

rufhed from the eaft and weft, in oppofite currents, towards a line acrofs the bay, and about the edge of the deep, rofe in the form of a great wave, to the height of five feet above the ordinary level, leaving the bottom of the bay dry, to the diftance of between 90 and 100 yards from its natural boundary. When the oppofite currents met, they made a clafhing noife, and foamed; and the ftronger impulfe being from the eaft, the wave, after rifing to its greateft height, rolled weftward, but flowly, diminifhing as it went, for the fpace of five minutes, when it wholly difappeared. As the wave fubfided, the water flowed back with fome force, and exceeded its original boundary four or five yards; then it ebbed again about ten yards, and again returned, and continued to ebb and flow in this manner for the fpace of two hours, the ebbings fucceeding each other at the diftance of about feven minutes, and gradually leffening till the water fettled into its ordinary level.

At the fame time that the undulation was obferved in the bay on the fouth fide of the village, the river on the north was feen to run back; the weeds at its bottom, which before pointed with the ftream, received a contrary direction; and its channel was left dry above twelve feet from either edge. Under the bridge, (which is fixty or feventy yards from the lake), the current failed, and the bed of the river appeared where there had been eighteen inches of water.

During the whole time that this phænomenon was obferved, the weather was calm. It could barely be perceived, that the direction of the clouds was from N. E. The barometer (as far as I can recollect) ftood the whole of that and the preceding day about 29½ inches.

On the next, and the four fucceeding days, an ebbing and flowing was obferved nearly about the fame time, and for the fame length of time, but not at all in the fame degree as on the firft day. A fimilar agitation was remarked at intervals, fome

C c

days

days in the morning, other days in the afternoon, till the 15th of October, since which time no such thing has been observed.

I HAVE not heard (although I have made particular enquiry) that any motion of the earth was felt in this neighbourhood, or that the agitation of the water was observed any where but about the village of Kenmore.

I HOPE the above account will furnish an answer to most of the questions contained in your letter. If there be any other circumstance about which you wish to have farther information, it will give me pleasure to be able to communicate it.   I am,

  Dear Sir,

   Your most obedient humble servant,

      THOMAS FLEMING.

N. B. THE village of Kenmore is situated nearly in the parallel of 56°, 35′, and about 1° west of the meridian of Edinburgh. Loch Tay extends from thence somewhat more than 15 miles W. S. W. Its medium breadth is not much less than a mile, and its depth must be very considerable, if one may judge from the height of the adjacent mountains.

              IX.

IX. Abstract of a Register of the Weather, *kept at* Branxholm for Ten Years, *ending December* 31. 1783.

[Communicated by the Duke of Buccleugh, *President, Jan.* 3. 1785.]

IN the register from which this abstract is taken, the numbers were marked every day at nine o'clock *A. M.* The quantity of rain was measured by means of a tin-cylinder, guarded by a wooden box, and sunk in the earth, into which the rain was received through a funnel, whereof the area was quadruple that of the cylinder. A gage, which floated on the surface of the water in the cylinder, had a rod fixed to it, divided into inches and tenths, which passed through the pipe of the funnel. The fourth part of the rise of this index marked the depth of rain which had fallen since the last observation, and these observations were generally made once in twenty-four hours.

Branxholm is situated on the Tiviot, about ten miles from its source, and near the ridge from which the country declines toward the east and west seas. It is about forty-four miles S. W. by W. of Berwick, and thirty-five N. E. of the head of the Solway frith.

Abstract

ABSTRACT for 1774.

Month.	Rain.	Barom.	Therm.	E'ly	W'ly
				Days.	
Jan.	.300	29.284		23	8
Feb.	3.425	28.900		5	23
March,	.750	29.380		23	8
April,	1.900	29.080		12	18
May,	3.450	29.220		28	3
June,	3.600	29.100		6	24
July,	2.450	29.213		31	0
Aug.	4.500	29.184		7	24
Sept.	3.350	29.083		20	10
Oct.	.950	29.700		7	24
Nov.	2.250	29.200		14	16
Dec.	2.325	29.361		9	22
Rain,	29.250			185	180
Mean,		29.225			

ABSTRACT for 1775.

Month.	Rain.	Barom.	Therm.	E'ly	W'ly
				Days.	
Jan.	5.350	29.040	36.00	13	18
Feb.	4.600	28.800	38.00	3	25
March,	2.450	28.150	40.30	5	26
April,	.700	28.563	46.30	4	26
May,	1.475	29.353	51.36	5	26
June,	1.500	29.233	57.05	19	11
July,	3.573	29.074	58.50	9	22
Aug.	4.425	29.000	56.51	4	27
Sept.	4.300	29.040	53.50	11	19
Oct.	4.550	29.000	44.16	3	28
Nov.	4.000	29.100	33.90	16	14
Dec.	1.650	29.122	34.65	7	24
Rain,	38.573			99	266
Mean,		28.956	45.85		

ABSTRACT for 1776.

Month.	Rain.	Barom.	Therm.	E'ly	W'ly
				Days,	
Jan.*	Snow lies	29.070	26.00	21	10
Feb.	6.070	28.500	34.72	8	21
March,	1.375	29.140	39.00	11	20
April,	1.550	29.300	45.40	5	25
May,	.725	29.333	48.00	12	19
June,	1.375	29.445	54.70	6	24
July,	3.425	29.303	58.55	4	27
Aug.	2.900	29.120	56.00	5	26
Sept.	2.750	29.150	50.30	9	21
Oct.	1.800	29.230	45.00	9	22
Nov.	2.450	29.050	38.00	11	19
Dec.	1.875	29.130	36.06	10	21
Rain,	26.295			111	255
Mean,		29.147	44.31		

ABSTRACT for 1777.

Month.	Rain.	Barom.	Therm.	E'ly	W'ly
				Days.	
Jan.	1.875	29.084	30.90	20	11
Feb.	3.383	29.171	31.43	17	11
March,	1.550	29.032	38.00	9	22
April,	2.825	29.263	40.00	17	13
May,	1.800	29.032	49.40	11	20
June,	2.450	29.180	51.90	10	20
July,	2.050	29.161	54.45	15	16
Aug.	2.450	29.180	57.00	4	27
Sept.	.750	29.283	53.90	2	28
Oct.	7.400	29.000	45.90	14	17
Nov.	2.750	29.100	39.00	4	26
Dec.	.250	29.110	34.23	17	14
Rain,	26.533			140	225
Mean,		29.133	43.84		

ABSTRACT

* The height of the rain-gage, when the snow melted on the 17th of February, is included in the sum of that month.

ABSTRACT for 1778.

Month.	Rain.	Barom.	Therm.	Wind, Ely	Wly
				Days.	
Jan.	2.200	29.200	32.550	8	23
Feb.	.600	29.000	34.650	8	20
March,	6.200	29.371	35.800	20	11
April,	1.925	28.323	42.500	15	15
May,	2.200	29.300	52.160	6	25
June,	2.400	29.230	57.270	4	26
July,	5.500	29.130	59.000	8	23
Aug.	1.775	29.320	56.320	8	23
Sept.	2.200	29.300	50.066	10	20
Oct.	6.250	28.950	40.700	21	10
Nov.	4.400	28.890	38.500	16	14
Dec.	4.350	29.000	39.130	8	23
Rain,	36.400			132	233
Mean,		29.084	44.888		

ABSTRACT for 1779.

Month.	Rain.	Barom.	Therm.	Wind, Ely	Wly
				Days	
Jan.	1.397	29.500	33.770	11	20
Feb.	1.700	29.700	43.700	00	28
March,	.250	29.350	41.900	12	19
April,	2.650	28.160	42.600	1	29
May,	3.025	29.100	49.000	12	19
June,	2.075	29.280	55.200	22	8
July,	4.975	29.150	61.400	10	21
Aug.	1.050	29.300	59.800	14	17
Sept.	4.975	29.045	52.770	2	28
Oct.	4.450	29.126	46.100	6	25
Nov.	1.175	28.900	38.000	8	22
Dec.	3.970	28.887	30.030	14	17
Rain,	31.692			112	253
Mean,		29.125	46.190		

ABSTRACT for 1780.

Month.	Rain.	Barom	Therm.	Wind, Ely	Wly
				Days.	
Jan.	Frost.	29.160	25.605	20	11
Feb.	1.250	29.000	32.290	10	19
March,	2.950	29.000	42.613	1	30
April,	2.500	28.900	40.700	20	10
May,	4.025	29.090	50.226	4	27
June,	2.100	29.213	55.000	8	22
July,	2.050	29.280	58.355	9	22
Aug.	.250	29.430	59.000	21	10
Sept.	3.350	29.000	54.900	15	15
Oct.	4.700	29.230	44.260	11	20
Nov.	1.975	28.180	34.600	10	20
Dec.	.350	29.530	35.700	10	21
Rain,	25.500			139	227
Mean,		29.085	44.445		

ABSTRACT for 1781.

Month.	Rain.	Barom.	Therm.	Wind, Ely	Wly
				Days.	
Jan.	1.300	29.142	32.300	15	16
Feb.	3.600	28.920	38.000	4	24
March,	.200	29.445	41.580	7	24
April,	1.850	29.160	44.500	9	21
May,	1.475	29.355	49.540	20	11
June,	2.000	29.200	55.130	21	9
July,	1.700	29.440	60.640	14	17
Aug.	6.250	29.160	58.000	15	16
Sept.	1.125	29.160	52.560	10	20
Oct.	.950	29.360	46.200	1	30
Nov.	4.250	29.000	38.000	7	23
Dec.	4.600	29.000	35.450	13	18
Rain,	29.300			136	229
Mean,		29.185	46.000		

ABSTRACT

ABSTRACT for 1782.

Month.	Rain.	Barom.	Therm.	Wind, E'ly	W'ly
				Days	
Jan.	7.450	29.900	36.000	5	26
Feb.	2.400	29.214	31.643	18	10
March,	3.850	28.900	35.260	13	18
April,	1.900	29.100	38.600	27	3
May,	5.500	28.960	45.562	15	16
June,	1.650	29.250	55.500	5	25
July,	1.750	29.194	58.226	8	23
Aug.	3.700	28.300	54.000	5	26
Sept.	4.700	29.166	49.333	12	28
Oct.	3.150	29.300	41.500	14	17
Nov.	.800	28.220	32.466	19	11
Dec.	1.350	29.226	33.260	13	18
Rain.	38.200				
Mean.		29.061	42.612	154	211

ABSTRACT for 1783.

Month.	Rain.	Barom.	Therm.	Wind, E'ly	W'ly
				Days.	
Jan.	3.025	28.700	34.000	5	26
Feb.	3.650	28.920	35.800	12	16
March,	1.700	29.026	35.000	17	14
April,	.100	29.447	46.433	12	18
May,	1.525	29.210	47.322	12	19
June,	2.300	29.137	54.100	12	18
July,	3.750	29.245	62.450	8	23
Aug.	2.700	29.200	56.600	13	18
Sept.	3.775	28.987	52.800	7	23
Oct.	4.450	29.074	45.000	0	31
Nov.	3.700	29.154	37.330	10	20
Dec.	1.050	29.184	33.700	17	14
Rain.	31.725				
Mean.		29.107	45.045	125	240

ABSTRACT for all the preceding Years.

Year.	Rain,	Barom.	Therm.	Wind, E'ly	W'ly
				Days.	
1774,	29.250	29.225		185	180
1775,	38.573	28.956	45.8500	99	266
1776,	26.295	29.147	44.3100	111	225
1777,	29.533	29.133	43.8400	140	225
1778,	36.400	29.035	44.8880	132	233
1779,	31.692	29.125	46.1900	112	253
1780,	25.500	29.085	44.4450	139	227
1781,	29.300	29.185	46.0000	136	229
1782,	38.200	29.061	42.6070	154	211
1783,	31.725	29.107	45.0449	125	240
Medium of 10 Years, Ditto, 9 Years	31.648	29.106	44.7930	133.3	231.9

COMPARATIVE

COMPARATIVE VIEW of the Depth of Rain at Branxholm, Dalkeith and Langholm, for five Years:

THE Rain at all these Places was measured as has been described above.

Month.	1773.			1774.			1775.			1776.			1777.		
	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.	Dalk.	Branx.	Lang.
Jan.	3.250	4.100	5.200	4.400	0.300	1.150	3.375	5.350	7.200	0.700	Snow lies	5.475	1.025	1.875	0.200
Feb.	1.000	2.375	2.500	2.150	3.425	3.200	2.200	4.600	5.100	3.650	6.870	2.600	0.975	3.383	3.500
March,	1.050	1.350	1.600	0.375	0.750	0.525	0.125	2.450	3.800	1.325	1.375	0.225	1.825	1.550	1.000
April,	2.400	3.200	3.900	1.200	1.900	3.275	0.400	0.700	1.200	0.925	1.550	0.375	3.525	2.825	4.500
May,	1.525	2.000	1.200	1.600	3.450	2.625	1.250	1.475	0.500	0.400	0.725	0.625	0.650	1.800	3.250
June,	1.600	1.125	1.000	3.100	3.600	3.025	0.300	1.500	0.400	1.775	1.375	3.125	1.800	2.450	4.000
July,	1.200	0.752	1.100	1.600	2.450	5.000	6.175	3.573	3.000	2.900	3.425	5.225	2.350	2.050	2.325
Aug.	1.800	1.850	3.425	3.675	4.500	4.450	3.050	4.425	6.000	1.900	2.900	5.500	1.575	2.450	4.250
Sept.	4.425	4.600	8.300	2.350	3.350	5.975	2.825	4.300	4.500	1.675	2.750	4.425	1.750	0.750	2.150
Oct.	1.475	6.125	6.125	1.175	0.950	0.875	6.125	4.550	2.700	1.300	1.800	4.225	4.600	7.400	6.750
Nov.	3.175	1.550	2.900	1.225	2.250	2.100	3.450	4.000	2.200	1.200	2.450		1.800	2.750	4.650
Dec.	2.575	3.625	1.600	2.125	2.325	2.205	0.275	1.650	2.700	1.900	1.875	2.361	0.950	0.250	0.375

Dalkeith lies 44 Miles N. by E; and Langholm 20 S. by W. from Branxholm.

RESULT of the preceding Comparison.

Year.	Dalkeith.	Branxholm.	Langholm.
1773,	25.473	32.652	38.850
1774,	27.925	29.250	34.405
1775,	29.550	38.573	39.300
1776,	20.650	26.295	34.161
1777,	22.025	29.533	36.950
Medium	25.1246	31.2606	36.7333

X.

X. THEORY *of the* EARTH; *or an* INVESTIGATION *of the Laws observable in the Composition, Dissolution, and Restoration of Land upon the Globe.* By JAMES HUTTON, M. D. F. R. S. EDIN. *and Member of the Royal Academy of Agriculture at* PARIS.

[*Read March* 7. *and April* 4. 1785.]

PART. I.

Prospect of the Subject to be treated of.

WHEN we trace the parts of which this terrestrial system is composed, and when we view the general connection of those several parts, the whole presents a machine of a peculiar construction by which it is adapted to a certain end. We perceive a fabric, erected in wisdom, to obtain a purpose worthy of the power that is apparent in the production of it.

WE know little of the earth's internal parts, or of the materials which compose it at any considerable depth below the surface. But upon the surface of this globe, the more inert matter is replenished with plants, and with animal and intellectual beings.

WHERE so many living creatures are to ply their respective powers, in pursuing the end for which they were intended, we are not to look for nature in a quiescent state; matter itself must be in motion, and the scenes of life a continued or repeated series of agitations and events.

THIS globe of the earth is a habitable world; and on its fitness for this purpose, our sense of wisdom in its formation

must

muſt depend.   To judge of this point, we muſt keep in view, not only the end, but the means alſo by which that end is obtained.   Theſe are, the form of the whole, the materials of which it is compoſed, and the ſeveral powers which concur, counteract, or balance one another, in procuring the general reſult.

THE form and conſtitution of the maſs are not more evidently calculated for the purpoſe of this earth as a habitable world, than are the various ſubſtances of which that complicated body is compoſed.   Soft and hard parts variouſly combine, to form a medium conſiſtence adapted to the uſe of plants and animals; wet and dry are properly mixed for nutrition, or the ſupport of thoſe growing bodies ; and hot and cold produce a temperature or climate no leſs required than a ſoil.   Inſomuch, that there is not any particular, reſpecting either the qualities of the materials, or the conſtruction of the machine, more obvious to our perception, than are the preſence and efficacy of deſign and intelligence in the power that conducts the work.

IN taking this view of things, where ends and means are made the object of attention, we may hope to find a principle upon which the comparative importance of parts in the ſyſtem of nature may be eſtimated, and alſo a rule for ſelecting the object of our enquiries.   Under this direction, ſcience may find a fit ſubject of inveſtigation in every particular, whether of *form*, *quality*, or *active power*, that preſents itſelf in this ſyſtem of motion and of life ; and which, without a proper attention to this character of the ſyſtem, might appear anomalous and incomprehenſible.

IT is not only by ſeeing thoſe general operations of the globe which depend upon its peculiar conſtruction as a machine, but alſo by perceiving how far the particulars, in the conſtruction of that machine, depend upon the general operations of the globe, that we are enabled to underſtand the conſtitution of this earth as a thing formed by deſign.   We ſhall thus alſo be led to acknowledge an order, not unworthy of Divine wiſdom, in

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a fubject which, in another view, has appeared as the work of chance, or as abfolute diforder and confufion.

To acquire a general or comprehenfive view of this mechanifm of the globe, by which it is adapted to the purpofe of being a habitable world, it is neceffary to diftinguifh three different bodies which compofe the whole. Thefe are, a folid body of earth, an aqueous body of fea, and an elaftic fluid of air.

It is the proper fhape and difpofition of thefe three bodies that form this globe into a habitable world; and it is the manner in which thefe conftituent bodies are adjufted to each other, and the laws of action by which they are maintained in their proper qualities and refpective departments, that form the Theory of the machine which we are now to examine.

Let us begin with fome general fketch of the particulars now mentioned.

1*ſt*, There is a central body in the globe. This body fupports thofe parts which come to be more immediately expofed to our view, or which may be examined by our fenfe and obfervation. This firft part is commonly fuppofed to be folid and inert; but fuch a conclufion is only mere conjecture; and we fhall afterwards find occafion, perhaps, to form another judgment in relation to this fubject, after we have examined ftrictly, upon fcientific principles, what appears upon the furface, and have formed conclufions concerning that which muft have been tranfacted in fome more central part.

2*dly*, We find a fluid body of water. This, by gravitation, is reduced to a fpherical form, and by the centrifugal force of the earth's rotation, is become oblate. The purpofe of this fluid body is effential in the conftitution of the world; for, befides affording the means of life and motion to a multifarious race of animals, it is the fource of growth and circulation to the organized bodies of this earth, in being the receptacle of the rivers, and the fountain of our vapours.

3*dly*,

3dly, We have an irregular body of land, raifed above the level of the ocean. This, no doubt, is the fmalleft portion of the globe; but it is the part to us by far moft interefting. It is upon the furface of this part that plants are made to grow; confequently, it is by virtue of this land that animal life, as well as vegetation, is fuftained in this world.

Laftly, We have a furrounding body of atmofphere, which completes the globe. This vital fluid is no lefs neceffary in the conftitution of the world than are the other parts; for there is hardly an operation upon the furface of the earth, that is not conducted or promoted by its means. It is a neceffary condition for the fuftenance of fire; it is the breath of life to animals; it is at leaft an inftrument in vegetation; and while it contributes to give fertility and health to things that grow, it is employed in preventing noxious effects from fuch as go into corruption. In fhort, it is the proper means of circulation for the matter of this world, by raifing up the water of the ocean, and pouring it forth upon the furface of the earth.

Such is the mechanifm of the globe; let us now mention fome of thofe powers by which motion is produced, and activity procured to the mere machine.

First, There is the progreffive force, or moving power, by which this planetary body, if folely actuated, would depart continually from the path which it now purfues, and thus be for ever removed from its end, whether as a planetary body, or as a globe fuftaining plants and animals, which may be termed a living world.

But this moving body is alfo actuated by gravitation, which inclines it directly to the central body of the fun. Thus it is made to revolve about that luminary, and to preferve its path.

It is alfo upon the fame principles, that each particular part upon the furface of this globe, is alternately expofed to the influence of light and darknefs, in the diurnal rotation of the earth, as well as in its annual revolution. In this manner are

produced

produced the viciſſitudes of night and day, ſo variable in the different latitudes from the equator to the pole, and ſo beautifully calculated to equalize the benefits of light, ſo variouſly diſtributed in the different regions of the globe.

GRAVITATION and the *vis incita* of matter thus form the firſt two powers diſtinguiſhable in the operations of our ſyſtem, and wiſely adapted to the purpoſe for which they are employed.

WE next obſerve the influence of light and heat, of cold and condenſation. It is by means of theſe two powers that the various operations of this living world are more immediately tranſacted; although the other powers are no leſs required, in order to produce or modify theſe great agents in the œconomy of life, and ſyſtem of our changing things.

WE do not now enquire into the nature of thoſe powers, or inveſtigate the laws of light and heat, of cold and condenſation, by which the various purpoſes of this world are accompliſhed; we are only to mention thoſe effects which are made ſenſible to the common underſtanding of mankind, and which neceſſarily imply a power that is employed. Thus, it is by the operation of thoſe powers that the varieties of ſeaſon in ſpring and autumn are obtained, that we are bleſſed with the viciſſitudes of ſummer's heat and winter's cold, and that we poſſeſs the benefit of artificial light and culinary fire.

WE are thus bountifully provided with the neceſſaries of life; we are ſupplied with things conducive to the growth and preſervation of our animal nature, and with fit ſubjects to employ and to nouriſh our intellectual powers.

THERE are other actuating powers employed in the operations of this globe, which we are little more than able to enumerate; ſuch are thoſe of electricity and magnetiſm.

POWERS of ſuch magnitude or force, are not to be ſuppoſed uſeleſs in a machine contrived ſurely not without wiſdom; but they are mentioned here chiefly on account of their general effect; and it is ſufficient to have named powers, of which the

actual

actual exiftence is well known, but of which the proper ufe in the conftitution of the world is ftill obfcure.

WE have thus furveyed the machine in general, with thofe moving powers, by which its operations, diverfified almoft *ad infinitum*, are performed. Let us now confine our view, more particularly, to that part of the machine on which we dwell, that fo we may confider the natural confequences of thofe operations which, being within our view, we are better qualified to examine.

THIS fubject is important to the human race, to the poffeffor of this world, to the intelligent being Man, who forefees events to come, and who, in contemplating his future intereft, is led to enquire concerning caufes, in order that he may judge of events which otherwife he could not know.

IF, in purfuing this object, we employ our fkill in refearch, not in forming vain conjectures ; and if *data* are to be found, on which Science may form juft conclufions, we fhould not long remain in ignorance with refpect to the natural hiftory of this earth, a fubject on which hitherto opinion only, and not evidence, has decided : For in no fubject is there naturally lefs defect of evidence, although philofophers, led by prejudice, or mifguided by falfe theory, have neglected to employ that light by which they fhould have feen the fyftem of this world.

BUT to proceed in purfuing a little farther our general or preparatory ideas. A folid body of land could not have anfwered the purpofe of a habitable world ; for a foil is neceffary to the growth of plants ; and a foil is nothing but the materials collected from the deftruction of the folid land. Therefore, the furface of this land, inhabited by man, and covered with plants and animals, is made by nature to decay, in diffolving from that hard and compact ftate in which it is found below the foil ; and this foil is neceffarily wafhed away, by the continual circulation of the water, running from the fummits of the mountains towards the general receptacle of that fluid.

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THE heights of our land are thus levelled with the ſhores; our fertile plains are formed from the ruins of the mountains; and thoſe travelling materials are ſtill purſued by the moving water, and propelled along the inclined ſurface of the earth. Theſe moveable materials, delivered into the ſea, cannot, for a long continuance, reſt upon the ſhore; for, by the agitation of the winds, the tides and currents, every moveable thing is carried farther and farther along the ſhelving bottom of the ſea, towards the unfathomable regions of the ocean.

IF the vegetable ſoil is thus conſtantly removed from the ſurface of the land, and if its place is thus to be ſupplied from the diſſolution of the ſolid earth, as here repreſented, we may perceive an end to this beautiful machine; an end, ariſing from no error in its conſtitution as a world, but from that deſtructibility of its land which is ſo neceſſary in the ſyſtem of the globe, in the œconomy of life and vegetation.

THE immenſe time neceſſarily required for this total deſtruction of the land, muſt not be oppoſed to that view of future events, which is indicated by the ſureſt facts and moſt approved principles. Time, which meaſures every thing in our idea, and is often deficient to our ſchemes, is to nature endleſs and as nothing; it cannot limit that by which alone it had exiſtence; and as the natural courſe of time, which to us ſeems infinite, cannot be bounded by any operation that may have an end, the progreſs of things upon this globe, that is, the courſe of nature, cannot be limited by time, which muſt proceed in a continual ſucceſſion. We are, therefore, to conſider as inevitable the deſtruction of our land, ſo far as effected by thoſe operations which are neceſſary in the purpoſe of the globe, conſidered as a habitable world; and ſo far as we have not examined any other part of the œconomy of nature, in which other operations and a different intention might appear.

WE have now conſidered the globe of this earth as a machine, conſtructed upon chemical as well as mechanical principles,

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by which its different parts are all adapted, in form, in quality, and in quantity, to a certain end; an end attained with certainty or fuccefs; and an end from which we may perceive wifdom, in contemplating the means employed.

But is this world to be confidered thus merely as a machine, to laft no longer than its parts retain their prefent pofition, their proper forms and qualities? Or may it not be alfo confidered as an organized body? Such as has a conftitution in which the neceffary decay of the machine is naturally repaired, in the exertion of thofe productive powers by which it had been formed.

This is the view in which we are now to examine the globe; to fee if there be, in the conftitution of this world, a reproductive operation, by which a ruined conftitution may be again repaired, and a duration or ftability thus procured to the machine, confidered as a world fuftaining plants and animals.

If no fuch reproductive power, or reforming operation, after due enquiry, is to be found in the conftitution of this world, we fhould have reafon to conclude, that the fyftem of this earth has either been intentionally made imperfect, or has not been the work of infinite power and wifdom.

Here is an important queftion, therefore, with regard to the conftitution of this globe; a queftion which, perhaps, it is in the power of man's fagacity to refolve; and a queftion which, if fatisfactorily refolved, might add fome luftre to fcience and the human intellect.

Animated with this great, this interefting view, let us ftrictly examine our principles, in order to avoid fallacy in our reafoning; and let us endeavour to fupport our attention, in developing a fubject that is vaft in its extent, as well as intricate in the relation of parts to be ftated.

The globe of this earth is evidently made for man. He alone, of all the beings which have life upon this body, enjoys the whole and every part; he alone is capable of knowing the

<div align="right">nature</div>

nature of this world, which he thus poſſeſſes in virtue of his proper right; and he alone can make the knowledge of this ſyſtem a ſource of pleaſure and the means of happineſs.

MAN alone, of all the animated beings which enjoy the benefits of this earth, employs the knowledge which he there receives, in leading him to judge of the intention of things, as well as of the means by which they are brought about; and he alone is thus made to enjoy, in contemplation as well as ſenſual pleaſure, all the good that may be obſerved in the conſtitution of this world; he, therefore, ſhould be made the firſt ſubject of enquiry.

Now, if we are to take the written hiſtory of man for the rule by which we ſhould judge of the time when the ſpecies firſt began, that period would be but little removed from the preſent ſtate of things. The Moſaic hiſtory places this beginning of man at no great diſtance; and there has not been found, in natural hiſtory, any document by which a high antiquity might be attributed to the human race. But this is not the caſe with regard to the inferior ſpecies of animals, particularly thoſe which inhabit the ocean and its ſhores. We find in natural hiſtory monuments which prove that thoſe animals had long exiſted; and we thus procure a meaſure for the computation of a period of time extremely remote, though far from being preciſely aſcertained.

IN examining things preſent, we have data from which to reaſon with regard to what has been; and, from what has actually been, we have data for concluding with regard to that which is to happen hereafter. Therefore, upon the ſuppoſition that the operations of nature are equable and ſteady, we find, in natural appearances, means for concluding a certain portion of time to have neceſſarily elapſed, in the production of thoſe events of which we ſee the effects.

IT is thus that, in finding the relics of ſea-animals of every kind in the ſolid body of our earth, a natural hiſtory of thoſe animals is formed, which includes a certain portion of time;

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and for the afcertaining this portion of time, we muft again have recourfe to the regular operations of this world. We fhall thus arrive at facts which indicate a period to which no other fpecies of chronology is able to remount.

In what follows, therefore, we are to examine the conftruction of the prefent earth, in order to underftand the natural operations of time paft; to acquire principles, by which we may conclude with regard to the future courfe of things, or judge of thofe operations, by which a world, fo wifely ordered, goes into decay; and to learn, by what means fuch a decayed world may be renovated, or the wafte of habitable land upon the globe repaired.

This, therefore, is the object which we are to have in view during this phyfical inveftigation; this is the end to which are to be directed all the fteps in our cofmological purfuit.

The folid parts of the globe are, in general, compofed of fand, of gravel, of argillaceous and calcareous ftrata, or of the various compofitions of thefe with fome other fubftances, which it is not neceffary now to mention. Sand is feparated and fized by ftreams and currents; gravel is formed by the mutual attrition of ftones agitated in water; and marly, or argillaceous ftrata, have been collected, by fubfiding in water with which thofe earthy fubftances had been floated. Thus, fo far as the earth is formed of thefe materials, that folid body would appear to have been the production of water, winds, and tides.

But that which renders the original of our land clear and evident, is the immenfe quantities of calcareous bodies which had belonged to animals, and the intimate connection of thefe maffes of animal production with the other ftrata of the land. For it is to be proved, that all thefe calcareous bodies, from the collection of which the ftrata were formed, have belonged to the fea, and were produced in it.

We find the marks of marine animals in the moft folid parts of the earth, confequently, thofe folid parts have been formed

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after the ocean was inhabited by those animals, which are proper to that fluid medium. If, therefore, we knew the natural history of those solid parts, and could trace the operations of the globe, by which they had been formed, we would have some means for computing the time through which those species of animals have continued to live. But how shall we describe a process which nobody has seen performed, and of which no written history gives any account? This is only to be investigated, *first*, in examining the nature of those solid bodies, the history of which we want to know; and, *2dly*, In examining the natural operations of the globe, in order to see if there now actually exist such operations, as, from the nature of the solid bodies, appear to have been necessary to their formation.

BUT, before entering more particularly into those points of discussion, by which the question is to be resolved, let us take a general view of the subject, in order to see what it is which science and observation must decide.

IN all the regions of the globe, immense masses are found, which, though at present in the most solid state, appear to have been formed by the collection of the calcareous *exuviæ* of marine animals. The question at present is not, in what manner those collections of calcareous relics have become a perfect solid body, and have been changed from an animal to a mineral substance; for this is a subject that will be afterwards considered; we are now only enquiring, if such is truly the origin of those mineral masses.

THAT all the masses of marble or limestone are composed of the calcareous matter of marine bodies, may be concluded from the following facts:

1st, THERE are few beds of marble or limestone, in which may not be found some of those objects which indicate the marine origin of the mass. If, for example, in a mass of marble, taken from a quarry upon the top of the Alps or

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Andes *, there fhall be found one cockle-fhell, or piece of coral, it muft be concluded, that this bed of ftone had been original-ly formed at the bottom of the fea, as much as another bed which is evidently compofed almoft altogether of cockle-fhells and coral. If one bed of limeftone is thus found to have been of a marine origin, every concomitant bed of the fame kind muft be alfo concluded to have been formed in the fame man-ner.

WE thus fhall find the greateft part of the calcareous maffes upon this globe to have originated from marine calcareous bo-dies; for whether we examine marbles, limeftones, or fuch fo-lid maffes as are perfectly changed from the ftate of earth, and are become compact and hard, or whether we examine the foft, earthy, chalky or marly ftrata, of which fo much of this earth is compofed, we ftill find evident proofs, that thofe beds had their origin from materials depofited at the bottom of the fea; and that they have the calcareous fubftance which they contain, from the fame fource as the marbles or the limeftones.

2*dly*, IN thofe calcareous ftrata, which are evidently of ma-rine origin, there are many parts that are of a fparry ftructure, that is to fay, the original texture of thofe beds, in fuch places, has been diffolved, and a new ftructure has been affumed, which is peculiar to a certain ftate of the calcareous earth. This change is produced by cryftallization, in confequence of a previous ftate of fluidity, which has fo difpofed the concreting parts, as to allow them to affume a regular fhape and ftructure proper to that fubftance. A body, whofe external form has been

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* " CETTE fommité élevée de 984 toifes au deffus de notre lac, et par conféquent de " 1172 au deffus de la mer, eft remarquable en ce que l'on y voit des fragmens d'huîtres " pétrifiés.——Cette montagne eft dominée par un rocher efcarpé, qui s'il neft pas in-" acceffible, eft du moins d'un bien difficile accès; il paroît prefqu'entierement compofé " de coquillages pétrifiés, renfermés dans un roc calcaire, ou marbre groffier noirâtre. " Les fragmens qui s'en detachent, et que l'on rencontre en montant à la Croix de fer, " font remplis de *turbinites* de différentes efpeces." M. DE SAUSSURE, *Voyage dans les Alpes,* p. 394.

been modified by this procefs, is called a *cryftal*; one whofe internal arrangement of parts is determined by it, is faid to be of a *fparry ftructure*; and this is known from its fracture.

3*dly*, THERE are, in all the regions of the earth, huge maffes of calcareous matter, in that cryftalline form or fparry ftate, in which perhaps no veftige can be found of any organized body, nor any indication that fuch calcareous matter had belonged to animals; but as, in other maffes, this fparry ftructure, or cryftalline ftate, is evidently affumed by the marine calcareous fubftances, in operations which are natural to the globe, and which are neceffary to the confolidation of the ftrata, it does not appear, that the fparry maffes, in which no figured body is formed, have been originally different from other maffes, which, being only cryftallized in part, and in part ftill retaining their original form, leave ample evidence of their marine origin.

WE are led, in this manner, to conclude, that all the ftrata of the earth, not only thofe confifting of fuch calcareous maffes, but others fuperincumbent upon thefe, have had their origin at the bottom of the fea, by the collection of fand and gravel, of fhells, of coralline and cruftaceous bodies, and of earths and clays, varioufly mixed, or feparated and accumulated. Here is a general conclufion, well authenticated in the appearances of nature, and highly important in the natural hiftory of the earth.

THE general amount of our reafoning is this, that nine tenths, perhaps, or ninety-nine hundredths of this earth, fo far as we fee, have been formed by natural operations of the globe, in collecting loofe materials, and depofiting them at the bottom of the fea; confolidating thofe collections in various degrees, and either elevating thofe confolidated maffes above the level on which they were formed, or lowering the level of that fea.

THERE is a part of the folid earth which we may at prefent neglect, not, as being perfuaded that this part may not alfo be

<div align="right">found.</div>

found to come under the general rule of formation with the reft, but as confidering this part to be of no confequence in forming a general rule, which fhall comprehend almoft the whole, without doing it abfolutely. This excluded part confifts of certain mountains and maffes of granite. Thefe are thought to be ftill older in their formation, and are very rarely, at leaft, found fuperincumbent on ftrata which muft be acknowledged as the productions of the fea.

HAVING thus found the greater part, if not the whole, of the folid land to have been originally compofed at the bottom of the fea, we may now, in order to form a proper idea of thefe operations, fuppofe the whole of this fea-born land to be again difperfed along the bottom of the ocean, the furface of which would rife proportionally over the globe. We would thus have a fpheroid of water, with granite rocks and iflands fcattered here and there. But this would not be the world which we inhabit; therefore, the queftion now is, how fuch continents, as we actually have upon the globe, could be erected above the level of the fea.

IT muft be evident, that no motion of the fea, caufed by this earth revolving in the folar fyftem, could bring about that end; for let us fuppofe the axis of the earth to be changed from the prefent poles, and placed in the equinoctial line, the confequence of this might, indeed, be the formation of a continent of land about each new pole, from whence the fea would run towards the new equator; but all the reft of the globe would remain an ocean. Some new points might be difcovered, and others, which before appeared above the furface of the fea, would be funk by the rifing of the water; but, on the whole, land could only be gained fubftantially at the poles. Such a fuppofition as this, if applied to the prefent ftate of things, would be deftitute of every fupport, as being incapable of explaining what appears.

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BUT even allowing that, by the changed axis of the earth, or any other operation of the globe, as a planetary body revolving in the folar fyftem, great continents of land could have been erected from the place of their formation, the bottom of the fea, and placed in a higher elevation, compared with the furface of that water, yet fuch a continent as this could not have continued ftationary for many thoufand years ; nor could a continent of this kind have prefented to us, every where within its body, maffes of confolidated marble, and other mineral fubftances, in a ftate as different as poffible from that in which they were, when originally collected together in the fea.

CONSEQUENTLY, befides an operation, by which the earth at the bottom of the fea fhould be converted into an elevated land, or placed high above the level of the ocean, there is required, in the operations of the globe, a confolidating power, by which the loofe materials that had fubfided from water, fhould be formed into maffes of the moft perfect folidity, having neither water nor vacuity between their various conftituent parts, nor in the pores of thofe conftituent parts themfelves.

HERE is an operation of the globe, whether chemical or mechanical, which is neceffarily connected with the formation of our prefent continents : Therefore, had we a proper underftanding of this fecret operation, we might thereby be enabled to form an opinion, with regard to the nature of that unknown power, by which the continents have been placed above the furface of that water wherein they had their birth.

IF this confolidating operation be performed at the bottom of the ocean, or under great depths of the earth, of which our continents are compofed, we cannot be witneffes to this mineral procefs, or acquire the knowledge of natural caufes, by immediately obferving the changes which they produce ; but though we have not this immediate obfervation of thofe changes of bodies, we have, in fcience, the means of reafoning from

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diſtant events; conſequently, of diſcovering, in the general powers of nature, cauſes for thoſe events of which we ſee the effects.

THAT the conſolidating operation, in general, lies out of the reach of our immediate obſervation, will appear from the following truth: All the conſolidated maſſes, of which we now enquire into the cauſe, are, upon the ſurface of the earth in a ſtate of general decay, although the various natures of thoſe bodies admit of that diſſolution in very different degrees *.

FROM every view of the ſubject, therefore, we are directed to look into thoſe conſolidated maſſes themſelves, in order to find principles from whence to judge of thoſe operations by which they had attained their hardneſs or conſolidated ſtate.

IT muſt be evident, that nothing but the moſt general acquaintance with the laws of acting ſubſtances, and with thoſe of bodies changing by the powers of nature, can enable us to ſet about this undertaking with any reaſonable proſpect of ſucceſs; and here the ſcience of Chemiſtry muſt be brought particularly to our aid; for this ſcience, having for its object the changes produced upon the ſenſible qualities, as they are called, of bodies, by its means we may be enabled to judge of that which is poſſible according to the laws of nature, and of that which, in like manner, we muſt conſider as impoſſible.

WHATEVER concluſions, therefore, by means of this ſcience, ſhall be attained, in juſt reaſoning from natural appearances, this muſt be held as evidence, where more immediate proof cannot be obtained; and, in a phyſical ſubject, where things actual are concerned, and not the imaginations of the human mind, this proof will be conſidered as amounting to a demonſtration.

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* STALACTICAL and certain ferruginous concretions may ſeem to form an exception to the generality of this propoſition. But an objection of this kind could only ariſe from a partial view of things; for the concretion here is only temporary, it is in conſequence of a ſolution, and it is to be followed by a diſſolution, which will be treated of in its proper place.

P A R T II.

An Investigation of the Natural Operations employed in consolidating the Strata of the Globe.

THERE are just two ways in which porous or spongy bodies can be consolidated, and by which substances may be formed into masses of a natural shape and regular structure; the one of these is simple *congelation* from a fluid state, by means of cold; the other is *accretion*; and this includes a separatory operation, as well as that by which the solid body is to be produced. But, in whichever of these ways solidity is to be procured, it must be brought about by first inducing fluidity, either immediately by the action of heat, or mediately with the assistance of a solvent, that is, by the operation of solution.

THUS, fire and water may be considered as the general agents in this operation which we would explore. We are, therefore, to consider well, what may be the consequences of consolidation by the one or other of those agents; and what may be their several powers with respect to this operation.

IF we are not informed in this branch of science, we may gaze without instruction upon the most convincing proofs of what we want to attain. If our knowledge is imperfect, we may form erroneous principles, and deceive ourselves in reasoning with regard to those works of nature, which are wisely calculated for our instruction.

THE strata, formed at the bottom of the sea, are to be considered as having been consolidated, either by aqueous solution and crystallization, or by the effect of heat and fusion. If it is in the first of these two ways that the solid strata of the globe have attained to their present state, there will be a certain uniformity observable in the effects; and there will be ge-

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neral laws, by which this operation muſt have been conducted. Therefore, knowing thoſe general laws, and making juſt obſervations with regard to the natural appearances of thoſe conſolidated maſſes, a philoſopher, in his cloſet, ſhould be able to determine, what may, and what may not have been tranſacted in the bowels of the earth, or below the bottom of the ocean.

LET us now endeavour to aſcertain what may have been the power of water, acting under fixed circumſtances, operating upon known ſubſtances, and conducting to a certain end.

THE action of water upon all different ſubſtances is an operation with which we are familiar. We have it in our power to apply water in different degrees of heat for the ſolution of bodies, and under various degrees of compreſſion; conſequently, there is no reaſon to conclude any thing myſterious in the operations of the globe, which are to be performed by means of water, unleſs an immenſe compreſſing power ſhould alter the nature of thoſe operations. But compreſſion alters the relation of evaporation only with regard to heat, or it changes the degree of heat which water may be made to contain; conſequently, we are to look for no occult quality in water acting upon bodies at the bottom of the deepeſt ocean, more than what can be obſerved in experiments which we have it in our power to try.

WITH regard again to the effect of time. Though the continuance of time may do much in thoſe operations which are extremely ſlow, where no change, to our obſervation, had appeared to take place; yet, where it is not in the nature of things to produce the change in queſtion, the unlimited courſe of time would be no more effectual, than the moment by which we meaſure events in our obſervations.

WATER being the general medium in which bodies collected at the bottom of the ſea are always contained, if thoſe maſſes of collected matter are to be conſolidated by ſolution, it muſt be by the diſſolution of thoſe bodies in that water as a menſtruum,

ſtruum, and by the concretion or cryſtallization of this diſſolved matter, that the ſpaces, firſt occupied by water in thoſe maſſes, are afterwards to be filled with a hard and ſolid ſubſtance ; but without ſome other power, by which the water contained in thoſe cavities and endleſs labyrinths of the ſtrata, ſhould be ſeparated in proportion as it had performed its taſk, it is inconceivable how thoſe maſſes, however changed from the ſtate of their firſt ſubſidence, ſhould be abſolutely conſolidated, without a particle of fluid water in their compoſition.

BESIDES this difficulty of having the water ſeparated from the porous maſſes which are to be conſolidated, there is another with which, upon this ſuppoſition, we have to ſtruggle. This is, From whence ſhould come the matter with which the numberleſs cavities in thoſe maſſes are to be filled ?

THE water in the cavities and interſtices of thoſe bodies compoſing ſtrata, muſt be in a ſtagnating ſtate ; conſequently, it can only act upon the ſurfaces of thoſe cavities which are to be filled up. But with what are they to be filled ? Not with water ; they are full of this already : Not with the ſubſtance of the bodies which contain that water; this would be only to make one cavity in order to fill up another. If, therefore, the cavities of the ſtrata are to be filled with ſolid matter, by means of water, there muſt be made to paſs through thoſe porous maſſes, water impregnated with ſome other ſubſtances in a diſſolved ſtate ; and the aqueous menſtruum muſt be made to ſeparate from the diſſolved ſubſtance, and to depoſit the ſame in thoſe cavities through which the ſolution moves.

BY ſuch a ſuppoſition as this, we might perhaps explain a partial conſolidation of thoſe ſtrata ; but this is a ſuppoſition, of which the caſe under conſideration does not admit ; for in the preſent caſe, which is that of materials accumulated at the bottom of the ocean, there is not proper means for ſeparating the diſſolved matter from the water included in thoſe enormous maſſes ; nor are there any means by which a circula-

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tion in thofe maffes may be formed. In this cafe, therefore, where the means are not naturally in the fuppofition, a philofopher, who is to explain the phænomenon by the natural operation of water in this fituation, muft not have recourfe to another agent, ftill more powerful, to affift his fuppofition, which cannot be admitted.

Thus, it will appear, that, to confolidate ftrata formed at the bottom of the fea, in the manner now confidered, operations are required unnatural to this place; confequently, not to be fuppofed in order to fupport a hypothefis.

But now, inftead of enquiring how far water may be fuppofed inftrumental in the confolidation of ftrata which were originally of a loofe texture, we are to confider how far there may be appearances in thofe confolidated bodies, by which it might be concluded, whether or not the prefent ftate of their confolidation has been actually brought about by means of that agent.

If water had been the menftruum by which the confolidating matter was introduced into the interftices of ftrata, maffes of thofe bodies could only be found confolidated with fuch fubftances as water is capable of diffolving; and thefe fubftances would be found only in fuch a ftate as the fimple feparation of the diffolving water might produce.

In this cafe, the confolidation of ftrata would be extremely limited; for we cannot allow more power to water than we find it has in nature; nor are we to imagine to ourfelves unlimited powers in bodies, on purpofe to explain thofe appearances, by which we fhould be made to know the powers of nature. Let us, therefore, attend, with every poffible circumfpection, to the appearances of thofe bodies, by means of which we are to inveftigate the principles of mineralogy, and know the laws of nature.

The queftion now before us concerns the confolidating fubftances of ftrata. Are thefe fuch as will correfpond to the diffolving

folving power of water, and to the ftate in which thofe fub-
ftances might be left by the feparation of their menftruum?
No; far, far from this fuppofition is the conclufion that necef-
farily follows from natural appearances.

WE have ftrata confolidated by calcareous fpar, a thing per-
fectly diftinguifhable from the ftalactical concretion of calca-
reous earth, in confequence of aqueous folution. We have
ftrata made folid by the formation of fluor, a fubftance not
foluble, fo far as we know, by water. We have ftrata confoli-
dated with fulphureous and bituminous fubftances, which do
not correfpond to the folution of water. We have ftrata con-
folidated with filiceous matter, in a ftate totally different from
that under which it has been obferved, on certain occafions, to
be depofited by water. We have ftrata confolidated by feld-
fpar, a fubftance infoluble in water. We have ftrata confoli-
dated by almoft all the various metallic fubftances, with their
almoft endlefs mixtures and fulphureous compofitions; that is
to fay, we find, perhaps, every different fubftance introduced
into the interftices of ftrata which had been formed by fubfi-
dence at the bottom of the fea.

IF it is by means of water that thofe interftices have been
filled with thofe materials, water muft be, like fire, an univer-
fal folvent, or caufe of fluidity, and we muft change entirely
our opinion of water in relation to its chemical character. But
there is no neceffity thus to violate our chemical principles, in
order to explain certain natural appearances; more efpecially
if thofe appearances may be explained in another manner, con-
fiftently with the known laws of nature.

IF, again, it is by means of heat and fufion that the loofe
and porous ftructure of ftrata fhall be fuppofed to have been
confolidated, then every difficulty which had occurred in rea-
foning upon the power or agency of water is at once removed:
The loofe and difcontinuous body of a ftratum may be clofed
by means of foftnefs and compreffion; the porous ftructure of
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the materials may be confolidated, in a fimilar manner, by the fufion of their fubftance; and foreign matter may be introduced into the open ftructure of ftrata, in form of ſteam or exhalation, as well as in the fluid ftate of fufion; confequently, heat is an agent competent for the confolidation of ftrata, which water alone is not. If, therefore, fuch an agent could be found acting in the natural place of ftrata, we muft pronounce it proper to bring about that end.

THE examination of nature gives countenance to this fuppofition, fo far as ftrata are found confolidated by every fpecies of fubftance, and almoft every poffible mixture of thofe different fubftances; confequently, however difficult it may appear to have this application of heat, for the purpofe of confolidating ftrata formed at the bottom of the ocean, we cannot, from natural appearances, fuppofe any other caufe, as having actually produced the effects which are now examined.

THIS queftion, with regard to the means of confolidating the ftrata of the globe, is, to natural hiftory, of the greateft importance; and it is effential in the theory now propofed to be given of the mineral fyftem. It would, therefore, require to be difcuffed with fome degree of precifion, in examining the particulars; but of thefe, there is fo great a field, and the fubject is fo complicated in its nature, that volumes might be written upon particular branches only, without exhaufting what might be faid upon the fubject; becaufe the evidence, though ftrong in many particulars, is chiefly to be enforced by a multitude of facts, confpiring, in a diverfity of ways, to point out one truth, and by the impoffibility of reconciling all thefe facts, except by means of one fuppofition.

BUT, as it is neceffary to give fome proof of that which is to be a principle in our reafoning afterwards, I fhall now endeavour to generalize the fubject as much as poffible, in order to anfwer that end, and, at the fame time, to point out the particular method of enquiry.

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THERE are to be found, among the various ftrata of the globe, bodies formed of two different kinds of fubftances, *filiceous* bodies, and thofe which may be termed *fulphureous.* With one or other, or both of thofe two fubftances, every different confolidated ftratum of the globe will be found fo intimately mixed, or clofely connected, that it muft be concluded, by whatever caufe thofe bodies of filiceous and fulphureous matter had been changed from a fluid to a concreted ftate, the ftrata muft have been fimilarly affected by the fame caufe.

THESE two fpecies of bodies, therefore, the filiceous and the fulphureous, may now be examined, in relation to the caufes of their concretion, with a view to determine, what has been the general concreting or confolidating power, which has operated univerfally in the globe ; and particularly to fhew, it has not been by means of any fluid folution, that ftrata in general have been confolidated, or that thofe particular fubftances have been cryftallized and concreted.

SILICEOUS matter, phyfically fpeaking, is not foluble in water ; that is to fay, in no manner of way have we been enabled to learn, that water has the power of diffolving this matter.

MANY other fubftances, which are fo little foluble in water, that their folubility could not be otherwife detected of themfelves, are made to appear foluble by means of filiceous matter ; fuch is feld-fpar, one of the component parts of rock-granite.

FELD-SPAR is a compound of filiceous, argillaceous, and calcareous earth, intimately united together. This compound filiceous body being, for ages, expofed to the weather, the calcareous part of it is diffolved, and the filiceous part is left in form of a foft white earth. But whether this diffolution is performed by pure water, or by means alfo of an acid, may perhaps be queftioned. This, however, is certain, that we muft confider filiceous fubftances as infoluble in water.

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THE water of Giezer in Iceland undoubtedly contains this ſubſtance in ſolution; but there is no reaſon to believe, that it is here diſſolved by any other than the natural means; that is, an alkaline ſubſtance, by which ſiliceous bodies may be rendered ſoluble in water.

IT may be, therefore, aſſerted, that no ſiliceous body having the hardneſs of flint, nor any cryſtallization of that ſubſtance, has ever been formed, except by fuſion. If, by any art, this ſubſtance ſhall be diſſolved in ſimple water, or made to cryſtal-lize from any ſolution, in that caſe, the aſſertion which has been here made may be denied. But where there is not the veſtige of any proof, to authoriſe the ſuppoſition of flinty matter be-ing diſſolved by water, or cryſtallized from that ſolution, ſuch an hypotheſis cannot be admitted, in oppoſition to general and evident appearances.

BESIDES this proof for the fuſion of ſiliceous bodies, which is indirect, ariſing from the indiſſolubility of that ſubſtance in water, there is another, which is more direct, being founded upon appearances which are plainly inconſiſtent with any other ſuppoſition, except that of ſimple fluidity induced by heat. The proof I mean is, the penetration of many bodies with a flinty ſubſtance, which, according to every collateral circumſtance, muſt have been performed by the flinty matter in a ſimply fluid ſtate, and not in a ſtate of diſſolution by a ſolvent.

THESE are flinty bodies perfectly inſulated in ſtrata both of chalk and ſand. It requires but inſpection to be convinced. It is not poſſible that flinty matter could be conveyed into the middle of thoſe ſtrata, by a menſtruum in which it was diſ-ſolved, and thus depoſited in that place, without the ſmalleſt trace of depoſition in the ſurrounding parts.

BUT, beſides this argument taken from what does not appear, the actual form in which thoſe flinty maſſes are found, demon-
<div align="right">ſtrates,</div>

ftrates, *firft*, That they have been introduced among thofe ftrata in a fluid ftate, by injection from fome other place.   2*dly*, That they have been difperfed in a variety of ways among thofe ftrata, then deeply immerfed at the bottom of the fea ; and, *laftly*, That they have been there congealed from the ftate of fufion, and have remained in that fituation, while thofe ftrata have been removed from the bottom of the ocean to the furface of the prefent land.

To defcribe thofe particular appearances would draw this paper beyond the bounds of an effay. We muft, therefore, refer thofe who would enquire more minutely into the fubject, to examine the chalk-countries of France and England, in which the flint is found varioufly formed ; the fand-hills interfperfed among thofe chalk-countries, which have been alfo injected by melted flint ; and the pudding-ftone of England, which I have not feen in its natural fituation. More particularly, I would recommend an examination of the infulated maffes of ftone, found in the fand-hills by the city of Bruffels ; a ftone which is formed by an injection of flint among fand, fimilar to that which, in a body of gravel, had formed the pudding-ftone of England *.

ALL thefe examples would require to be examined upon the fpot, as a great part of the proof for the fufion of the flinty fubftance, arifes, in my opinion, from the form in which thofe bodies are found, and the ftate of the furrounding parts. But there are fpecimens brought from many different places, which contain, in themfelves, the moft evident marks of this injection of the flinty fubftance in a fluid ftate. Thefe are pieces of foffil wood, penetrated with a filiceous fubftance, which are brought from England, Germany, and Lochneagh in Ireland.

IT appears from thefe fpecimens, that there has fometimes been a prior penetration of the body of wood, either with

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* ACCURATE defcriptions of thofe appearances, with drawings, would be, to natural hiftory, a valuable acquifition.

irony matter, or calcareous fubftance. Sometimes, again, which is the cafe with that of Lochneagh, there does not feem to have been any penetration of thofe two fubftances. The injected flint appears to have penetrated the body of this wood, immerfed at the bottom of the fea, under an immenfe compreffion of water. This appears from the wood being penetrated partially, fome parts not being penetrated at all.

Now, in the limits between thofe two parts, we have the moft convincing proofs, that it had been flint in a fimple fluid ftate which had penetrated the wood, and not in a ftate of folution.

Firft, Because, however little of the wood is left unpenetrated, the divifion is always diftinct between the injected part and that which is not penetrated by the fluid flint. In this cafe, the flinty matter has proceeded a certain length, which is marked, and no farther; and, beyond this boundary, there is no partial impregnation, nor a gradation of the flintifying operation, as muft have been the cafe if filiceous matter had been depofited from a folution. *2dly*, The termination of the flinty impregnation has affumed fuch a form, precifely, as would naturally happen from a fluid flint penetrating that body.

In other fpecimens of this mineralizing operation, foffil wood, penetrated, more or lefs, with ferruginous and calcareous fubftances, has been afterwards penetrated with a flinty fubftance. In this cafe, with whatever different fubftances the woody body fhall be fuppofed to have been penetrated in a ftate of folution by water, the regular ftructure of the plant would ftill have remained, with its vacuities varioufly filled with the petrifying fubftances, feparated from the aqueous menftruum, and depofited in the vafcular ftructure of the wood.

There cannot be a doubt with regard to the truth of this propofition; for as it is, we frequently find parts of the confolidated wood, with the vafcular ftructure remaining perfectly

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in its natural shape and situation; but if it had been by aqueous solution that the wood had been penetrated and consolidated, all the parts of that body would be found in the same natural shape and situation.

This, however, is far from being the case; for while, in some parts, the vascular structure is preserved entire, it is also evident, that, in general, the woody structure is variously broken and dissolved by the fusion and crystallization of the flint. There are so many and such various convincing examples of this, that, to attempt to describe them, would be to exceed the bounds prescribed for this dissertation; but such specimens are in my possession, ready for the inspection of any person who may desire to study the subject.

We may now proceed to consider sulphureous substances, with regard to their solubility in water, and to the part which these bodies have acted in consolidating the strata of the globe.

The sulphureous substances here meant to be considered, are substances not soluble in water, so far as we know, but fusible by heat, and inflammable by means of heat and vital air. These substances are of two kinds; the one more simple, the other more compound.

The most simple kind is composed of two different substances, *viz.* phlogiston, with acid or metallic substances; from which result, on the one hand, sulphur, and, on the other, metals, both properly so called. The more compound sort, again, is oily matter, produced by vegetables, and forming bituminous bodies.

The *first* of these is found naturally combined with almost all metallic substances, which are then said to be mineralized with sulphur. Now, it is well known, that this mineralizing operation is performed by means of heat or fusion; and there is no person skilled in chemistry that will pretend to say, this may be done by aqueous solution. The combination of iron and sulphur, for example, may easily be performed by fusion;

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but, by aqueous folution, this particular combination is again refolved, and forms an acido-metallic, that is, a vitriolic fubftance, after the phlogifton (which refufes aqueous folution) has been feparated from the compofition, by means of the joint operation of vital air.

THE variety of thefe fulphureo-metallic fubftances, in point of compofition, is almoft indefinite; but, unlefs they were all foluble in water, this could not have happened by the action of that folvent. If we fhall allow any one of thofe bodies to have been formed by the fluidity of heat, they muft all have been formed in the fame manner; for there is fuch a chain of connection among thofe bodies in the mineral regions, that they muft all have been compofed, either, on the one hand, by aqueous folution, or, on the other, by means of heat and fufion.

HERE, for example, are cryftallized together in one mafs, *firft*, *Pyrites*, containing fulphur, iron, copper; *2dly*, *Blend*, a compofition of iron, fulphur, and calamine; *3dly*, *Galena*, confifting of lead and fulphur; *4thly*, *Marmor metallicum*, being the terra ponderofa, faturated with the vitriolic acid; a fubftance infoluble in water; *5thly*, *Fluor*, a faturation of calcareous earth, with a peculiar acid, called the acid of fpar, alfo infoluble in water; *6thly*, *Calcareous fpar*, of different kinds, being calcareous earth faturated with fixed air, and fomething befides, which forms a variety in this fubftance; *laftly*, *Siliceous fubftance*, or *Quartz cryftals*. All thefe bodies, each poffeffing its proper fhape, are mixed in fuch a manner as it would be endlefs to defcribe, but which may be expreffed in general by faying, that they are mutually contained in, and contain each other.

UNLESS, therefore, every one of thefe different fubftances may be diffolved in water, and cryftallized from it, it is in vain to look for the explanation of thefe appearances in the operations of nature, by the means of aqueous folution.

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On the other hand, heat being capable of rendering all these substances fluid, they may be, with the greatest simplicity, transported from one place to another; and they may be made to concrete altogether, at the same time, and distinctly separate in any place. Hence, for the explanation of those natural appearances, which are so general, no further conditions are required, than the supposition of a sufficient intensity of subterraneous fire or heat, and a sufficient degree of compression upon those bodies, which are to be subjected to that violent heat, without calcination or change. But, so far as this supposition is not gratuitous, the appearances of nature will be thus explained.

I shall only mention one specimen, which must appear most decisive of the question. It is, I believe, from an Hungarian mine. In this specimen, petro-silex, pyrites, and cinnabar, are so mixed together, and crystallized upon each other, that it is impossible to conceive any one of those bodies to have had its fluidity and concretion from a cause which had not affected the other two. Now, let those who would deny the fusion of this siliceous body explain how water could dissolve these three different bodies, and deposit them in their present shape. If, on the contrary, they have not the least shadow of reason for such a gratuitous supposition, the present argument must be admitted in its full force.

Sulphur and metals are commonly found combined in the mineral regions. But this rule is not universal; for they are also frequently in a separate state. There is not, perhaps, a metal, among the great number which are now discovered, that may not be found native, as they are called, or in their metallic state.

Metallic substances are also thus found in some proportion to the disposition of the particular metals, to resist the mineralizing operations, and to their facility of being metallized by fire and fusion. Gold, which refuses to be mineralized with

sulphur,

fulphur, is found generally in its native ftate. Iron, again, which is fo eafily mineralized and fcorified, is feldom found in its malleable ftate. The other metals are all found more or lefs mineralized, though fome of them but rarely in the native ftate.

Besides being found with circumftances thus correfponding to the natural facility, or to the impediments attending the metallization of thofe different calces, the native metals are alfo found in fuch a fhape, and with fuch marks, as can only agree with the fufion of thofe bodies ; that is to fay, thofe appearances are perfectly irreconcileable with any manner of folution and precipitation.

For the truth of this affertion, among a thoufand other examples, I appeal to that famous mafs of native iron, difcovered, by Mr Pallas, in Siberia. This mafs being fo well known to all the mineralifts of Europe, any comment upon its fhape and ftructure will be unneceffary *.

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* Since this Differtation was written, M. de la Peyrouse has difcovered a native manganefe. The circumftances of this mineral are fo well adapted for illuftrating the prefent doctrine, and fo well related by M. de la Peyrouse, that I fhould be wanting to the intereft of mineral knowledge, were I not to give here that part of his Memoir.

" Lorsque je fis inférer dans le journal de phyfique de l'année 1780, au mois de Janvier, une Differtation contenant la claffification des mines de manganèfe, je ne connoiffois point, à cette epoque, la mine de manganèfe native. Elle a la couleur de fon régule : elle falit les doigts de la même teinte. Son tiffu paroit auffi lamelleux, et les lames femblent affecter une forte de divergence. Elle a ainfi que lui, l'éclat métallique ; comme lui elle fe laiffe applatir fous le marteau, et s'exfolie fi l'on redouble les coups ; mais une circonftance qui eft trop frappante pour que je l'omette, c'eft la figure de la manganèfe native, fi prodigieufement conforme à celle du régule, qu'on s'y laifferoit tromper, fi la mine n'étoit encore dans fa gangue : figure très-effentielle à obferver ici, parce qu'elle eft due à la nature même de la manganèfe. En effet, pour réduire toutes les mines en général, il faut employer divers flux appropriés. Pour la reduction de la manganèfe, bien loin d'ufer de ce moyen, il faut, au contraire, éloigner tout flux, produire la fufion, par la feule violence et la promptetude du feu. Et telle eft la propenfion naturelle et prodigieufe de la manganèfe à la vitrification, qu'on n'a pu parvenir encore à réduire fon régule en un feul culot ; on trouve dans le creufet plufieurs petits boutons, qui forment autant de culots

WE come now to the *second* species of inflammable bodies called oily or bituminous. Thefe fubftances are alfo found varioufly mixed with mineral bodies, as well as forming ftrata of themfelves; they are, therefore, a proper fubject for a particular examination.

IN the procefs of vegetation, there are produced oily and refinous fubftances; and from the collection of thefe fubftances at the bottom of the ocean, there are formed ftrata, which have afterwards undergone various degrees of heat, and have been varioufly changed, in confequence of the effects of that heat, according as the diftillation of the more volatile parts of thofe bodies has been fuffered to proceed.

IN order to underftand this, it muft be confidered, that, while immerfed in water, and under infuperable compreffion, the vegetable, oily, and refinous fubftances, would appear to be unalterable by heat; and it is only in proportion as certain chemical feparations take place, that thefe inflammable bodies are changed in their fubftance by the application of heat. Now, the moft general change of this kind is in confequence of evaporation, or the diftillation of their more volatile parts, by which oily fubftances become bituminous, and bituminous fubftances become coaly.

THERE is here a gradation which may be beft underftood by comparing the extremes.

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lots féparés. Dans la mine de manganèfe native, elle n'eft point en une feule maffe; elle eft difpofée également en plufieurs culots féparés, et un peu applatis, comme ceux que l'art produit; beaucoup plus gros, à la vérité, parce que les agens de la nature doivent avoir une autre énergie, que ceux de nos laboratoires; et cette reffemblance fi exacte, femble devoir vous faire penfer que la mine native à été produite par le feu, tout comme fon régule. La préfence de la chaux argentée de la manganèfe, me permettroit de croire que la nature n'a fait que réduire cette chaux. Du refte, cette mine native eft très-pure, et ne contient aucune partie attirable à l'aimant. Cette mine, unique jufqu'à ce moment, vient, tout comme les autres manganèfe que j'ai décrites, des mines de fer de *Sem*, dans la vallée de *Viederfos*, eu Comté de Foix." *Journal de Phyfique, Janvier* 1786.

On the one hand, we know by experiment, that oily and bituminous fubftances can be melted and partly changed into vapour by heat, and that they become harder and denfer, in proportion as the more volatile parts have evaporated from them. On the other hand, coaly fubftances are deftitute of fufibility and volatility, in proportion as they have been expofed to greater degrees of heat, and to other circumftances favourable to the diffipation of their more volatile and fluid parts.

If, therefore, in mineral bodies, we find the two extreme ftates of this combuftible fubftance, and alfo the intermediate ftates, we muft either conclude, that this particular operation of heat has been thus actually employed in nature, or we muft explain thofe appearances by fome other means, in as fatisfactory a manner, and fo as fhall be confiftent with other appearances.

In this cafe, it will avail nothing to have recourfe to the falfe analogy of water diffolving and cryftallizing falts, which has been fo much employed for the explanation of other mineral appearances. The operation here in queftion is of a different nature, and neceffarily requires both the powers of heat and proper conditions for evaporation.

Therefore, in order to decide the point, with regard to what is the power in nature by which mineral bodies have become folid, we have but to find bituminous fubftance in the moft complete ftate of coal, intimately connected with fome other fubftance, which is more generally found confolidating the ftrata, and affifting in the concretion of mineral fubftances. But I have in my poffeffion the moft undoubted proof of this kind. It is a mineral vein, or cavity, in which are blended together coal of the moft fixed kind, quartz and marmor metallicum. Nor is this all; for the fpecimen now referred to is contained in a rock of this kind, which every naturalift now-a-days will allow to have congealed from a fluid ftate of fufion. I have alfo fimilar fpecimens from the fame place, in which the

coal

coal is not of that fixed and infufible kind, which burns without flame or fmoak, but is bituminous or inflammable coal.

WE have hitherto been refting the argument upon a fingle point, for the fake of fimplicity or clearnefs, not for want of thofe circumftances which fhall be found to corroborate the theory. The ftrata of foffil coal are found in almoft every intermediate ftate, as well as in thofe of bitumen and charcoal. Of the one kind is that foffil coal which melts or becomes fluid upon receiving heat; of the other, is that fpecies of coal, found both in Wales and Scotland, which is perfectly infufible in the fire, and burns like coaks, without flame or fmoak. The one fpecies abounds in oily matter, the other has been diftilled by heat, until it has become a *caput mortuum*, or perfect coal.

THE more volatile parts of thefe bituminous bodies are found in their feparate ftate on fome occafions. There is a ftratum of limeftone in Fifefhire near Raith, which, though but flightly tinged with a black colour, contains bituminous matter, like pitch, in many cavities, which are lined with calcareous fpar cryftallized. I have a fpecimen of fuch a cavity, in which the bitumen is in fphericles, or rounded drops, immerfed in the calcareous fpar.

Now, it is to be obferved, that, if the cavity in the folid limeftone or marble, which is lined with calcareous cryftals containing pyrites, had been thus encrufted by means of the filtration of water, this water muft have diffolved calcareous fpar, pyrites and bitumen. But thefe natural appearances would not even be explained by this diffolution and fuppofed filtration of thofe fubftances. There is alfo required, *firft*, a caufe for the feparation of thofe different fubftances from the aqueous menftruum in which they had been diffolved: 2*dly*, An explanation of the way in which a diffolved bitumen fhould be formed into round hard bodies of the moft folid ftructure ; and, *laftly*, Some probable means for this complicated operation being performed,

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formed,

formed, below the bottom of the ocean, in the clofe cavity of a marble ftratum.

Thus, the additional proof, from the facts relating to the bituminous fubftances, confpiring with that from the phænomena of other bodies, affords the ftrongeft corroboration of this opinion, that the various concretions found in the internal parts of ftrata have not been occafioned by means of aqueous folution, but by the power of heat and operation of fimple fufion, preparing thofe different fubftances to concrete and cryftallize in cooling.

The arguments which have been now employed for proving that ftrata have been confolidated by the power of heat, or by the means of fufion, have been drawn chiefly from the infoluble nature of thofe confolidating fubftances in relation to water, which is the only general menftruum that can be allowed for the mineral regions. But there are found in the mineral kingdom, many folid maffes of fal gem, which is a foluble fubftance. It may be now enquired, How far thefe maffes, which are not unfrequent in the earth, tend either to confirm the prefent theory, or, on the contrary, to give countenance to that which fuppofes water the chief inftrument in confolidating ftrata.

The formation of falt at the bottom of the fea, without the affiftance of fubterranean fire, is not a thing unfuppofable, as at firft fight it might appear. Let us but fuppofe a rock placed acrofs the gut of Gibraltar, (a cafe nowife unnatural), and the bottom of the Mediterranean would be certainly filled with falt, becaufe the evaporation from the furface of that fea exceeds the meafure of its fupply.

But ftrata of falt, formed in this manner at the bottom of the fea, are as far from being confolidated by means of aqueous folution, as a bed of fand in the fame fituation; and we cannot explain the confolidation of fuch a ftratum of falt by means of water, without fuppofing fubterranean heat employed,

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to evaporate the brine which would fucceffively occupy the interftices of the faline cryftals. But this, it may be obferved, is equally departing from the natural operation of water, as the means for confolidating the fediment of the ocean, as if we were to fuppofe the fame thing done by heat and fufion. For the queftion is not, If fubterranean heat be of fufficient intenfity for the purpofe of confolidating ftrata by the fufion of their fubftances; the queftion is, Whether it be by means of this agent, fubterranean heat, or by water alone, without the operation of a melting heat, that thofe materials have been varioufly confolidated.

The example now under confideration, confolidated mineral falt, will ferve to throw fome light upon the fubject; for as it is to be fhewn, that this body of falt had been confolidated by perfect fufion, and not by means of aqueous folution, the confolidation of ftrata of indiffoluble fubftances, by the operation of a melting heat, will meet with all that confirmation which the confiftency of natural appearances can give.

The falt rock in Chefhire lies in ftrata of red marl. It is horizontal in its direction. I do not know its thicknefs, but it is dug thirty or forty feet deep. The body of this rock is perfectly folid, and the falt, in many places, pure, colourlefs and tranfparent, breaking with a fparry cubical ftructure. But the greateft part is tinged by the admixture of the marl, and that in various degrees, from the flighteft tinge of red, to the moft perfect opacity. Thus, the rock appears as if it had been a mafs of fluid falt, in which had been floating a quantity of marly fubftance, not uniformly mixed, but every where feparating and fubfiding from the pure faline fubftance.

There is alfo to be obferved a certain regularity in this feparation of the tinging from the colourlefs fubftance, which, at a proper diftance, gives to the perpendicular fection of the rock a diftinguifhable figure in its ftructure. When looking at this appearance near the bottom of the rock, it, at firft, pre-

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fented me with the figure of regular ftratification ; but, upon examining the whole mafs of rock, I found, that it was only towards the bottom that this ftratified appearance took place ; and that, at the top of the rock, the moft beautiful and regular figure was to be obferved ; but a figure the moft oppofite to that of ftratification. It was all compofed of concentric circles ; and thefe appeared to be the fection of a mafs, compofed altogether of concentric fpheres, like thofe beautiful fyftems of configuration which agates fo frequently prefent us with in miniature. In about eight or ten feet from the top, the circles growing large, were blended together, and gradually loft their regular appearance, until, at a greater depth, they again appeared in refemblance of a ftratification.

THIS regular arrangement of the floating marly fubftance in the body of falt, which is that of the ftructure of a coated pebble, or that of concentric fpheres, is altogether inexplicable upon any other fuppofition, than the perfect fluidity or fufion of the falt, and the attractions and repulfions of the contained fubftances. It is in vain to look, in the operations of folution and evaporation, for that which nothing but perfect fluidity or fufion can explain.

THIS example of a mineral falt congealed from a melted ftate, may be confirmed from another which I have from Dr BLACK, who fuggefted it to me. It is an alkaline falt, found in a mineral ftate, and defcribed in the Philofophical Tranfactions, *anno* 1771. But to underftand this fpecimen, fomething muft be premifed with regard to the nature of foffil alkali.

THE foffil alkali cryftallizes from a diffolved ftate, in combining itfelf with a large portion of the water, in the manner of alum ; and, in this cafe, the water is effential to the conftitution of that tranfparent cryftalline body ; for, upon the evaporation of the water, the tranfparent falt lofes its folidity, and becomes a white powder. If, inftead of being gently dried,

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the cryftalline falt is fuddenly expofed to a fufficient degree of heat, that is, fomewhat more than boiling water, it enters into the ftate of aqueous fufion, and it boils, in emitting the water by means of which it had been cryftallized in the cold, and rendered fluid in that heated ftate. It is not poffible to cryftallize this alkaline falt from a diffolved ftate, without the combination of that quantity of water, nor to feparate that water without deftroying its cryftalline ftate.

BUT in this mineral fpecimen, we have a folid cryftalline falt, with a ftructure which, upon fracture, appears to be fparry and radiated, fomething refembling that of zeolite. It contains no water in its cryftallization, but melts in a fufficient heat, without any aqueous fufion. Therefore, this falt muft have been in a fluid ftate of fufion, immediately before its congelation and cryftallization.

IT would be endlefs to give examples of particular facts, fo many are the different natural appearances that occur, attended with a variety of different circumftances.

THERE is one, however, which is peculiarly diftinct, admits of fufficiently accurate defcription, and contains circumftances from which conclufions may be drawn with clearnefs. This is the iron-ftone, which is commonly found among the argillaceous ftrata, attendant upon foffil coal, both in Scotland and in England.

THIS ftone is generally found among the bituminous fchiftus, or black argillaceous ftrata, either in feparate maffes of various fhapes and fizes, or forming of itfelf ftrata which are more or lefs continuous in their direction among the fchiftus or argillaceous beds.

THIS mineral contains in general from 40 to 50 *per cent.* of iron, and it lofes near one third of its weight in calcination. Before calcination it is of a gray colour, is not penetrable by water, and takes a polifh. In this ftate, therefore, it is perfectly folid; but being calcined, it becomes red, porous, and tender.

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THE fact to be proved with regard to thefe iron-ftones is this, That they have acquired their folid ftate from fufion, and not in concreting from any aqueous folution.

To abridge this difquifition, no argument is to be taken from contingent circumftances, (which, however, are often found here as well as in the cafe of marbles); fuch only are to be employed as are general to the fubject, and arife neceffarily from the nature of the operation.

IT will be proper to defcribe a fpecies of thefe ftones, which is remarkably regular in its form. It is that found at Aberlady in Eaft Lothian.

THE form of thefe iron-ftones is that of an oblate or much compreffed fphere, and the fize from two or three inches diameter to more than a foot. In the circular or horizontal fection, they prefent the moft elegant feptarium *; and, from the examination of this particular ftructure, the following conclufions may be drawn.

Firft, THAT the fepta have been formed by the uniform contraction of the internal parts of the ftone, the volume of the central parts diminifhing more than that of the circumference; by this means, the feparations of the ftone diminifh, in a progreffion from the centre towards the circumference.

2*d*, THAT there are only two ways in which the fepta muft have received the fpar with which they are filled, more or lefs, either, *firft*, By infinuation into the cavity of the fepta after thefe were formed; or, 2*dly*, By feparation from the fubftance of the ftone, at the fame time that the fepta were forming.

WERE the firft fuppofition true, appearances would be obfervable, fhewing that the fparry fubftance had been admitted, either through the porous ftructure of the ftone, or through proper apertures communicating from without. Now, if either one or other of thefe had been the cafe, and that the ftone had been confolidated from no other caufe than concretion from a

<div align="right">diffolved</div>

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* Plate I.

diffolved ftate, that particular ftructure of the ftone, by means of which the fpar had been admitted, muft appear at prefent upon an accurate examination.

THIS, however, is not the cafe, and we may reft the argument here. The fepta reach not the circumference; the furface of the ftone is folid and uniform in every part; and there is not any appearance of the fpar in the argillaceous bed around the ftone.

IT, therefore, neceffarily follows, that the contraction of the iron-ftone, in order to form fepta, and the filling of thefe cavities with fpar, had proceeded *pari paſſu*; and that this operation muft have been brought about by means of fufion, or by congelation from a ftate of fimple fluidity and expanfion.

IT is only further to be obferved, that all the arguments which have been already employed, concerning mineral concretions from a fimply fluid ftate, or that of fufion, here take place. I have feptaria of this kind, in which, befides pyrites, iron-ore, calcareous fpar, and another that is ferruginous and compound, there is contained filiceous cryftals; a cafe which is not fo common. I have them alfo attended with circumftances of concretion and cryftallization, which, befides being extremely rare, are equally curious and interefting.

THERE is one fact more which is well worth our attention, being one of thofe which are fo general in the mineral regions. It is the cryftallizations which are found in clofe cavities of the moft folid bodies.

NOTHING is more common than this appearance. Cavities are every where found clofely lined with cryftallizations, of every different fubftance which may be fuppofed in thofe places. Thefe concretions are well known to naturalifts, and form part of the beautiful fpecimens which are preferved in the cabinets of collectors, and which the German mineralifts have termed *Drufen*. I fhall only particularize one fpecies, which may be defcribed upon principle, and therefore may be a pro-

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per fubject on which to reafon, for afcertaining the order of production in certain bodies. This body, which we are now to examine, is of the agate fpecies.

We have now been confidering the means employed by nature in confolidating ftrata which were originally of an open ftructure; but in perfectly folid ftrata, we find bodies of agate, which have evidently been formed in that place where they now are found. This fact, however, is not ftill that of which we are now particularly to enquire; for this, of which we are to treat, concerns only a cavity within this agate; now, whatever may have been the origin of the agate itfelf, we are to fhew, from what appears within its cavity, that the cryftallizations which are found in this place had arifen from a fimply fluid ftate, and not from that of any manner of folution.

The agates now in queftion are thofe of the coated kind, fo frequent in this country, called pebbles. Many of thefe are filled with a filiceous cryftallization, which evidently proceeds from the circumference towards the centre. Many of them, again, are hollow. Thofe cavities are varioufly lined with cryftallized fubftances; and thefe are the object of the prefent examination.

But before defcribing what is found within, it is neceffary to attend to this particular circumftance, that the cavity is perfectly inclofed with many folid coats, impervious to air or water, but particularly with the external cortical part, which is extremely hard, takes the higheft polifh, and is of the moft perfect folidity, admitting the paffage of nothing but light and heat.

Within thefe cavities, we find, *firft*, The coat of cryftals with which this cavity is always lined; and this is general to all fubftances concreting, in fimilar circumftances, from a ftate of fufion; for when thus at liberty they naturally cryftallize. *2dly*, We have frequently a fubfequent cryftallization, fet upon the firft, and more or lefs immerfed in it. *3dly*, There is alfo
                                                                fometimes

fometimes a third cryftallization, fuperincumbent on the fecond, in like manner as the fecond was on the firft. I fhall mention fome particulars.

I HAVE one fpecimen, in which the primary cryftals are filiceous, the fecondary thin foliaceous cryftals of deep red but tranfparent iron-ore, forming elegant figures, that have the form of rofes. The tertiary cryftallization is a frofting of fmall filiceous cryftals upon the edges of the foliaceous cryftals.

IN other fpecimens, there is firft a lining of colourlefs filiceous cryftals, then another lining of amethyftine cryftals, and fometimes within that, fuliginous cryftals. Upon thefe fuliginous and amethyftine cryftals are many fphericles or hemifpheres of red compact iron-ore, like hæmatites.

IN others, again, the primary cryftals are filiceous, and the fecondary calcareous. Of this kind, I have one which has, upon the calcareous cryftals, beautiful tranfparent filiceous cryftals, and iron-fphericles upon thefe.

Laftly, I HAVE an agate formed of various red and white coats, and beautifully figured. The cavity within the coated part of the pebble is filled up without vacuity, firft, with colourlefs filiceous cryftals; fecondly, with fuliginous cryftals; and, laftly, with white or colourlefs calcareous fpar. But between the fpar and cryftals there are many fphericles, feemingly of iron, half funk into each of thefe two different fubftances.

FROM thefe facts, I may now be allowed to draw the following conclufions:

Firft, THAT concretion had proceeded from the furface of the agate body inwards. This neceffarily follows from the nature of thofe figured bodies, the figures of the external coats always determining the fhape of thofe within, and never, contrarily, thofe within affecting thofe without.

2dly, THAT when the agate was formed, the cavity then contained every thing which now is found within it, and nothing more.

3dly,

3dly, THAT the contained fubftances muft have been in a fluid ftate, in order to their cryftallizing.

Laftly, THAT as this fluid ftate had not been the effect of folution in a menftruum, it muft have been fluidity from heat and fufion.

THERE are in jafpers and agates many other appearances, from whence this laft conclufion may be formed with great certainty and precifion; but it is hoped, that what has been now given may fuffice for eftablifhing that propofition without any doubt.

IT muft not be here objected, That there are frequently found filiceous cryftals and amethyfts containing water; and that it is impoffible to confine water even in melted glafs. It is true, that here, at the furface of the earth, melted glafs cannot, in ordinary circumftances, be made to receive and inclofe condenfed water; but let us only fuppofe a fufficient degree of compreffion in the body of melted glafs, and we can eafily imagine it to receive and confine water, as well as any other fubftance. But if, even in our operations, water, by means of compreffion, may be made to endure the heat of red hot iron without being converted into vapour, what may not the power of nature be able to perform? The place of mineral operations is not on the furface of the earth; and we are not to limit nature with our imbecility, or eftimate the powers of nature by the meafure of our own.

To conclude this long chemico-mineral difquifition, I have fpecimens in which the mixture of calcareous, filiceous and metallic fubftances, in almoft every fpecies of concretion which is to be found in mineral bodies, may be obferved, and in which there is exhibited, in miniature, almoft every fpecies of mineral tranfaction, which, in nature, is found upon a fcale of grandeur and magnificence. They are nodules contained in the whinftone, porphyry, or bafaltes of the Calton-hill, by Edinburgh; a body which is to be afterwards examined, when

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it will be found to have flowed, and to have been in fufion, by the operation of fubterraneous heat.

THIS evidence, though moſt concluſive with regard to the application of fubterraneous heat, as the means employed in bringing into fufion all the different fubſtances with which ſtrata may be found conſolidated, is not directly a proof that ſtrata had been conſolidated by the fufion of their proper fubſtance. It was neceſſary to fee the general nature of the evidence, for the univerſal application of fubterraneous heat, in the fufion of every kind of mineral body. Now, that this has been done, we may give examples of ſtrata conſolidated without the introduction of foreign matter, merely by the foftening or fufion of their own materials.

FOR this purpoſe, we may conſider two different ſpecies of ſtrata, ſuch as are perfectly ſimple in their nature, of the moſt diſtinct fubſtances, and whoſe origin is perfectly underſtood, confequently, whoſe fubfequent changes may be reaſoned upon with certainty and clearneſs. Theſe are the ſiliceous and calcareous ſtrata ; and theſe are the two prevailing fubſtances of the globe, all the reſt being, in compariſon of theſe, as nothing ; for unleſs it be the bituminous or coal ſtrata, there is hardly any other which does not neceſſarily contain more or leſs of one or other of theſe two fubſtances. If, therefore, it can be ſhewn, that both of thoſe two general ſtrata have been conſolidated by the ſimple fufion of their fubſtance, no *deſideratum* or doubt will remain, with regard to the nature of that operation which has been tranfacted at great depths of the earth, places to which all acceſs is denied to mortal eyes.

WE are now to prove, *firſt*, That thoſe ſtrata have been conſolidated by ſimple fufion ; and, *2dly*, That this operation is univerſal, in relation to the ſtrata of the earth, as having produced the various degrees of ſolidity or hardneſs in theſe bodies.

I SHALL firſt remark, that a fortuitous collection of hard bodies, ſuch as gravel and ſand, can only touch in points, and

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cannot, while in that hard ſtate, be made to correſpond ſo pre-
ciſely to each other's ſhape as to conſolidate the maſs.   But if
theſe hard bodies ſhould be ſoftened in their ſubſtance, or
brought into a certain degree of fuſion, they might be adapted
mutually to each other, and thus conſolidate the open ſtructure
of the maſs.   Therefore, to prove the preſent point, we have
but to exhibit ſpecimens of ſiliceous and calcareous ſtrata which
have been evidently conſolidated in this manner.

Of the firſt kind, great varieties occur in this country.   It is,
therefore, needleſs to deſcribe theſe particularly.   They are the
conſolidated ſtrata of gravel and ſand, often containing abun-
dance of feld-ſpar, and thus graduating into granite ; a body,
in this reſpect, perfectly ſimilar to the more regular ſtrata which
we now examine.

The ſecond kind, again, are not ſo common in this country,
unleſs we conſider the ſhells and coralline bodies in our lime-
ſtones, as exhibiting the ſame example, which indeed they do.
But I have a ſpecimen of marble from Spain, which may be
deſcribed, and which will afford the moſt ſatisfactory evidence
of the fact in queſtion.

This Spaniſh marble may be conſidered as a ſpecies of pud-
ding-ſtone, being formed of calcareous gravel ; a ſpecies of
marble which, from Mr Bowles's Natural Hiſtory, appears to
be very common in Spain.   The gravel of which this marble
is compoſed, conſiſts of fragments of other marbles of different
kinds.   Among theſe, are different ſpecies of *oolites* marble,
ſome ſhell marbles, and ſome compoſed of a chalky ſubſtance,
or of undiſtinguiſhable parts.   But it appears, that all theſe
different marbles had been conſolidated or made hard, then
broken into fragments, rolled and worn by attrition, and thus
collected together, along with ſome ſand or ſmall ſiliceous bo-
dies, into one maſs.   *Laſtly,* This compound body is conſoli-
dated in ſuch a manner as to give the moſt diſtinct evidence,
                                                                    that

that this had been executed by the operation of heat or fimple fufion.

THE proof I give is this, That befides the general conformation of thofe hard bodies, fo as to be perfectly adapted to each other's fhape, there is, in fome places, a mutual indentation of the different pieces of gravel into each other; an indentation which refembles perfectly that junction of the different bones of the *cranium*, called futures, and which muft have neceffarily required a mixture of thofe bodies while in a foft or fluid ftate.

THIS appearance of indentation is, by no means, fingular or limited to one particular fpecimen. I have feveral fpecimens of different marbles, in which fine examples of this fpecies of mixture may be perceived. But in this particular cafe of the Spanifh pudding-ftone, where the mutual indentation is made between two pieces of hard ftone, worn round by attrition, the foftening or fufion of thefe two bodies is not fimply rendered probable, but demonftrated.

HAVING thus proved, that thofe ftrata had been confolidated by fimple fufion, as propofed, we now proceed to fhew, that this mineral operation had been not only general, as being found in all the regions of the globe, but univerfal, in confolidating our earth in all the various degrees, from loofe and incoherent fhells and fand, to the moft folid bodies of the filiceous and calcareous fubftances.

To exemplify this in the various collections and mixtures of fands, gravels, fhells and corals, were endlefs and fuperfluous. I fhall only take, for an example, one fimple homogeneous body, in order to exhibit it in the various degrees of confolidation, from the ftate of fimple incoherent earth to that of the moft folid marble. It muft be evident that this is chalk; naturally a foft calcareous earth, but which may be alfo found confolidated in every different degree.

THROUGH the middle of the ifle of Wight, there runs a ridge of hills of indurated chalk. This ridge runs from the

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isle of Wight directly weſt into Dorſetſhire, and goes by Corf-
caſtle towards Dorcheſter, perhaps beyond that place. The ſea
has broke through this ridge at the weſt end of the iſle of
Wight, where columns of the indurated chalk remain, called
the needles; the ſame appearance being found upon the oppo-
ſite ſhore in Dorſetſhire.

IN this field of chalk, we find every gradation of that ſoft
earthy ſubſtance to the moſt conſolidated body of this indurated
ridge, which is not ſolid marble, but which has loſt its chalky
property, and has acquired a kind of ſtony hardneſs.

WE want only further to ſee this cretaceous ſubſtance in its
moſt indurated and conſolidated ſtate; and this we have in the
north of Ireland, not far from the Giants Cauſeway. I have
examined cargoes of this limeſtone brought to the weſt of Scot-
land, and find the moſt perfect evidence of this body having
been once a maſs of chalk, which is now a ſolid marble.

THUS, if it is by means of fuſion that the ſtrata of the earth
have been, in many places, conſolidated, we muſt conclude,
that all the degrees of conſolidation, which are indefinite, have
been brought about by the ſame means.

Now, that all the ſtrata of the mineral regions, which are
thoſe only now examined, have been conſolidated in ſome de-
gree, is a fact for which no proof can be offered here, but muſt
be ſubmitted to experience and enquiry; ſo far, however, as
they ſhall be conſidered as conſolidated in any degree, which
they certainly are in general, we have inveſtigated the means
which had been employed in that mineral operation.

WE have now conſidered the concretions of particular bo-
dies, and the general conſolidation of ſtrata; but it may be
alleged, that there is a great part of the ſolid maſs of this
earth not properly comprehended among thoſe bodies which
have been thus proved to be conſolidated by means of fuſion.
The body here alluded to is granite; a maſs which is not ge-
nerally ſtratified, and which, being a body perfectly ſolid, and

forming

forming fome part in the ftructure of this earth, deferves to be
confidered.

THE nature of granite, as a part of the ftructure of the
earth, is too intricate a fubject to be here confidered, where we
only feek to prove the fufion of a fubftance from the evident
marks which are to be obferved in a body. We fhall, therefore,
only now confider one particular fpecies of granite; and if this
fhall appear to have been in a fluid ftate of fufion, we may be
allowed to extend this property to all the kind.

THE fpecies now to be examined comes from the north coun-
try, about four or five miles weft from Portfoy, on the road
to Huntly. I have not been upon the fpot, but am informed
that this rock is immediately connected or continuous with the
common granite of the country. This indeed appears in the
fpecimens which I have got; for, in fome of thefe, there is to
be perceived a gradation from the regular to the irregular fort.

THIS rock may indeed be confidered, in fome refpects, as a
porphyry; for it has an evident ground, which is feld-fpar, in
its fparry ftate; and it is, in one view, diftinctly maculated with
quartz, which is tranfparent, but fomewhat dark-coloured *.

CONSIDERED as a porphyry, this fpecimen is no lefs fingular
than as a granite. For, inftead of a filiceous ground, maculated
with the rhombic feld-fpar, which is the common ftate of por-
phyry, the ground is uniformly cryftallized, or a homogeneous
regular feld-fpar, maculated with the tranfparent filiceous fub-
ftance. But as, befides the feld-fpar and quartz, which are the
conftituent parts of the ftone, there is alfo mica, in fome
places, it may, with propriety, be termed a granite.

THE fingularity of this fpecimen confifts, not in the nature
or proportions of its conftituent parts, but in the uniformity
of the fparry ground, and the regular fhape of the quartz mix-
ture. This filiceous fubftance, viewed in one direction, or
longitudinally, may be confidered as columnar, prifmatical,

or

* Plate II. fig. 1. 2. 3.

or continued in lines running nearly parallel. Thefe columnar bodies of quartz are beautifully impreffed with a figure on the fides, where they are in contact with the fpar. This figure is that of furrows or channels, which are perfectly parallel, and run acrofs the longitudinal direction of the quartz. This is reprefented in fig. 4. This ftriated figure is only feen when, by fracture, the quartz is feparated from the contiguous fpar.

BUT what I would here more particularly reprefent is, the tranfverfe fection of thofe longitudinal filiceous bodies. Thefe are feen in fig. 1. 2. and 3. They have not only feparately the forms of certain typographic characters, but collectively give the regular lineal appearance of types fet in writing.

IT is evident from the infpection of this foffil, that the fparry and filiceous fubftances had been mixed together in a fluid ftate ; and that the cryftallization of the fparry fubftance, which is rhombic, had determined the regular ftructure of the quartz, at leaft in fome directions.

THUS, the filiceous fubftance is to be confidered as included in the fpar, and as figured according to the laws of cryftallization proper to the fparry ground ; but the fpar is alfo to be found included in the quartz. It is not, indeed, always perfectly included or inclofed on all fides ; but this is fometimes the cafe, or it appears fo in the fection. Fig. 5. 6. 7. 8. 9. and 10. are thofe cafes magnified, and reprefent the different figured quartz inclofing the feld-fpar. In one of them, the feld-fpar, which is contained within the quartz, contains alfo a fmall triangle of quartz, which it inclofes. Now, it is not poffible to conceive any other way in which thofe two fubftances, quartz and feld-fpar, could be thus concreted, except by congelation from a fluid ftate, in which they had been mixed.

THERE is one thing more to be obferved with regard to this curious fpecies of granite. It is the different order or arrangement of the cryftallization or internal ftructure of the feld-fpar ground, in two contiguous parts of the fame mafs. This is to be

be perceived in the polifhed furface of the ftone, by means of the reflection of light.

THERE is a certain direction in which, viewing the ftone, when the light falls with a proper obliquity, we fee a luminous reflection from the internal parts of the ftone. This arifes from the reflecting furfaces of the fparry ftructure or minute cracks, all turned in one direction, confequently, giving that luminous appearance only in one point of view.

Now, all the parts of the ftone in which the figured quartz is directed in the fame manner, or regularly placed in relation to each other, prefent that fhining appearance to the eye at one time, or in the fame point of direction. But there are parts of the mafs, which, though immediately contiguous and properly continuous, have a different difpofition of the figured quartz; and thefe two diftinguifhed maffes, in the fame furface of the polifhed ftone, give to the eye their fhining appearance in very different directions. Fig. 3. fhows two of thofe figured and fhining maffes, in the fame plane or polifhed furface.

IT muft be evident, that, as the cryftallization of the fparry ftructure is the figuring caufe of the quartz bodies, there muft be obferved a certain correfpondency between thofe two things, the alinement (if I may be allowed the expreffion) of the quartz, and the fhining of the fparry ground. It muft alfo appear, that, at the time of congelation of the fluid fpar, thofe two contiguous portions had been differently difpofed in the cryftallization of their fubftance. This is an obfervation which I have had frequent opportunities of making, with refpect to maffes of calcareous fpar.

UPON the whole, therefore, whether we fhall confider granite as a ftratum or as an irregular mafs, whether as a collection of feveral materials, or as the feparation of fubftances which had been mixed, there is fufficient evidence of this body having been confolidated by means of fufion, and in no other manner.

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We are thus led to suppose, that the power of heat and operation of fusion must have been employed in consolidating strata of loose materials, which had been collected together and amassed at the bottom of the ocean. It will, therefore, be proper to consider, what are the appearances in consolidated strata that naturally should follow, on the one hand, from fluidity having been, in this manner, introduced by means of heat, and, on the other, from the interstices being filled by means of solution; that so we may compare appearances with the one and other of those two suppositions, in order to know that with which they may be only found consistent.

The consolidation of strata with every different kind of substance was found to be inconsistent with the supposition, that aqueous solution had been the means employed for this purpose. This appearance, on the contrary, is perfectly consistent with the idea, that the fluidity of these bodies had been the effect of heat; for, whether we suppose the introduction of foreign matter into the porous mass of a stratum for its consolidation, or whether we shall suppose the materials of the mass acquiring a degree of softness, by means of which, together with an immense compression, the porous body might be rendered solid; the power of heat, as the cause of fluidity and vapour, is equally proper and perfectly competent. Here, therefore, appearances are as decidedly in favour of the last supposition, as they had been inconsistent with the first.

But if strata have been consolidated by means of aqueous solution, these masses should be found precisely in the same state as when they were originally deposited from the water. The perpendicular section of those masses might shew the compression of the bodies included in them, or of which they are composed; but the horizontal section could not contain any separation of the parts of the stratum from one another.

If, again, strata have been consolidated by means of heat, acting in such a manner as to soften their substance, then, in

cooling,

cooling, they muft have formed rents or feparations of their fubftance, by the unequal degrees of contraction which the contiguous ftrata may have fuffered. Here is a moft decifive mark by which the prefent queftion muft be determined.

THERE is not in nature any appearance more diftinct than this of the perpendicular fiffures and feparations in ftrata. Thefe are generally known to workmen by the terms of veins or backs and cutters; and there is no confolidated ftratum that wants thefe appearances. Here is, therefore, a clear decifion of the queftion, Whether it has been by means of heat, or by means of aqueous folution, that collections of loofe bodies at the bottom of the fea have been confolidated into the hardeft rocks and moft perfect marbles.

ERROR never can be confiftent, nor can truth fail of having fupport from the accurate examination of every circumftance. It is not enough to have found appearances decifive of the queftion, with regard to the two fuppofitions which have been now confidered, we may farther feek confirmation of that fuppofition which has been found alone confiftent with appearances.

IF it be by means of heat and fufion that ftrata have been confolidated, then, in proportion to the degree of confolidation they have undergone from their original ftate, they fhould, *cæteris paribus*, abound more with feparations in their mafs. But this conclufion is found confiftent with appearances. A ftratum of porous fand-ftone does not abound fo much with veins and cutters as a fimilar ftratum of marble, or even a fimilar ftratum of fand-ftone that is more confolidated. In proportion, therefore, as ftrata have been confolidated, they are in general interfected with veins and cutters; and in proportion as ftrata are deep in their perpendicular fection, the veins are wide, and placed at greater diftances. In like manner, when ftrata are thin, the veins are many, but proportionally narrow.

IT is thus, upon chemical principles, to be demonftrated, That all the folid ftrata of the globe have been condenfed by

means

means of heat, and hardened from a ſtate of fuſion. But this propoſition is equally to be maintained from principles which are mechanical. The ſtrata of the globe, beſides being formed of earths, are compoſed of ſand, of gravel, and fragments of hard bodies, all which may be conſidered as, in their nature, ſimple; but theſe ſtrata are alſo found compoſed of bodies which are not ſimple, but are fragments of former ſtrata, which had been conſolidated, and afterwards were broken and worn by attrition, ſo as to be made gravel. Strata compoſed in this manner have been again conſolidated; and now the queſtion is, By what means?

If ſtrata compoſed of ſuch various bodies had been conſolidated, by any manner of concretion, from the fluidity of a diſſolution, the hard and ſolid bodies muſt be found in their entire ſtate, while the interſtices between thoſe conſtituent parts of the ſtratum are filled up. No partial fracture can be conceived as introduced into the middle of a ſolid maſs of hard matter, without having been communicated from the furrounding parts. But ſuch partial ſeparations are found in the middle of thoſe hard and ſolid maſſes; therefore, this compound body muſt have been conſolidated by other means than that of concretion from a ſtate of a ſolution.

The Spaniſh marble already deſcribed, as well as many conſolidated ſtrata of ſiliceous gravel, of which I have ſpecimens, afford the cleareſt evidence of this fact. Theſe hard bodies are perfectly united together, in forming the moſt ſolid maſs; the contiguous parts of ſome of the rounded fragments are interlaced together, as has already been obſerved; and there are partial ſhrinkings of the maſs forming veins, traverſing ſeveral fragments, but perfectly filled with the ſparry ſubſtance of the maſs, and ſometimes with parts of the ſtone diſtinctly floating in the tranſparent body of ſpar. Now, there is not, beſides heat or fuſion, any known power in nature by which theſe effects might be produced. But ſuch effects are general to all

<div align="right">conſolidated</div>

confolidated maffes, although not always fo well illuftrated in a cabinet fpecimen.

THUS we have difcovered a truth that is confirmed by every appearance, fo far as the nature of the fubject now examined admits. We now return to the general operation, of forming continents of thofe materials which had been depofited at the bottom of the fea.

PART III.

Inveftigation of the Natural Operations employed in the Production of Land above the Surface of the Sea.

WE feek to know that operation by means of which maffes of loofe materials, collected at the bottom of the fea, were raifed above its furface, and transformed into folid land.

WE have found, that there is not in this globe (as a planet revolving in the folar fyftem) any power or motion adapted to the purpofe now in view ; nor, were there fuch a power, could a mafs of fimply collected materials have continued any confiderable time to refift the waves and currents natural to the fea, but muft have been quickly carried away, and again depofited at the bottom of the ocean. But we have found, that there had been operations, natural to the bowels of this earth, by which thofe loofe and unconnected materials have been cemented together, and confolidated into maffes of great ftrength and hardnefs ; thofe bodies are thus enabled to refift the force of waves and currents, and to preferve themfelves, for a fufficient time, in their proper fhape and place, as land above the general furface of the ocean.

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WE now defire to know, how far thofe internal operations of the globe, by which folidity and ftability are procured to the beds of loofe materials, may have been alfo employed in raifing up a continent of land, to remain above the furface of the fea.

THERE is nothing fo proper for the erection of land above the level of the ocean, as an expanfive power of fufficient force, applied directly under materials in the bottom of the fea, under a mafs that is proper for the formation of land when thus erected. The queftion is not, how fuch a power may be procured; fuch a power has probably been employed. If, therefore, fuch a power fhould be confiftent with that which we found had actually been employed in preparing the erected mafs; or, if fuch a power is to be reafonably concluded as accompanying thofe operations which we have found natural to the globe, and fituated in the very place where this expanfive power appears to be required, we fhould thus be led to perceive, in the natural operations of the globe, a power as efficacious for the elevation of what had been at the bottom of the fea into the place of land, as it is perfect for the preparation of thofe materials to ferve the purpofe of their elevation.

IN oppofition to this conclufion, it will not be allowed to allege, that we are ignorant how fuch a power might be exerted under the bottom of the ocean; for the prefent queftion is not, what had been the caufe of heat, which has appeared to have been produced in that place; but, if this power of heat, which has certainly been exerted at the bottom of the ocean for confolidating ftrata, had been employed alfo for another purpofe, that is, for raifing thofe ftrata into the place of land.

WE may, perhaps, account for the elevation of land, by the fame caufe with that of the confolidation of ftrata, already inveftigated, without explaining the means employed by nature in procuring the power of heat, or fhewing from what general fource of action this particular power had been derived; but, by finding in fubterranean heat a caufe for any other change, be-
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fides the confolidation of porous or incoherent bodies, we fhall generalize a fact, or extend our knowledge in the explanation of natural appearances.

THE power of heat for the expanfion of bodies, is, fo far as we know, unlimited; but by the expanfion of bodies placed under the ftrata at the bottom of the fea, the elevation of thofe ftrata may be affected; and the queftion now to be refolved regards the actual exertion of this power of expanfion, How far it is to be concluded as having been employed in the production of this earth above the level of the fea.

BEFORE attempting to refolve that queftion, it may be proper to obferve, there has been exerted an extreme degree of heat below the ftrata formed at the bottom of the fea; and this is precifely the action of a power required for the elevation of thofe heated bodies into a higher place. Therefore, if there is no other way in which we may conceive this event to have been brought about, confiftent with the prefent ftate of things, or what actually appears, we fhall have a right to conclude, that fuch had been the order of procedure in natural things, and that the ftrata formed at the bottom of the fea had been elevated, as well as confolidated, by means of fubterraneous heat.

THE confolidation of ftrata by means of fufion or the power of heat, has been concluded from the examination of nature, and from finding, that the prefent ftate of things is inconfiftent with any other fuppofition. Now, again, we are confidering the only power that may be conceived as capable of elevating ftrata from the bottom of the fea, and placing fuch a mafs above the furface of the water. It is a truth unqueftionable, that what had been originally at the bottom of the fea, is at prefent the higheft of our land. In explaining this appearance, therefore, no other alternative is left, but either to fuppofe ftrata elevated by the power of heat above the level of the prefent fea, or the furface of the ocean reduced many miles below the

height

height at which it had fubfifted during the collection and indu-
ration of the land which we inhabit.

Now, if, on the one hand, we are to fuppofe no general
power of fubterraneous fire or heat, we leave to our theory no
means for the retreat of the fea, or the lowering of its furface;
if, on the other hand, we are to allow the general power of
fubterraneous heat, we cannot have much difficulty in fuppo-
fing, either the furface of the fea to have fubfided, or the bot-
tom of the ocean, in certain parts, to have been raifed by a
fubterranean power above the level of its furface, according as
appearances fhall be found to require the one or other of thofe
conclufions. Here, therefore, we are again remitted to the hi-
ftory of nature, in order to find matter of fact by which this
queftion may be properly decided.

If the prefent land had been difcovered by the fubfiding of
the waters, there has not been a former land, from whence
materials had been procured for the conftruction of the prefent,
when at the bottom of the fea; for there is no veftige remain-
ing of that land, the whole land of the prefent earth having
been formed evidently at the bottom of the fea. Neither could
the natural productions of the fea have been accumulated, in
the fhape in which we now find them, on the furface of this
earth; for how fhould the Alps and Andes have been formed
within the fea from the natural productions of the water? Con-
fequently, this is a fuppofition inconfiftent with every natural
appearance.

The fuppofition, therefore, of the fubfidence of the former
ocean, for the purpofe of difcovering the prefent land, is befet
with more difficulty than the fimple erection of the bottom of
the former ocean; for, *firft*, There is a place to provide for the
retirement of the waters of the ocean; and, *2dly*, There is re-
quired a work of equal magnitude; this is, the fwallowing up
of that former continent, which had procured the materials
of the prefent land.

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ON the one hand, the subsiding of the surface of the ocean would but make the former land appear the higher; and, on the other, the sinking the body of the former land into the solid globe, so as to swallow up the greater part of the ocean after it, if not a natural impossibility, would be at least a superfluous exertion of the power of nature. Such an operation as this would discover as little wisdom in the end elected, as in the means appropriated to that end; for, if the land be not wasted and worn away in the natural operations of the globe, why make such a convulsion in the world in order to renew the land? If, again, the land naturally decays, why employ so extraordinary a power, in order to hide a former continent of land, and puzzle man?

LET us now consider how far the other proposition, of strata being elevated by the power of heat above the level of the sea, may be confirmed from the examination of natural appearances.

THE strata formed at the bottom of the ocean are necessarily horizontal in their position, or nearly so, and continuous in their horizontal direction or extent. They may change, and gradually assume the nature of each other, so far as concerns the materials of which they are formed; but there cannot be any sudden change, fracture or displacement naturally in the body of a stratum. But, if these strata are cemented by the heat of fusion, and erected with an expansive power acting below, we may expect to find every species of fracture, dislocation and contortion, in those bodies, and every degree of departure from a horizontal towards a vertical position.

THE strata of the globe are actually found in every possible position: For from horizontal, they are frequently found vertical; from continuous, they are broken and separated in every possible direction; and, from a plane, they are bent and doubled. It is impossible that they could have originally been formed, by the known laws of nature, in their present state and position;

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and the power that has been neceffarily required for their change, has not been inferior to that which might have been required for their elevation from the place in which they had been formed.

In this cafe, natural appearances are not anomalous. They are, indeed, infinitely various, as they ought to be, according to the rule; but all thofe varieties in appearances confpire to prove one general truth, *viz.* That all which we fee had been originally compofed according to certain principles, eftablifhed in the conftitution of the terraqueous globe; and that thofe regular compofitions had been afterwards greatly changed by the operations of another power, which had introduced apparent confufion among things firft formed in order and by rule.

It is concerning the operation of this fecond power that we are now enquiring; and here the apparent irregularity and diforder of the mineral regions are as inftructive, with regard to what had been tranfacted in a former period of time, as the order and regularity of thofe fame regions are conclufive, in relation to the place in which a former ftate of things had produced that which, in its changed ftate, we now perceive.

We are now to conclude, that the land on which we dwell had been elevated from a lower fituation by the fame agent which had been employed in confolidating the ftrata, in giving them ftability, and preparing them for the purpofe of the living world. This agent is matter actuated by extreme heat, and expanded with amazing force.

If this has been the cafe, it will be reafonable to expect, that fome of the expanded matter might be found condenfed in the bodies which have been heated by that igneous vapour; and that matter, foreign to the ftrata, may have been thus introduced into the fractures and feparations of thofe indurated maffes.

We have but to open our eyes to be convinced of this truth. Look into the fources of our mineral treafures; afk the miner,

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from whence has come the metal into his vein? Not from the earth or air above, not from the ftrata which the vein traverfes; thefe do not contain one atom of the minerals now confidered : There is but one place from whence thefe minerals may have come; this is, the bowels of the earth, the place of power and expanfion, the place from whence muft have proceeded that intenfe heat by which loofe materials have been confolidated into rocks, as well as that enormous force by which the regular ftrata have been broken and difplaced.

Our attention is here peculiarly called upon, where we have the opportunity of examining thofe mineral bodies, which have immediately proceeded from the unknown region, that place of power and energy which we want to explore; for, if fuch is the fyftem of the earth, that materials are firft depofited at the bottom of the ocean, there to be prepared in a certain manner, in order to acquire folidity, and then to be elevated into the proper place of land, thefe mineral veins, which contain matter abfolutely foreign to the furface of the earth, afford the moft authentic information with regard to the operations which we want to underftand. It is thefe veins which we are to confider as, in fome meafure, the continuation of that mineral region, which lies neceffarily out of all poffible reach of our examination. It is, therefore, peculiarly interefting to know the ftate in which things are to be found in this place, which may be confidered as intermediate between the folid land, upon the one hand, and the unknown regions of the earth, upon the other.

We are now to examine thofe mineral veins; and thefe may be confidered, firft, in relation to their form, independent of their fubftance or particular contents; and, fecondly, in relation to the contained bodies, independent of their form.

In examining confolidated ftrata, we remarked veins and cutters as a proof of the means by which thofe bodies had been confolidated. In that cafe, the formation of thefe veins is

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a regulated procefs, determined by the degree of fufion, and the circumftances of condenfation or refrigeration. In refpect of thefe, the mineral veins now to be examined are anomalous. They are; but we know not why or how. We fee the effect; but, in that effect, we do not fee the caufe. We can fay, negatively, that the caufe of mineral veins is not that by which the veins and fiffures of confolidated ftrata have been formed; confequently, that it is not the meafured contraction and regulated condenfation of the confolidated land which has formed thofe general mineral veins; however, veins, fimilar in many refpects, have been formed by the co-operation of this caufe.

Having thus taken a view of the evident diftinction between the veins or contractions that are particular to the confolidated body in which they are found, and thofe more general veins which are not limited to that caufe, we may now confider what is general in the fubject, or what is univerfal in thefe effects of which we wifh to inveftigate the caufe.

The event of higheft generalization or univerfality, in the form of thofe mineral veins, is fracture and diflocation. It is not, like that of the veins of ftrata, fimple feparation and meafured contraction; it is violent fracture and unlimited diflocation. In the one cafe, the forming caufe is in the body which is feparated; for, after the body had been actuated by heat, it is by the reaction of the proper matter of the body, that the chafm which conftitutes the vein is formed. In the other cafe, again, the caufe is extrinfic in relation to the body in which the chafm is formed. There has been the moft violent fracture and divulfion; but the caufe is ftill to feek; and it appears not in the vein; for it is not every fracture and diflocation of the folid body of our earth, in which minerals, or the proper fubftances of mineral veins, are found.

We are now examining matter of fact, real effects, from whence we would inveftigate the nature of certain events which do not now appear. Of thefe, two kinds occur; one which has

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acted in relation to the hardnefs and folidity, or the natural conftitution of the body; the other, to its fhape or local fituation. The firft has been already confidered; the laft is now the fubject of enquiry.

But, in examining thofe natural appearances, we find two different kinds of veins; the one neceffarily connected with the confolidating caufe; the other with that caufe of which we now particularly enquire. For, in thofe great mineral veins, violent fracture and diflocation is the principle; but there is no other principle upon which ftrata, or maffes formed at the bottom of the fea, can be placed at a height above its furface. Hence, in thofe two different operations, of forming mineral veins, and erecting ftrata from a lower to a higher place, the principle is the fame; for neither can be done without violent fracture and diflocation.

We now only want to know, how far it is by the fame power, as well as upon the fame principle, that thofe two operations have been made. An expanfive force, acting from below, is the power moft proper for erecting maffes; but whether it is a power of the fame nature with that which has been employed in forming mineral veins, will beft appear in knowing the nature of their contents. Thefe, therefore, may be now confidered.

Every fpecies of fracture, and every degree of diflocation and contortion, may be perceived in the form of mineral veins; and there is no other general principle to be obferved in examining their form. But, in examining their contents, fome other principle may appear, fo far as, to the diflocating power or force, there may be fuperadded matter, by which fomething in relation to the nature of the power may be known. If, for example, a tree or a rock fhall be found fimply fplit afunder, although there be no doubt with regard to fome power having been applied in order to produce the effect, yet we are left merely to conjecture at the power. But when wedges of wood or

iron

iron, or frozen water, fhould be found lodged in the cleft, we might be enabled, from this appearance, to form a certain judgment with regard to the nature of the power which had been applied. This is the cafe with mineral veins. We find them containing matter, which indicates a caufe ; and every information in this cafe is interefting to the theory.

THE fubftances contained in mineral veins are precifely the fame with thofe which, in the former part of this paper, we have confidered as being made inftrumental in the confolidation of ftrata ; and they are found in every fpecies of mixture and concretion.

BUT, befides this evidence for the exertion of extreme heat, in that procefs by which thofe veins were filled, there is another important obfervation to be gathered from the infpection of this fubject. There appears to have been a great mechanical power employed in the filling of thefe veins, as well as that neceffarily required in making the firft fracture and divulfion.

THIS appears from the order of the contents, or filling of thefe veins, which is a thing often obferved to be various and fucceffive. But what it is chiefly now in view to illuftrate, is that immenfe force which is manifefted in the fracture and difperfion of the folid contents which had formerly filled thofe veins. Here we find fragments of rock and fpar floating in the body of a vein filled with metallic fubftances ; there, again, we fee the various fragments of metallic maffes floating in the fparry and filiceous contents.

ONE thing is demonftrable from the infpection of the veins and their contents ; this is, the fucceffive irruptions of thofe fluid fubftances breaking the folid bodies which they meet, and floating thofe fragments of the broken bodies in the vein. It is very common to fee three fucceffive feries of thofe operations ; and all this may be perceived in a fmall fragment of ftone, which a man of fcience may examine in his clofet, often

better

better than defcending to the mine, where all the examples are found on an enlarged fcale.

LET us now confider what power would be required to force up, from the moft unfathomable depth of the ocean, to the Andes or the Alps, a column of fluid metal and of ftone. This power cannot be much lefs than that required to elevate the higheft land upon the globe. Whether, therefore, we fhall confider the general veins as having been filled by mineral fteams, or by fluid minerals, an elevating power of immenfe force is ftill required, in order to form as well as fill thofe veins. But fuch a power acting under the confolidated maffes at the bottom of the fea, is the only natural means for making thofe maffes land.

IF fuch have been the operations that are neceffary for the production of this land; and if thefe operations are natural to the globe of this earth, as being the effect of wifdom in its contrivance, we fhall have reafon to look for the actual manifeftation of this truth in the phænomena of nature, or thofe appearances which more immediately difcover the actual caufe in the perceived effect.

To fee the evidence of marble, a body that is folid, having been formed of loofe materials collected at the bottom of the fea, is not always eafy, although it may be made abundantly plain; and to be convinced that this calcareous ftone, which calcines fo eafily in our fires, fhould have been brought into fufion by fubterraneous heat, without fuffering calcination, muft require a chain of reafoning which every one is not able to attain. But when fire burfts forth from the bottom of the fea, and when the land is heaved up and down, fo as to demolifh cities in an inftant, and fplit afunder rocks and folid mountains, there is nobody but muft fee in this a power, which may be fufficient to accomplifh every view of nature in erecting land, as it is fituated in the place moft advantageous for that purpofe.

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The only queſtion, therefore, which it concerns us to decide at preſent, is, Whether thoſe operations of extreme heat, and violent mechanic force, be only in the ſyſtem as a matter of accident; or if, on the contrary, they are operations natural to the globe, and neceſſary in the production of ſuch land as this which we inhabit. The anſwer to this is plain: Theſe operations of the globe, remain at preſent with undiminiſhed activity, or in the fulneſs of their power.

A ſtream of melted lava flows from the ſides of Mount Ætna. Here is a column of weighty matter raiſed an immenſe height above the level of the ſea, and rocks of an enormous ſize are projected from its orifice ſome miles into the air. Every one acknowledges that here is the liquefying power and expanſive force of ſubterranean fire, or violent heat. But that Sicily itſelf had been raiſed from the bottom of the ocean, and that the marble called Sicilian Jaſper, had its ſolidity upon the ſame principle with the lava, would ſtumble many a naturaliſt to acknowledge. Nevertheleſs, I have in my poſſeſſion a table of this marble, from which it is demonſtrable, that this calcareous ſtone had flowed, and been in ſuch a ſtate of fuſion and fluidity as lava.

Here is a compariſon formed of two mineral ſubſtances, to which it is of the higheſt importance to attend. The ſolidity and preſent ſtate of the one of theſe is commonly thought to be the operation of fire; of the other, again, it is thought to be that of water. This, however, is not the caſe. The immediate ſtate and condition of both theſe bodies is now to be conſidered as equally the effect of fire or heat. The reaſon of our forming ſuch a different judgment with regard to theſe two ſubjects is this; we ſee, in the one caſe, the more immediate connection of the cauſe and the effect, while, in the other, we have only the effects from whence we are in ſcience to inveſtigate the cauſe.

BUT

But, if it were neceffary always to fee this immediate con-
nection, in order to acknowledge the operation of a power
which, at prefent, is extinguifhed in the effect, we fhould lofe
the benefit of fcience, or general principles, from whence parti-
culars may be deduced, and we fhould be able to reafon no bet-
ter than the brute. Man is made for fcience; he reafons from
effects to caufes, and from caufes to effects; but he does not
always reafon without error. In reafoning, therefore, from ap-
pearances which are particular, care muft be taken how we ge-
neralize; we fhould be cautious not to attribute to nature, laws
which may perhaps be only of our own invention.

The immediate queftion now before us is not, if the fubter-
raneous fire, or elevating power, which we perceive fometimes
as operating with fuch energy, be the confolidating caufe of
ftrata formed at the bottom of the fea; nor, if that power be
the means of making land appear above the general furface of
the water; for, though this be the end we want to arrive at ul-
timately, the queftion at prefent in agitation refpects the laws of
nature, or the generality of particular appearances.

Has the globe within it fuch an active power as fits it for
the renovation of that part of its conftitution which may be
fubject to decay? Are thofe powerful operations of fire, or fub-
terraneous heat, which fo often have filled us with terror and
aftonifhment, to be confidered as having always been? Are
they to be concluded as proper to every part upon the globe,
and as continual in the fyftem of this earth? If thefe points in
queftion fhall be decided in the affirmative, we can be at no
lofs in afcertaining the power which has confolidated ftrata, nor
in explaining the prefent fituation of thofe bodies, which had
their origin at the bottom of the fea. This, therefore, fhould
be the object of our purfuit; and, in order to have demonftra-
tion in a cafe of phyfical enquiry, we muft again have recourfe
to the book of nature.

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The general tendency of heat is to produce fluidity and softnefs ; as that of cold is, on the contrary, to harden foft and fluid bodies. But this foftening power of heat is not uniform in its nature ; it is made to act with very different effect, according to the nature of the fubftance to which it is applied. We are but limited in the art of increafing the heat or the cold of bodies ; we find, however, extreme difference in their fubftances with refpect to fufibility.

A fusible fubftance, or mineral compofition in a fluid ftate, is emitted from thofe places of the earth at which fubterraneous fire and expanfive force are manifefted in thofe eruptive operations. In examining thefe emitted bodies, men of fcience find a character for fuch productions, in generalizing the fubftance, and underftanding the natural conftitution of thofe bodies. It is in this manner, that fuch a perfon, finding a piece of lava in any place of the earth, fays with certainty, Here is a ftone which had congealed from a melted ftate.

Having thus found a diftinguifhing character for thofe fufed fubftances called, in general, lavas, and having the moft vifible marks for that which had been actually a volcano, naturalifts, in examining different countries, have difcovered the moft undoubted proofs of many ancient volcanos, which had not been before fufpected. Thus, volcanos will appear to be not a matter of accident, or as only happening in a particular place, they are general to the globe, fo far as there is no place upon the earth that may not have an eruption of this kind ; although it is by no means neceffary for every place to have had thofe eruptions.

Volcanos are natural to the globe, as general operations ; but we are not to confider nature as having a burning mountain for an end in her intention, or as a principal purpofe in the general fyftem of this world. The end of nature in placing an internal fire or power of heat, and a force of irrefiftible expanfion, in the body of this earth, is to confolidate the fediment

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collected at the bottom of the fea, and to form thereof a mafs of permanent land above the level of the ocean, for the purpofe of maintaining plants and animals. The power appointed for this purpofe is, as on all other occafions, where the operation is important, and where there is any danger of a fhortcoming, wifely provided in abundance; and there are contrived means for difpofing of the redundancy. Thefe, in the prefent cafe, are our volcanos.

A VOLCANO is not made on purpofe to frighten fuperftitious people into fits of piety and devotion, nor to overwhelm devoted cities with deftruction; a volcano fhould be confidered as a fpiracle to the fubterranean furnace, in order to prevent the unneceffary elevation of land, and fatal effects of earthquakes; and we may reft affured, that they, in general, wifely anfwer the end of their intention, without being in themfelves an end, for which nature had exerted fuch amazing power and excellent contrivance.

LET us take a view of the moft elevated places of the earth; if the prefent theory is juft, it is there that we fhould find volcanos. But is not this the cafe? There are volcanos in the Andes; and round the Alps we find many volcanos, which are in France upon the one fide, and in Germany upon the other, as well as upon the Italian fide, where Vefuvius ftill continues to exhibit violent eruptions.

IT is not meant to allege, that it is only upon the fummit of a continent volcanos fhould appear. Subterraneous fire has fometimes made its appearance in burfting from the bottom of the fea. But, even in this laft cafe, land was raifed from the bottom of the fea, before the eruption made its exit into the atmofphere. It muft alfo be evident, that, in this cafe of the new ifland near Santorini, had the expanfive power been retained, inftead of being difcharged, much more land might have been raifed above the level of the ocean.

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Now, the eruption of that elaſtic force through the bottom of the ſea, may be confidered as a waſte of power in the operations of the globe, where the elevation of indurated ſtrata is an object in the exertion of that power; whereas, in the centre of a continent ſufficiently elevated above the level of the ſea, the eruption of that fiery vapour calculated to elevate the land, while it may occaſionally deſtroy the habitations of a few, provides for the ſecurity and quiet poſſeſſion of the many.

In order to ſee the wiſdom of this contrivance, let us confider the two extreme places at which this eruption of ignited matter may be performed. Theſe are, on the one hand, within a continent of land, and, on the other, at the bottom of the ocean. In the one caſe, the free eruption of the expanding power ſhould be permitted; becauſe the purpoſe for which it had been calculated to exiſt, has been accompliſhed. In the other, again, the free eruption of that powerful matter ſhould be repreſſed; becauſe there is reſerved for that power much of another operation in that place. But, according to the wiſe conſtitution of things, this muſt neceſſarily happen. The eruption of the fiery vapour from volcanos on the continent or land, is interrupted only occaſionally, by the melted bodies flowing in the ſubterraneous chimney; whereas, at the bottom of the ocean, the contact of the water neceſſarily tends to cloſe the orifice, by accumulating condenſed matter upon the weakeſt place.

If this be a juſt theory of the natural operations of the globe, we ſhall have reaſon to expect, that great quantities of this melted matter or fuſible ſubſtance may be found in form of lava, among the ſtrata of the earth, where there are no viſible marks of any volcano, or burning mountain, having exiſteſt. Here, therefore, is an important point to be determined; for, if it ſhall appear, that much of this melted matter, analogous to lava, has been forced to flow among the ſtrata which had been formed at the bottom of the ſea, and now are found

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forming dry land above its furface, it will be allowed, that we have difcovered the fecret operations of nature concocting future land, as well as thofe by which the prefent habitable earth had been produced from the bottom of the abyfs. Here, therefore, we fhall at prefent reft the argument, with endeavouring to fhew that fuch is actually the cafe.

It appears from CRONSTEDT's Mineralogy, that the rockftone, called trap by the Swedes, the amygdaloides and the fchwarts-ftein of the Germans, are the fame with the whinftone of this country. This is alfo fully confirmed by fpecimens from Sweden, fent me by my friend Dr GAHN. Whatever, therefore, fhall be afcertained with regard to our whinftone, may be fo far generalized or extended to the countries of Norway, Sweden, and Germany.

The whinftone of Scotland is alfo the fame with the toadftone of Derbyfhire, which is of the amygdaloides fpecies ; it is alfo the fame with the ragftone of the fouth of Staffordfhire, which is a fimple whinftone, or perfect trap. England, therefore, muft be included in this great fpace of land, the mineral operations of which we explore ; and alfo Ireland, of which the Giants Caufeway, and many others, are fufficient proof.

In the fouth of Scotland, there is a ridge of hills, which extends from the weft fide of the ifland in Galloway to the eaft fide in Berwickfhire, compofed of granite, of fchiftus, and of filiceous ftrata. The Grampians on the north, again, form another range of mountains of the fame kind ; and between thefe two great fields of broken, tumbled and diftorted ftrata, there lies a field of leffer hardnefs and confolidation, in general ; but a field in which there is a great manifeftation of fubterraneous fire, and of exerted force.

The ftrata in this fpace confift, in general, of fandftone, coal, limeftone or marble, ironftone, and marl or argillaceous ftrata, with ftrata of analogous bodies, and the various compofitions of thefe. But what is to the prefent purpofe is this, that,

that, through all this fpace, there are interfperfed immenfe quantities of whinftone ; a body which is to be diftinguifhed as very different from lava ; and now the difpofition of this whinftone is to be confidered.

SOMETIMES it is found in an irregular mafs or mountain, as Mr CRONSTEDT has properly obferved ; but he has alfo faid, that this is not the cafe in general. His words are : " It is " oftener found in form of veins in mountains of another " kind, running commonly in a ferpentine manner, contrary " or acrofs to the direction of the rock itfelf."

THE origin of this form, in which the trap or whinftone appears, is moft evident to infpection, when we confider that this folid body had been in a fluid ftate, and introduced, in that ftate, among ftrata which preferved their proper form. The ftrata appear to have been broken, and the two correfpondent parts of thofe ftrata are feparated to admit the flowing mafs of whinftone.

A FINE example of this kind may be feen upon the fouth fide of the Earn, on the road to Crief. It is twenty-four yards wide, ftands perpendicular, and appears many feet above the furface of the ground. It runs from that eaftward, and would feem to be the fame with that which croffes the river Tay, in forming Campfy-lin above Stanley, as a leffer one of the fame kind does below it. I have feen it at Lednoc upon the Ammon, where it forms a cafcade in that river, about five or fix miles weft of Campfy-lin. It appears to run from the Tay eaft through Strathmore, fo that it may be confidered as having been traced for twenty or thirty miles, and weftwards to Drummond caftle, perhaps much farther.

Two fmall veins of the fame kind, only two or three feet wide, may be feen in the bed of the Water of Leith, traverfing the horizontal ftrata, the one is above St BERNARD's well, the other immediately below it. But, more particularly, in the fhire of Ayr, to the north of Irvine, there are to be feen upon

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the coaft, between that and Scarmorly, in the fpace of about twenty miles, more than twenty or thirty fuch dykes (as they are called) of whinftone. Some of them are of a great thicknefs; and, in fome places, there is perceived a fhort one, running at right angles, and communicating with other two that run parallel.

THERE is in this country, and in Derbyfhire *, another regular appearance of this ftone, which CRONSTEDT has not mentioned. In this cafe, the ftrata are not broken in order to have the whinftone introduced, they are feparated, and the whinftone is interjected in form of ftrata, having various degrees of regularity, and being of different thicknefs. On the fouth fide of Edinburgh, I have feen, in little more than the fpace of a mile from eaft to weft, nine or ten maffes of whinftone interjected among the ftrata. Thefe maffes of whinftone are from three or four to an hundred feet thick, running parallel in planes inclined to the horizon, and forming with it an angle of about twenty or thirty degrees, as may be feen at all times in the hill of Salifbury Craggs.

HAVING thus defcribed thefe maffes, which have flowed by means of heat among the ftrata of the globe, ftrata which had been formed by fubfidence at the bottom of the fea, it will now be proper to examine the difference that fubfifts between thefe fubterraneous lavas, as they may be termed, and the analogous bodies, which are proper lavas, in having iffued out of a volcano †.

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* See Mr WHITEHURST's Theory of the Earth.

† The Chevalier de Dolomieu, in his accurate examination of Ætna and the Lipari iflands, has very well obferved the diftinction of thefe two different fpecies of lavas; but without feeming to know the principle upon which this effential difference depends. No bias of fyftem, therefore, can here be fuppofed as perverting the Chevalier's view, in taking thofe obfervations; and thefe are interefting to the prefent theory, as correfponding perfectly with the facts from whence it has been formed. It will be proper to give the account of thefe in his own words.

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THERE can be no doubt that thefe two different fpecies of bodies have had the fame origin, and that they are compofed of the fame materials nearly; but from the different circum-ftances of their production, there is formed a character to thefe bodies, by which they may be perfectly diftinguifhed. The difference of thofe circumftances confifts in this; the one has been emitted to the atmofphere in its fluid ftate, the other only came to be expofed to the light in a long courfe of time, after it had congealed under the compreffion of an immenfe load of earth, and after certain operations, proper to the mineral re-gions, had been exercifed upon the indurated mafs. This is the caufe of the difference between thofe erupted lavas; and our whinftone, toadftone, and the Swedifh trap, which may be termed fubterraneous lava. The vifible effects of thofe different opera-tions may now be mentioned.

IN the erupted lavas, thofe fubftances which are fubject to calcine and vitrify in our fires, fuffer fimilar changes, when de-livered from a compreffion which had rendered them fixed, though

LA zeolite eft tres-commune dans certains laves de l'Ethna; il feroit peut-être poffible d'y en rencontrer des morceaux auffi gros que ceux que fournit l'ifle de Ferroé. Quoi-que cette fubftance femble ici appartenir aux laves, je ne dirai cependant point que tou-tes les zeolites foient volcaniques, ou unies à des matieres volcaniques; celles que l'on trouve en Allemagne font, dit-on, dans des circonftances differentes; mais je doit an-noncer que je n'ai trouvé cette fubftance en Sicile, que dans les feules laves qui evidem-ment ont coulé dans la mer, et qui ont été recouvertes par fes eaux. La zeolite des la-ves n'eft point une dejection volcanique, ni une production du feu, ni même un matiere que les laves aient enveloppée lorfqu'elles etoient fluides; elle eft le refultat d'une opera-tion et d'une combinaifon pofterieure, auxquelles les eaux de la mer ont concouru. Les laves qui n'ont pas été fubmergées, n'en contiennent jamais. J'ai trouvé ces obferva-tions fi conftantes, que par-tout où je rencontrois de la zeolite, j'étois fûr de trouver d'autres preuves de fubmerfion, et partout où je voyois des laves recouvertes des dépôts de l'eau, j'étois fûr de trouver de la zeolite, et un de ces faits m'a toujours indiqué l'au-tre. Je me fuis fervi avec fucces de cette obfervation pour diriger mes recherches, et pour connoitre l'antiquité des laves. *Mineralogie de Volcans, par M. Faujas de Saint-Fond.* Here would appear to be the diftinction of fubterraneous lava, in which zeolite and calcareous fpar may be found, and that which has flowed from a volcano, in which neither of thefe are ever obferved.

though in an extremely heated ftate. Thus, a lava in which there is much calcareous fpar, when it comes to be expofed to the atmofphere, or delivered from the compreffing force of its confinement, effervefces by the explofion of its fixed air; the calcareous earth, at the fame time, vitrifies with the other fub-ftances : Hence fuch violent ebullition in volcanos, and hence the emiffion of fo much pumice-ftone and afhes, which are of the fame nature.

In the body of our whinftone, on the contrary, there is no mark of calcination or vitrification. We frequently find in it much calcareous fpar, or the *terra calcarea aerata*, which had been in a melted ftate by heat, and had been cryftallized by congelation into a fparry form. Such is the *lapis amygdaloides*, and many of our whinftone rocks, which contain pebbles cryftallized and varioufly figured, both calcareous, filiceous, and of a mixture in which both thefe fubftances form diftinct parts. The fpecimens of this kind, which I have from the whinftone or porphyry rock of the Calton-hill, exhibit every fpecies of mineral operation, in forming jafper, figured agate, and marble; and they demonftrate, that this had been per-formed by heat or fufion.

I do not mean to fay, that this demonftration is direct; it is conditional, and proceeds upon the fuppofition, that the bafal-tic or porphyry rock, in which thofe fpecimens are found, is a body which had been in a melted ftate. Now, this is a fuppo-fition for which I have abundance of evidence, were it re-quired; but naturalifts are now fufficiently difpofed to admit that propofition; they even draw conclufions from this fact, which, I think, they are not fufficiently warranted in doing; that is, from this appearance, they infer the former exiftence of volcanos in thofe places. For my part, though I have made the moft ftrict examination, I never faw any veftige of fuch an event. That there are, in other countries, evident marks of volcanos which have been long extinguifhed, is unqueftionably

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true ; but naturalifts, imagining that there are no other marks of fubterraneous fire and fufion, except in the production of a lava, attribute to a volcano, as a caufe, thefe effects, which only indicate the exertion of that power which might have been the caufe of a volcano.

If the theory now given be juft, a rock of marble is no lefs a mark of fubterraneous fire and fufion, than that of the bafaltes ; and the flowing of bafaltic ftreams among ftrata broken and difplaced, affords the moft fatisfactory evidence of thofe operations by which the body of our land had been elevated above the furface of the fea ; but it gives no proof that the eruptive force of mineral vapours had been difcharged in a burning mountain. Now, this difcharge is effential in the proper idea of a volcano.

Besides this internal mark of an unerupted lava in the fubftance of the ftone or body of the flowing mafs, there are others which belong to it in common with all other mineral ftrata, confolidated by fubterraneous fire, and changed from the place of their original formation ; this is, the being broken and diflocated, and having veins of foreign matter formed in their feparations and contractions.

If thefe are mineral operations, proper to the lower regions of the earth, and exerted upon bodies under immenfe compreffion, fuch things will be fometimes found in the unerupted lavas, as well as in the contiguous bodies with which they are affociated. If, on the contrary, thefe are operations proper to the furface of the earth, where the diffolving power of water and air take place, and where certain ftalactical and ferruginous concretions are produced by thefe means ; then, in erupted lavas, we fhould find mineral concretions, which concretions fhould be denied to bodies which had been confolidated at the bottom of the fea ; that is to fay, where, without the operation of fubterraneous fire, no changes of that kind could have taken place, as has already been obferved. But in the unerupted fpecies

cies of lava, that is to fay, in our whinftone, every fpecies of mineral appearance is occafionally to be found. Let thofe who have the opportunity to examine, fay, what are to be found in proper lavas, that is, thofe of the erupted kind. Sir WILLIAM HAMILTON informed me, when I fhewed him thofe mineral veins and fpars in our whinftone, that he had never obferved the like in lavas.

WE have now formed fome conclufions with regard to the nature and production of thofe parts of the land of this globe which we have had the means of examining perfectly; but from the accounts of travellers, and from the fpecimens which are brought to us from diftant parts, we have reafon to believe, that all the reft of the earth is of the fame nature with that which has been now confidered. The great maffes of the earth are the fame every where; and all the different fpecies of earths, of rocks or ftone, which have as yet appeared, are to be found in the little fpace of this our ifland.

IT is true, that there are peculiar productions in the mineral kingdom which are rare, as being found only in few places; but thefe things are merely accidental in relation to the land, for they belong in property to thofe parts of the mineral region which we never fee. Such are, the diamond of the eaft, the platina of the weft, and the tin of Cornwall, Germany, and Sumatra. Gold and filver, though found in many countries, do not appear to be immediately neceffary in the production of a habitable country. Iron, again, is univerfal in the operations of the globe, and is found often in that profufion which equals its utility. Between thefe two extremes, we find all other minerals, that is to fay, here and there in moderate quantity, and apparently in fome proportion to their ufe. But all thefe fubftances are to be confidered as the vapours of the mineral regions, condenfed occafionally in the crevices of the land; and it is only the rocks and ftrata (in which thofe mineral veins are found) that are now examined with regard to their original

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compofition at the bottom of the fea, as well as to that opera-
tion by which thofe bodies had been indurated in their fub-
ftance, and elevated from the place in which they had been
formed.

THUS, we have fufficient reafon to believe, that, in knowing
the conftruction of the land in Europe, we know the conftitu-
tion of the land in every part of the globe. Therefore, we
may proceed to form general conclufions, from the knowledge
of the mineral region, thus acquired in ftudying thofe parts
which are feen.

HAVING thus found, *firft*, That the confolidated and indu-
rated maffes of our ftrata had fuffered the effects of violent heat
and fufion ; *2dly*, That thofe ftrata, which had been formed in
a regular manner at the bottom of the fea, have been violently
bended, broken and removed from their original place and fitu-
ation ; and, *laftly*, Having now found the moft indubitable
proof, that the melting, breaking, and removing power of fub-
terraneous fire, has been actually exerted upon this land which
we examine, we cannot hefitate in afcribing thefe operations as
a caufe to thofe effects which are expofed to our view. Now,
thefe may be confidered as confifting in the folid ftate and pre-
fent fituation of thofe ftratified bodies, originally formed by
fubfidence in the ocean ; appearances which cannot, in reafon,
be afcribed to any other caufe, and which, upon this principle,
are perfectly explained.

IT is not meant to fpecify every particular in the means em-
ployed by nature for the elevation of our land. It is fufficient
to have fhewn, that there is, in nature, means employed for the
confolidating of ftrata, formed originally of loofe and incoherent
materials ; and that thofe fame means have alfo been employed
in changing the place and fituation of thofe ftrata. But how
defcribe an operation which man cannot have any opportunity
of perceiving ? Or how imagine that, for which, perhaps, there
are not proper data to be found? We only know, that the land
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is raifed by a power which has for principle fubterraneous heat ; but how that land is preferved in its elevated ftation, is a fubject in which we have not even the means to form conjecture ; at leaft, we ought to be cautious how we indulge conjecture in a fubject where no means occur for trying that which is but fuppofition.

WE now proceed, from the facts which have been properly eftablifhed, to reafon with regard to the duration of this globe, or the general view of its operations, as a living world, maintaining plants and animals.

P A R T   IV.

Syftem of Decay and Renovation obferved in the Earth.

PHILOSOPHERS obferving an apparent diforder and confufion in the folid parts of this globe, have been led to conclude, that there formerly exifted a more regular and uniform ftate, in the conftitution of this earth ; that there had happened fome deftructive change ; and that the original ftructure of the earth had been broken and difturbed by fome violent operation, whether natural, or from a fupernatural caufe. Now, all thefe appearances, from which conclufions of this kind have been formed, find the moft perfect explanation in the theory which we have been endeavouring to eftablifh ; for they are the facts from whence we have reafoned, in difcovering the nature and conftitution of this earth : Therefore, there is no occafion for having recourfe to any unnatural fuppofition of evil, to any deftructive accident in nature, or to the agency of any preternatural caufe, in explaining that which actually appears.

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IT is neceſſary for a living or inhabited world, that this ſhould conſiſt of land and water. It is alſo neceſſary, that the land ſhould be ſolid and ſtable, reſiſting, with great power, the violent efforts of the ocean ; and, at the ſame time, that this ſolid land ſhould be reſolved by the influence of the ſun and atmoſphere, ſo as to decay, and thus become a ſoil for vegeta-tion. But theſe general intentions are perfectly fulfilled in the conſtitution of our earth, which has been now inveſtigated. This great body being formed of different mixed maſſes, ha-ving various degrees of hardneſs and ſolubility, proper ſoil for plants is ſupplied from the gradual reſolution of the ſolid parts ; fertility in thoſe ſoils ariſes from the mixture of different ele-mentary ſubſtances ; and ſtability is procured to that vegetable world, by the induration of certain bodies, thoſe rocks and ſtones, which protect the ſofter maſſes of clay and ſoil.

IN this manner, alſo, will eaſily be explained thoſe natural ap-pearances which diverſify the ſurface of the earth for the uſe of plants and animals, and thoſe objects which beautify the face of nature for the contemplation of mankind. Such are, the diſtinctions of mountains and valleys, of lakes and rivers, of dry barren deſarts and rich watered plains, of rocks which ſtand apparently unimpaired by the lapſe of time, and ſands which fluctuate with the winds and tides. All theſe are the ef-fects of ſteady cauſes ; each of theſe has its proper purpoſe in the ſyſtem of the earth ; and in that ſyſtem is contained ano-ther, which is that of living growing bodies, and of animated beings.

BUT, beſides this, man, the intellectual being, has, in this ſubject of the mineral kingdom, the means of gratifying the deſire of knowledge, a faculty by which he is diſtinguiſhed from the animal, and by which he improves his mind in know-ing cauſes. Man is not ſatisfied, like the brute, in ſeeing things which are ; he ſeeks to know how things have been, and what they are to be. It is with pleaſure that he obſerves

order

order and regularity in the works of nature, inſtead of being diſguſted with diſorder and confuſion ; and he is made happy from the appearance of wiſdom and benevolence in the deſign, inſtead of being left to ſuſpect in the Author of nature, any of that imperfection which he finds in himſelf.

LET us now take a view of that ſyſtem of mineral œconomy, in which may be perceived every mark of order and deſign, of provident wiſdom and benevolence.

WE have been endeavouring to prove, that all the continents and iſlands of this globe had been raiſed above the ſurface of the ocean ; we have alſo aimed at pointing out the cauſe of this tranſlation of matter, as well as of the general ſolidity of that which is raiſed to our view ; but however this theory ſhall be received, no perſon of obſervation can entertain a doubt, that all, or almoſt all we ſee of this earth, had been originally formed at the bottom of the ſea. We have now another object in our view ; this is to inveſtigate the operations of the globe, at the time that the foundation of this land was laying in the waters of the ocean, and to trace the exiſtence and the nature of things, before the preſent land appeared above the ſurface of the waters. We ſhould thus acquire ſome knowledge of the ſyſtem according to which this world is ruled, both in its preſervation and production ; and we might be thus enabled to judge, how far the mineral ſyſtem of the world ſhall appear to be contrived with all the wiſdom, which is ſo manifeſt in what are termed the animal and vegetable kingdoms.

IT muſt not be imagined that this undertaking is a thing unreaſonable in its nature ; or that it is a work neceſſarily beſet with any unſurmountable difficulty ; for, however imperfectly we may fulfil this end propoſed, yet, ſo far as it is to natural cauſes that are to be aſcribed the operations of former time, and ſo far as, from the preſent ſtate of things, or knowledge of natural hiſtory, we have it in our power to reaſon from effect to cauſe, there are, in the conſtitution of the world, which we

now

now examine, certain means to read the annals of a former earth.

THE object of enquiry being the operations of the globe, during the time that the prefent earth was forming at the bottom of the fea, we are now to take a very general view of nature, without defcending into thofe particulars which fo often occupy the fpeculations of naturalifts, about the prefent ftate of things. We are not at prefent to enter into any difcuffion with regard to what are the primary and fecondary mountains of the earth; we are not to confider what is the firft, and what the laft, in thofe things which now are feen; whatever is moft ancient in the ftrata which we now examine, is fuppofed to be collecting at the bottom of the fea, during the period concerning which we are now to enquire.

WE have already confidered thofe operations which had been neceffary in forming our folid land, a body confifting of materials originally depofited at the bottom of the ocean; we are now to inveftigate the fource from whence had come all thofe materials, from the collection of which the prefent land is formed; and from knowing the ftate in which thofe materials had exifted, previoufly to their entering the compofition of our ftrata, we fhall learn fomething concerning the natural hiftory of this world, while the prefent earth was forming in the fea.

WE have already obferved, that all the ftrata of the earth are compofed either from the calcareous relicts of fea animals, or from the collection of fuch materials as we find upon our fhores. At a grofs computation, there may perhaps be a fourth part of our folid land, which is compofed from the matter that had belonged to thofe animals. Now, what a multitude of living creatures, what a quantity of animal œconomy muft have been required for producing a body of calcareous matter which is interfperfed throughout all the land of the globe, and which certainly forms a very confiderable part of that mafs!

Therefore

Therefore, in knowing how thofe animals had lived, or with what they had been fed, we fhall have learned a moft interefting part of the natural hiftory of this earth; a part which it is neceffary to have afcertained, in order to fee the former operations of the globe, while preparing the materials of the prefent land. But, before entering upon this fubject, let us examine the other materials of which our land is formed.

GRAVEL forms a part of thofe materials which compofe our folid land; but gravel is no other than a collection of the fragments of folid ftones worn round, or having their angular form deftroyed by agitation in water, and the attrition upon each other, or upon fimilar hard bodies. Confequently, in finding maffes of gravel in the compofition of our land, we muft conclude, that there had exifted a former land, on which there had been tranfacted certain operations of wind and water, fimilar to thofe which are natural to the globe at prefent, and by which new gravel is continually prepared, as well as old gravel confumed or diminifhed by attrition upon our fhores.

SAND is the material which enters, perhaps in greateft quantity, the compofition of our land. But fand is no other than fmall fragments of hard and folid bodies, worn or rounded more or lefs by attrition; confequently, the fame natural hiftory of the earth, which is inveftigated from the maffes of gravel, is alfo applicable to thofe maffes of fand which we find forming fo large a portion of our prefent land throughout all the earth.

CLAY is now to be confidered as the laft of thofe materials of which our ftrata are compofed; but, in order to underftand the nature of this ingredient, fomething muft be premifed.

CLAY is a mixture of different earths or hard fubftances, in an impalpable ftate. Thofe fubftances are chiefly the filiceous and aluminous earths. Other earths are occafionally mixed in clays, or perhaps always to be found in fome fmall portion. But this does not affect the general character of clay; it only forms a fpecial variety in the fubject. A fenfible or confiderable

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ble portion of calcareous earth, in the compofition of clay, conftitutes a marl, and a fufficient admixture of fand, a loam.

An indefinite variety of thofe compofitions of clay form a large portion of the prefent ftrata, all indurated and confolidated in various degrees ; but this great quantity of filiceous, argillaceous, and other compound fubftances, in form of earth or impalpable fediment, correfponds perfectly with that quantity of thofe fame fubftances which muft have been prepared in the formation of fo much gravel and fand, by the attrition of thofe bodies in the moving waters.

Therefore, from the confideration of thofe materials which compofe the prefent land, we have reafon to conclude, that, during the time this land was forming, by the collection of its materials at the bottom of the fea, there had been a former land containing materials fimilar to thofe which we find at prefent in examining the earth. We may alfo conclude, that there had been operations fimilar to thofe which we now find natural to the globe, and neceffarily exerted in the actual formation of gravel, fand and clay. But what we have now chiefly in view to illuftrate is this, that there had then been in the ocean a fyftem of animated beings, which propagated their fpecies, and which have thus continued their feveral races to this day.

In order to be convinced of that truth, we have but to examine the ftrata of our earth, in which we find the remains of animals. In this examination, we not only difcover every genus of animal which at prefent exifts in the fea, but probably every fpecies, and perhaps fome fpecies with which at prefent we are not acquainted. There are, indeed, varieties in thofe fpecies, compared with the prefent animals which we examine, but no greater varieties than may perhaps be found among the fame fpecies in the different quarters of the globe. Therefore, the fyftem of animal life, which had been maintained in the ancient fea, had not been different from that which now fubfifts, and of which it belongs to naturalifts to know the hiftory.

It

IT is the nature of animal life to be ultimately fupported from matter of vegetable production. Inflammable matter may be confidered as the *pabulum* of life. This is prepared in the bodies of living plants, particularly in their leaves expofed to the fun and light. This inflammable matter, on the contrary, is confumed in animal bodies, where it produces heat or light, or both. Therefore, however animal matter, or the pabulum of life, may circulate through a feries of digefting powers, it is conftantly impaired or diminifhing in the courfe of this œconomy, and, without the productive power of plants, it would finally be extinguifhed.

THE animals of the former world muft have been fuftained during indefinite fucceffions of ages. The mean quantity of animal matter, therefore, muft have been preferved by vegetable production, and the natural wafte of inflammable fubftance repaired with continual addition; that is to fay, the quantity of inflammable matter neceffary to the animal confumption, muft have been provided by means of vegetation. Hence we muft conclude, that there had been a world of plants, as well as an ocean replenifhed with living animals.

WE are now, in reafoning from principles, come to a point decifive of the queftion, and which will either confirm the theory, if it be juft, or confute our reafoning, if we have erred. Let us, therefore, open the book of Nature, and read in her records, if there had been a world bearing plants, at the time when this prefent world was forming at the bottom of the fea.

HERE the cabinets of the curious are to be examined; but here fome caution is required, in order to diftinguifh things perfectly different, which fometimes are confounded.

FOSSIL WOOD, to naturalifts in general, is wood dug up from under ground, without enquiring whether this had been the production of the prefent earth, or that which had preceded it in the circulation of land and water. The queftion is important, and the folution of it is, in general, eafy. The vege-

table

table productions of the prefent earth, however deep they may be found buried beneath its furface, and however ancient they may appear, compared with the records of our known times, are new, compared with the folid land on which they grew; and they are only covered with the produce of a vegetable foil, or the alluvion of the prefent land on which we dwell, and on which they had grown. But the foffil bodies which form the prefent fubject of enquiry, belonged to former land, and are found only in the fea-born ftrata of our prefent earth. It is to thefe alone that we appeal, in order to prove the certainty of former events.

MINERALIZED wood, therefore, is the object now enquired after; that wood which had been lodged in the bottom of the fea, and there compofed part of a ftratum, which hitherto we have confidered as only formed of the materials proper to the ocean. Now, what a profufion of this fpecies of foffil wood is to be found in the cabinets of collectors, and even in the hands of lapidaries, and fuch artificers of polifhed ftones! In fome places, it would feem to be as common as the agate.

I SHALL only mention a fpecimen in my own collection. It is wood petrified with calcareous earth, and mineralized with pyrites. This fpecimen of wood contains in itfelf, even without the ftratum of ftone in which it is embedded, the moft perfect record of its genealogy. It had been eaten or perforated by thofe fea-worms which deftroy the bottoms of our fhips. There is the cleareft evidence of this truth. Therefore, this wood had grown upon land which ftood above the level of the fea, while the prefent land was only forming at the bottom of the ocean.

WOOD is the moft fubftantial part of plants, as fhells are the more permanent part of marine animals. It is not, however, the woody part alone of the ancient vegetable world that is tranfmitted to us in the record of our mineral pages. We have the type of many fpecies of foliage, and even of the

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moſt delicate flower; for, in this way, naturaliſts have deter-
mined, according to the Linnæan ſyſtem, the ſpecies, or at
leaſt the genus, of the plant. Thus, the exiſtence of a vegeta-
ble ſyſtem at the period now in contemplation, ſo far from be-
ing doubtful, is a matter of phyſical demonſtration.

THE profuſion of this vegetable matter, delivered into the
ocean, which then generated land, is alſo evidenced in the
amazing quantities of mineral coal, which is to be found in
perhaps every region of the earth.

NOTHING can be more certain, than that all the coaly or bi-
tuminous ſtrata have had their origin from the ſubſtance of ve-
getable bodies that grew upon the land. Thoſe ſtrata, though,
in general, perfectly conſolidated, often ſeparate horizontally in
certain places; and there we find the fibrous or vaſcular ſtruc-
ture of the vegetable bodies. Conſequently, there is no doubt
of foſſil coal being a ſubſtance of vegetable production, how-
ever animal ſubſtances alſo may have contributed in forming
this collection of oleaginous or inflammable matter.

HAVING thus aſcertained the ſtate of a former earth, in
which plants and animals had lived, as well as the gradual pro-
duction of the preſent earth, compoſed from the materials of
a former world, it muſt be evident, that here are two opera-
tions which are neceſſarily conſecutive. The formation of the
preſent earth neceſſarily involves the deſtruction of continents
in the ancient world; and, by purſuing in our mind the natu-
ral operations of a former earth, we clearly ſee the origin of
that land, by the fertility of which, we, and all the animated
bodies of the ſea, are fed. It is in like manner, that, contemplating
the preſent operations of the globe, we may perceive the actual
exiſtence of thoſe productive cauſes, which are now laying the
foundation of land in the unfathomable regions of the ſea, and
which will, in time, give birth to future continents.

BUT though, in generalizing the operations of nature, we
have arrived at thoſe great events, which, at firſt ſight, may

fill the mind with wonder and with doubt, we are not to fup-
pofe, that there is any violent exertion of power, fuch as is re-
quired in order to produce a great event in little time ; in na-
ture, we find no deficiency in refpect of time, nor any limita-
tion with regard to power.   But time is not made to flow in
vain; nor does there ever appear the exertion of fuperfluous
power, or the manifeftation of defign, not calculated in wifdom
to effect fome general end.

THE events now under confideration may be examined with
a view to fee this truth ; for it may be enquired, why deftroy
one continent in order to erect another ? The anfwer is plain ;
Nature does not deftroy a continent from having wearied of a
fubject which had given pleafure, or changed her purpofe, whe-
ther for a better or a worfe ; neither does fhe erect a continent
of land among the clouds, to fhew her power, or to amaze
the vulgar man : Nature has contrived the productions of ve-
getable bodies, and the fuftenance of animal life, to depend
upon the gradual but fure deftruction of a continent ; that is
to fay, thefe two operations neceffarily go hand in hand.
But with fuch wifdom has nature ordered things in the œcono-
my of this world, that the deftruction of one continent is not
brought about without the renovation of the earth in the pro-
duction of another ; and the animal and vegetable bodies, for
which the world above the furface of the fea is levelled with
its bottom, are among the means employed in thofe operations,
as well as the fuftenance of thofe living beings is the proper
end in view.

THUS, in underftanding the proper conftitution of the pre-
fent earth, we are led to know the fource from whence had
come all the materials which nature had employed in the con-
ftruction of the world which appears ; a world contrived in
confummate wifdom for the growth and habitation of a great
diverfity of plants and animals ; and a world peculiarly adapted
                                                                    to

to the purposes of man, who inhabits all its climates, who meafures its extent, and determines its productions at his pleafure.

THE whole of a great object or event fills us with wonder and aftonifhment, when all the particulars, in the fucceffion of which the whole had been produced, may be confidered without the leaft emotion. When, for example, we behold the pyramids of Egypt, our mind is agitated with a crowd of ideas that highly entertains the perfon who underftands the fubject ; but the carrying a heavy ftone up to the top of a hill or mountain would give that perfon little pleafure or concern. We wonder at the whole operation of the pyramid, but not at any one particular part.

THE raifing up of a continent of land from the bottom of the fea, is an idea that is too great to be conceived eafily in all the parts of its operation, many of which are perhaps unknown to us ; and without being properly underftood, fo great an idea may appear like a thing that is imaginary. In like manner, the co-relative, or correfponding operation, the deftruction of the land, is an idea that does not eafily enter into the mind of man in its totality, although he is daily witnefs to part of the operation. We never fee a river in a flood, but we muft acknowledge the carrying away of part of our land, to be funk at the bottom of the fea ; we never fee a ftorm upon the coaft, but we are informed of a hoftile attack of the fea upon our country ; attacks which muft, in time, wear away the bulwarks of our foil, and fap the foundations of our dwellings. Thus, great things are not underftood without the analyzing of many operations, and the combination of time with many events happening in fucceffion.

LET us now confider what is to be the fubject of examination, and where it is that we are to obferve thofe operations which muft determine either the ftability or the inftability of this land on which we live.

OUR

OUR land has two extremities; the tops of the mountains, on the one hand, and the fea-fhores, on the other: It is the interme-diate fpace between thefe two, that forms the habitation of plants and animals. While there is a fea-fhore and a higher ground, there is that which is required in the fyftem of the world: Take thefe away, and there would remain an aqueous globe, in which the world would perifh. But, in the natural operations of the world, the land is perifhing continually; and this is that which now we want to underftand.

UPON the one extremity of our land, there is no increafe, or there is no acceffion of any mineral fubftance. That place is the mountain-top, on which nothing is obferved but conti-nual decay. The fragments of the mountain are removed in a gradual fucceffion from the higheft ftation to the loweft. Be-ing arrived at the fhore, and having entered the dominion of the waves, in which they find perpetual agitation, thefe hard fragments, which had eluded the refolving powers natural to the furface of the earth, are incapable of refifting the powers here employed for the deftruction of the land. By the attri-tion of one hard body upon another, the moving ftones and rocky fhore, are mutually impaired. And that folid mafs, which of itfelf had potential ftability againft the violence of the waves, affords the inftruments of its own deftruction, and thus gives occafion to its actual inftability.

IN order to underftand the fyftem of the heavens, it is ne-ceffary to connect together periods of meafured time, and the diftinguifhed places of revolving bodies. It is thus that fyftem may be obferved, or wifdom, in the proper adapting of powers to an intention. In like manner, we cannot underftand the fyftem of the globe, without feeing that progrefs of things which is brought about in time, thus meafuring the natural operations of the earth with thofe of the heavens. This is pro-perly the bufinefs of the prefent undertaking.

OUR

OUR object is to know the time which had elapſed ſince the foundation of the preſent continent had been laid at the bottom of the ocean, to the preſent moment in which we ſpeculate on theſe operations. The ſpace is long; the data for the calculations are, perhaps, deficient: No matter; ſo far as we know our error, or the deficiency in our operation, we proceed in ſcience, and ſhall conclude in reaſon. It is not given to man to know what things are truly in themſelves, but only what thoſe things are in his thought. We ſeek not to know the preciſe meaſure of any thing; we only underſtand the limits of a thing, in knowing what it is not, either on the one ſide or the other.

WE are inveſtigating the age of the preſent earth, from the beginning of that body which was in the bottom of the ſea, to the perfection of its nature, which we conſider as in the moment of our exiſtence; and we have neceſſarily another æra, which is collateral, or correſpondent, in the progreſs of thoſe natural events. This is the time required, in the natural operations of this globe, for the deſtruction of a former earth; an earth equally perfect with the preſent, and an earth equally productive of growing plants and living animals. Now, it muſt appear, that, if we had a meaſure for the one of thoſe correſponding operations, we would have an equal knowledge of the other.

THE formation of a future earth being in the bottom of the ocean, at depths unfathomable to man, and in regions far beyond the reach of his obſervation, here is a part of the proceſs which cannot be taken as a principle in forming an eſtimate of the whole. But, in the deſtruction of the preſent earth, we have a proceſs that is performed within the limits of our obſervation; therefore, in knowing the meaſure of this operation, we ſhall find the means of calculating what had paſſed on a former occaſion, as well as what will happen in the

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composition

composition of a future earth. Let us, therefore, now attempt
to make this estimate of time and labour.

THE highest mountain may be levelled with the plain from
whence it springs, without the loss of real territory in the
land; but when the ocean makes encroachment on the basis of
our earth, the mountain, unsupported, tumbles with its weight;
and with that accession of hard bodies, moveable with the agi-
tation of the waves, gives to the sea the power of undermining
farther and farther into the solid basis of our land. This is
the operation which is to be measured; this is the mean pro-
portional by which we are to estimate the age of worlds that
have terminated, and the duration of those that are but begin-
ning.

BUT how shall we measure the decrease of our land? Every
revolution of the globe wears away some part of some rock
upon some coast; but the quantity of that decrease, in that
measured time, is not a measurable thing. Instead of a revo-
lution of the globe, let us take an age. The age of man does
no more in this estimate than a single year. He sees, that the
natural course of things is to wear away the coast, with the at-
trition of the sand and stones upon the shore; but he cannot
find a measure for this quantity which shall correspond to time,
in order to form an estimate of the rate of this decrease.

BUT man is not confined to what he sees; he has the expe-
rience of former men. Let us then go to the Romans and the
Greeks in search of a measure of our coasts, which we may
compare with the present state of things. Here, again, we are
disappointed; their descriptions of the shores of Greece and of
Italy, and their works upon the coast, either give no measure
of a decrease, or are not accurate enough for such a purpose.

IT is in vain to attempt to measure a quantity which escapes
our notice, and which history cannot ascertain; and we might
just as well attempt to measure the distance of the stars with-

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out a parallax, as to calculate the deftruction of the folid land without a meafure correfponding to the whole.

The defcription which POLYBIUS has given of the Pontus Euxinus, with the two oppofite Bofphori, the Meotis, the Propontis, and the Port of Byzantium, are as applicable to the prefent ftate of things, as they were at the writing of that hiftory. The filling up of the bed of the Meotis, an event which, to POLYBIUS, appeared not far off, muft alfo be confidered as removed to a very diftant period, though the caufes ftill continue to operate as before.

But there is a thing in which hiftory and the prefent ftate of things do not agree. It is upon the coaft of Spain, where POLYBIUS fays there was an ifland in the mouth of the harbour of New Carthage. At prefent, in place of the ifland, there is only a rock under the furface of the water. It muft be evident, however, that the lofs of this fmall ifland affords no proper ground of calculation for the meafure or rate of wafting which could correfpond to the coaft in general; as neither the quantity of what is now loft had been meafured, nor its quality afcertained.

Let us examine places much more expofed to the fury of the waves and currents than the coaft of Carthagena, the narrow fretum, for example, between Italy and Sicily. It does not appear, that this paffage is fenfibly wider than when the Romans firft had known it. The Ifthmus of Corinth is alfo apparently the fame at prefent as it had been two or three thoufand years ago. Scilla and Charibdis remain now, as they had been in ancient times, rocks hazardous for coafting veffels which had to pafs that ftrait.

It is not meant by this to fay, thefe rocks have not been wafted by the fea, and worn by the attrition of moving bodies, during that fpace of time; were this true, and that thofe rocks, the bulwarks of the land upon thofe coafts, had not been at all impaired from that period, they might remain

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for ever, and thus the fyftem of interchanging the place of fea and land upon this globe might be fruftrated. It is only meant to affirm, that the quantity which thofe rocks, or that coaft, have diminifhed from the period of our hiftory, has either been too fmall a thing for human obfervation, or, which is more probable, that no accurate meafurement of the fubject, by which this quantity of decreafe might have been afcertained, had been taken and recorded. It muft be alfo evident, that a very fmall operation of an earthquake would be fufficient to render every means of information, in this manner of menfu-ration, unfatisfactory or precarious.

Pliny fays Italy was diftant from Sicily a mile and a half; but we cannot fuppofe that this meafure was taken any other-wife than by computation, and fuch a meafure is but little cal-culated to afford us the juft means of a comparifon with the prefent diftance. He alfo fays, indeed, that Sicily had been once joined with Italy. His words are : " Quondam Brutio " agro cohærens, mox interfufo mari avulfa *." But all that we can conclude from this hiftory of Pliny is, that, in all times, to people confidering the appearances of thofe two ap-proached coafts, it had feemed probable, that the fea formed a paffage between the two countries which had been once united; in like manner as is ftill more immediately perceived, in that fmaller disjunction which is made between the ifland of Anglefey and the continent of Wales.

The port of Syracufe, with the ifland which forms the greater and leffer, and the fountain of Arethufa, the water of which the ancients divided from the fea with a wall, do not feem to be altered. From Sicily to the coaft of Egypt, there is an uninter-rupted courfe of fea for a thoufand miles; confequently, the wind, in fuch a ftretch of fea, fhould bring powerful waves againft thofe coafts. But, on this coaft of Egypt, we find the rock on which was formerly built the famous tower of Pharos; and

* Lib. 3. cap. 8.

and alfo, at the eaftern extremity of the port Eunofte, the fea-bath, cut in the folid rock upon the fhore. Both thofe rocks, buffeted immediately with the waves of the Mediterranean fea, are, to all appearance, the fame at this day as they were in ancient times *.

MANY other fuch proofs will certainly occur, where the different parts of thofe coafts are examined by people of obfervation and intelligence. But it is enough for our prefent purpofe, that this decreafe of the coafts in general has not been obferved; and that it is as generally thought, that the land is gaining upon the fea, as that the fea is gaining upon the land.

To fum up the argument, we are certain, that all the coafts of the prefent continents are wafted by the fea, and conftantly wearing away upon the whole; but this operation is fo extremely flow, that we cannot find a meafure of the quantity in order to form an eftimate. Therefore, the prefent continents of the earth, which we confider as in a ftate of perfection, would, in the natural operations of the globe, require a time indefinite for their deftruction.

BUT, in order to produce the prefent continents, the deftruction of a former vegetable world was neceffary; confequently, the production of our prefent continents muft have required a time which is indefinite. In like manner, if the former continents were of the fame nature as the prefent, it muft have required another fpace of time, which alfo is indefinite, before they had come to their perfection as a vegetable world.

WE have been reprefenting the fyftem of this earth as proceeding with a certain regularity, which is not perhaps in nature, but which is neceffary for our clear conception of the fyftem of nature. The fyftem of nature is certainly in rule, although we may not know every circumftance of its regulation. We are under a neceffity, therefore, of making regular

ſuppoſitions,

* Lettres fur l'Egypte, M. SAVARY.

suppofitions, in order to come at certain conclufions which may be compared with the prefent ftate of things.

IT is not neceffary that the prefent land fhould be worn away and wafted, exactly in proportion as new land fhall appear ; or, converfely, that an equal proportion of new land fhould always be produced as the old is made to difappear. It is only required, that, at all times, there fhould be a juft proportion of land and water upon the furface of the globe, for the purpofe of a habitable world.

NEITHER is it required in the actual fyftem of this earth, that every part of the land fhould be diffolved in its ftructure, and worn away by attrition, fo as to be floated in the fea. Parts of the land may often fink in a body below the level of the fea, and parts again may be reftored, without waiting for the general circulation of land and water, which proceeds with all the certainty of nature, but which advances with an imperceptible progreffion. Many of fuch apparent irregularities may appear, without the leaft infringement on the general fyftem. That fyftem is comprehended in the preparation of future land at the bottom of the ocean, from thofe materials which the diffolution and attrition of the prefent land may have provided, and from thofe which the natural operations of the fea afford.

IN thus accomplifhing a certain end, we are not to limit nature with the uniformity of an equable progreffion, although it be neceffary in our computations to proceed upon equalities. Thus alfo, in the ufe of means, we are not to prefcribe to nature thofe alone which we think fuitable for the purpofe, in our narrow view. It is our bufinefs to learn of nature (that is by obfervation) the ways and means, which in her wifdom are adopted ; and we are to imagine thefe only in order to find means for further information, and to increafe our knowledge from the examination of things which actually have been. It is in this manner, that intention may be found in nature ; but

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this intention is not to be fuppofed, or vainly imagined, from what we may conceive to be.

We have been now fuppofing, that the beginning of our prefent earth had been laid in the bottom of the ocean, at the completion of the former land ; but this was only for the fake of diftinctnefs. The juft view is this, that when the former land of the globe had been complete, fo as to begin to wafte and be impaired by the encroachment of the fea, the prefent land began to appear above the furface of the ocean. In this manner we fuppofe a due proportion to be always preferved of land and water upon the furface of the globe, for the purpofe of a habitable world, fuch as this which we poffefs. We thus, alfo, allow time and opportunity for the tranflation of animals and plants to occupy the earth.

But, if the earth on which we live, began to appear in the ocean at the time when the laft began to be refolved, it could not be from the materials of the continent immediately preceding this which we examine, that the prefent earth had been conftructed ; for the bottom of the ocean muft have been filled with materials before land could be made to appear above its furface.

Let us fuppofe that the continent, which is to fucceed our land, is at prefent beginning to appear above the water in the middle of the Pacific Ocean, it muft be evident, that the materials of this great body, which is formed and ready to be brought forth, muft have been collected from the deftruction of an earth which does not now appear. Confequently, in this true ftatement of the cafe, there is neceffarily required the deftruction of an animal and vegetable earth prior to the former land ; and the materials of that earth which is firft in our account, muft have been collected at the bottom of the ocean, and begun to be concocted for the production of the prefent earth, when the land immediately preceding the prefent had arrived at its full extent.

This,

THIS, however, alters nothing with regard to the nature of thofe operations of the globe. The fyftem is ftill the fame. It only protracts the indefinite fpace of time in its exiftence, while it gives us a view of another diftinct period of the living world; that is to fay, the world which we inhabit is compofed of the materials, not of the earth which was the immediate predeceffor of the prefent, but of the earth which, in afcending from the prefent, we confider as the third, and which had preceded the land that was above the furface of the fea, while our prefent land was yet beneath the water of the ocean. Here are three diftinct fucceffive periods of exiftence, and each of thefe is, in our meafurement of time, a thing of indefinite duration.

WE have now got to the end of our reafoning; we have no data further to conclude immediately from that which actually is: But we have got enough; we have the fatisfaction to find, that in nature there is wifdom, fyftem, and confiftency. For having, in the natural hiftory of this earth, feen a fucceffion of worlds, we may from this conclude that there is a fyftem in nature; in like manner as, from feeing revolutions of the planets, it is concluded, that there is a fyftem by which they are intended to continue thofe revolutions. But if the fucceffion of worlds is eftablifhed in the fyftem of nature, it is in vain to look for any thing higher in the origin of the earth. The refult, therefore, of our prefent enquiry is, that we find no veftige of a beginning,—no profpect of an end.

XI.
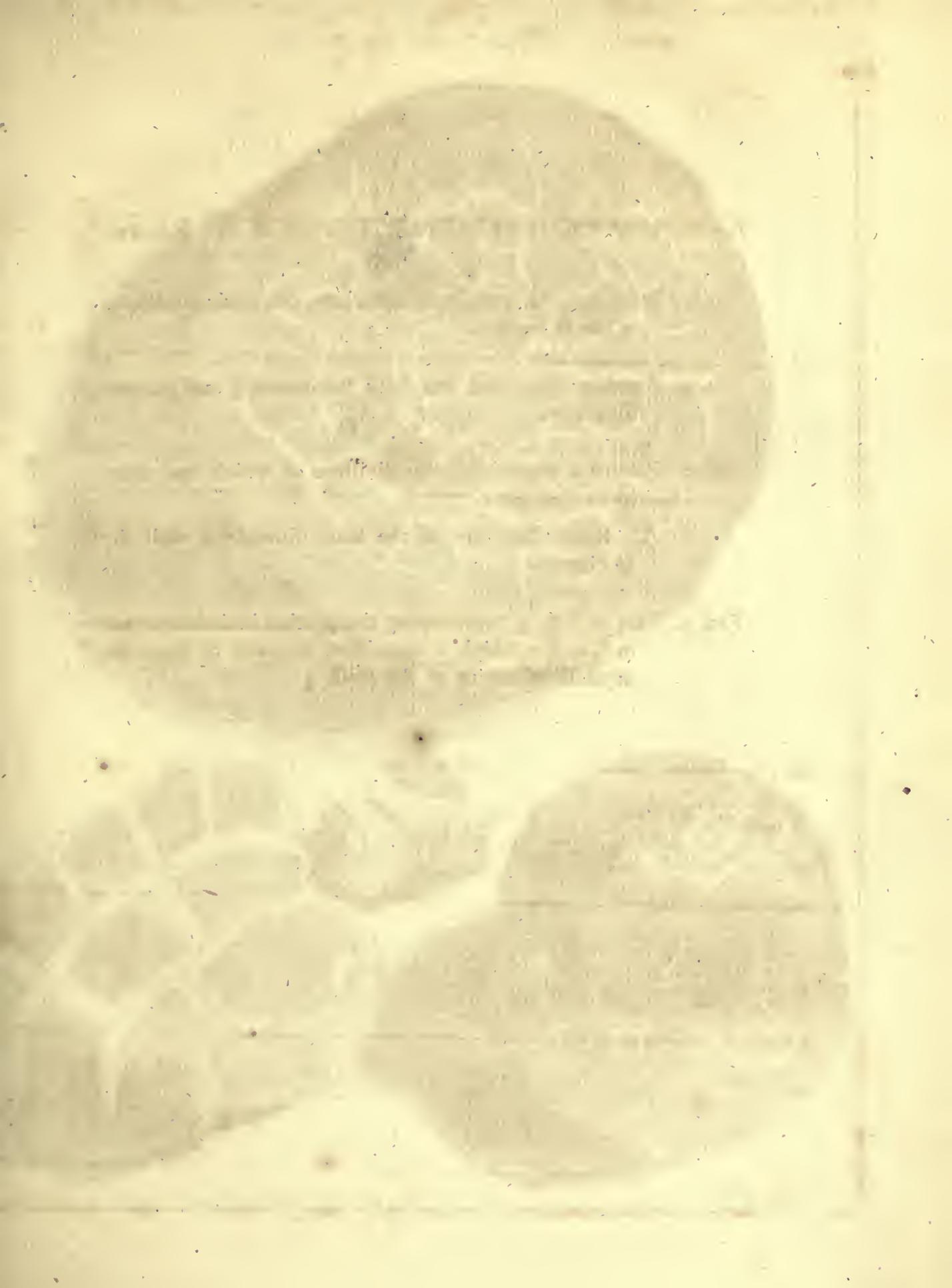
EXPLANATION of Plate I. Theory of the Earth.

Fig. 1. Section of an iron-stone septarium, cut horizontally, as it lies in its bed.

Fig. 2. Another septarium, cut both horizontally and perpendicularly.

Fig. 3. Part of a septarium, the divisions of which are more in straight lines.

All these three are of the same dimensions with the specimens.

Fig. 4. Part of Fig. 3. representing the portion included within *a, b, c, d, e,* which is magnified, in order to show the crystallised cavity of the septa.
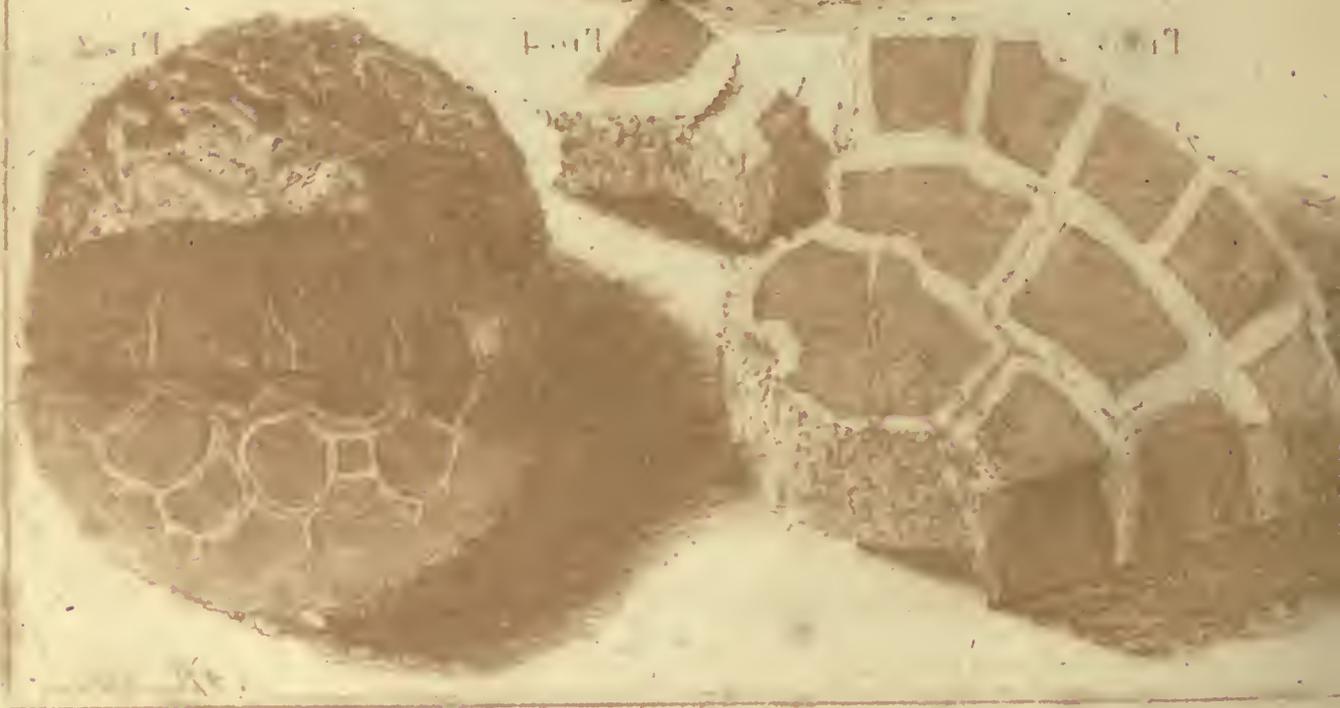
FIG. 1.
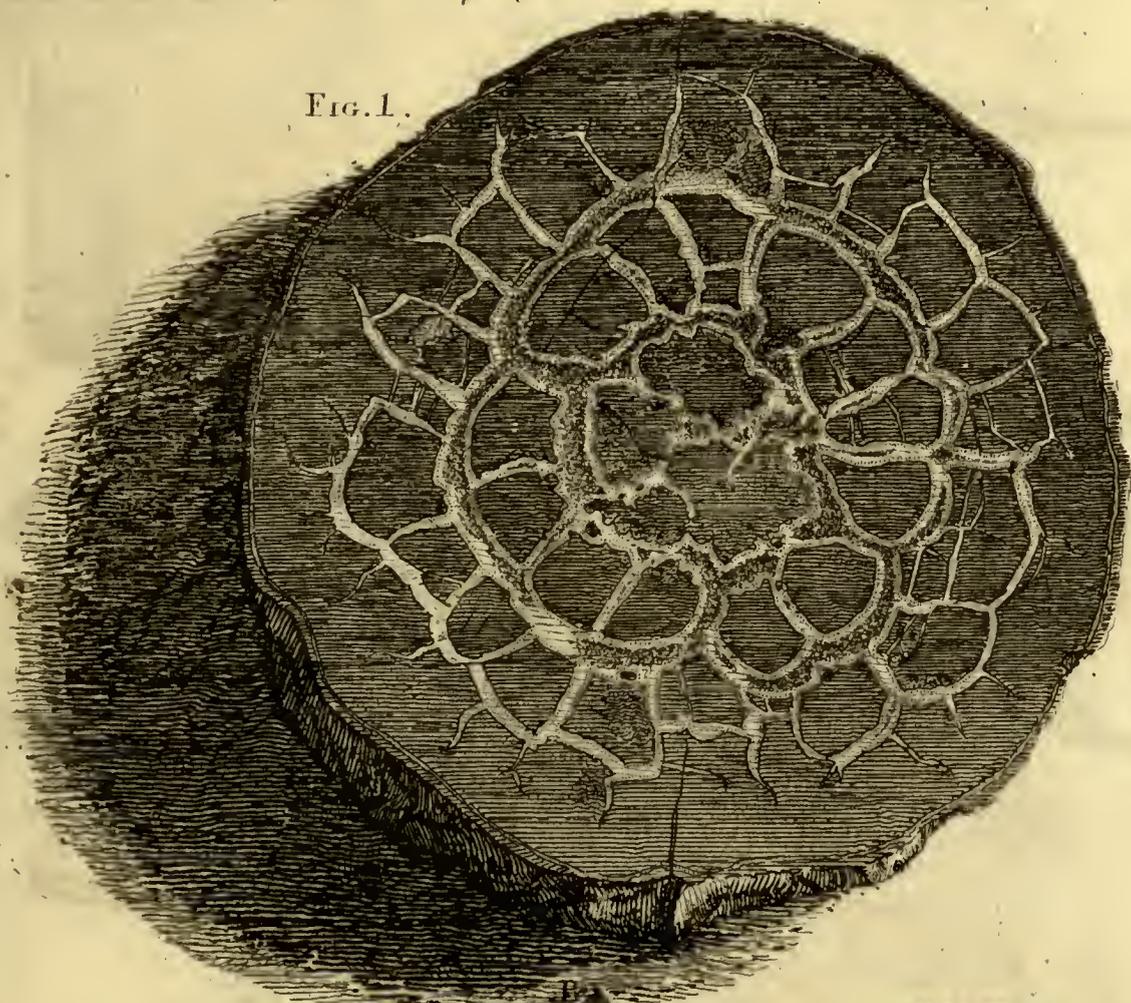
FIG. 3.

FIG. 4.

FIG. 2.

J. Bain del. et inci:
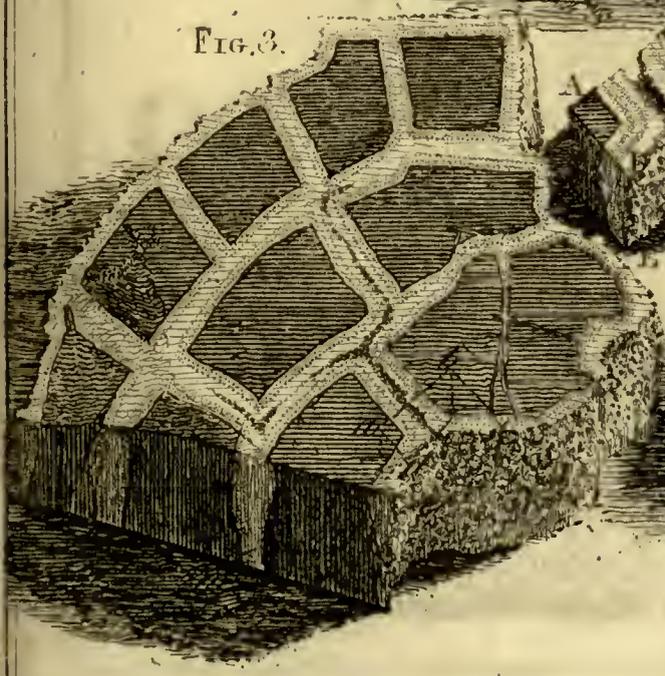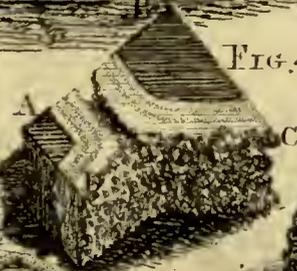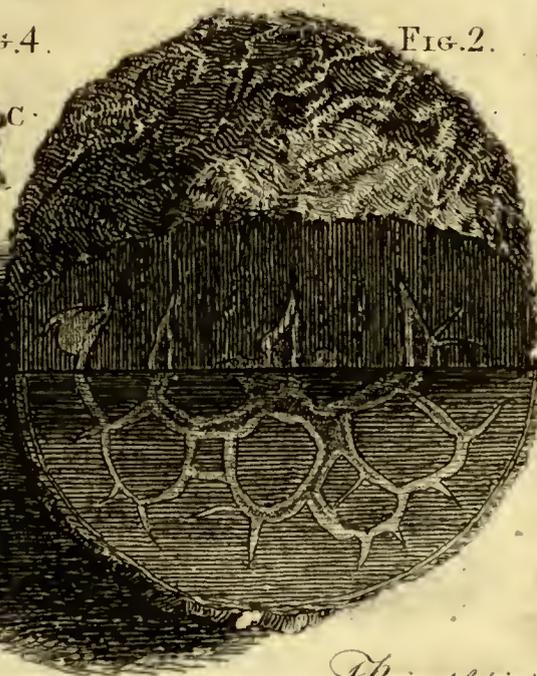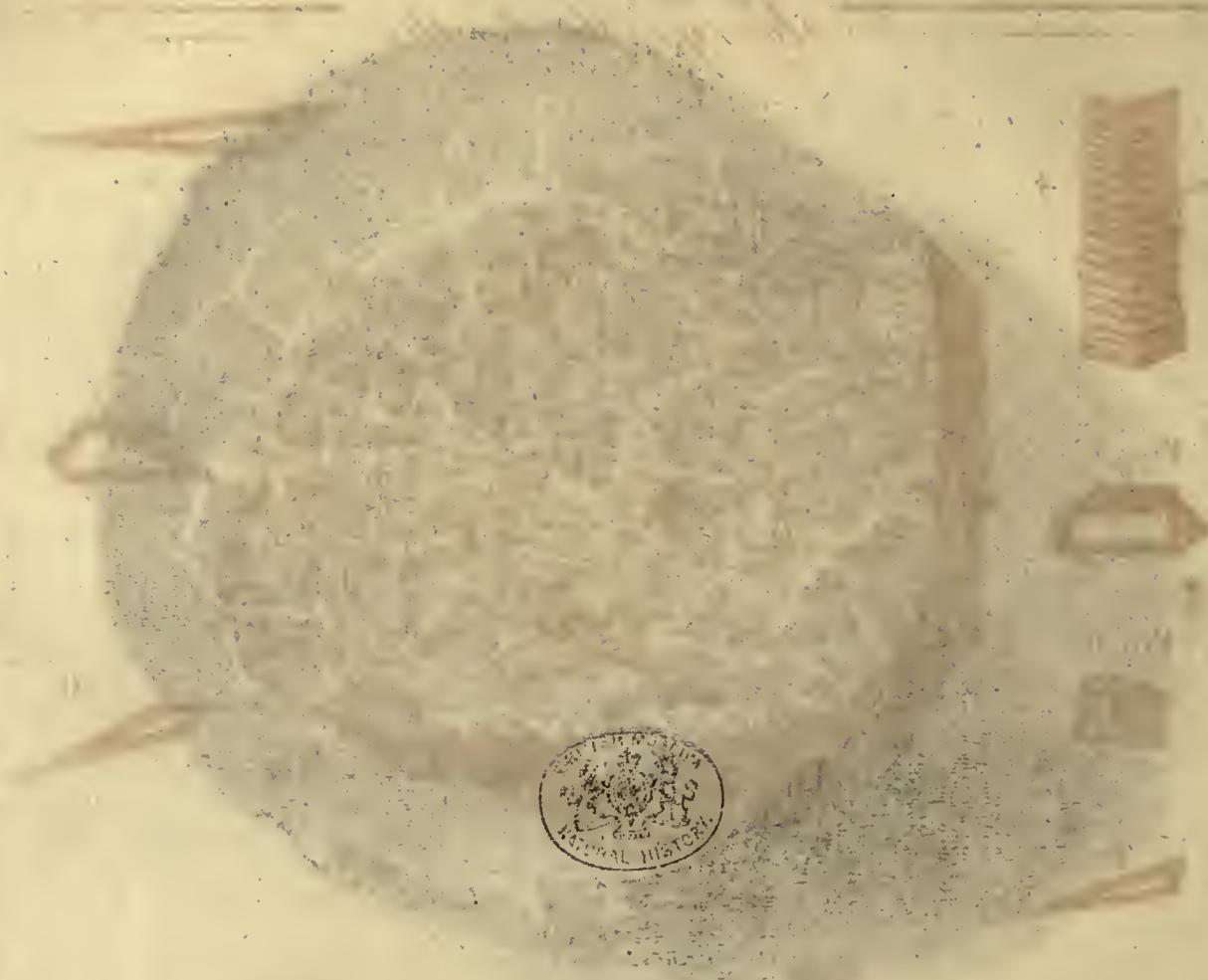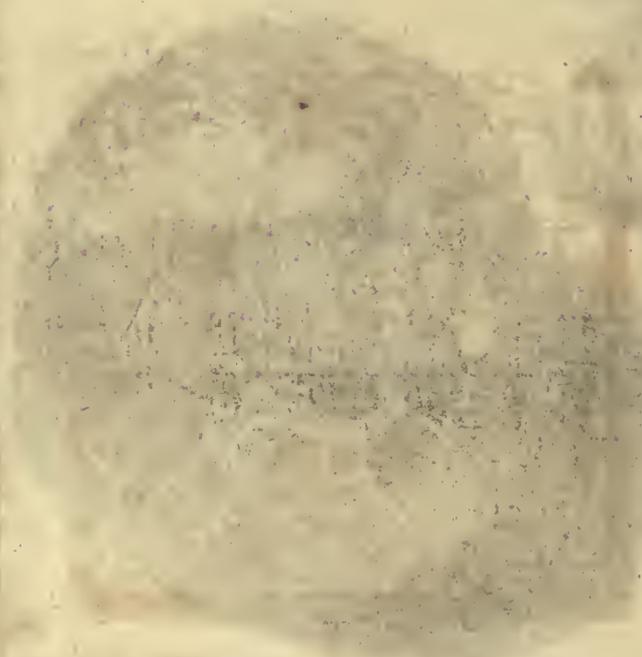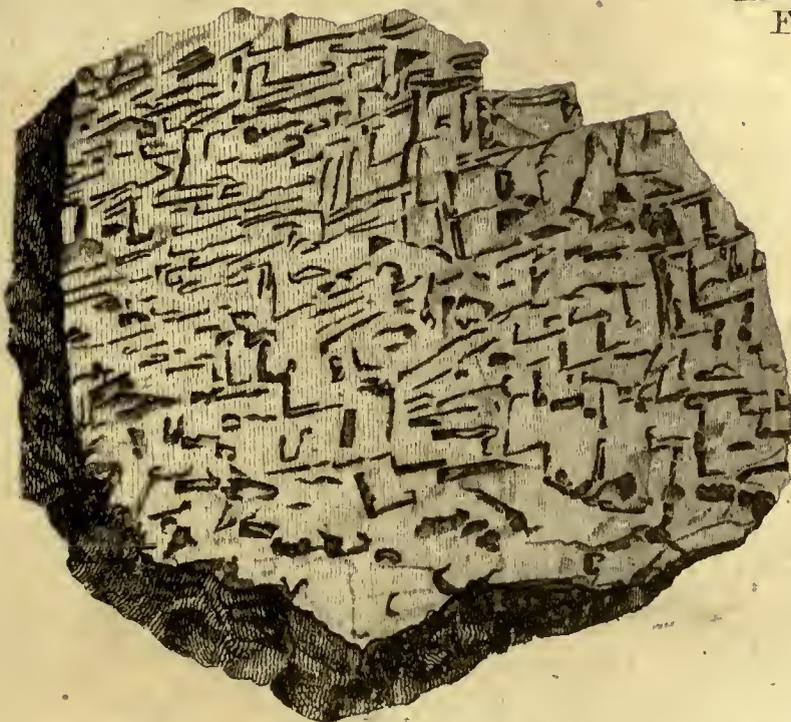
FIG. 1.

FIG. 4.

FIG. 8.

FIG. 5.

FIG. 9.

FIG. 6.

FIG. 10.

FIG. 7.

FIG. 2.

FIG. 3.
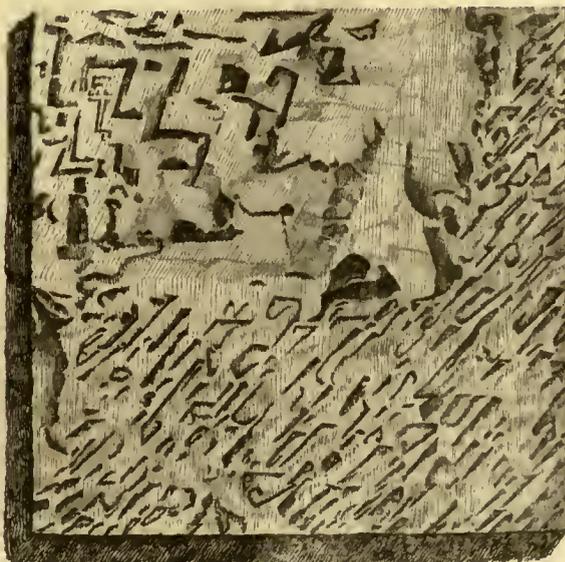
XI. *The* ORBIT *and* MOTION *of the* GEORGIUM SIDUS *determined directly from Observations, after a very easy and simple Method. By* JOHN ROBISON, *M. A. F. R. S. EDIN. and Professor of Natural Philosophy in the University of* EDINBURGH.

[*Read by the Author, March* 6. 1786.]

THE accuracy of modern observations has discovered irregularities in the motions of Jupiter and Saturn, which our knowledge of the laws of planetary gravitation has not as yet enabled us to explain. I have, therefore, long thought it probable that there may be planets without the orbit of Saturn, of sufficient magnitude to occasion these irregularities. This conjecture is confirmed by the discovery of a new planet.

On the 13th of March 1781, Mr HERSCHEL, an astronomer of great ardour and ingenuity, observed a Star, near the foot of Castor, whose steady light attracted his attention. He immediately applied to his telescope a higher magnifying power, and discovered an augmentation of its apparent diameter. Two days after, he observed that it had changed its place; and, taking it for a comet, he wrote an account of his observation to Dr MASKELYNE, Astronomer-royal, who got sight of this Star on the 17th of March. An account of this discovery was soon given to the other astronomers of Europe, who have continued to observe it with unceasing attention. I did not obtain a sight of it till August 1782.

Almost at its first appearance, the English astronomers supposed it to be a Planet. They were led to this opinion by various circumstances which rendered it very probable; such as,

its

its vicinity to the Ecliptic, the direction of its motion, and its being nearly ftationary at the time of its difcovery, in fuch an afpect with refpect to the Sun, as correfponds to the ftationary appearance of the Planets. The French aftronomers imagined it a Comet, although it had not that train of faint light which ufually diftinguifhes thofe bodies ; and, in the courfe of the year 1781, endeavoured to determine the elements of its motion on this fuppofition, but could not find out fuch as would correfpond with its fucceffive appearances. They at laft found themfelves obliged to fuppofe, that it moved round the Sun in an orbit nearly circular. Mr LEXEL, Profeffor of aftronomy at St Peterfburg, was the firft who attempted a computation of its motion on this principle ; and fhowed that a circular orbit, the radius of which is about nineteen times the diftance of the earth from the fun, would very nearly agree with all the obfervations made during the year 1781. The firft diftinct information which I got of it was in June 1782, from Mr MINTO, a gentleman of this place, who communicated to me a feries of excellent obfervations made by Profeffor SLOP at Pifa. This feries contained the means of determining with accuracy the ftationary points of the Planet in October 1781 and March 1782, and its oppofition in December 1781. From thefe, I was enabled to afcertain with great eafe, the radius of its circular orbit. For, at its ftationary appearance, we have the fquare of

the cofine of its elongation from the Sun $= \dfrac{r^2-1}{r^3-1}$; r being the

radius, and the earth's mean diftance being 1. The oppofition in December 1781, gives us one place of the Planet as viewed from the Sun, independent of all hypothefes. With thefe data, it was eafy for me to determine the apparent place of the Star for any time, and compare it with obfervation ; and the refult of this comparifon was fuch as to fhow, that the opinion was very nearly true, the greateft errors not amounting

to

to more than what might reafonably be attributed to the inac-
curacy of obfervation.

ASTRONOMERS were every where engaged in the fame re-
fearch; and it occurred to fome of them, that the Star might
poffibly have been obferved before, by thofe who were employ-
ed in making catalogues of the Zodiacal Stars. Mr BODE of
Berlin had juft publifhed a valuable work, in which all the
catalogues of the Stars were included. He had recourfe to
his papers, where he had marked all the difference of thefe
catalogues, in order to difcover whether any Star, obferved
by one aftronomer, and omitted by another, might not be
this Star of Mr HERSCHEL, paying attention to thofe diffe-
rences only which he could find in the parts of the Zodiac,
through which the nearly determined orbit of this newly dif-
covered Planet might be fuppofed to pafs. Among others, he
found the Star, No. 964. of MAYER's Catalogue, not obferved
by others, and but once obferved by MAYER, who could
not therefore difcover any motion in it. Mr BODE imme-
diately examined the heavens, and could not find this Star.
He farther found, that the elements of the new Planet affigned
to it that very apparent place, in the month of September
1756, one of the years in which MAYER was occupied with
thefe obfervations. On examining the regifter of MAYER's
obfervations, it was found, that he had obferved the Star, No. 964.
on the 25th of September 1756. This was notified to Mr BODE,
in September 1781. He immediately made this information
public; and it has fince been currently fuppofed, that the Star
obferved by MAYER was the Planet of HERSCHEL.

IT was found, even before the end of 1782, that the circu-
lar hypothefis was not exact, and that the angular motion of
the Planet round the Sun was increafing. This fhowed, that
the Planet was not moving in a circle, but in an excentric orbit,
and was approaching to the Sun. Aftronomers, therefore, be-
gan to inveftigate the inequality of this angular heliocentric
motion, in order to difcover the form and pofition of the ellipfe

defcribed

defcribed by the Planet. This was a very difficult tafk; for the very fmall inequality of the motion fhowed that the orbit was nearly circular; and the arch already defcribed was not much more than the fiftieth part of the whole circumference. The folution of the problem requires us to determine, from the variation of curvature difcoverable in this fmall arch, to what part of the circumference it belongs. This requires the utmoft accuracy in the obfervations, and great fagacity in making deductions from them *. But, taking it for granted that the 964th Star of MAYER's Catalogue was the new Planet, the problem becomes fufceptible of a very eafy folution; for that Star is fituated more than a quarter of a revolution from the place of the Planet in 1782, and fo fortunately, that almoft the whole effect of the excentricity and inequality of the motion is accumulated. Aftronomers, therefore, availed themfelves of this obfervation of Mr BODE, and quickly found, by repeated trials, elements of the motions, which correfponded perfectly with MAYER's obfervation, and all thofe made fince Mr HERSCHEL firft got fight of the Planet. But they do not all feem difpofed to confefs their obligation to Mr BODE. Some of them affect to have deduced their elements directly from obfervations, by the formulæ expreffive of the elliptical motion of the Planets, and to be agreeably furprifed with afterwards obferving the coincidence of their elements with this obfervation of MAYER. They have not given a detail of their methods of inveftigation.

OF

* THE firft perfon who obtained any direct information of the elliptical orbit of the Planet was the celebrated Abbé BOSCOVICH, who, in October or November 1781, deduced elements of its orbit from the obfervations of Mr MECHAIN. His method is exceedingly ingenious, and remarkable for that fimplicity and geometrical elegance which characterife all his performances. It did not come to my knowledge till the beginning of this prefent year 1787, when I found it in the Collection which he publifhed at Baffano, in 1785, in five volumes. He makes ufe of the fame phyfical principles which I employed in January 1783, to determine the orbit by the two oppofitions which had then been obferved, combined with another obfervation, made at the diftance of a fydereal year from one of the oppofitions. This method I communicated to Dr MASKELYNE in 1783.

Of all the theories of this Planet which I have feen, that of M. DE LA PLACE, communicated to the Royal Academy of Sciences at Paris, appears the moſt accurate, and very nearly correfponds to the obfervations which have been made fince the time of its publication. This theory was announced to the public in the *Connoiſſance des Mouvemens Celeſtes*, as deduced directly from the recent obfervations, by a method peculiar to M. DE LA PLACE. This I hoped to find in an excellent differtation on the elliptical motion of the Planets, publiſhed by him in 1784. But, although I found this work full of new and valuable information, as might be expected from this eminent mathematician, I was difappointed in my hopes of learning the procefs by which he had deduced his theory of the new Planet. He has, indeed, inferted in this work the elements of its orbit, and the four obfervations which he had employed for determining them, by a new method of confidering the planetary motions, with which he was then occupied, but which he does not explain. When I compared M. DE LA PLACE's theory with thofe obfervations, I found fuch differences as would have allowed him to make choice of elements confiderably different. It appears, therefore, that, before applying his method, he has corrected the obfervations on fome juftifiable principle, which I regret exceedingly that he has not communicated, fince he has been fo fuccefsful in the ufe of it. It would, doubtlefs, have been much more deferving of the notice of mathematicians than the empirical one which I have adopted in the fubfequent part of this paper.

In fpring 1784, I framed a fet of elements which correfponded with the obfervations made at that time with abundant accuracy. Mr MINTO, whom I have already mentioned, alfo communicated to me elements, little differing from mine, and equally accurate. Both thefe were deduced from a fuppofition that the Star obferved by MAYER was the new Planet. We had, by this time, great advantages over our predeceffors; for a

much

much larger portion of the arch had been obferved; and, which was of immenfe confequence, three oppofitions had been obferved, which gave us three pofitions of the Planet, independent of all hypothefes. The arches defcribed between thefe oppofitions being thus determined, free from all uncertainty, the acceleration of the Planet's motion became known; and a method now offered of determining, by interpolation, its heliocentric place, at any intermediate moment, with very great accuracy. And now, by chufing fuch obfervations of the Star as fhould give a great difference between the heliocentric and geocentric place, the radius of the earth's orbit became a bafe, by which we could meafure, with confiderable accuracy, its diftance from the Sun. Thus, having both its pofition and diftance from the Sun, we could affign its abfolute place in the heavens, and confequently the form of its path.

In the beginning of 1785, another oppofition was obferved, and thus a method obtained of deducing the elements directly. But this required a procefs fo extremely complicated, in order to obtain tolerable accuracy in the refult, that I had not the courage to attempt it. I waited patiently till a fifth oppofition fhould be obferved with four intercepted arches. This, I faw, would afford a method extremely fimple and eafy, and, at the fame time, fufceptible of confiderable accuracy. It is this method which I have now the honour to lay before this Society; and I hope that the Gentlemen who hear me will not think it altogether unworthy of their attention: For it is furely defirable not to reft our knowledge of the motions of this Planet on mere conjecture, whatever probability there may be of its truth from the coincidence of obfervations. I muft, at the fame time, acknowledge beforehand, that the refult of my inveftigation has not enabled me to determine the elements of its motion with perfect certainty. It has, on the contrary, convinced me, that, if we do not admit that the new Planet is the fame with

964 of MAYER, near half a century muſt elapſe before the ele-
ments of its motion can be determined with a preciſion equal
to that which is attained in the caſe of the other Planets. But
the method aſſigns certain limits, and theſe not very wide, with-
in which all the circumſtances of its motion muſt be compre-
hended. This alone muſt be regarded as a conſiderable attain-
ment.

THE heliocentric place of the Planet in oppoſition to the Sun,
on the 21ſt of December 1781, was determined by me, from
obſervations made on the 19th and 28th of that month, by
Dr MASKELYNE, combined with obſervations made by Profeſ-
ſor SLOP at Piſa, on the 22d, 23d, 27th, and 28th. The helio-
centric place at the oppoſition 1782, was determined from ob-
ſervations made by Dr MASKELYNE on the 14th and 28th of
December, combined with thoſe of Profeſſor SLOP on the 22d,
25th, and 26th of that month. The place of oppoſition in
1783 was determined from my own obſervations on the 26th,
27th, 28th of December, and the 5th of January following.
The place at oppoſition January 3d 1785, was determined from
my own obſervations on the 28th and 29th of December, and
the 1ſt and 6th of January. The place at oppoſition 1786,
was determined from my own obſervations on the 29th, 30th,
and 31ſt of December, and the 1ſt, 3d, and 8th of January.
The method which I took for combining theſe obſervations, in
order to get rid of the inaccuracy to which each of them was
liable, was as follows: The arch deſcribed between any two
ſucceſſive oppoſitions gave me a pretty near approximation to
the diſtance of the Planet from the Sun, by means of the Kep-
lerian law, that the ſquares of the angular motions are inverſe-
ly as the cubes of the diſtances. The heliocentric angular
motion, at any oppoſition, muſt be very nearly a medium be-
tween the angular motions with which the arches, intercepted
between it and the preceding and following oppoſition, would
be uniformly deſcribed. Thus I obtained, with ſufficient ac-
curacy,

curacy, the heliocentric angular motion at the three interme-
diate oppofitions. The angular velocities at the two extreme
oppofitions were determined with equal accuracy, by fuppofing,
that the changes of angular velocity followed a regular law.
Thus I was enabled to determine the geocentric motion for a
few days before and after oppofition, and confequently to af-
fign, from each obfervation, the precife time and place where
the Planet would be in oppofition to the Sun. Thefe determi-
nations differed from each other in no cafe 10″. It is demon-
ftrable, that the affumptions made for this combination of ob-
fervations could not produce an error of 2″. I therefore,
with confidence, took the means of thefe determinations for
the places of the Planet, in its apparent oppofitions to the Sun.

THE times and apparent longitudes and latitudes of the Planet
are expreffed in the following table:

	M. T. Ed.	Long.	Lat. N.
	h. ′ ″	s. ° ′ ″	′ ″
1781. Dec. 21.	17. 44. 33	3. 00. 52. 11	15. 07
1782. Dec. 26.	08. 56. 56	3. 05. 20. 29	18. 56
1783. Dec. 31.	00. 46. 24	3. 09. 50. 52	22. 10
1785. Jan. 3.	17. 28. 56	3. 14. 23. 02	25. 40
1786. Jan. 8.	10. 39. 31	3. 18. 57. 05	28. 52

MY manner of obferving obliged me to compare the Planet
with two fixed Stars which did not differ from it, or from each
other, more than one degree in declination. This obliged me
to employ fome Stars which are to be found in MAYER's Cata-
logue alone. I have, therefore, always made ufe of this Catalogue.
If, therefore, the following theory be confronted with an ob-
fervation, where the geocentric place of the Planet is deduced
from a comparifon of it with a Star *in its neighbourhood*, and if
the place of this Star be deduced from BRADLEY's, or DE LA
CAILLE's Catalogues, the longitude will be found about 6″ too
fmall, or as much too great.

                                                    THE

THE manner of obfervation, and the inftrument which I make ufe of, appear to me to have feveral advantages which are not unworthy of the attention of Aftronomers. An account of them will therefore be communicated on fome future occafion.

FROM thefe places, it is eafy to determine the inclination of the Planet's orbit to the plane of the Ecliptic, and the place of its Node, which are as follow :

<center>

	s. ° ″ ′
Long. Node, Jan. 1. 1786.	2. 12. 48. 45
Inclin. Orbit,	46. 26

</center>

I WAS now enabled to reduce thefe Ecliptic places to the orbit itfelf, and thus to determine the arches of this orbit defcribed during the intervals between the oppofitions.

I THEN took the oppofition which was obferved on the 31ft of December 1783 for an epoch, to which all the obfervations fhould be reduced. The interval of time between this and the preceding oppofition was 369 *d.* 15 *h.* 49′. 28″. I counted back another equal interval, which brought me within a few minutes of the time of oppofition 1781, and I computed (by means of the heliocentric motion, already determined for that oppofition with fufficient accuracy) the place of the Planet for the beginning of the above mentioned interval. In like manner, I computed its place for two equal intervals of 369 *d.* 15 *h.* 49′ 28″, reckoned forward from the epoch. Thus I obtained four angles in the orbit, defcribed in equal intervals of time. The differences of thefe angles fhowed the inequality of the Planet's angular motion. From this inequality alone, we are to determine the chief elements of its excentric orbit.

I IMMEDIATELY found, that thefe differences, ftrictly taken, had irregularities which are inconfiftent with the moft remarkable circumftances of the Planet's motions. It appeared, therefore, that the obfervations muft be corrected, as far as is confiftent with the probability of their inaccuracy. With refpect

<center>R r</center>

to the obfervations of Dr MASKELYNE and Mr SLOP, made with inftruments equal to any in Europe, this inaccuracy fhould not be fuppofed greater than 5″. With refpect to my own, I will allow it to amount to 10″.

THE queftion is now, upon what good principle we may prefume to correct the obfervations. When the Planet appears ftationary, we have the beft opportunity of afcertaining its diftance from the Sun, by means of an imperfect knowledge of its angular motion, the earth's diftance from the Sun affording a bafe moft advantageoufly fituated. Mr MINTO has communicated to me Mr SLOP's obfervations of the Planet when in this fituation. On 1782, March, 6 *d*. 6 *h*. 14′. 56″. M. T. Greenwich, the apparent longitude of the Planet was obferved 2 *s*. 28°. 49′. 27″. on the Ecliptic. The five obferved oppofitions give us the firft and fecond differences of the heliocentric motion at thofe oppofitions. By thefe means we obtain, by the ufual methods of interpolation, the heliocentric place of the Planet at the time of the above obfervation, and this without an error amounting to 2″. By comparing this with the geocentric place, we obtain the Planet's diftance from the Sun = 18,9053. By making a fimilar interpolation for March 7 *d*. 6 *h*. 14′. 56″, we obtain another heliocentric place of the Planet. The difference of thefe two places gives the diurnal heliocentric motion = 43″,4365. But a Planet defcribing round the Sun a circle whofe radius is 18, 9053, will have its diurnal motion = 43″,1647.

FROM this it is demonftrable, that the Planet's diftance from the Sun is greater than half the parameter of its orbit; and that its true anomaly, or diftance from its aphelion, is more than 90º *. On the other hand, we find, from the continual acceleration of its motion, that, at the oppofition 1785, the Planet had

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* FOR the angular velocity of a body in an ellipfe, is to that of a body in a circle, at the fame diftance, in the fubduplicate ratio of the half parameter to the diftance.

had not yet arrived at its perihelion. Hence it is demonſtrable, that the differences of the arches deſcribed in equal times ſhould form a ſeries of numbers continually decreaſing, very ſlowly at firſt, but afterwards more rapidly.

Upon this principle, we may venture to correct the obſervations. In this correction there is ſtill a choice; for we may make the decreaſe of the ſeries either more or leſs rapid. The ellipſes which ariſe from the extremes of the ſeries formed upon this principle, will evidently be the limits which comprehend the principal elements of the eccentric motion; and, ſince we allow ourſelves very little liberty in the correction, it is preſumable, that theſe limits will not be very wide.

From the above obſervation of the Planet in its ſtationary point, we find that its angular velocity does not greatly exceed that of a Planet revolving in a circle; and a ſimilar uſe being made of Mr Maskelyne's firſt obſervations, will ſhow, that the heliocentric motion of the Planet in April 1781 hardly exceeded the motion in a circle at the ſame diſtance. We may, therefore, preſume that its true anomaly does not much exceed 90°. Therefore, the ſeries of firſt differences, adapted to this ſituation, muſt decreaſe very ſlowly, whilſt the ſecond differences muſt increaſe alſo very ſlowly. This will appear by examining the tables of any of the Planets. I ſhall, therefore, begin by giving to the ſecond differences a very ſmall increaſe, and to the firſt differences a very ſmall diminution. This will be done by a correction not exceeding 3″ in any of the obſervations; and this muſt be allowed to be far within the limits of probability. The firſt obſervation has its longitude diminiſhed 1″; the ſecond has its longitude increaſed 2½″; the third has its longitude increaſed by the ſame quantity, and the fourth and fifth have their longitudes increaſed 3″. The times correſponding to the above mentioned equal intervals, and the correſponding corrected longitudes, cleared from

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the effects of aberration and mutation, and reduced to the orbit, and to the epoch of opposition 1783, are as follow :

M. T. Green.

	b. ' ''	s. ° ' ''
1781. Dec. 21.	17. 20. 17	3. 00. 53. 50
1782. Dec. 26.	09. 09. 45	3. 05. 21. 16,5
1783. Dec. 31.	00. 59. 13	3. 09. 50. 37,5
1785. Jan. 3.	16. 48. 41	3. 14. 21. 52
1786. Jan. 8.	08. 38. 09	3. 18. 54. 58

THESE give us the following intercepted arches, with their first and second differences :

° ' ''	' ''	''
4. 27. 26,5		
4. 29. 21	1. 54,5	
4. 31. 14,5	1. 53,5	1
4. 33. 06	1. 51,5	2

FROM these data, the elliptical orbit of the Planet is to be constructed. Various methods present themselves of doing this, depending on the equations between the mean and true anomaly. But I found that, unless the quantities involving the fourth power of the excentricity were introduced into the equation, I could not determine the place of the aphelion with tolerable accuracy. The equation in this form would be almost intractable. I therefore searched for a method which would be more simple, when applied to the present case, which has been rendered so particular, by the determination already obtained of the quarter of the orbit in which the Planet has been observed. The following method occurred to me, and is, indeed, as obvious as it is simple, while it is also susceptible of great accuracy.

LET ACP (fig. 1.) be the elliptical orbit of the Planet, P the perihelion, S the focus in which the Sun is placed, and O the

centre ;

centre ; and let A, B, C, D, E, be the places of the Planet in its fucceffive oppofitions to the Sun ; draw the chords AB, BC, CD, DE, AC, CE, and the radii vectores AS, BS, CS, DS, ES. We may fuppofe that the points χ and γ, where the chords AC, CE, are interfected by the radii vectores BS, DS, are in the middle of thofe chords. For, let us fuppofe that thofe chords are bifected in χ and γ by radii SB and SD, the rectilineal tri-angles ABS, BCS are equal, and the fegments cut off by the chords AB, BC are very nearly equal ; thefe fegments are very fmall in comparifon with the triangles ABχ, BχC, and thefe triangles are very fmall in comparifon with the triangles AχS, χCS. Therefore, the elliptical fectors ABS, BCS, are very near-ly equal, and B is very nearly the place of the Planet at the fe-cond oppofition.

LET the angles ASB be $= u$, BSC $= v$, CSD $= x$, DSE $= y$, ASC $= w$, CSE $= z$, AχS $= \chi$, and CγS $= \gamma$.

Then, $\qquad$ AS : Aχ $= fin. \chi : fin. u,$
and $\quad$ Cχ, or Aχ : CS $= fin. v : fin. \chi.$
therefore, $\quad$ AS : CS $= fin. v : fin. u,$
alfo, $\qquad$ ES : CS $= fin. x : fin. y.$

THUS, we have obtained the ratio of the three diftances AS, CS, ES, and we have the angles ASC, CSE, given by obfervation. This is all that is neceffary for conftructing the ellipfe, by means of the 21ft prop. of NEWTON's Principia, B. I. or of a theorem to be delivered afterwards.

THIS ellipfe will be found to have its femitranfverfe axis about nineteen times the earth's diftance from the Sun, and its excentricity about $\frac{1}{20}$ of its femitranfverfe axis, and the angle PSC about 73°. As it approaches very near to the form of the ellipfe really defcribed by the Planet, we may difcover, by its means, the errors which have arifen from the fuppofition that the fectors ASB, BSC, are equal, when Aχ is equal to χB.

FOR

For this purpose, bisect AE in F, draw OF*x* and SF*c* ; make *x*c to Cc, as cS to cF ; draw C*φ*S, and draw OK parallel AE : It is evident that *x*c may be considered as a straight line parallel to EA ; the segments E*x*F, F*x*A, are equal, and the triangles EFS, FSA, are equal ; therefore the elliptical spaces E*x*FS, *x*FSA are equal ; but the triangles *x*cF, CcS are equal, their altitudes being reciprocally as their bases ; therefore, the elliptical sectors ACS, CSE, are equal, and C is the place of the Planet at the third opposition. Now, cF is nearly equal to the versed sine of cA, which is an arch of about 9°, and is therefore about $\frac{1}{80}$ of cS. *x*c is to cF as OK to KF ; and therefore *x*c is nearly $\frac{1}{20}$ of cF, or $\frac{1}{1600}$ of cS. Cc is $\frac{1}{80}$ of *x*c, or $\frac{1}{128000}$ of cS. Therefore the angle CSc does not exceed two seconds. If a similar construction be made for the points B and D, it will be found that the angles BSb, DSd, will not exceed $\frac{1}{8}$ of a second. For BS, CS, DS, are nearly equal, and bH and dG are nearly $\frac{1}{4}$ of cF ; therefore Bb and Dd are nearly $\frac{1}{16}$ of Cc.

HENCE it is evident, that this simple and obvious construction will give the elements of the orbit with all the accuracy that can be attained by any direct methods from our observations, because the errors of observation are much greater than this ; and if the observations are not equalised according to some probable principle, as has been attempted above, elements cannot be obtained which will be consistent with them all. The corrections which must be made for this equalisation are much greater than this error ; and, therefore, no direct methods can give more accurate elements.

THIS error, small as it is, may be very easily corrected, by computing its quantity in the ellipse already constructed. This

computation muſt be exceedingly near the truth, becauſe the ellipſe is very near the truth. But the trouble of this previous conſtruction may be avoided by means of the following conſiderations: The triangles $\varkappa$Fc, δGd, are nearly ſimilar; and therefore, cF : dG $=$ AE^2 : CE^2 nearly; therefore the triangle $\varkappa$cF : δGd $=$ AE^4 : CE^4 nearly; alſo, Sc $=$ Sd nearly; therefore, Cc : Dd (or, φF : γG $=$) AE^4 : CE^4 nearly; but AE is nearly double of CE; therefore, φF : γG $=$ 16 : 1 nearly; alſo, φF : χH $=$ 16 : 1 nearly.

Now,	CS : Cγ $= \text{ſin. } \gamma : \text{ſin. } x$,	
and	Cγ : Eγ $=$ Cγ : Eγ,	
and	Eγ : ES $= \text{ſin. } y : \text{ſin. } \gamma$,	
therefore,	CS : ES $=$ C$\gamma \times \text{ſin. } y$: E$\gamma \times \text{ſin. } x$.	
Let	CS : eS $= \text{ſin. } y : \text{ſin. } x$,	
then,	ES : eS $=$ Eγ : Cγ,	
and	ES : Ee $=$ Eγ : Cγ — Eγ, $=$ Eγ : 2γG.	

IN like manner, make CS : aS $= \text{ſin. } u : \text{ſin. } v$, and we ſhall have AS : Aa $=$ Aχ : 2χH nearly, $=$ Eγ : 2γG nearly, and Ee : Aa $=$ ES : AS nearly, and therefore Ee nearly equal to Aa.

Make	AS : So $= \text{ſin. } z : \text{ſin. } w$,	
then, (becauſe SE : AS $=$ E$\varphi \times \text{ſin. } w$: A$\varphi \times \text{ſin. } z$)		
we have	SE : So $=$ Eφ : Aφ,	
and	SE : Eo $=$ Eφ : Aφ — Eφ, $=$ Aφ : 2φF nearly,	
or	SE : Eo $=$ 2Eγ : 32γG, $=$ Eγ : 16γG nearly.	

Hence it follows that Eo is nearly equal to eight times Ee.

Laſtly, Make aS : Sε $= \text{ſin. } z : \text{ſin. } w$, then we ſhall have aS : Sε $=$ AS : So, and Aa : εo $=$ AS : SE, and therefore εo nearly equal to Aa, or to Ee; therefore eε is nearly ſix times Ee.

HENCE

HENCE may be derived the following rule for approximating to the true ratios of AS and ES to CS :

$$\text{Make} \quad CS : aS = \textit{fin. } u : \textit{fin. } v,$$
$$CS : eS = \textit{fin. } y : \textit{fin. } x,$$
$$eS : \alpha S = \textit{fin. } w : \textit{fin. } z,$$
$$aS : \varepsilon S = \textit{fin. } z : \textit{fin. } w.$$

Then make $AS = aS + \dfrac{a\alpha}{6}$, and $ES = eS - \dfrac{\varepsilon e}{6}$. Then the points A, C, E, will be in the circumference of an ellipfe, of which S is the focus, and O the centre, and having the fectors ASC, CSE, very nearly equal.

THE approximation will be much eafier, and almoft as accurate, if $\dfrac{1}{6}$ of the difference of the logarithms of aS and αS be added to the logarithm of aS, for the logarithm of AS, and $\dfrac{1}{6}$ of the difference of the logarithms of εS and eS be subtracted from the logarithm of eS for the logarithm of ES.

IT may even be fufficient to add $\dfrac{1}{6}$ of the difference of the logarithms of eS and εS to the logarithms of aS, and to subtract it from the logarithm of eS.

THE following Theorem may be of ufe for conftructing the ellipfe, and, I believe, is new :

LET DAP be an ellipfe, (fig. 2.) of which O is the centre, S the focus, and ap the directrix ; from any three points A, C, E, draw lines Aa, Cc, Ee, perpendicular to the directrix ; draw the radii AS, CS, ES ; draw AK, αCH, and εE, perpendicular to Aa, and AG, CF, perpendicular to ES, and Sp perpendicular to ap.

LET

LET AS be $= a$, CS $= c$, ES $= e$, the angle ASE $= x$, CSE $= y$, and ESP $= z$.

IT is evident that EH : EK $=$ ιx : ιA, $=$ CS — ES : AS — ES, $= c - e : a - e$; alſo, SF $= c.\cos, y$, SG $= a.\cos, x$, CF $= c.\sin, y$, and AG $= a.\sin, x$; alſo, the angle FCH $=$ GAK, $=$ ESP, $= z$.

THEREFORE, FH $=$ CF.$\tan, z$, $= c.\sin, y.\tan, z$, and GK $= a.\sin, x.\tan, z$; therefore, EH $= e - c.\cos, y + c.\sin, y.\tan, z$, and EK $= e - a.\cos, x + a.\sin, x.\tan, z$; therefore, $c - e : a - e = e - c.\cos, y + c.\sin, y.\tan, z : e - a.\cos, x + a.\sin, x.\tan, z$, and $(c - e).(e - a.\cos, x) + (c - e).a.\sin, x.\tan, z = (a - e).(e - c.\cos, y) + (a - e).c.\sin, y.\tan, z$. This gives,

$$\operatorname{Tan}, z = \frac{(c - e).(e - a.\cos, x) - (a - e).(e - c.\cos, y)}{c.(a - e).\sin, y - a.(c - e).\sin, x}$$

Or, more conveniently for logarithms,

$$\operatorname{Tan}, z = \frac{c.(a - e).\cos, y - a.(c - e).\cos, x - e.(a - c)}{c.(a - e).\sin, y - a.(c - e).\sin, x}$$

Then, by the common theorems, we have the excentricity $\varepsilon = \dfrac{a - e}{e.\cos, z - a.\cos, (x + z)}$, the mean diſtance being $= 1$. The aphelion and perihelion diſtances are $1 + \varepsilon$ and $1 - \varepsilon$. By their means, we obtain the mean anomalies correſponding to the true anomalies OSA and OSE. The difference of the mean anomalies is to $360°$, as the time between the appulſes of the Planet to the points A and E to the time of a ſydereal revolution. The ſquare of a ſydereal year is to the ſquare of the time of this revolution, as 1 to the cube of the Planet's mean diſtance from the Sun.

This proceſs gives us the following elements :

Mean Diſtance,   -   -   19,08247
Excentricity,   -   -   0,9006
Periodic Time,   -   -   83,359 Years.

Mean

		s	°	′	″
Mean Anomaly at E,		4.	00.	32.	51
Longitude of the Aphelion, } for the Epoch		11.	23.	09.	51
Longitude of the Node, } 1783, Dec. 31.		2.	12.	46.	14
Inclination of the Orbit, - -		00.	00.	46.	25

THESE elements agree with all the obſervations made ſince Mr HERSCHEL's diſcovery of the Planet, with abundant accuracy, the differences being as often, and as much, in defect as in exceſs. When I compared them with MAYER's obſervation of the Star, No. 964. I found the calculated place of the Planet only 3′. 52″ to the weſtward of the Star, and 1″ to the northward. As theſe elements ſeem to be formed on good principles, I cannot help being of opinion, that that Star was the Planet now obſerved. If, in forming the elements, I had ſuppoſed that the ſecond differences of the arches were conſtant, (a ſuppoſition quite allowable,) I ſhould have obtained elements almoſt preciſely the ſame with thoſe which I formerly deduced from the ſuppoſition that the Star, No. 964. of MAYER's Catalogue, was the Planet. This aſſumption would not have occaſioned an alteration of one ſecond in any of the places above uſed.

ALTHOUGH it now appeared unneceſſary to make any farther trial, I made another correction of the obſervations, ſo as to produce a ſeries of ſecond differences, which ſhould decreaſe as rapidly as was conſiſtent with the probable inaccuracy of the obſervations. This gave me the following elements:

Mean Diſtance,	-	-	19,18254
Excentricity,	-	-	0,88461

		s	°	′	″
Mean Longitude, } 1786 Jan. 1.		3.	23.	17.	03
Long. of Aphelion, } M. T. Green.		11.	17.	32.	54

	y.	d.	h.	′
Periodic Time,	84.	06.	04.	48

THESE elements alſo agreed very well with the obſervations ſince HERSCHEL's diſcovery; as alſo with MAYER's obſervations: But if theſe elements be compared with the obſervation of the

ſtation

ſtation in March 1782, they produce an angular motion, which differs conſiderably from what appears by interpolation, ſhowing that the mean diſtance is conſiderably too great.

It reſults from this inveſtigation, that the elements of the orbit are contained between theſe extremes, and are probably much nearer to the firſt ſet. A conſiderable time muſt elapſe before they can be determined with accuracy, from obſervations made ſince March 1781. But the probability that MAYER obſerved the Planet is ſo great, that I am decidedly of opinion that it is the ſame with No. 964. of his catalogue. If this be granted, we can obtain the elements with all the accuracy that is attained in the other Planets : For the place of MAYER's Star is within ſix degrees of the Aphelion, as determined by the firſt ſet of elements, and all the effects of its excentricity are nearly accumulated in 1781; and are therefore moſt eaſily deduced from the obſervations. I ſhall therefore ſubjoin another ſet of elements accommodated to this ſuppoſition; they were formed by me about two years ago in the uſual way, by repeated trial, till the reſult ſhould agree with MAYER's obſervations, and with all the others which I had then collected. I have not found any reaſon ſince that time to make any change, unleſs perhaps the inclination of the orbit may be increaſed about 10″.

Mean Diſtance,	- -	19,0858
Excentricity,	- -	0,90737

	s. ° ′ ″
Mean Longitude, 1786 Jan. 1. Noon. M. T. Green.	3. 23. 41. 13
Longitude of the Aphelion,	11. 23. 10. 38
Longitude of the Node,	2. 12. 48. 45
Inclination of the Orbit,	00. 00. 46. 26
	h. ′ ″
Periodic Time in Days,	30456. 01. 40. 48
Mean diurnal Motion,	42″,551

I MAY juſt obſerve in this place, that if I were diſpoſed, with ſome aſtronomers, to admit that the Star, No. 34. Tauri of the Britannic Catalogue, is the new Planet, the elements formed on

the

the fuppofition of the moft rapid decreafe of the fecond diffe-
rences will agree very well with Flamstead's obfervation of
that Star on December 13. 1690, being only 40″, or perhaps on-
ly 12″, to the weftward of it. But the latitude differs more
than two minutes from Flamstead's latitude, which is right-
ly deduced from the Zenith diftance. This is too great an er-
ror for him to commit in the obfervation, and we fhould there-
fore reject the fuppofition on this account alone. But there are
ftronger reafons for rejecting it, arifing from the difagreement
of thofe elements with the obfervations made on the ftations of
the Planet in October 1781, and March and October 1782,
which give us a very near approximation to its diftance from
the Sun. When compared with obfervations of the Planet
near its ftationary points in the Spring, they give the geocentric
longitude confiderably too great, while they give it too fmall
for the fimilar obfervations in Autumn.

The appearance of this Planet has ferved to exercife the in-
genuity of mathematicians, by a problem confiderably different
from that afforded by the motions of comets in very excentric
orbits ; and, by this means, has favoured the public with ma-
ny improvements in analytical knowledge. My profeffional
duty has made me confine myfelf chiefly to the fearch of
fuch methods as might be very intelligible to perfons poffeffed
of fmall degrees of mathematical knowledge. The method
now exhibited has this advantage in an eminent degree ; and
therefore, although it will not engage the attention of fkilful
mathematicians, I hope it will be ufeful, becaufe it may incite
beginners to a zealous profecution of this noble ftudy, by fhow-
ing them fome of its moft pleafing gratifications. I may add,
that the method now exhibited is one of the moft likely to give
us an accurate knowledge of the Planet's motion. Another pe-
riod of four years will enable us to apply it to arches of double
extent, which will diminifh the errors arifing from the unavoid-
able inaccuracy of obfervations to one fourth of their prefent
quantity, and a comparifon of the new elements with thofe now

given,

given, will enable us to diminifh them as much again. When it is confidered, that in thofe elements no attention has been paid to the gravitation of the Planet to the other fix, it will ftill more clearly appear how abundantly accurate they are for the pur-pofes of aftronomical computation.

I TOOK another method of obtaining elements, by means of the ratio of three diftances from the Sun; namely, by interpo-lating heliocentric places of the Planet, for the times of its vici-nity to its ftations, and comparing thefe with its geocentric places. It is eafy to fee, that this method alfo is fufceptible of great accuracy, after having obferved five oppofitions, which give us fecond and third differences of the heliocentric places, and therefore afford a proper application of the methods of in-terpolation. Elements deduced in this way, almoft perfectly coincided with the above. I alfo obtained, in January 1784, a fet of elements very nearly the fame, by means of the three oppo-fitions which had then been obferved, and by the help of a theorem which I make ufe of in my elements of phyfical aftro-nomy, *viz.* That the velocity of a body, in any point of the path which it defcribes by the action of a centripetal force, is that which it would acquire if uniformly impelled by the cen-tripetal force along $\frac{1}{4}$ of that chord of the ofculating circle which paffes through the centre of forces.

I SHALL here fubjoin tables for computing the motion of this Planet.

TABLE I. contains the Radical Mean Longitudes of the Planet, Aphelion, and Node; for the Mean Time of noon at Green-wich, at the beginning of the Aftronomical Year, that is, for the Mean Noon of the 31ft of December immediately preceding. It alfo contains the Mean Sydereal Motions of the Planet for months, days, and hours, and the preceffion of the Equinoxes at the beginning of each month. The fydereal motions are chofen in preference to the tropical, becaufe the motions of the aphelion and node are not yet known. One application of the preceffion of the equinoctial points, is therefore fufficient.

<div align="right">TABLE.</div>

TABLE II. contains the Elliptic Equation of the Planet. The argument is the Mean Anomaly, or the Mean Longitude of the Planet—the Longitude of the Aphelion.

TABLE III. contains the Logarithm of the Planet's diſtance from the Sun, the Earth's mean diſtance being 1. The argument is the Mean Anomaly of the Planet.

TABLE IV. contains the Heliocentric Latitude of the Planet, the Reduction to the Ecliptic, and the Reduction of the Logarithm of the diſtance from the Sun. The argument is the Orbital Longitude of the Planet—the Longitude of the Node.

TABLE V. contains the Geocentric Aberration of the Planet, for reducing its true to the apparent place. The argument is the Elongation of the Planet from the Sun.

EXAMPLE.

REQUIRED the heliocentric place of the Planet for 1787, January 13 *d.* 04 *h.* 56′ 00″ M. T. Greenwich.

	s. ° ′ ″		s. ° ′ ″		s. ° ′ ″
1787. M. Lon. Plan.	3. 28. 00. 12,5	Lon. Aphel.	11. 23. 11. 28	Lon. Nod.	2. 12. 49. 35
Jan.	0. 00. 00. 00		3. 28. 09. 35		3. 23. 32. 35
13. ⎰ M. Mot.	.9. 13,2		———		———
4 ⎱	,7,1	M. An.	4. 04. 58. 07	Arg. Lat.	1. 10. 43. 00
56′	1,7			Hel. Lat. N.	30. 15
	———	Log. diſt. ☉	1.2694179		
Eq. Orbit,	3. 28. 09. 34,5	Red. Log.	168		
	4. 36. 59,3		———		
	———	Log. curt. diſt.	1. 2694011		
	3. 23. 32. 35,2				
Prec.—Red.	7,4				
	———				
Plan. for M. Eqˣ.	3. 23. 32. 27,8				

IT will be remarked, that the deviations from obſervations made near the vernal ſtations are in defect, while thoſe near the autumnal ſtations are in exceſs. Hence it may be preſumed, that the mean diſtance and periodic time are ſomewhat too ſmall, and the aphelion too far advanced on the ecliptic. I did not remark this till after I had computed the tables; and it is a tedious taſk to make the computation a-new. I have publiſhed them, not in the perſuaſion that they are perfect, but becauſe none have as yet been publiſhed in Britain, and I have ſeen only thoſe of DE LA PLACE and ORIANI, both of which are leſs conſiſtent with obſervations than mine.

TABLE I.

RADICAL MEAN PLACES, AND MOTIONS.

	M. Lon. Plan.	Lon. Aphel.	Lon. Node.
	s ° ' "	s ° ' "	s ° ' "
1756	11. 13. 43. 43,1	11. 22. 25. 48	2. 12. 23. 35
1781	3. 02. 01. 16,5	10. 23. 06. 26	2. 12. 44. 34
1782	3. 06. 20. 59,0	11. 23. 07. 16	2. 12. 45. 24
1783	3. 10. 40. 41,0	11. 23. 08. 07	2. 12. 46. 14
1784	3. 15. 00. 23,0	11. 23. 08. 57	2. 12. 47. 05
1785	3. 19. 20. 48,0	11. 23. 09. 48	2. 12. 47. 55
1786	3. 23. 40. 30,5	11. 23. 10. 38	2. 12. 48. 45
1787	3. 28. 00. 12,5	11. 23. 11. 28	2. 12. 49. 35
1788	4. 02. 19. 54,7	11. 23. 12. 19	2. 12. 50. 26
1789	4. 06. 40. 19,5	11. 23. 13. 09	2. 12. 51. 16
1790	4. 11. 00. 01,7	11. 23. 13. 59	2. 12. 52. 06
1791	4. 15. 19. 23,9	11. 23. 14. 50	2. 12. 52. 57
1792	4. 19. 39. 06,1	11. 23. 15. 40	2. 12. 53. 47
1793	4. 23. 29. 30,9	11. 23. 16. 31	2. 12. 54. 32
1794	4. 28. 19. 13,1	11. 32. 17. 21	2. 12. 55. 28
1795	5. 02. 38. 55,3	11. 23. 18. 12	2. 12. 56. 18

Month.	M. Motion.	P. Eq.
	° ' "	"
Jan. 0	00. 00. 00,0	0,0
Feb. 0	00. 21. 59,1	4,3
Mar. 0	00. 41. 50,6	8,3
Apr. 0	1. 03. 49,8	12,5
May, 0	1. 25. 06,4	16,7
June, 0	1. 47. 05,5	20,9
July, 0	2. 08. 22,1	25,1
Aug. 0	2. 30. 21,3	29,3
Sept. 0	2. 52. 20,4	33,6
Oct. 0	3. 13. 37,0	37,8
Nov. 0	3. 35. 36,1	42,0
Dec. 0	3. 56. 52,8	46,1

N. B. In taking out the M. Mot. for any day in a leap year, after the 29th of February, reckon one day more.

D.	M. Mot.	H.	Mot.
	' "		"
1	0. 42,5	1	1,8
2	1. 25,1	2	3,6
3	2. 07,7	3	5,3
4	2. 50,2	4	7,1
5	3. 32,7	5	8,9
6	4. 15,3	6	10,6
7	4. 57,9	7	12,4
8	5. 40,5	8	14,2
9	6. 23,0	9	16,0
10	7. 05,6	10	17,7
11	7. 48,1	11	19,5
12	8. 30,7	12	21,3
13	9. 13,2	13	23,1
14	9. 55,8	14	24,8
15	10. 38,3	15	26,6
16	11. 20,9	16	28,4
17	12. 03,4	17	30,1
18	12. 46,0	18	31,9
19	13. 28,5	19	33,7
20	14. 11,1	20	35,5
21	14. 53,6	21	37,2
22	15. 36,2	22	39,0
23	16. 18,7	23	40,8
24	17. 01,3	24	42,5
25	17. 43,8	25	
26	18. 26,4	26	
27	19. 08,9	27	
28	19. 51,5	28	
29	20. 34,0	29	
30	21. 16,6	30	
31	21. 59,1	31	

TAB. II. ELLIPTICAL EQUATION.

Arg. M. An.

°	0 — (° ′ ″)	Diff. (′ ″)	I. — (° ′ ″)	Diff. (′ ″)	II. — (° ′ ″)	Diff. (′ ″)	°
0	0. 00. 00,0	5. 23,0	2. 35. 22,4	4. 44,7	4. 34. 36,5	2. 57,7	30
1	0. 05. 23,0	5. 23,0	2. 40. 07,1	4. 42,5	4. 37. 34,2	2. 53,2	29
2	0. 10. 46,0	5. 22,8	2. 44. 49,6	4. 39,9	4. 40. 27,4	2. 48,4	28
3	0. 16. 08,8	5. 22,5	2. 49. 29,5	4. 37,2	4. 43. 15,8	2. 43,7	27
4	0. 21. 31,3	5. 22,2	2. 54. 06,7	4. 34,5	4. 45. 59,5	2. 38,9	26
5	0. 26. 53,5	5. 21,9	2. 58. 41,2	4. 31,7	4. 48. 38,4	2. 34,2	25
6	0. 32. 15,4	5. 21,3	3. 03. 12,9	4. 28,8	4. 51. 12,6	2. 29,1	24
7	0. 37. 36,7	5. 20,7	3. 07. 41,7	4. 25,8	4. 53. 41,7	2. 24,0	23
8	0. 42. 57,4	5. 20,1	3. 12. 07,5	4. 22,8	4. 56. 05,7	2. 19,2	22
9	0. 48. 17,5	5. 19,3	3. 16. 30,3	4. 19,6	4. 58. 24,9	2. 14,1	21
10	0. 53. 36,8	5. 18,5	3. 20. 49,9	4. 16,4	5. 00. 39,0	2. 08,9	20
11	0. 58. 55,3	5. 17,6	3. 25. 06,3	4. 13,2	5. 02. 47,9	2. 03,8	19
12	1. 04. 12,9	5. 16,6	3. 29. 19,5	4. 09,8	5. 04. 51,7	1. 58,5	18
13	1. 09. 29,5	5. 15,5	3. 33. 29,3	4. 06,4	5. 06. 50,2	1. 53,2	17
14	1. 14. 45,0	5. 14,4	3. 37. 35,7	4. 03,0	5. 08. 43,4	1. 47,9	16
15	1. 19. 59,4	5. 13.2	3. 41. 38,7	3. 59,3	5. 10. 31,3	1. 42,6	15
16	1. 25. 12,6	5. 11,8	3. 45. 38,0	3. 55,8	5. 12. 13,9	1. 37,1	14
17	1. 30. 24,4	5. 10,5	3. 49. 33,8	3. 52,0	5. 13. 51,0	1. 31,7	13
18	1. 35. 34,9	5. 09,0	3. 53. 25,8	3. 48,3	5. 15. 22,7	1. 26,1	12
19	1. 40. 43,9	5. 07,4	3. 57. 14,1	3. 44,3	5. 16. 48,8	1. 20,7	11
20	1. 45. 51,3	5. 05,7	4. 00. 58,4	3. 40,6	5. 18. 09,5	1. 15,0	10
21	1. 50. 57,0	5. 04,1	4. 04. 39,0	3. 36,5	5. 19. 24,5	1. 09,4	9
22	1. 56. 01,1	5. 02,3	4. 08. 15,5	3. 32,5	5. 20. 33,9	1. 03,8	8
23	2. 01. 03,4	5. 00,3	4. 11. 48,0	3. 28,4	5. 21. 37,7	0. 58,0	7
24	2. 06. 03,7	4. 58,5	4. 15. 16,4	3. 24,2	5. 22. 35,7	0. 52,3	6
25	2. 11. 02,2	4. 56,3	4. 18. 40,6	3. 19,9	5. 23. 28,0	0. 46,6	5
26	2. 15. 58,5	4. 54,3	4. 22. 00,5	3. 15,5	5. 24. 14,6	0. 40,7	4
27	2. 20. 52,8	4. 52,1	4. 25. 16,0	3. 11,2	5. 24. 55,3	0. 34,9	3
28	2. 25. 44,9	4. 49,9	4. 28. 27,2	3. 07,0	5. 25. 30,2	0. 29,1	2
29	2. 30. 34,8	4. 47,6	4. 31. 34,2	3. 02,3	5. 25. 59,3	0. 23,1	1
30	2. 35. 22,4		4. 34. 36,5		5. 26. 22,4		0
	+		+		+		
	XI.		X.		IX.		

XII. ABSTRACT *of a* REGISTER *of the* WEATHER, *kept at* HAWKHILL, *near Edinburgh; containing Observations of the Thermometer, the Quantity of Rain and Evaporation, from* 1771 *to* 1776 *inclusive.*

[*Communicated by Mr* MACGOWAN.]

THIS Abstract contains the medium heat for the half of each month, and is a continuation of that inserted in the last Volume of the *Physical and Literary Essays.*

HAWKHILL is situated 1½ mile N. E. of Edinburgh.

THE Observations of the Thermometer were made every day at 8 o'clock A. M.

Months.		1771.			1772.		
1st and 2d halfs.		Ther.	Rain.	Evapor.	Ther.	Rain.	Evapor.
		Deg.	Inch.	Inch.	Deg.	Inch.	Inch.
January,	1	31.80			32.40		
	2	34.56	1.043	0.343	30.56	2.681	0.000
February,	1	35.00			29.42		
	2	38.28	1.165	3.395	32.46	1.385	0.000
March,	1	35.80			36.00		
	2	36.00	0.538	0.958	38.00	1.685	0.805
April,	1	38.46			43.20		
	2	44.86	0.440	2.540	42.60	1.299	2.549
May,	1	47.66			48.93		
	2	53.12	1.385	3.335	49.31	2.024	3.854
June,	1	54.46			55.93		
	2	56.93	0.482	4.382	58.40	2.997	4.367
July,	1	59.06			60.26		
	2	57.93	1.848	4.248	57.06	3.688	4.188
August,	1	57.26			58.00		
	2	56.00	3.229	3.429	56.75	2.710	3.018
September,	1	52.46			53.60		
	2	50.93	1.742	1.942	49.46	3.261	
October,	1	46.86			50.73		3.294
	2	46.75	5.591	1.491	46.88	3.513	
November,	1	41.46			44.13		
	2	42.26	3.765	0.815	39.33	5.659	0.749
December,	1	43.53			42.00		
	2	39.12	0.966	0.666	37.31	1.282	0.572
Sums,			22.194	24.544		32.184	23.558
Means,		45.85			45.53		

Months.		1773.			1774.		
1st and 2d halfs.		Therm.	Rain.	Evapor.	Therm.	Rain.	Evapor.
		Deg.	Inch.	Inch.	Deg.	Inch.	Inch.
January,	1	39.06			28.46		
	2	38.06	3.526	1.436	29.75	2.775	
February,	1	32.14			34.14		3.699
	2	38.00	1.154	0.504	38.28	2.024	
March,	1	40.46			34.06		
	2	43.66	1.225	1.695	40.18	0.859	1.759
April,	1	42.40			43.13		
	2	48.80	3.530	3.530	43.13	1.737	3.387
May,	1	44.33			46.73		
	2	52.81	1.827	3.477	46.50	3.490	3.540
June,	1	54.13			54.80		
	2	56.26	0.873	3.673	55.40	3.868	3.268
July,	1	56.33			57.40		
	2	59.06	1.405	6.805	57.50	1.513	4.463
August,	1	60.40			58.13		
	2	56.12	1.283	3.583	56.37	4.818	3.168
September,	1	53.26			52.40		
	2	49.33	3.680		51.00	2.925	2.525
October,	1	47.20		5.385	51.06		
	2	44 87	2.955		45.50	1.305	2.105
November,	1	41.53			40.63		
	2	34.93	3.369	0.119	35.50	2.179	2.179
December,	1	35.60			37.40		
	2	37.25	3.915	1.715	37.25	2.692	0.000
Sums,			28.842	31.922		30.185	30.093
Means,		46.08			44.86		

Months.		1775.			1776.		
	1st and 2d halfs.	Therm.	Rain.	Evapor.	Therm.	Rain.	
		Deg.	Inch.	Inch.	Deg.	Inch.	
January,	1	39.10			33.33		Medium of heat for the six preceding years, deg. 45.06.
	2	36.50	4.591	2.040	25.16	3.262	
February,	1	37.64			36.32		
	2	40.50	3.014	2.214	35.00	2.355	
March,	1	39.80			37.60		
	2	40.31	1.586	2.836	44.12	1.465	
April,	1	44.83			43.60		
	2	48.83	0.578	3.928	48.20	1.213	
May,	1	52.60			47.36		
	2	52.88	1.422	5.272	51.22	0.626	
June,	1	55.66			55.00		
	2	57.53	1.209	3.309	56.00	2.367	
July,	1	58.20			58.16		
	2	60.06	5.806	3.556	60.56	3.075	
August,	1	59.10			58.60		
	2	56.21	2.364	2.514	54.86	2.410	
September,	1	53.20			55.00		
	2	53.33	3.820	1.920	48.60	2.755	
October,	1	48.86			48.60		
	2	41.75	5.309	2.109	45.38	1.735	
November,	1	38.00			45.80		
	2	37.93	3.615	0.165	36.13	2.750	
December,	1	41.16			42.54		
	2	36.00	0.760	0.660	33.00	2.080	
Sums,			34.298	30.754		26.093	
Means,		47.08			45.84		

Greateft

Greateſt Degrees of Cold and Heat, obſerved at Hawkhill, from 1766 to 1776 incluſive.

	Fahr. Therm.
1767. January 17. at 8½ h. P. M. - -	17.50
1768. January 3. at 10 h. P. M. -	17.00
17. at 8 h. A. M. -	17.00
1772. February 1. at 7¾ h. A. M. - - -	12.00
N. B. At Selkirk the thermometer, ſame morning, continued from 6 h. to 8 h. A. M. -	1.50
1774. January 12. at 7 h. A. M. - -	17.00
N. B. Selkirk at 8 h. A. M. -	12.00
And the preceding night at 12 h.	8.00
1776. January 31. at 8 h. A. M. -	14.00
Same h. at Obſervatory, Hawkhill,	11.00
At Botanic garden, at 6 h. A. M. ſaid day, - -	5.00
1770. Auguſt 5. at 3½ h. P. M. - -	81.15

Proportion of the Weſt Wind to the Eaſt for every Month, de-duced from Obſervations made at Hawkhill from 1764 to 1771 both incluſive.

N. B. The South Wind, and all to the Weſt of the Meridian, are reckoned Weſt. The North Wind, and all to the Eaſt of the Meridian, are reckoned Eaſt.

Months.	W. wind.	E. wind.	Months.	W. wind.	E. wind.
January,	22.0	9.0	July,	17.9	13.1
February,	18.6	9.6	Auguſt,	21.3	9.7
March,	17.6	13.4	September,	20.4	9.6
April,	15.9	14.1	October,	23.9	7.1
May,	14.5	16.5	November,	22.0	8.0
June,	15.6	14.4	December,	20.0	11.0
For the whole year, 229.7 Weſt, 135.5 Eaſt.					
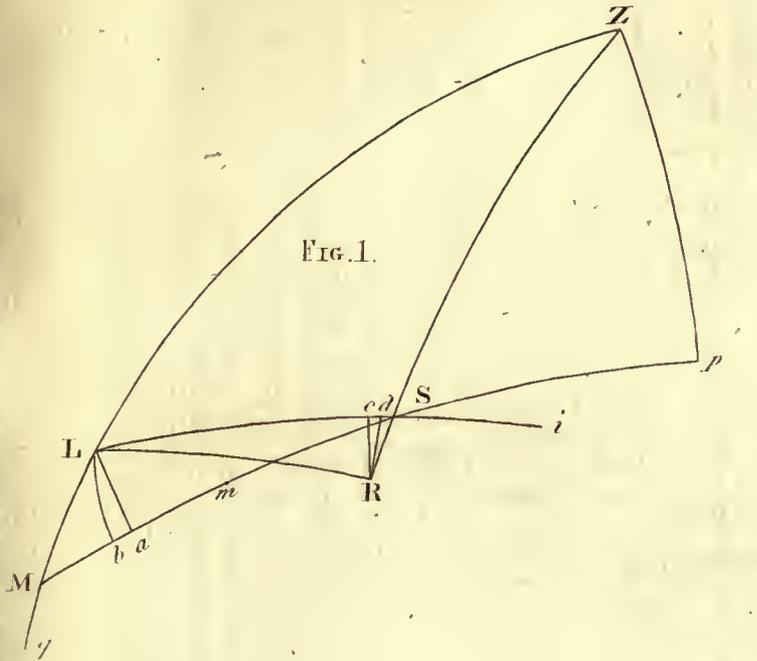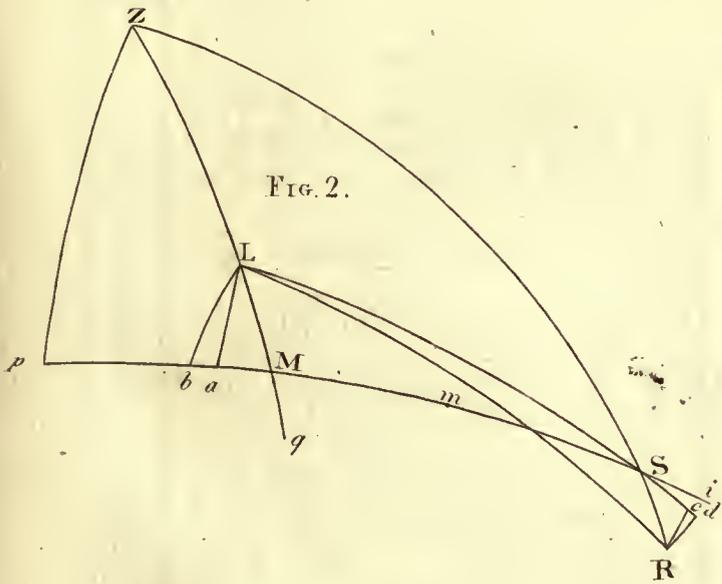
END OF PAPERS OF THE PHYSICAL CLASS.

Fig. 1.

Fig. 2.

Fig. 1.

Fig. 2.

TAB. II. ELLIPTICAL EQUATION.

Arg. M. An.

o	III. —	Diff.	IV. —	Diff.	V. —	Diff.	o
0	5. 26. 22,4		4. 51. 23,4		2. 52. 12,4		30
		0. 17,4		2. 42,8		5. 08,1	
1	5. 26. 39,8	0. 11,4	4. 48. 40,6	2. 48,4	2. 47. 04,3	5. 12,0	29
2	5. 26. 51,2	0. 05,4	4. 45. 52,2	2. 53,8	2. 41. 52,3	5. 15,3	28
3	5. 26. 56,6	0. 00,6	4. 42. 58,4	3. 00,1	2. 36. 37,0	5. 18,7	27
4	5. 26. 56,0	0. 08,6	4. 39. 58,3	3. 05,0	2. 31. 18,3	5. 21,9	26
5	5. 26. 48,4		4. 36. 53,3		2. 25. 56,4	5. 25,1	25
		0. 11,5		3. 10,9			
6	5. 26. 36,9	0. 18,6	4. 33. 42,4	3. 16,4	2. 20. 31,3	5. 28,1	24
7	5. 26. 18,3	0. 24,6	4. 30. 26,0	3. 21,7	2. 15. 03,2	5. 31,0	23
8	5. 25. 53,7	0. 30,7	4. 27. 04,3	3. 27,3	2. 09. 32,2	5. 33,8	22
9	5. 25. 23,0	0. 36,8	4. 23. 37,0	3. 32,5	2. 03. 58,4	5. 36,5	21
10	5. 24. 46,2		4. 20. 04,5		1. 58. 21,9	5. 39,0	20
		0. 42,7		3. 38,0			
11	5. 24. 03,5	0. 48,9	4. 16. 26,5	3. 43,2	1. 52. 42,9	5. 41,5	19
12	5. 23. 14,6	0. 55,2	4. 12. 43,3	3. 48,3	1. 47. 01,4	5. 43,7	18
13	5. 22. 19,4	1. 00,7	4. 08. 55,0	3. 53,4	1. 41. 17,7	5. 46,0	17
14	5. 21. 18,7	1. 07,2	4. 05. 01,6	3. 58,6	1. 35. 31,7	5. 47,9	16
15	5. 20. 11,5		4. 01. 03,0		1. 29. 43,6	5. 50,0	15
		1. 13,1		4. 03,4			
16	5. 18. 58,4	1. 19,1	3, 56. 59,6	4. 08,4	1. 23. 53,6	5. 51,9	14
17	5. 17. 39,3	1. 25,3	3. 52. 51,2	4. 13,2	1. 18. 01,7	5. 53,5	13
18	5. 16. 14,0	1. 31,5	3. 48. 38,0	4. 18,0	1. 12. 08,2	5. 55,1	12
19	5. 14. 42,5	1. 37,3	3. 44. 20,0	4. 22,7	1. 06. 13,1	5. 56,6	11
20	5. 13. 05,2		3. 39. 57,3		1. 00. 16,5	5. 57,9	10
		1. 43,3		4. 27,2			
21	5. 11. 21,9	1. 49,6	3. 35. 30,1	4. 31,7	0. 54. 18,6	5. 59,0	9
22	5. 09. 32,3	1. 55,3	3. 30. 58,4	4. 36,2	0. 48. 19,6	6. 00,2	8
23	5. 07. 37,0	2. 01,4	3. 26. 22,2	4. 40,6	0. 42. 19,4	6. 01,0	7
24	5. 05. 35,6	2. 07,4	3. 21. 41,6	4. 44,8	0. 36. 18,4	6. 01,9	6
25	5. 03. 28,2		3. 16. 56,8		0. 30. 16,5	6. 02,5	5
		2. 12,9		4. 48,9			
26	5. 01. 15,3	2. 19,5	3. 12. 07,9	4. 53,0	0. 24. 14,0	6. 03,0	4
27	4. 58. 55,8	2. 24,8	3. 07. 14,9	4. 57,0	0. 18. 11,0	6. 03,5	3
28	4. 56. 31,0	2. 31,0	3. 02. 17,9	5. 00,8	0. 12. 07,5	6. 03,7	2
29	4. 54. 00,0	2. 36,6	2. 57. 17,1	5. 04,7	0. 06. 03,8	6. 03,8	1
30	4. 51. 23,4		2. 52. 12,4		0. 00. 00,0		0
	+		+		+		
	VIII.		VII.		VI.		

T t

TAB. III. Logarithm of the Planet's Distance from the Sun.

Arg. M. An.

♀	O Logar.	Diff.	I. Logar.	Diff.	II. Logar.	Diff.	♀
0	1.3008817		1.2984548		1.2916063		30
		27		1619		2914	
1	1.3008790	82	1.2982929	1669	1.2913149	2949	29
2	1.3008708	137	1.2981260	1718	1.2910200	2983	28
3	1.3008571	192	1.2979542	1767	1.2907217	3015	27
4	1.3008379	246	1.2977775	1816	1.2904202	3047	26
5	1.3008133	300	1.2975959	1865	1.2901155	3078	25
6	1.3007833	355	1.2974094	1912	1.2898077	3109	24
7	1.3007478	410	1.2972182	1959	1.2894968	3140	23
8	1.3007068	464	1.2970224	2006	1.2891828	3169	22
9	1.3006604	519	1.2968218	2053	1.2888659	3197	21
10	1.3006085	573	1.2966165	2100	1.2885462	3225	20
11	1.3005512	626	1.2964065	2145	1.2882237	3252	19
12	1.3004886	680	1.2961920	2190	1.2878985	3277	18
13	1.3004206	734	1.2959730	2235	1.2875708	3302	17
14	1.3003472	788	1.2957495	2279	1.2872406	3326	16
15	1.3002684	842	1.2955216	2324	1.2869080	3350	15
16	1.3001842	895	1.2952892	2367	1.2865730	3372	14
17	1.3000947	948	1.2950525	2409	1.2862358	3394	13
18	1.2999999	1001	2.2948116	2452	1.2858964	3414	12
19	1.2998998	1053	1.2945664	2494	1.2855550	3434	11
20	1.2997945	1106	1.2943170	2535	1.2852116	3454	10
21	1.2996839	1160	1.2940635	2575	1.2848662	3472	9
22	1.2995679	1212	1.2938060	2615	1.2845190	3488	8
23	1.2994467	1264	1.2935445	2655	1.2841702	3504	7
24	1.2993203	1315	1.2932790	2695	1.2838198	3518	6
25	1.2991888	1366	1.2930095	2733	1.2834680	3532	5
26	1.2990522	1417	1.2927362	2770	1.2831148	3545	4
27	1.2989105	1469	1.2924592	2806	1.2827603	3558	3
28	1.2987636	1519	1.2921786	2843	1.2824045	3569	2
29	1.2986117	1569	1.2918943	2879	1.2820476	3580	1
30	1.2984548		1.2916063		1.2816896		0
	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	
	XI.		X.		IX.		

TAB. III. Logarithm of the PLANET's Distance from the Sun.

Arg. M. An.

°	III. Logar.	Diff.	IV. Logar.	Diff.	V. Logar.	Diff.	°
0	1.2816896		1.2710423		1.2627235		30
1	1.2813308	3588	1.2707098	3325	1.2625225	2010	29
2	1.2809712	3596	1.2703799	3299	1.2623274	1951	28
3	1.2806110	3602	1.2700528	3271	1.2621382	1892	27
4	1.2802503	3607	1.2697288	3240	1.2619552	1830	26
5	1.2798891	3612	1.2694078	3210	1.2617785	1767	25
6	1.2795275	3616	1.2690899	3179	1.2616080	1705	24
7	1.2791656	3619	1.2687754	3145	1.2614439	1641	23
8	1.2788036	3620	1.2684644	3110	1.2612863	1576	22
9	1.2784416	3620	1.2681570	3074	1.2611352	1511	21
10	1.2780797	3619	1.2678533	3037	1.2609906	1446	20
11	1.2777181	3616	1.2675534	2999	1.2608526	1380	19
12	1.2773567	3614	1.2672574	2960	1.2607214	1312	18
13	1.2769958	3609	1.2669653	2921	1.2605969	1245	17
14	1.2766354	3604	1.2666773	2880	1.2604793	1176	16
15	1.2762757	3597	1.2663936	2837	1.2603686	1107	15
16	1.2759168	3589	1.2661143	2793	1.2602647	1039	14
17	1.2755589	3579	1.2658396	2747	1.2601677	970	13
18	1.2752020	3569	1.2655695	2701	1.2600777	900	12
19	1.2748461	3559	1.2653041	2654	1.2599948	829	11
20	1.2744915	3546	1.2650434	2607	1.2599190	758	10
21	1.2741384	3531	1.2647875	2559	1.2598504	688	9
22	1.2737868	3516	1.2645367	2508	1.2597888	616	8
23	1.2734367	3501	1.2642911	2456	1.2597345	543	7
24	1.2730884	3483	1.2640507	2404	1.2596874	471	6
25	1.2727420	3464	1.2638157	2350	1.2596475	399	5
26	1.2723976	3444	1.2635861	2296	1.2596148	327	4
27	1.2720553	3423	1.2633620	2241	1.2595893	255	3
28	1.2717152	3401	1.2631434	2186	1.2595711	182	2
29	1.2713775	3377	1.2629305	2129	1.2595601	110	1
30	1.2710423	3352	1.2627235	2070	1.2595564	37	0
	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	
	VIII.		VII.		VI.		

TABLE IV.

	o. N. VI. S. Lat.	Red.	R. log	I. N. VII. S. Lat.	Red.	R. log	II. N. VIII. S. Lat.	Red.	R. log	
°	′　″	″		′　″	″		′　″	″		°
0	00. 00	0	0	23. 12	8	99	40. 12	8	297	30
1	00. 49	0	0	23. 54	8	105	40. 36	8	303	29
2	1. 37	1	1	24. 36	8	111	40. 59	8	309	28
3	2. 26	1	1	25. 17	9	117	41. 21	8	314	27
4	3. 14	1	2	25. 57	9	124	41. 43	7	320	26
5	4. 03	2	3	26. 37	9	130	42. 04	7	325	25
6	4. 51	2	4	27. 17	9	137	42. 24	7	330	24
7	5. 39	2	6	27. 56	9	143	42. 43	7	335	23
8	6. 28	3	8	28. 35	9	150	43. 02	7	340	22
9	7. 16	3	10	29. 13	9	157	43. 20	6	345	21
10	8. 04	3	12	29. 50	9	164	43. 37	6	349	20
11	8. 51	4	14	30. 27	9	170	43. 53	6	354	19
12	9. 39	4	17	31. 03	9	177	44. 08	6	358	18
13	10. 26	4	20	31. 29	9	184	44. 23	5	362	17
14	11. 14	4	23	32. 14	9	191	44. 37	5	366	16
15	12. 01	5	26	32. 49	9	198	44. 50	5	369	15
16	12. 48	5	30	33. 23	9	205	45. 02	4	372	14
17	13. 34	5	33	33. 57	9	211	45. 13	4	376	13
18	14. 21	6	38	34. 30	9	219	45. 24	4	379	12
19	15. 07	6	42	35. 02	9	226	45. 34	4	381	11
20	15. 53	6	46	35. 33	9	233	45. 43	3	384	10
21	16. 38	6	51	36. 04	9	239	45. 51	3	386	9
22	17. 23	7	55	36. 34	9	246	45. 58	3	389	8
23	18. 08	7	61	37. 04	9	253	46. 04	2	390	7
24	18. 53	7	65	37. 33	9	259	46. 10	2	392	6
25	19. 37	7	71	38. 01	9	265	46. 15	2	393	5
26	20. 21	7	76	38. 29	9	272	46. 18	1	394	4
27	21. 04	8	82	38. 56	9	278	46. 21	1	394	3
28	21. 47	8	88	39. 22	8	285	46. 23	1	394	2
29	22. 30	8	93	39. 47	8	291	46. 25	0	395	1
30	23. 12	8	99	40. 12	8	297	46. 26	0	396	0
	XI. S. V. N.	+	—	X. S. IV. N.	+	—	IX. S. III. N.	+	—	

TAB. V.

Elong.		Ab.
		″
0.	00	—24
	10	—23
	20	—21
I.	00	—19
	10	—17
	10	—15
II.	20	—13
	10	—10
	20	— 7
III.	00	— 3
	10	— 0
	20	+ 3
IV.	00	+ 6
	01	+ 9
	02	+ 11
V.	00	+ 12
	10	+ 14
	20	+ 15
VI.	00	+ 16

II.

PAPERS OF THE LITERARY CLASS.

I. ESSAY *on the* ORIGIN *and* STRUCTURE *of the* EUROPEAN LEGISLATURES. *By* ALLAN MACONOCHIE, *Esq;* Advocate, F. R. S. EDIN. *and Professor of Public Law in the University of* EDINBURGH.

PART I.

Of the Period previous to the Conquest of the Western Empire.

[*Read by the Author, Dec.* 15. 1783.]

INTRODUCTION.

THE fall of the feudal system was accomplished, in the principal states of Europe, at a period when the revival of learning had diffused in society a spirit of reflection, and communicated, to the better sort, some knowledge of the history of the Greek and Roman republics. As it was, in general, the kings who conducted the attack on the privileges of the feudal nobility, the principal part of the spoils had fallen naturally to their share. But the people were warlike, the nobles were still animated with the pride of rank, of family, and of their ancient consequence, and men, in general, had begun to speculate on their rights, and were unaccustomed to perceive, with satisfaction, the whole powers of government centred in the crown.

Hence

Hence the rights of the kings, of the nobility, and of the people, came to be a matter of general difcuffion : And as men are ufually prejudiced in favour of the wifdom of their remote anceftors, and derive their more common notions of their political rights from what was cuftomary in ancient times, the merits of the difpute were univerfally fuppofed to turn on the hiftorical queftion of fact, What conftitution was adopted by the original founders of each particular nation.

Hence the firft refearches into the ancient hiftory of the European governments were made with a view to fupport the tenets of political factions. Thofe who wifhed to gain the favour of courts laboured to prove the ancient fovereignty of the Gothic kings, and founded their fyftems on the defpotic powers of the leader of a conquering army, and the abfolute nature of a right of conqueft ; from whence they inferred, that the privileges of the ariftocracy were ufurpations on the crown, and the rights of the people the grants of its bounty. The partizans of the people again endeavoured to trace the political rights of the commons to a remote antiquity, and exhibited them as underftood and exercifed in the fulleft manner in the earlieft ages of the conftitution ; and they contended, that the happinefs of thofe times was to be reftored only, by the people refuming the conftitutional powers which kings and nobles had alternately ufurped. In fine, thofe who had imbibed from the Greek and Roman claffics, or from family-connections, a profound reverence for ariftocratic virtues, together with a proportionable averfion to plebeian manners, delighted to efpoufe the caufe of the falling nobility, to difplay the ancient powers of the order, and to confute their antagonifts, by tracing the circumfcribed limits of the royal prerogative in remote times, the oppreffions under which the commons laboured, and the little importance they poffeffed in national affairs.

In this way, opinions with regard to the original ftructure of the European governments entered into the creeds of contending
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ing factions; and though thefe, in courfe of time, ceafed to be the fubject of profeffedly polemical writing, their influence is ftill fenfible in guiding the views of the hiftorian, and blunting the difcernment of the philofopher and politician. The hiftoriographer of France, even in thefe days, maintains the abfolute legiflative authority of the Merovingian princes. The Abbé MABLY, and Englifh authors of no inferior reputation, Lord LITTELTON, Dr STUART, &c. affirm the remote antiquity of the reprefentation of the commons; and MONTESQUIEU and HUME have conferred their fanction on the ariftocratic fyftem. When a controverfy is thus circumftanced, men of information are apt to indulge fcepticifm, and abandon the fubject; while fecond-rate authors feize it as lawful game, court popularity, by afferting errors that fuit the tafte of the times, and treat thofe with abufe who venture to reject them.

BUT there is, in fact, no period where there is better encouragement to hope that an enquiry may be purfued with fuccefs. The very fcepticifm of the literary world, which has begun to efcape from the factions of the laft century, if not fuffered to mar its induftry, will give enlargement to its views, and candour to its difquifitions. Many important facts in the hiftory of rude nations, akin to thofe which founded the Gothic governments, have been afcertained: Many ancient records, to which the public had formerly no accefs, have been publifhed; and the efforts of great men, during the prefent century, to render hiftory an object of philofophical fpeculation, have roufed a fpirit of enlightened obfervation, and taught perfons, poffeffed of literary curiofity, how to direct their refearches.

I FLATTER myfelf thefe obfervations will afford me fome apology, for prefuming to treat of a fubject which has formerly drawn the attention of fo many perfons of the firft abilities. My fentiments on it are the refult of an enquiry, to which duty, as well as inclination, prompted me; and, if they have no other merit, I truft they will at leaft be attended with

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the advantage of fuggefting an object for the labours of the fociety, highly interefting to us as citizens, as well as lovers of fcience.

When we confider, with impartiality, the controverfy about the ancient European conftitutions, the firft reflection that fuggefts itfelf is, that there muft be fome foundation in truth for the different opinions that have been adopted with regard to them. The partizans of each of the three fyftems produce evidence which goes a certain length in fupporting it. There is, therefore, reafon to fuppofe, that all the fyftems are chiefly erroneous, in fo far as they are exclufive of each other; and that there muft be an hypothefis, which, if difcovered, would folve every difficulty, and involve in itfelf the doctrines of all the fyftems, to a certain extent.

Proceeding on this idea, and reflecting what this hypothefis may be, we are foon fatisfied that it muft be fome very fimple one. It is agreed on all hands, that the conquerors of the empire were in a very rude ftate of fociety at the æra of their fettlements. Their difpofition to emigrate as nations is alone fufficient to demonftrate, that hufbandry was very imperfectly practifed among them, and that their principal dependence was on their flocks and herds. In fuch circumftances, we may be affured, that the practice taken notice of by Cæsar and Tacitus, *arva per annos mutant et fupereft ager*, ftill prevailed; and, of courfe, that as yet exclufive and permanent property in land had not been generally introduced, and that a feparation of profeffions was unknown. Their fituation, therefore, created no call for an improved jurifprudence, or for much exertion of legiflative wifdom; and without this call, laws cannot be numerous, nor government complicated *.

But

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* Even fo late as the period fince which the Swedifh laws have been preferved, there are traces of the fame migratory ftate of fociety having prevailed. " Coluerunt difcreti " et diverfi," fays Shernhook, " ædificiis tranfitoriis, et in annum aut menfem pofitis:"
Wherefore

But it is not enough to be affured, that the arrangements of fociety among the conquerors were extremely fimple, or that an independence, natural to rude men, ftill prevailed, and was equally inconfiftent with defpotifm in chiefs, and with that fpirit of fubordination, and fyftematic ftructure of laws, on which civil liberty depends. We muft endeavour to learn exactly what the ftructure of fociety among the Gothic nations was, while ftill remaining in their original feats; and to afcertain the influence which fettlement, in the cultivated provinces of the empire, where laws and government had been long eftablifhed, neceffarily produced on the political fituation of the conquerors.

A very flight view of the hiftory of Europe points out abundant materials for this extenfive enquiry. The nations of this continent appear to have followed almoft the fame route to civilization, advancing only with more or lefs celerity, in proportion as they were fituated in countries more or lefs fruitful, and more or lefs expofed to foreign intercourfe. At the commencements of hiftory, we find the rifing republics in the neighbourhood of the Mediterranean poffeffed of inftitutions and traditions which indicate that they had recently emerged from that fituation in which the more inland nations on the north of them ftill remained. After a few centuries had elapfed, Gaul and South Britain are found, at the invafion of Cæsar, a tranfcript of Greece and Italy and Spain, when banifhing their kings and eftablifhing republics. Germany, more inland, retained ftill her rude form, her extenfive confederacies, and difpofition to emigration ; while Finland, Caledonia, and Scandinavia, were little different from a North American wildernefs. Thefe countries, however, became formidable before the fall of the weftern empire ; and Scandinavian tribes croffed the Baltic,

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Wherefore he adds, the *leges vetuftiffimæ* directed the farmer to have a houfe for himfelf, and *trinas* for the flaves, cattle and corn, he might carry about with him in his journeyings, to be put up when he fojourned in one place, " perinde ut fepes excepta tantum " ea quæ villam includeret," p. 295.

and repeopled the countries which the conquerors of the Romans had abandoned. Germany then proceeded as southern Europe had done before her. She became fit to coalesce with Gaul under the government of the Franks; and petty states, rising on the coasts of the Baltic and German ocean, addicted to navigation and military adventure, restored in the north somewhat of the early ages of Greece and Italy.

In the mean time, the feudal law, characterised by its domestic subordination, its tenures, its hereditary offices, and its titled nobility, and destined to create very lasting and very singular impressions on the European governments and manners, began to appear in the empire of the Franks. The wealth of Gaul naturally made the inconveniences arising from the imperfection of the German laws, be felt there with extreme severity. Men accordingly had there recourse to the expedient which they have universally resorted to for protection, wherever the progress of property has outstripped that of law. When law is in its infancy, and wealth has accumulated, though the political union is loose, and the authority of the magistrate feeble, the domestic authority of the heads of families is strong, and the union among their branches firm and intimate. The love of power, therefore, induces the opulent to extend their households, by employing their surplus wealth in engaging retainers; and the desire of safety prompts the less opulent to court admission into these little societies, and to promise support in return for protection. Hence the personal relation of patron and client was established; and the great importance of this relation, in turbulent times, naturally led men to have recourse to the Roman arts of conveyancing, (which were still preserved among the natives) for ascertaining its obligations, and rendering it permanent and adequate to the protection of their property. In this way, lands, already used as the means of purchasing retainers, came also to be impledged in constituting this relation; which, of course, from being personal, temporary, and dependent on mutual inclination, gra-

dually

dually became indiffoluble, hereditary and real. The family of MARTEL endeavoured to avail itfelf of the feudal combinations, in order to ftrengthen its own authority, and to introduce fome firmnefs into the fubordination of the citizens. By thefe means, they grew into the conftitution of the ftate, and were enabled, during the convulfions which tore it in the fall of that houfe, to reduce every political inftitution in the French empire, under the forms of their arrangements.

SPAIN, when advancing by fimilar fteps to Gaul, was overwhelmed by the Saracens, in the beginning of the eighth century. But as Catalonia foon after fell under the dominion of CHARLEMAGNE, the feudal tenures naturally found their way into that province, and were afterwards diffufed through the reft of Spain, which was reconquered piece-meal, and chiefly by combinations of adventurers, who had to defend as well as conquer their acquifitions; and who muft have found, that the feudal tenures were inftitutions extremely well fuited to their fituation. The Anglo-faxons, already accuftomed to the perfonal relation of vaffalage, and, through their connections with the continent, beginning to employ the feudal tenures, received them, at the eftablifhment of the Normans, as the laws of their conqueror. The other European nations were, however, in different circumftances. As they were poffeffed of little wealth, their combinations for its protection were lefs general and lefs confolidated; and as they had efcaped conquefts by nations where the feus obtained, they adopted them only by flow degrees, and in a very partial manner. Among nations, as among individuals, the practices of the more fkilful are imitated by thofe who are lefs accomplifhed and informed. Hence the northern kingdoms imported the feudal laws, becaufe they were the laws of their more cultivated neighbours; becaufe they were better calculated than their own loofe cuftoms, to afcertain their rights; and becaufe it flattered the vanity of their grandees, to bear titles fimilar to thofe of the dignified nobility of France and the German empire.

pire. As in those nations, however, the feudal law was a plant of foreign growth, it was seldom able to acquire the vigour it possessed in its native soil. The restraints and forfeitures, which the Lombard lawyers had ingrafted on it, were frequently rejected; its titles of honour very often remained empty names, without political consequence; and, as it was in this manner employed merely for show, or for the ascertaining of private rights, much of the ancient constitution of the government was preserved unimpaired.

IF these observations are in any measure just, the history of the constitution of the different European nations may be much elucidated by institutions ascertained to have existed in their sister countries, during the corresponding periods of their progress. The rise of the constitutions of the Greek and Italian states will derive light from what is known of the Gaulic, German and Scandinavian tribes. The Norwegians, Angles, Saxons, Jutes and Danes, of the seventh, eighth and ninth centuries, will be found to resemble the Germans of Cæsar and Tacitus. The constitutions of the Anglo-saxons, of the Franks before the feus, of the Visigoths in Spain, and of the Norwegians in Iceland, ought to be extremely similar. And the more modern governments of Denmark, Sweden, Poland and Hungary, may be expected to retain more of the ancient Saxon and Scottish constitutions, than can be expected in the present British government, new modelled by the feudal law, and subjected, for ages, to the gradual but powerful influence of legislative wisdom and national cultivation.

HAVING recourse, as occasion requires, to the ample field of evidence pointed out by these observations, I shall endeavour to ascertain the form of government of the Gothic nations in their original seats; I shall examine the alterations it underwent upon their settlement in the Roman provinces; and I shall attempt to trace its progress and revolutions under the predominancy of the feudal system *.

<div align="right">PART</div>

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* This last part is not published in the present volume.

PART I.

SECTION I. *Of the Government of the German Nations while in their original Territories.*

THE German nations, when defcribed by CÆSAR and TA-CITUS, exhibited the fame difpofition for emigration and conqueft, which afterwards, in the times of ALARIC and CLOVIS, gained them poffeffion of the Roman provinces. We may, therefore, look into the ftructure of fociety, which thefe great authors defcribe, for the caufes of this reftlefs fpirit ; and we may likewife infer, from the permanency of a temper fo cha-racteriftic of national manners, that, during this long interval, the political circumftances of the Germans had continued near-ly unchanged. Having, therefore, recourfe to the lively picture which CÆSAR and TACITUS have left us, a little attention to the general circumftances of the Germanic nations will enable us to perceive in it, with fufficient precifion, the forms of their conftitution, and the nature of their government.

THE Germans lived in a country interfected with woods, rivers and mountains. However much, therefore, they were in-clined to indulge in the indolence of the paftoral life, their coun-try did not permit them to refide, like Tartars, in moveable ha-bitations. Hence they fojourned in annual huts, and cultivated a little fpot of ground for a crop, in aid of the produce of their cattle. Hence, too, they found it every where neceffary to have ftrong holds, to which they carried their property in time of danger. Thefe holds or *pagi*, as the Greeks and Romans called them, were the natural refort of the tribes in their neighbour-hood, and feem to have been every where the firft embryos of the towns and little ftates with which ancient Europe fo much abounded. The *pagus* was ufually fituate on an eminence, on

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an ifland in a river, or in the receffes of a wood ; and it was fortified by palifadoes and mounds of earth.

THE point of union, which was thus formed among a few tribes, neceffarily produced affemblies of the whole warriors belonging to them, and the election of one of their chiefs to be their king or common leader.   He held his office for life ; becaufe it was men almoft independent that gave it him, who never doubted but that they could deprive him of it at pleafure, and who continued him in it, becaufe they had no motive to change him for another *.   It was likewife ufually conferred at his death on a perfon of his family.   No diftinction could be lefs invidious, or therefore would more readily fix the fuffrages in favour of a candidate, than his relationfhip to a deceafed chief.   Thus it is faid, *Reges ex nobilitate fumunt.*   The chiefs of the tribes that reforted to the pagus were the natural counfellors of the king, as their influence was the principal means of engaging the warriors in any common meafure.   Thefe chiefs were, no doubt, like the kings, ufually elected out of particular families.   TACITUS thus mentions the election of the chiefs of the fubordinate tribes : " Eliguntur in iifdem conciliis principes " qui jura per pagos vicofque reddunt. Centeni fingulis ex plebe " comites, concilium fimul et auctoritas adfunt." *De Mor. Germ. c.* 12.

BUT though each pagus acknowledged, in general, no fuperior, yet the circumftances of fociety induced numbers of them to confederate ; and, when wars happened, a common leader of the confederacy was chofen of courfe.   Men who live on the produce of

<div align="right">herds</div>

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* Dr STUART, and fome other authors, have laid it down as certain, that thefe chiefs held their offices only for a year. I cannot, however, difcover any good authority for this opinion, though favoured by MONTESQUIEU, contrary to the fpirit of his fyftem. It is oppofed by the univerfal practice of rude nations. The appellation of kings, applied univerfally to the chiefs of rude tribes, is inconfiftent with it. And as the kings of modern Europe were always underftood to hold their offices for life ; and as, in general, the great provincial magiftrates, in the ages after the conqueft of the empire, did fo likewife, unlefs deprived, there feems every reafon to believe, that the office of a German chief was equally permanent.

herds can subsist together in great bodies; and the leisure they en-
joy, and the whole habits of their lives, prompt them to engage in
military enterprises. In this way, leagues for offence, and, of
course, for defence likewise, are universally formed; and the
confederates, in order to carry on their common undertakings,
naturally choose a leader, whose powers endure as long as there
is use for them. Thus, says CÆSAR, " Quum bellum civitas
" aut illatum defendit aut infert, magistratus qui ei bello præ-
" sint, ut vitæ necisque habeant potestatem deliguntur. In pace
" nullus est communis magistratus, sed principes regionum, at-
" que pagorum, inter suos jus dicunt, controversiasq; minuunt."
STRABO observes the same of the Lucanian states, a part of the
ancient confederacy of the Samnites : " Τον μεν εν αλλον χρονον
" (*viz.* ειρηνην) εδημοκρατευΐο; εν δε τοις πολεμοις ηρειΐο βασιλευς, υπο των
" νεμομενων αρχας." *Lib.* 6. 254.

THESE leagues, of a number of cantons or pagi, seem to have
been attended, in perhaps every nation under heaven, with one
very important institution, *viz.* a distribution of the confede-
rates into regular numbers. A great body of men, who carry
on war for a considerable length of time, must soon perceive the
advantage, and even necessity of order and arrangement; and
the most simple of all arrangements, is the regulating by numbers
the contingents that each pagus should furnish. As soon again
as this measure is adopted, each pagus is under the necessity of
taking a similar method for raising and managing its contingent.
Each tribe belonging to a pagus will, of course, be called on
to furnish a certain number, and each great family in the tribe
a portion of this number. By this means, every canton, and
the parts of a canton, come naturally to be characterised by
their respective contingents, and the whole country itself seems
to be arranged into a series of divisions for military purposes.
" Definitur et numerus : says TACITUS, centeni ex singulis pagis
" sunt : idque ipsum inter suos vocantur, et quod primo nume-
" rus jam nomen et honor est." *De Mor. Germ. cap.* 6. We
find

find this fpecies of arrangement, not only in all countries where the Germans eftablifhed themfelves, but among the Ifraelites, as appears from the Mofaic inftitutions; among the Tartar nations, as far back as their hiftory reaches; among the ancient ftates of Greece * and Italy; and the Roman legion itfelf feems to have derived from the fame fource its original form †.

It is natural to fuppofe, that, when a confederacy of neighbouring pagi had long fubfifted, a feeling of fomewhat of national union will be apt to arife. The common leader, occafionally chofen for a war, will be fo often elected, as at laft to retain his powers for life. He will therefore become a king, like the chief of a pagus, and will be a princeps regionis, with feveral principes pagorum, in fuch a fubordination to him as the chiefs of vici, or of primary tribes, were originally to the chiefs of pagi. Thefe combined pagi again may become the allies of a great and lefs confolidated confederacy. Thus Tacitus defcribes particularly the great confederacy of the Suevi; and he enumerates above thirty of the nations belonging to it. Cæsar fays ‡, That each pagus or nation belonging to this confederacy fent forth 1000 men to war every fummer; by which means, as it confifted of an hundred pagi, an allied army of 100,000 men was annually formed. But Tacitus again mentions, that, in one fingle nation of the Suevi, *viz.* the Semnones, there were an hundred pagi. It appears, therefore, that the

Semnones

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* Homer fpeaks of decuriæ as known;

Πολλαι κεν δικαδες δευοιαίο οινοχοιο. Il. lib. ii. v. 128.

And he attributes to Nestor the inftitution of the Greeks fighting by tribes and curiæ;

Κριν' ανδρας καία φυλα καία φρηίρας Αγαμεμνον
'Ως φρηίρη φρηίρηϕιν αρηγη φυλα δε φυλοις· Il. lib. ii. v. 362.

† It is remarkable, that the nature, univerfality and antiquity of this inftitution fhould have efcaped Prefident Montesquieu's obfervation. He attributes it to the Merovingian princes, Clotaire and Chilperic, and fays, it was introduced into both France and England, in order that each diftrict fhould anfwer for any robberies committed in it. *Efprit des Loix, lib.* 30. *c.* 17. Dr Stuart has entertained more juft notions of it. Differtation on the Englifh conftitution. *Note, p.* 231.

‡ De Bello Gall. lib. 4. cap. 1.

Semnones were themselves a national confederacy, at the same time that they were only a single ally in the great league of the Suevi.

We have evidence, that this military arrangement coincided with the natural distinctions of tribes and families. At the same time that Tacitus mentions the former, he observes as to the latter, That " non casus nec fortuita conglobatio turmam aut cu- " neum facit, sed familiæ et propinquitates." And Cæsar mentions, that lands were occupied " gentibus cognationibusque *."

Such being the general arrangement of the Germans, it is easy to perceive the nature of those assemblies, about which there has been so much discussion. All writers agree in the gravity and decorum of the assemblies of savages. The chief sits in council with the aged, the warriors forming a circle around them. The chief, or the seniors, begin the deliberation, but all take a decent part in it, and the whole resolve ; " the con- " sent of the youth being as essential as that of the old †." Again, after the warriors are subjected to a degree of military order, we may reasonably conjecture, that it will be employed in their political assemblies. All rude nations love parade ; and as, on such occasions, it contributes much to decorum, as well as discipline, their assembly must tend to become a military review, at the same time that it retains the character of a political and religious convention. It is true, the descriptions of Cæsar and Tacitus do not countenance this notion

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* Thwrocs, or rather perhaps an anonymous author of a chronicle, as old as 1358, when mentioning the settlement of the Hungarians in Panonia, under their seven leaders, may also be urged in support of this opinion. " Et unicuique exercitui, capitaneum specialem " præficientes, centurionesque ac decanos, more solito constituerunt. Et unusquisque " exercitus 30,857 continebat. Nam in secundo eorundem de Scythia egressu de cen- " tum et octo tribubus ducenta et sedecim millia, de unaquaque, *sciz.* tribu, duo millia ar- " matorum, excepto familiæ numero eduxisse perhibeatur." Scriptores rerum Hungaricarum, 4to, v. i. p. 100.

† Pen's letter to the Pennsylvanian traders. See also Kolben of the Hottentots. Hist. Gen. des voyages, t. 6. p. 500. Also Colden's history of the six nations, &c. &c.

of order and regularity in the German diets. At the fame time, as TACITUS relates, that they affembled in arms, it çan fcarce be doubted, that, by degrees, the regularity of a military review would be introduced. It is, indeed, not eafy to conceive, how the vaft multitudes of armed men, mentioned as affembling on public affairs, could obferve any order, unlefs arranged in regular divifions. We know likewife, that the Tartars affembled in their *curiltay* in this manner, each tribe arranged under its proper banner. We know, that the ancient Greek ecclefia * and the Roman comitia were alfo military mufters and reviews. We know, that the affemblies of the Weapontact in modern Europe were likewife employed for this purpofe. And we know, that the Franks, who attended the affemblies called *mallum*, *placitum*, and *parliament*, were obliged to appear in arms †, and thofe who had banners, to carry them along with them. The Irifh, in the fame manner, wore arms in their national and provincial conventions. And I fhall afterwards have occafion to obferve, that the pofpolite in Poland, and the ancient diet of the German empire, affembled in a military form. We may reafonably then hold, that the ftructure of the different gradations of affemblies, among the ancient Germans, was extremely uniform, and wore a military afpect. In each affembly, its proper chief would prefide, accompanied with a council of the chiefs of thofe tribes which reforted to it ; and the war-
riors

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* HOMER thus relates the affembling of the Greeks in diet when befieging Troy :

——————————— ἐστιχοωντο

Ἰλιαδον εις αγορην.   Il. lib. ii. v. 92.

† THE affembly of the Franks in the campus martius of the cities of Gaul, defcribed by GREGORY of Tours, is manifeftly a military review. " Tranfacto vero anno, juffit " (fciz. Clovis) omnem cum armorum apparatu advenire phalangem, oftenfuram in cam- " po martio fuorum armorum nitorem ;" and he is mentioned as going through the ranks and examining their condition, lib. ii. c. 27. And when, under the fecond race, the Franks were called forth to affemble in military array, their magiftrates were named *capitanei*, and the meeting a *placitum*. *Capit. A. D.* 807. This military appellation is common to all the great magiftrates in both the Gothic and Sclavonic nations. Vayvode, bannus, heretoge, are often tranflated capitanei, duces, *&c.*

riors of such tribes would attend in military array, under the chiefs of their subdivisions. At any rate, we are certain, that the warriors attended in person, and in arms, whether in regular array or not; and every person, in the least acquainted with the character of rude nations, will be persuaded, that the personal presence of the warriors was not a matter of mere form. It is only by the opportunity of persuasion, which numerous assemblies afford, and by that deference to the authority of persons of eminence, and that contagious enthusiasm which are there felt, that men, untamed by laws or cultivation, can be induced to pursue common measures. Hence national diets are the great engine by which leaders conduct affairs, before government acquires its powers: And accordingly, attendance on them is among the first duties of the citizen that are enforced. But when government has once attained its energy, kings and magistrates have no occasion for numerous councils, in order to accomplish their purposes. On the contrary, they dread them as rivals or masters; and they know, that the less formidable they can render them, by diminishing their numbers or their influence, their own power becomes in proportion uncontrolled *.

THERE is, however, abundance of direct evidence, that the warriors were not mere spectators of the deliberations of their chiefs in the German assemblies. TACITUS expressly mentions their approving or rejecting, by certain known signs, the proposals or advices that persons, distinguished by their functions, their age, descent, eloquence, or reputation in war, thought proper to offer. And he, in particular, remarks, that those who were of consequence enough to deliver their sentiments in this manner, pretended to no right to command compliance with them, but only hoped to influence or persuade.

THE

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* AND again, when government becomes feeble, there are examples of national assemblies reappearing. In the fall of the western empire, the government, finding itself unable to animate the torpid and disjointed mass of the Gaulic nations, attempted to rouse its powers by the aid of national assemblies. SIRMOND not. ad Sidon. apolin. p. 245. See also DUBO's Hist. Cret. t. i. p. 241,—255. And to a similar cause is chiefly to be attributed the entry of the plebeians into the European legislatures.

THE accounts left us by TACITUS, of the powers exercised by these assemblies, scarce require any commentary. They were held regularly at stated intervals, and also on occasion of any extraordinary occurrence. Religion was employed to preserve moderation and decency in them, and feasting to promote sociality and good humour. Without doubt, every affair that created a public interest was there agitated. We find accordingly, that capital crimes were there tried, and probably no where else; since even the leaders of the nation in war could not punish military offences without the sanction of the priests. And, in general, it is only a popular assembly, or a priesthood, that can, with safety, venture to award punishments, in ages where revenge is virtue*. An individual that presumed to condemn on his own judgment would have the whole relations of the criminal, and, of consequence, in process of time, the whole nation for his foe. It is stated by LIVIUS, as one of the great causes of umbrage against the last TARQUIN, that he took upon him to try citizens without the aid of councils.

THE functions of the chiefs, we may reasonably judge, were, in general, ministerial. Even in battle, they conducted their armies rather by example than by authority. We may be sure, therefore, that, in peace, where the expediency of obedience is less obvious, their authority would be still weaker; and that, on all occasions, when any exertion of power was to be made, they would seek for a sanction to their conduct from the judgment of others. In judicial matters, there can be no doubt that they performed merely the functions of magistrates, not of judges. They received a large proportion of the fines, which were the punishment of crimes. This itself shows, that it could not belong to them, who were to reap a profit from the punishment,

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* AND war, rather than a prosecution at law, the usual consequence of an injury. See the Rules, introduced by the Anglo-Saxon laws, for restraining these private wars within certain limits. *W. L. L. Sax. passim.*

ment, to decide on the propriety of inflicting it *; whereas, if it was their bufinefs to apprehend and accufe, to take the judgment of the judges, and to carry it into execution, the fine was no more than a neceffary reward to ftimulate their activity in repreffing wrongs, and compenfate the rifk, as well as labour, which, in the infancy of government, muft attend this duty. Independently, however, of this general prefumption, the hiftory of all the ancient judicatures in Europe affords every where the moft convincing evidence, that the chiefs of the German and other conquering tribes exercifed only minifterial powers in matters of judicature. I can, however, but juft touch on it. In the firft ages after the German conqueft, we find the flaves of the kings, and of the provincial chiefs, exercifing moft frequently, in the adminiftration of juftice, the functions of their mafters. Thefe functions then muft have been purely minifterial; for we know that no flave, nor even an emancipated perfon, could bear witnefs where a freeman was concerned; and moft certainly, therefore, could never have been his judge. Accordingly, the effects of this ftate of the judicial power are equally confpicuous and extenfive. The functions of the king in the trial of peers in a bed of juftice in France; the functions of the high fteward of England, the reprefentative of the king in the trial of Britifh peers; the functions of every baron, or deputy of a baron, in the court of the barony, of the bans and vayvodes in Hungary and Poland, of the lagmen in Sweden, of the fheriff and hundreder in England †; in fhort, the di-

<center>c 2</center> ftinction

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* In the eaft, where the priefthood has ftripped the people of the judicial power, no part of the fines for delinquencies are paid to the judges.

† I QUOTE the following ftatute as evidence, not only of the diftinction being obferved in Scotland, but of the anxiety of our anceftors to feparate the judicial and minifterial functions: " Statuit dominus rex quod nullus juftitiarius vicecomes vel ballivus, fedeat " ad judicium faciendum fuper appellatione et refponfione coram eis facta. Sed cum ad " judicium venerint; exeant de curia; et libere tenentes de curia judicium faciant; et re- " vocato jufticiario, vicecomite vel ballivo, in curiam, judicium penes eos factum coram " ipfo judice reddatur." *Quon. attach. cap.* 66. There is a fimilar regulation in the eftablifhments of St Lewis, from which, no doubt, the law of the Scottifh barons was borrowed.

ſtinction between the judges of the fact and the law, which is
to be found almoſt univerſally in nations ariſing from a rude
ſtate, all manifeſtly flow from this common ſource, and, of con-
ſequence, unite in eſtabliſhing it as a principle of importance in
the hiſtory of the public law of Europe. In all rude nations,
the laws are few, ſimple and preciſe; and it never occurs to
their imagination, that any doubt can ariſe about the interpre-
tation of them. When, therefore, their public aſſemblies have,
on the accuſation of the injured, or of the chief, convicted a
perſon of a violation of the law, the pronouncing, as well as
executing the ſentence, is committed, as a matter of courſe, to
the chief, though he was to profit by the conviction. In pro-
ceſs of time, however, as law becomes complicated, there is
room for doubt as to its interpretation, and the chief has re-
courſe to the aſſiſtance of aſſeſſors or deputies for this purpoſe.
Hence it happens, that the king, in almoſt all countries, is na-
turally the ſource, both of the judicial procedure by which
courts of juſtice exerciſe their power, and of that magiſtracy
which interprets the law, while the nation*, as naturally try, or
delegate thoſe who try, how far individuals have, in fact, com-
mitted the wrongs of which they are accuſed. We have exam-
ples in the kings and archons of Athens, in the kings, conſuls
and pretors of Rome, as well as in the Gothic magiſtracy, of the
former powers, and of the latter, in the trials by the ſuffrages
of the Greek and Roman tribes, of the county courts and na-
tional aſſemblies in modern Europe; and in thoſe by the διαιτηται,
or arbiters, delegated from the tribes in Greece, the judices pe-
danei, delegated from the Roman tribes, the ſcabini from the
Gothic and French tribes, the nembda from the Swediſh, he-
red fougd from the Daniſh, the judices nobilium from the
Hungarian, and the lawmen, and their ſucceſſors the juries,
from the Anglo-ſaxon and Norman aſſemblies †.

The

* Enlightened, but, I apprehend, by no means bound by this interpretation.

† This origin of juries has been controverted by very learned writers; but, I think,
it is capable of being eſtabliſhed. And the only plauſible arguments againſt it ſeem to
me

THE conftitutional authority of the German chiefs was probably not more extenfive in political than in judicial affairs. It appears from CÆSAR, that they had the prerogative of regulating the annual eftablifhments of the tribes *. This, however, it is likely, was no more than one of thofe res minores, about which, TACITUS fays, the chiefs alone confulted: " Facilitatem partiendi camporum fpatia preftant, arva per an- " nos mutant et fupereft ager." In fuch a country, it was no greater prerogative in a king to diftribute the lands, than to choofe a camp for an army is in a general. It was, befides, a thing of that nature which a national diet could not well arrange; and, therefore, like the journeyings of a Tartar horde, was naturally left to the difcretion of the chief, who would, however, confult, of courfe, with the fubordinate chiefs on the bufinefs. The neceffity of obferving an order in the pofition of the tribe is likewife proved by the old laws of Sweden, which directed, with anxiety, the arrangement (fitus and ordo) of the cottages of villagers; and that they fhould be furrounded with a pallifado, in order, no doubt, that the inhabitants might make their defence with greater facility and effect, in cafe of an attack. *Shernhook*, 295.

IN military affairs, the power of the chiefs would be moft confpicuous. Although the choice of peace or war lay with the people, the conducting of military operations was neceffarily committed to the chiefs. " De majoribus rebus omnes con- " fultant, ita tamen ut ea quoque, quorum penes plebem arbi- " trium eft, apud principes pertractentur;" *Mor. Germ. c.* 11. A

considerable

me to have arifen from not making fufficient allowance for thofe varieties which ought to be expected among inftitutions of the fame kind in different countries, efpecially when the comparifon is made at different ftages of their progrefs.

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* " NEQUE quifquam agri modum certum aut fines proprios habet; fed magiftratus ac " princeps in annos fingulos gentibus cognationibufque hominum qui una coierunt quan- " tum eis et quo loco vifum eft attribuunt agri, atque anno poft alio tranfire cogunt." *Bell. Gall. c.* 21. " Agri pro numero cultorum, ab univerfis per vicos occupantur, " quos mox inter fe fecundum dignationem partiuntur." *Mor. Germ.* 26.

confiderable degree of coercion muft be exercifed by a leader, in a warlike expedition that continues for any length of time, and the natural privilege of diftributing the booty, and the mere fplendor of precedence, muft augment greatly his influence.

THESE remarks, I flatter myfelf, will fufficiently point out my idea of the general ftructure of the German governments. Men, ftill cherifhing the independence of the favage ftate, were forced to take meafures for the defence of their rifing property. That property occafioned wars, and wars introduced confederacies, military arrangements, and fome degree of fubordination. This fubordination, however, did not deprive the minute tribes, of which the confederacies ultimately confifted, of their internal powers. A petty chief, with his tribe, formed by intermarriages into a clan, which claimed a common blood, were like the an-cient φρατριαι of Attica, or tribules of Italy ; fo many communi-ties, poffeffed of judicative, legiflative and executive powers, within themfelves, fimilar to thofe exercifed by the national confederacy. In this way, the form of fociety was nearly inde-ftructible ; and even thofe revolutions which wars occafion would probably contribute to preferve it. When a nation proved unfortunate, its parts coalefced under a different name, and the country was as formidable and warlike as before. Thus we find, in TACITUS, the names of nations which afterwards diftin-guifhed the conquerors of the empire. But, in his time, they, in general, were the names of only remote and inconfiderable ftates, which arofe not to confequence till the confederacies, that were then predominant, had given way in the courfe of contend-ing with the Roman arms. And again it feems reafonable to con-jecture, that this warfare was the principal caufe of preferving in vigour, during fo many centuries, the fpirit of emigration and conqueft in Germany. By difcouraging agriculture, it retained the Germans in the paftoral life, and, of confequence, cherifhed in them the inclination, as well as fupplied the means for great enterprifes. Hence thofe extenfive confederacies, fo

essential

effential to fuch enterprifes, and efpecially to wars carried on by barbarous tribes againft the Roman legions, remained in full energy; and that progrefs in the arts of induftry was prevented, which otherwife, in the courfe of a few centuries, would naturally have transformed every pagus into a little republic, and its ardent and active affociations with its neighbours, into the cold alliances of agricultural ftates.

THE foregoing idea of the general form of the government of the Germans is ftrongly confirmed by what we know of the ancient conftitution of Sweden and Iceland. Iceland was peopled by a feries of Norwegian colonies, who fled their country, on the conqueft of it by HAROLD *with the beautiful hair*, in *A. D.* 878. The colonies formed little communities with elective chiefs. Thefe, by degrees, combined together, and held affemblies, under a common leader, in each of the four great provinces into which the ridges of mount Hecla divide the ifland: And, at laft, thefe four provinces likewife confederated, and formed a republic, under one chief magiftrate, in *A. D.* 928. The whole country was arranged into regular divifions, called provinces, hundreds, and reeps. The magiftrates held their offices for life. At the diets, whether of the diftricts or of the nation, the magiftrate celebrated religious rites; and it is, in particular, mentioned, that the lagman, or chief of the nation, performed human facrifices at the alting, or great annual affembly. In it too, befides the arrangement of political matters, appeals were received from the provincial courts, and rejudged in its prefence, and under its infpection, by the former judges; and the lagman's bufinefs was to carry into execution what the alting ordered. The judges of each diftrict were called repftiorar; and chofen, by the diet, among the wealthieft and moft refpectable of its members.*. There was a fucceffion of thirty-eight lagmans, which continued till 1262, when the republic

was

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* THESE probably correfponded to the fcabini and red. boran, or. lawmen of the Franks and Saxons.

was deftroyed by the Danes. I have taken this account from the Icelandic hiftorian Arngrimus Jonas, a native of the ifland, and a perfon who appears to have had abundance of authentic materials for his work.

The Swedifh government feems to have arifen in the fame manner as that of Iceland, without the intervention of foreign conqueft, or any very violent domeftic revolution. The moft ancient written law in Sweden is thought to be about as old as the period of Charlemagne. Each province had its own peculiar laws, which were collected fucceffively into different codes, and, though not entirely the fame, refembled each other extremely. Shernhook fays, that the original courts of juftice were the provincial affemblies or lagmanfting, but that, in procefs of time, the provinces were divided into hæredas or trientes, and thefe again into fierdings or quadrantes. He fays, the hæredas derived their name *from yielding a certain number of military forces.* In the province of Upland, they were termed hundreds, and the chiefs hundreders ; for each diftrict, whether hæreda or fierding, had chiefs *. The chief of the province was called lagman, which he tranflates legumvir, and was fupreme magiftrate, in both civil and religious affairs, as long as the provinces remained independent. The lagmanfting judged appeals, and punifhed the chiefs and judges of hæredas and fierdings, who judged corruptly, or refufed juftice ; and groundlefs appellants were likewife punifhed. After the provinces confederated, a common chief, or king, arofe, and a national diet, called the landfting, was annually held. The lagmans and the dignified clergy, after the nation became Chriftian, formed the fenate in this affembly. The people at firft chofe the lagmans. After the rife of a king, it appears from the ancient laws, that he had a right to felect the lagmans out of leets, prefented to him by the people of the refpective diftricts. In fome provinces, however, the lagman had rendered his office hereditary, had affumed

* This is precifely the arrangement of Denmark.

fumed the title of duke, and had ufually named a deputy, who
had the title of lagman. But GUSTAVUS ERICSON deprived
both the people and the dukes of their privileges in this parti-
cular; and, of confequence, the lagmans ceafed to form the fe-
nate of the national diet. " Ut enim ex judicibus his, (fo
" SHERNHOOK terms the lagman), olim fenatores, ita hodie ex
" fenatoribus his, judices provinciales conftituuntur."

I SHALL not detain the Society with pointing out the perfect
coincidence between the general ftructure of the ancient Swedifh
and Icelandic conftitution, and that which I have attributed to
the Aborigines in Germany; nor, after what is ftated in the
introduction to this paper, do I think it neceffary to make any
remarks to fhow, that I am entitled to avail myfelf of the re-
femblance in fupport of my opinion *.

INDEPENDENTLY, however, of the general form of the Ger-
man governments, there were fome circumftances in the nation-
al manners, which, though not immediately entering into the
ftructure of the conftitution, demand particular attention, be-
caufe they contained fources of future revolutions. In the
ftate of favages, or when men fubfift on fpontaneous produce,
the political union hardly exercifes any control over individuals.
Nothing is more common than for a fingle perfon to pro-
pofe to his tribe to make war; and, though the tribe re-
ject the meafure, to perfift and go to war, either by himfelf, or
with the affiftance of a few that relifh his propofal. After-
wards, when farms and herds are known, men ftill retain the
right of avenging their own wrongs; and their new poffeffions
are a fort of dominions, which they rule with a fpecies of that

d independent

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* WHAT we know of the rude governments of the Welfh, Irifh, Danes, and Caledo-
nians, correfponds with the idea of that of the Germans, given in the text. Every
where the clans chofe their chiefs from particular races, and confederated clans chofe
their *reguli* and *fubreguli* in the fame manner. L. L. WALLIÆ, 164. and 184. Tractat.
varii de Reg. Dan. WARE's antiquities of Ireland. LESLIE, BUCHANAN, *paffim*. The
tanift was chofen in the lifetime of the chief, and fucceeded him at his death. Even
at this day the Scots clans conceive they are entitled to change their chief, if he act dif-
gracefully.

independent fovereignty, with which, in the favage ftate, they governed their own conduct. The jus vitæ et necis, competent to the Germans over wives, children and flaves, is mentioned by TACITUS. And we find, after the conqueft of the Roman provinces, the rights of making war and levying troops every where recognifed, as one of the powers of the private proprietor. It has been thought, that this right of waging war was a privilege ufurped by the feudal nobles; but a further enquiry has fully proved, that it was an inheritance tranfmitted down to them from the origin of the nation. And, in fact, it was not an inheritance which had been preferved by them entire; for, either from apprehenfion of the end of the world approaching, or other caufes of more fteady operation, they had gradually fubmitted it to various reftrictions; and, in particular, that they fhould only ufe it in revenge for perfonal injuries, and not on account of property or intereft*. I have marked below, abundant evidence of this right of making war †; but I cannot forbear mentioning, in particular, that ARNGRIMUS JONAS tells us of a ftranger that acquired vaft eftates to himfelf in Iceland, during the fubfiftence of the Icelandic republic, by a fort of right of conqueft, refulting from his victories in wars with individuals ‡.

In a ftate of fociety where men retained fuch a degree of independence, it is manifeft, that, in proportion as property became

<div style="text-align:right">came</div>

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* BEAUMANOIR coutume de Clermont, cap. 59.

† Ordenamiento de Alcala, tit. 29. HURBERTS Statuta Poloniæ, *voce* Guerra, p. 190. L L. Alfred. § 28. L L. Jnæ, § 9. L L. Edin. § 1. BOUQUET Droit public, p. 312. and 447. L L S. Steph. r. Reg. Hungar. cap. 33. Codes of the Barbarians, *paffim.* where family wars are fuppofed. L L. Roberti i. c. 20. Eftablifhments de St LOUIS, et Ordinances des ROIS de France, *paffim.* But, efpecially, BEAUMANOIR, loc. cit. where he enters into a full detail about it.

‡ In COOK's laft voyage, the following cuftom among the iflanders of the Pacific ocean is mentioned: "If a perfon kill another in a quarrel, the friends of the deceafed "affemble and engage the furvivor and his adherents. If they conquer, they take pof-"feffion of the houfe, lands and goods of the other party; but, if conquered, the reverfe "takes place." *Vol.* ii. *p.* 173.

came confiderable, it would be employed as means to gain power and protection. It is remarked by travellers, that all favage nations are hofpitable, fond of interchanging prefents, and of public feafting ; but, among them, fuch indulgences are practifed merely on account of the pleafure they afford, whereas the introduction of wealth in the fources of fubfiftence produces a variety of interefts formerly unknown, and hofpitality is practifed, and prefents beftowed, as the means of procuring fecurity, diftinction, or power. Hence among the Germans, every wealthy perfon had his retainers that frequented his table, and received from him protection, and various favours, in return for their aid, and for the prefents they gave him. The chiefs, in particular, whofe hofpitality was fupported by prefents from the whole members of their tribes, naturally ftrove to diftinguifh themfelves by their followers, and to attract around them the enterprifing youths of the firft families in the ftate. Tacitus * makes particular mention of this inftitution, and terms the retainers comites, probably a literal tranflation of the German *leuch* or *leude*. Authors have very frequently confounded thefe with the principes vicorum et pagorum which, in the preceding chapter, he diftinguifhes by the fame name of comites ; and where perhaps they have not confounded them, they have never, as far as I recollect, pointed out clearly the diftinction between them. No two orders of men, however, could be more different ; and the defcription of both is fo accurate, that there feems to be no room for miftake. The chiefs of diftricts were elders, were civil magiftrates, were military leaders, the heads of the nation, and the natural counfellors both of prince and people †, refpectable by their experience, gravity and authority. But the retainers of the king were young men, his guards, his own perfonal partizans, fupported by his munificence, courters of his favour, expectants of promotion from it, and fworn to maintain his

d 2   glory,

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* Cap. 13.   † Kolben of the Hottentots.

glory, and defend his person, at the expence even of their life *.
After mentioning, that the young men were solemnly intro-
duced into the diets, and there armed, TACITUS obferves in
fubftance †, that it was no fhame to be numbered among the
retainers of a great man. Diftinction and power confifted in be-
ing always furrounded with a circle of chofen youths. They
were an ornament in peace, and in war a fafeguard. It was a
matter of great emulation among the chiefs, which fhould have
the braveft and moft numerous retainers. The fame, merely
of a fuperiority in this refpect, was often decifive of a war.
It was alfo a matter of emulation among the retainers, which
fhould be firft in favour with his chief; for there were diffe-
rent ranks among them according to that favour ‡. Their fer-
vice was proportionably zealous. To have furvived their chief
in battle was an indelible difgrace. Their moft facred obliga-
tion

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* I WILL not, however, prefume to determine, that, even fo early as TACITUS, the
principes vicorum may not, in general, have been retainers of the kings. It would,
no doubt, be a natural object of policy for the kings to extend their influence, by efta-
blifhing a domeftic relation between them and the fons of the chiefs of tribes; and thefe,
when promoted to be chiefs, might, though abfent, preferve their claim to this relation,
while younger men, or perfons of lefs confequence, would attend in the royal houfehold.

† NEC rubor inter comites afpici. Gradus quinetiam et ipfe comitatus habet, judicio
ejus, quem fectantur: Magnaque et comitum emulatio, quibus primus apud principem
fuum locus; et principum, cui plurimi et acerrimi comites. Hæc dignitas, hæ vires,
magno femper electorum juvenum globo circumdari, in pace decus, in bello præfidium.
Nec folum in fua gente cuique, fed apud finitimas quoque civitates id nomen, ea gloria
eft, fi numero ac virtute comitatus emineat: Expetuntur enim legationibus, et muneri-
bus ornantur, et ipfa plerumque fama bella profligant. Cum ventum in aciem, turpe
principi virtute vinci; turpe comitatui, virtutem principis non adæquare. Jam vero in-
fame in omnem vitam ac probrofum, fuperftitem principi fuo ex acie receffiffe. Illum de-
fendere, tueri, fua quoque fortia facta gloriæ ejus adfignare, præcipuum facramentum eft.
Magnumque comitatum non nifi vi belloque tuere: Exigunt enim principis fui liberali-
tate illum bellatorem equum illam cruentam victricemque frameam. Nam epulæ, et
quamquam incompti, largi tamen apparatus pro ftipendio cedunt. Materia munificentiæ
per bella et raptus. Nec arare terram, aut expectare annum, tam facile perfuaferis,
quam vocare hoftes et vulnera mereri: Pigrum quinimmo et iners videtur fudore adqui-
rere, quod poffis fanguine parare. *De Mor. Germ. c.* 13. 14.

‡ Somewhat probably like thofe of DAVID's mighty men.

tion was to defend him, and to promote his glory. War was, however, effential to retain them. The battle-horfe, the victorious fpear, were prefents that they expected, and a plentiful and open board was the wages of their fervice. But it was to war alone that recourfe could be had for the means of this munificence; for war, and not labour, fuited the national temper, and furnifhed a neceffary occupation to a numerous youth, averfe to induftry, and fond of adventure.

Such a body poffeffed the fame refemblance to the chiefs of pagi, that the celeres and ιππεις of the Roman and Lacedemonian kings bore to the fenators of Rome and Sparta. Diony-sius, after defcribing the celeres, gives the following account of the ιππεις, which may be properly enough fubjoined to Ta-citus's picture of the German leuchs: " Παρ εκεινοις (τοις Λακεδαιμο-" νιοις) οι γενναιοτατοι των νεων φυλακες ησαν των βασιλεων. Οις εχρωντο κατα τας " πολεμας παρασπισταις, ιππευσι τε εισι η πεζοις." *Dionyf. Halic. Rom. Antiq. lib.* 2.

PART I.

Section II. *Of the Opinions, that the feudal Tenures and feudal Nobility commenced in ancient Germany.*

IT will naturally be expected, that, before proceeding to trace the government of the Germans after their eftablifhment in the empire, I fhould take notice of certain opinions, entertained by authors of eminence, which are extremely adverfe to the foregoing account of its original ftructure. It has been very generally thought, that, immediately upon the conqueft, the governments became feudal; and M. de Montesquieu, and many others, hold, that the feudal fubordination, and that hereditary nobility which made fo diftinguifhed a figure under

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the predominancy of the feus, actually subsisted in the woods of Germany *. Accordingly, this opinion has been urged in behalf of the system which exhibits the European governments as originally aristocratical, and is indeed so obviously allied with it, that it is certainly here necessary to consider a little the evidence on which it rests.

I. THE arguments for this extreme antiquity of the feus are founded, either on particular facts with respect to the peculiar manners of the Germanic nations, or on a general theory of the powers of the chiefs of rude tribes. The arguments of the former class, I must confess, appear to me to rest on very insufficient grounds. M. DE MONTESQUIEU traced the feudal tenures, in the presents of the war-horse, or of the bloody spear, and in the feasts which the German chiefs gave to their retainers in return for military service. But the Abbé de MABLY has justly observed, that, in the same way, the present European armies might be termed feudal vassals, holding their pay as a fief on condition of their service.

Dr STUART †, after very properly remarking, that territories are appropriated by communities, long before separate estates in land are acquired by individuals, lays it down, that the feudal relation of lands commenced in the subordination of the domains of the weaker communities to those of the stronger. He accordingly traces the origin of fiefs, in the dependent state of certain of the German and Gaulic tribes on others; and he confirms his hypothesis by the Cimbri, in the times of MARIUS, having demanded lands from the Romans, and offering, in re-

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* I OUGHT likewise, perhaps, to take notice of the absolute sovereignty which has been attributed to the German kings, and of a representation, like that of the commons, supposed to have been known to the German tribes. But, I believe, these notions have never obtained much credit with the learned world, nor have been thought by it to rest on any thing more solid than the delusion of system.

† Dissertation on the English constitution, View of society in Europe, and other works.

turn, to affift them in their wars. But, in every age, nations
find it expedient to arrange themfelves under the protection of
their more powerful neighbours ; and where an alliance on
equal terms is not to be obtained, the protection muft be paid
for by a tribute in money, or a contingent of troops, to be em-
ployed in executing the meafures of the more powerful ftate.
If fuch a ftipulation is to be accounted a feudal contract, Athens
and Lacedemon were the feudal lords of Greece, and Rome the
feudal lord of half the known world. If there were any evi-
dence, that alliances of this fort had been formed by a fur-
render of the territory of the protected to the dominion of the
protector, or that territories were conceived to have been pledg-
ed in fecurity of thefe treaties, then, no doubt, a ftriking re-
femblance between them and the feudal relation of modern
times would be eftablifhed. But no fuch evidence has been pro-
duced ; and the fluctuating ftate of thefe alliances in Gaul, and
the little progrefs the Germans had made in municipal law, can
leave no doubt, that they were confidered as merely perfonal
contracts, and, in truth, poffeffed neither the folidity of a real
vaffalage, nor any connection with the fubtile diftinction be-
tween the dominium directum and dominium utile of land.*.

Mr MILLAR has treated, with much ingenuity, the argu-
ment founded on the natural progrefs of rude nations †. He
fuppofes, that the chief will naturally, at the feparation of
farms, have very large domains affigned him, great part of which
he will employ in creating eftates *at will* for his retainers, who,
in return for this precarious poffeffion, muft labour or fight for
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* CÆSAR relates, *lib. 6. c. 11. de Bell. Gall.* That the Sequani and Ædui were the
heads of factions in Gaul. The Sequani, by the aid of the Germans, fo got the better of
the Ædui, " ut magnam partem clientium ab Æduis ad fe tranfducerent obfidefque, ab
" iis principum filios acciperint, et publice jurare cogerent, *Nihil fe contra Sequanos*
" *concilii moturos, et partem finitime agri per vim occupatam poffiderunt.*" Things changed
after CÆSAR's arrival. The Ædui recovered their old clients, and they, and CÆSAR's
other friends, the Remi, obtained many new ones.

† Origin of Ranks, p. 194. and 260.

him when he requires them. And, on this ground, and on the power thence conferred, and on the gradual furrender thus occafioned, of the eftates of fmall proprietors, in confideration of protection, he explains the rife of a feudal relation in many diftant countries, and that right of property and inheritance over their dominions, which travellers have afcribed to feveral kings in Africa and the eaft *, as Benin, Congo, &c.

I HAVE not, however, been able to difcover any example of the retainers of the chief of a rude tribe holding lands from him in this manner. The lots of the Roman clients were as much their own as the larger eftates of their patrons were theirs. The Italian equites received a war-horfe and a ring, which may probably, at firft, have been marks of royal favour, but we do not hear of ufufructuary eftates being allotted for them. Befides, we may be very certain, that, long after farms are feparately cultivated, land is in great abundance, and to be got for the occupying. To prefent, therefore, in fuch times, a retainer with uncultivated land would be no favour; and as to lands which

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* IN the quarto edition, Mr MILLAR ftated this doctrine more ftrongly. He there lays it down, that the chief, in confequence of his ancient prerogative of prefiding over the joint labours of the community, will, at the feparation of farms, impofe fuch conditions and limitations on the fhares of individuals, as render them dependent on him for the continuance of their poffeffion: And that, in this way, and by the extent of his peculiar domains, his authority becomes almoft unlimited. It is evident, that, if this opinion were well founded, the government of all fmall and rude communities of hufbandmen would be defpotic, which is certainly not the cafe. And, accordingly, the argument on which it refts, though ingenious, admits of being obviated. The chief arranges the annual farms of rude tribes, and poffibly, too, may prefide over the labour of the tribe, if employed on a common farm; but, as may be reafonably conjectured from the independent fpirit of uncultivated men, and, as is proved by the fales of lands by the American tribes, the chief is not, on that account, reckoned the proprietor of their territory. That, like the fpontaneous produce of it, is accounted the common right of the whole freemen. And afterwards, when the annual farm becomes perpetual, or portions of land are feized upon by individuals, land is ftill in fuch vaft abundance, that the fpots, thus occupied, are naturally confidered as the right of the poffeffor, as abfolutely as the crop which he formerly reaped from his annual farm, or the prey which he feized in the fports of the field. Accordingly, we do not find, that, in any of the original monarchies of Greece, Italy and Gaul, the kings were ever confidered as the proprietors of their dominions.

which a petty chief had flaves to cultivate, he would always find it prudent to retain the whole produce of them; becaufe, if beftowed in hofpitality, it would procure him much greater influence, than if the poffeffions, which yielded it, were diftributed among a few individuals. Afterwards, again, when the greater part of the foil is appropriated by individuals, the diftricts which remain uncultivated are commons, over which the neighbouring inhabitants have eftablifhed rights of fervitude, and cannot be touched by a chief, till government is armed with all its powers *. Forfeitures and conquefts are the true fource of the overgrown domains of princes; and, where the latter have not happened, the former are fcarcely able to compenfate thofe difmemberments, which provifions for younger branches of the royal family neceffarily occafion †.

WITH regard to the powers of certain African and Afiatic kings, and the circumftances of refemblance, obferved by travellers, between the ftate of property in their dominions and the feudal arrangements of it in Europe, I fhall only remark, that there are many particulars, connected with the feudal fyftem, which are not characteriftic of it; and, therefore, though difcovered elfewhere, will not juftify the inference that they refulted from feudal inftitutions. Thus, in many countries, armies are paid in lands; in many, every proprietor yields military fervice; and, in many, the opulent acquire confequence by means of clients and retainers. But the fingular and diftinguifhing circumftance from which the feudal law acquired its character, and to which its more remarkable effects are to be afcribed, (fuch as, patrimonial magiftracies, titles of honour, fcale of fubordination, and all

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* IN Sweden, the king is vefted with the diftricts which were formerly the common domains of communities. But no fingle community would beftow fuch a gift on its chief; whereas, where there is a number united under a king, every one may be prevailed upon to give up its own, in order to get government fupported, by means of fimilar conceffions from the reft.

† EVEN confifcation for capital crimes feems to have been unknown to the Romans before the Lex Cornel. de profcrip. CICERO pro domo. Breach of fidelity was capital in both patron and client, but furely was not attended with forfeiture of eftates.

thofe various fhackles, by which it feparated ranks, and rendered governments at once feeble and indiffoluble) appears to be peculiar to Europe. I believe the nations of this continent alone afford an example of the relation of patron and client being made *real;* or, in other words, the patrimonial interefts of both parties in a land eftate rendered dependent on their fidelity in fulfilling its duties *.

II. THE feudal nobility make fo confpicuous a figure in the hiftory of the middle ages, that it is nowife furprifing authors fhould have judged, that the German conquerors were originally fubject to an ariftocracy, which afterwards became the rulers of their new eftablifhments. Accordingly, Mr HUME has held, that the principal proprietors of land were, without any election, the conftituent members of the legiflative affemblies of the Anglo-faxons. Moft authors of eminence that treat of the feudal inftitutions have reafoned on the fuppofition, that there was an order of nobles which enjoyed the firft rank of fociety among the German nations, at the period of their emigration. And M. DE MONTES-QUIEU has fpecified the leudes or fidels (appellations which he confiders as fynonimous) as forming this order, and enjoying the exclufive capacity of being eligible to offices, and of receiving from the crown ufufructuary grants of land, (called fifcs or benefices) on condition of military fervice. And while he confiders the leudes as the fame with thofe perfonal friends and retainers of the kings, termed comites by TACITUS, (an opinion which is now, I believe, univerfally admitted to be juft) he reprefents them as a *nobleffe d'origine* or patrician order, in which the antruftions, or thofe leudes who attended more particularly on the court, formed the firft clafs. He quotes expreffions, employed in the codes

* I AM befides apt, in the prefent cafe, to believe, that the hiftorical facts reforted to have been mifunderftood. Hiftoire générale des voyages, t. 6. p. 28. Ibid, p. 255. 263. 265. 264. 321. 318. The governments on the Gold Coaft are obviously the production of conqueft and fuperftition, and the nobles appear to be very independent, and to be proprietors of their eftates.

codes of the Barbarians, or other ancient works, as evidence of his opinion; and he confirms it, by attempting to fhow its fit-nefs to explain circumftances in the hiftory of the Franks. I fhall, with due refpect, ftate a different opinion, confider the evidence that ftands againft it, and fupport it by evidence which appears to me conclufive in its favour.

If the Germans were diftributed into clans, as the terms *cognationes, gentes, familiæ, et propinquitates,* ufed by Cæsar and Tacitus as defcriptive of their arrangements, clearly import, and as the laws in their codes, with refpect to family feuds, prove, I think we may be certain, that no fuperior clafs of men, feparated in blood from other freemen, was recognifed among them. A clan always efteems itfelf of the blood of its chief. He is no more than the elder branch of a family, from which the mean-eft of his followers, as well as himfelf, are vain of deriving their defcent. He owes their attachment to this prejudice; and he knows too well the value of it, and how much his influ-ence depends on the ftrength of it, to attempt weakening it, by laying claim to a diftinction from fuperiority of blood, till combinations with his equals, or the progrefs of laws, infpire him with different views.

Among the Germans, no doubt, as well as every where elfe, the virtues and eminence of the parents reflected luftre on their progeny. And this, I conceive, is all that we ought to under-ftand by the nobility of race, which is fo often mentioned as belonging to individuals*; though we believe, that the perfonal honour of being admitted among the domeftic companions

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* The ranks among the Ifraelites, before the captivity, illuftrate this opinion. The whole freemen of every tribe held that they were defcended of the fame blood; but each confiderable branch of a tribe had a head, and each tribe a prince or chief; and thefe elders, as they were called, being ufually chofen from particular families, formed numbers of diftinguifhed races in the nation.

It may alfo be obferved, that, in rude times, men are determined, in their marriages, more by the perfonal attractions of women than by thofe of wealth, rank, and intereft, which dictate fo powerfully in cultivated ages. Hence, as in early times, women of the higheft perfonal endowments will ufually fall to the lot of men who have attained di-
ftinction;

of the king was frequently conferred on the fons of thofe who had enjoyed it; and that the fons of the fubordinate chiefs, when candidates for the offices of their deceafed fathers, derived great advantages from their defcent.

THE arguments which have been ufed for a *nobleffe d'origine*, neither aim at obviating the foregoing obfervations, nor reft on circumftances that have been found to bear examination. The monopoly of offices which the fidels enjoyed is evidently of no confequence, when it is underftood, that the term *fidel* was applied to every perfon that took the oath of allegiance *. The leudes were certainly, in their origin, the perfonal companions of the kings; and there is furely neither evidence nor argument for their having become a hereditary order previous to the Gothic conquefts †. The high compofitions, afterwards prefcribed for wrongs committed againft them, and ftill higher for thofe againft the upper clafs of them, called *antruftions*, were no more than confequences of their perfonal connection with the fovereign, and their refidence at court, where crimes incurred a triple penalty ‡. And the expreffions, which are frequently to be found, relative to diftinctions of rank among the freemen, inftead of vindicating the exiftence of a patrician order, do, in fact, fhow, from the loofenefs with which they are ufed, that no fuch order was recognifed in the ftate. Nothing may more fafely be depended on as evidence that orders of nobility were unknown, than the want which authors betray of precife

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ftinction; the families of chiefs will naturally, in the courfe of a few generations, acquire that marked fuperiority in character and figure, which travellers have often obferved and miftaken for an indication of an original diverfity in the race, and for the remains of ancient conquefts and intermixtures of nations.

* BOUQUET Droit publique, p. 105.

† ON the contrary, it is remarkable, that the fignification of the term feems to have been enlarged on the continent till it loft its peculiar import, and became at laft co-extenfive with that of *fidelis*. Thus we read, "Cumque Lingonas civitatem veniffet Dagobertus, tantam " in univerfis Leudibus fuis, tam fublimibus quam pauperibus juftitiam," &c. FREDEG. Chron. § 58. See alfo § 87. In this way, it probably produced the term lieges hommes; and it was no doubt natural enough for a king to call his *gens d'armes* companions.

‡ BOUQUET Droit publique, p. 103.

terms for diftinguifhing the fuperior ranks of perfons. And accordingly, we have full evidence, that even the terms expreffive of free birth and noble defcent continued to be ufed indifcriminately, low down in the feudal times *.

THIS laft circumftance, I apprehend, while it proves there was no patrician order among the conquerors, indicates alfo the origin of the genuine nobility of Europe. That nobility, as it is deftitute of all titles of office or honour, exhibits no trace of owing any part of its luftre to the favour of kings, or to ufurpations of magiftracy. But its numbers, its prerogatives, the documents of its hiftory, and its character, concur to prove, that it is the remains of nations of freemen, and derives its honours from having preferved, uncontaminated by fervile or ignoble occupations, that high fpirit which, as independent warriors, and as equals, the conquerors of Europe received pure and unadulterated from the bounty of nature.

THE ftate of perfons in thofe European nations which have been fartheft removed from innovation is entirely agreeable to this opinion. In *A. D.* 1480, about 300,000 nobles affembled in the diet of Poland. The Polifh pofpolite, or comitia paludata, is, in truth, an affembly of the freemen and warriors of the nation †. The fimple burgeffes can hardly be faid to be

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* MONTESQUIEU quotes the term *optimates,* in the Burgundian laws, as evidence of a hereditary nobility. But it might exprefs magiftrates, or antruftions, or men of wealth. Nothing can be more loofe than the manner in which terms of this kind were employed. GREGORY of Tours often applies the term *valde ingenuus* to perfons; and he feems to have no word for characterifing the defcendents of the *priores regni,* or *feniores civitatum.* Again, he fays of one of his predeceffors, " Civis Turonicus de inferioribus populi ingenuus ta-" men." In a charter of Carloman, it is faid, " Et congruum obfequium ficut homines in-" genui exhibeant, ne eorum ingenuitas, vel nobilitas vilefcat." See alfo HEINEC. Antiq. Germ. v. ii. p. 52. *et feq.* Abrégé de Henault, *ad ann.* 1270. The terms *potentes, potentiores, boni generis, nobilioris generis, de nobilioribus,* are the only means even the laws have for defcribing perfons of more confequence than others. BALUZ. p. 278. 334. *&c.* L L. Vifig. lib. 6. t. 1. c. 2. Mention is often made of the *ingenuitas regni* affembling. HOODY, p. 188. *Francs hommes* was, even in feudal times, a term fynonimous with gentlemen or nobleffe. THAUMASSIERE Notes on Affifes de Jeruf. p. 270.

† CROMER, bifhop of Warne, fays, " Eft pari dignatione Polonica nobilitas, nec eft " ulla in ea patritiorum comitumve difcrimen." And PROCHNIEKEGO fays, in his de-

as yet naturalized ; for they cannot, by law, hold property in land without the liberties of their respective towns. And as to the husbandmen, their servile condition is well known. In the same manner, in Hungary, the nobles form the nation. The maxim of the lawyers is, *Nobilitas liberorum nomine intelligitur* *. The husbandmen are servi adscriptitii. The inhabitants of towns are still considered as emancipated slaves, whose testimony is admissible against a noble only for a debt of a florin, or under, unless the case happens within the city to which they belong. Hence the assemblies of even the subdivisions of their counties consist only of nobles ; and their decanus, or tithing man, who was always accounted a simple freeman in ancient times, in France, England, and Spain, and one, by no means, of much consideration, is accordingly, at this day, in Hungary, a noble and a magistrate, exercising the very functions which the ancient laws of the western nations attributed to their magistrate of the same name.

THERE can be no doubt, likewise, that, in Sweden and Denmark, before the emancipation of adscriptitii, freemen and nobles were precisely synonimous terms. And, in truth, only the emancipated adscriptitii of the crown appear to have there obtained the full right of citizenship.

EVERY person acquainted with the documents extant of the ancient state of Europe will find, that they so clearly refer to a distribution of ranks, similar to what we have been observing, that they cannot be understood on a different supposition. I shall cite one example of this which appears to be extremely decisive. In the succeeding parts of this paper, there will be occasion to found a great deal on the following general fact †, *viz.* That, at the conquest of the western empire, the former

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scription of Poland, " Sunt in regno titulo Ducali insigniti, sed qui cum reliquis nobili-
" bus jure utuntur communi—unde tanta omnium et par libertas."

* WERBEUCS, p. 10.

† Which almost every monument of the names in question may be quoted in evidence of.

mer arrangement of the Germans into *pagi**, centuries and decenaries, immediately appeared in the Roman provinces, which were every where divided and fubdivided into diftricts, diftinguifhed by thefe or correfponding names ; and that, in each of thefe diftricts, the former fpecies of fubordination remained, *viz*. a chief, who was magiftrate in peace, and leader in war, and an affembly of the warriors of it, competent equally for deliberation and action.   The chiefs, or governors of pagi or large diftricts, were called, in the Latin of thofe times, duces, comites, gardingi, banni, vaivodæ, heretogæ, aldermanni.   The heads of fubdivifions were named after them refpectively, quingentenarii, centenarii, decani.   The higher magiftrates had deputies that affifted them in their functions. Thefe were called in Latin vicarii, and fometimes vicecomites ; but, in general, they retained the names which, in their native language, belonged to their principals. Thus they had the titles of gerefas, graffs, grieves, fcyregraffs, margraffs, thiuphads, laghmans, *&c*.

In procefs of time, the military and enterprifing fpirit of the conquerors was greatly damped, by the influence of their new fituation, and various regulations were thought of to enforce compliance with their common duty, as defenders of their acquifitions.   Among thefe, we find, in the code of the Vifigoths, called the fuerojufgo †, a law which enacts, that, if the duke, count, or warden, failed in their duty, they forfeited their goods, and were liable to punifhment ; and that, as to all inferior perfons, *viz*. thofe who called out the army, or thofe who were called out, then, " Non folum ducentis ictibus flagellorum " verberati, fed et turpi decalvatione fœdati fingulas infuper li- " bras auri cogantur exfolvere ;" and that, if they had not fubftance to defray this fine, they fhould be condemned to flavery.

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* Pagus is ufed in the ancient codes and early writers as fynonimous with civitas and comitatus. Civitas fometimes is employed for urbs, but generally in the fenfe of municipium, or of a fubordinate ftate, comprehending a town and territory. *Greg. Tur. lib. 7.* § 6. 12. 13. 33. *&c.* Cæsar, *&c.* ufes pagus in this way, feptem Helvetiorum pagi, *&c.* The French pais, and German termination gaw, are fuppofed to be derived from it.

† Lib. 9. tit. 2. l. 9.

flavery. We have it, in the fame law, fpecifically pointed out, that the perfons fubject to this punifhment were the leaders of the fubdivifions of counties, *viz.* the decani, centenarii, quingentenarii, thiuphadi, together with the fervi dominici, or under-ftewarts and fervile inhabitants of the royal domains, and all the freemen, arranged by their diftricts, whether Goths or Romans. Nor were the moft confiderable proprietors not included in this enumeration; for we find it directed, that thofe who are included in it fhould bring with them to the army the tenth part of their flaves in arms; and, in the preamble, it is complained, that people conceal their flaves, though poffeffed of multitudes employed in agriculture, and do not bring with them to the army the twentieth part of their family. On the other hand, the law not only fhows, that it was deftined to extend to every perfon, *cunctis populis regni*, but it fpecifies the majoris loci perfonæ to be the dux, comes, five etiam gardingus, all others being claffed as inferiores perfonæ, although mention is notwithftanding made of feniors leading their vaffals and commanding them in the army. Thus the circumftance, *viz.* fuperiority over vaffals, that was afterwards fo characteriftic of feudal greatnefs, was not then held to diftinguifh a perfon from the reft of the nation; but a feudal lord is claffed as a perfona inferior, and is menaced with fine, whipping, and even flavery, equally with the loweft freeman.

WE have here, therefore, a very clear defcription of the ranks of perfons, *viz.* magiftrates, freemen, and different claffes of men of fervile condition *; and we are fure, that there was no patrician order diftinct from the other freemen, for feveral reafons: 1*ft*, No clafs of perfons is mentioned which could form fuch an order; whereas, in a law framed for calling forth the

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* WE find the fame orders fpecified in the following paffage of an ancient author: " Vetus confuetudo pro lege apud Francos et Suevos inolevit, ut fi quis nobilis, minifteri- " alis, vel colonus, coram fuo judice pro hujufmodi exceffibus reus inventus fuerit, an- " tequam mortis fententia puniatur, ad confufionis fuæ ignominiam, nobilis canem, mini- " fterialis fellam, rufticus aratri rotam, de comitatu in proximum comitatum geftare co- " gatur." *Lib.* 2. *de Geft. Federic. c.* 18. See alfo *L L. Alleman. tit.* 90.

nation in arms, a nobility, belonging to a warlike people, muſt have made a diſtinguiſhed figure. 2*dly*, It is inconſiſtent with the idea of a patrician order, to comprehend them within the deſcription of perſonæ inferiores, and rank them under the low-eſt magiſtrates; yet it is manifeſt, that the enumeration in the law affords no other place for them. 3*dly*, Though the account given of the perſonæ inferiores ſhows there was no patrician order then recogniſed, that deſcription of perſons is enumerated among them, which afterwards, when the lower ranks were emancipated, and the third eſtate formed, was diſtinguiſhed as noble. This claſs, therefore, by comprehending tithing men and hundreders, which, in the eaſt of Europe, are offices held by nobles only, and alſo feudal lords and vaſſals, who, retaining the profeſſion of arms, compoſed the nobleſſe of after ages in the weſt of Europe, proves, that we have no occaſion to look farther for the origin of a patrician order, nor reaſon to ima-gine, that it is poſſible to diſcover it at the emigration from Ger-many, diſtinguiſhed, by hereditary honours, from the reſt of the conquerors. Accordingly, we find the Viſigoths enacting, that every freeman of the national blood might offer himſelf as a candidate for the crown *. We find, that family names, ſo eſſential to patrician diſtinctions, were ſcarcely known in Eu-rope till the twelfth century †. And we find, that the nobili-

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* MONTESQUIEU attributes the election of military leaders, on account of merit only, to the national adherence to the royal blood in the appointment of kings, and ſuppoſes the power of the mayors of the palace proceeded from the old cuſtom, that *duces ex virtute ſumunt*. But the monarchs who founded the European ſtates were themſelves duces, and owed their authority to that character, and not to their more hereditary one of being chiefs of petty tribes. Clovis, Alaric, Genſeric, were the Brennuſes and Arminiuſes of their times. Hence the thrones of Europe were long, *de jure*, purely elective. The ancient form of creating a king was exactly that which TACITUS deſcribes in the election of a dux; and the forms of the modern coronations are ſtill that of an election. The major palatii was originally no more than the principal domeſtic of the king. We find majores domus noſtræ mentioned in the plural number, and one quitting the office for a biſhoprick. It was the great extent and growth of the houſehold which rendered the mayors ſo powerful.

† SPELMAN, in his letters to ROSECRANTZ, ſays, He had not obſerved a *cognomen gentile* attributed to a Lombard, Frank, Saxon, or Dane, in the firſt ages after the conqueſt. Dr HICKES

ty of Europe inherit neither appellations, as a peculiar order, nor titles of honour, nor official functions, except such as they manifestly have acquired from the feudal arrangements.

IN order to prevent mistakes, it is necessary to add further, that the intermixture of nations which the conquest produced, the freedom which men of professions that appeared ignoble to the conquerors possessed, and which men of servile condition acquired, and the differences which were constantly increasing between the wealth of individuals, necessarily introduced a real diversity in the ranks of freemen. Accordingly, in the more uncultivated districts, where the tribes or clans of the predominant nations retained, for some time, their genealogies, such tribes arrogated a degree of superiority; and, in the richer countries, though the clans soon disappeared, wealth and descent not only produced such distinctions as we know arise from them in civilized times, (distinctions then attended with no absolute separation of ranks) but, by means of the vast influence which the imperfection of law suffers them to usurp, introduced into the structure of society, and even into the codes of political institutions, a manifest tendency to the construction of that patrician order and aristocratic authority, which, during the feudal ages, nearly monopolised the sovereignty of the European nations *.

HICKES thinks, that the practice of using two names came to prevail in England in the Norman times; and that, during the crusades, the cognomen became a nomen gentile. *Dissert. p.* 29.

* THE Bavarian laws enact, that, in case of blows given in a tumult or meeting, the offender should pay a fine, " unicuique secundum suam genealogiam." And, in case of a sedition, while the principal persons engaged in it (called, however, simply homines) incurred a fine of 200 solidi, the populi minores and liberi paid only 40 solidi. *Tit.* 2. *c.* 3. and 4. And, in *c.* 20. five genealogies are mentioned which are entitled to a double fine; and the Agilolfingi, from among whom the duke was chosen, had right to a quadruple fine. In *A. D.* 797, the nobiliores paid, for disobeying a summons, four solidi, while the ingenui paid two, and the liti one. BALUZ. *p.* 278. By *L L. Visig. lib.* 6. *tit.* 1. nobiles potentioresque personæ, ut primates palatii, eorumque filii, were not to be exposed to torment, on account of an accusation of theft, *&c.*; and a persona inferior was forbid to accuse nobiliorem se vel potentiorem.

II.

II. *A* Dissertation *to prove that* Troy *was not taken by the* Greeks. *By* John Maclaurin, *Esq; Advocate, and* F. R. S. Edin.

[*Read by the Author, Feb. 16. 1784.*]

Non anni domuere decem, non mille carinæ. Virg.

IT cannot well be difputed, that, till the Greeks were poffeffed of the art of writing, they could have nothing that deferved the name of hiftory. When that art was introduced among them is uncertain; but there is reafon to believe, it was not known to them at the time of the Trojan war, as there is no mention of any writing in all the works of Homer; for the tablets, of which he fpeaks in one paffage, did not contain any writing, but only marks or figns *. At any rate, it cannot be fuppofed, that writing was much known or practifed, at that time, or indeed for long after. It appears from many charters, and other deeds, in this country, that men of the firft families and fortunes in it could not, a few centuries ago, write their

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names;

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* Iliad. vi. 168. So Eustathius fays exprefsly; and the reafon he affigns, is, that letters were the invention of later times. He might have added, that it appears from feveral other paffages in Homer, that with him γραφειν does not fignify *to write*, but *to trace* or *mark*; nor σημα *a letter*, but *a mark*, or *fign*, or *credential*. Iliad vii. 175. 187. 188. 189.; and Odyff. xxiv. 328. And σημα has unqueftionably this fignification in xxiii. 206. In this paffage refpecting *Bellerophon*, had Madam Dacier and Mr Pope adverted to this, they would not have tranflated this paffage as they have done. Πορε δε οι σημαία λυγρα, clearly means, that he gave him a token or credential that was meant to be deftructive to him; and γραψας θυμοφθορα πολλα, that he traced in thefe folded tables many marks or figns, that gave to underftand he was defirous of his death. There is, likewife, no mention of writing in the Æneid; which fhews, that Virgil thought it the invention of later times.

names; yet it is clear, from our having the use of coined money in commerce, and of cavalry in war, as well as from several other circumstances, that we were more civilized in those days than the Greeks could pretend to be when they first invaded Asia.

THOSE, therefore, of the Greek writers who chose to relate ancient events might shape their stories as they pleased. There could be nothing to contradict them, but a vague and confused tradition, (if there was so much) which, it is plain, would, at no time, be much regarded, and would soon be forgot or disbelieved, if the accounts of these writers were more flattering or favourable to their countrymen. Indeed, the Greeks seem all along to have had a natural inclination to pervert and falsify facts, and this drew upon them the severest reproaches from the lovers of truth.

———— *Quicquid Græcia mendax*
Audet in historia.

IT may, perhaps, be said, that this is no more than the assertion of a Roman satirist, which ought not to be listened to. But it is easy to support JUVENAL's testimony by that of some of the most judicious Greek writers themselves. DIODORUS SICULUS informs us, that the ancient historians contradicted one another so much, that those of later times, who felt they had talents for writing history, abandoned all remote, and betook themselves to recent periods; and THUCYDIDES shews, that not only with regard to ancient, but even as to recent events, the Greeks, his contemporaries, were very ill informed. In his introduction, he expresses himself as follows: " It is " very difficult to find out the truth as to ancient affairs; for " men content themselves with reports as to past events, with- " out being at the trouble to examine them, even though they " relate to their own country." And he refers for proof, to the

celebrated

celebrated ftory of Harmodius and Aristogiton. Of this he gives the detail in his fixth book; " Becaufe neither the " Athenians, or others, knew who was the tyrant at the time, " or what was the real fact that happened." Poems had been compofed, and ftatues erected, in honour of thofe men, as being the champions of liberty, and the deliverers of their country, by a bold ftroke, in putting its tyrant to death; but it appears, from the narrative of Thucydides, that all this was undeferved, and proceeded from a grofs miftake; for they did not kill Hippias, who was the tyrant, but his brother Hipparchus; and him, not from a love of their country, or hatred of tyranny, but from very unworthy motives, which it would be indelicate to explain *.

If the Athenians, the moft enlightened people of Greece, could be fo mifled as to an event which happened but eighty-two years before the Peloponnefian war, what liberties might not Homer take, in relating the circumftances of an expedition which preceded, by many centuries, the age in which he lived, and as to which, in all probability, there was no record or writing whatever?

It is, indeed, fuppofed by the author of the life of Homer, commonly afcribed to Herodotus, that he was only 168 years later than the Trojan war; but, from what Thucydides fays, it fhould feem that he thought he was long pofterior † to it; and that, in fact, he was fo, is apparent from feveral paffages in his works. In one place, he fays, that Diomede lifted, brandifhed, and threw a ftone, which two men, fuch as men are now-a-days, would not be able to carry; and, in another, that Hector lifted, brandifhed, and threw a ftone, which two men, fuch as men are now-a-days, would not be able to heave from the ground into a cart; but fo great a degeneracy could not have

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* It took its rife from παιδεραςια. Thucydides fays Aristogiton ειχεν αυτον.

† Πολυ υςερον.

have happened in a century and a half. Besides, that he wrote from *report*, and knew nothing certain, he himself declares, in his address to the Muses, with which he introduces the catalogue of the Grecian ships and forces; which implies, that he was not only very long posterior to the event he chose for his subject, but that there was no record or history of it extant when he wrote.

MANY proofs might be brought of HOMER's story being generally disbelieved or doubted of among the ancients. A few shall be mentioned: And, first, I refer to the history of HELEN's birth. LÆDA, the wife of TYNDARUS, was delivered (it is said) of two eggs, in one of which were POLLUX and HELEN, in the other CASTOR and CLYTEMNESTRA. The former being the offspring of JUPITER, metamorphosed into a swan, were immortal; the latter, coming from TYNDARUS, subject to dissolution. And, it is added, that, when CASTOR drew near his end, his brother begged of the gods that he might be exempted from death as well as himself. This, it seems, could not be altogether complied with; but, to gratify him as far as fate would permit, it was decreed that they should live and die by turns. This is evidently an allegory, and generally thought to be an astronomical one. Now, if HELEN was not a real, but an allegorical personage, what becomes of the Trojan war?

THE story of the egg is not to be found in HOMER; but the alternate life and death of CASTOR and POLLUX is mentioned in the Odyssey *, though not consistent with a passage in the Iliad, to be afterwards quoted, which declares them both dead. Madame DACIER, in a note on this passage of the Iliad, says, that the fable of CASTOR and POLLUX was posterior to HOMER; but the passage of the Odyssey, just now referred to, proves the contrary. HORACE seems to have thought, that the whole had been invented before HOMER's time, as he commends him for not having begun with the egg:

Nec gemino Trojanum bellum orditur ab ovo.

But

* xi. 302.

But there would have been no place for the compliment, if he could not have committed the fault. Be this as it may, the allegory is certainly of a very ancient date, and proves, that the authors of it did not believe HOMER's account of the Trojan war. Indeed, it goes further: It proves, they did not believe there had been a Trojan war at all; in support of which opinion, much may be said and has been said *.

2dly, IT is clear that HERODOTUS disbelieved, or very much doubted the Greek account of the Trojan war.—That very intelligent and inquisitive historian informs us †, That he asked the Egyptian priests, whether what the Greeks alleged to have happened at Troy was *a foolish story* ‡? And he says they told him, that PARIS and HELEN, in their passage from Sparta to Troy, were overtaken by a storm, which drove them to Egypt, where some of their servants having disclosed the crime they had committed, PROTEUS, who then reigned at Memphis, seized and detained their persons, and the effects which they had brought with them: That when the Greeks came before Troy, and demanded back HELEN and her effects, the Trojans answered, that they had neither, both being in Egypt; but the Greeks, not believing this, besieged the town, and took it; and then MENELAUS, finding that what they had said was true, proceeded to Egypt, where his wife and goods were restored to him. HERODOTUS then quotes several passages of the Iliad to prove, that HOMER knew HELEN was not in Troy, but in Egypt, and had perverted the fact for the sake of his poetry. He adds, that he, too, subscribes to what was said with regard to HELEN's not being in Troy, for this reason, that it was impossible to believe PRIAM so devoid of understanding, as that he would have

expofed

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* See PERNETY's Fables Egyptiennes et Grecques devoilées, tom. ii. And that the history of the Trojan war was no more than an allegory is taken for granted by GEBELIN DE LA COUR, in his Monde Primitif, ii. 400.; and by BRYANT, in his Mythology.

† Lib. 2. ‡ Ματαιος λογος.

expofed his kingdom to deftruction for a woman, if he had had her to deliver up.

THIS is a very curious paffage. It proves clearly, that HE- RODOTUS, before he converfed with the Egyptian priefts, doubted extremely of the account given by the Greeks of the Trojan war. He feems, however, to have altered his opinion, in con- fequence of what they told him MENELAUS had reported when he came to Egypt. That account, if true, removed, no doubt, the chief difficulty he had, which was, the incredibility of PRIAM's refufal to reftore HELEN, when demanded by the Greeks ; but, if he had reflected a little, he muft have been fa- tisfied, that it could not be true that HELEN was not in Troy during the fiege. If fhe had not been there, it is impoffible to believe that the Greeks would not have difcovered this in lefs than ten years. They muft very foon have come at the fact. When they did, they would have retired, if the recovery of her and her effects was the object of the war. Or, fuppofing that the hope of plunder would have made them continue it, yet MENELAUS furely would have gone for her to Egypt him- felf, or, at leaft, fent fome perfon thither to enquire about her. Indeed, the affertion of the Trojans was, of itfelf, fufficient to have induced him to take that trouble. This has been remark- ed by RICCIUS*, who juftly maintains, that HOMER's ftory as to this point is the more credible of the two : " Quis vero non " videat, magis præ fe ferre fpeciem fabulæ id quod narrabant " facerdotes, quam quod habet HOMERUS; eftne, quæfo, veri- " fimile in ea ambiguitate perdurare voluiffe Græcos decem " annos ? Cum recipiendæ HELENÆ tam effet cupidus MENE- " LAUS, non mitteret ftatim aliquos in Ægyptum qui exquire- " rent, an vere apud PROTEUM illa detineretur ? Non id om- " nino faciendum cenferent frater AGAMEMNON fupremus co- " piarum imperator, NESTOR aliique duces ? Quæ major abfur- " ditas, quæ infignior imprudentia, quæ craffior ftoliditas de
                                                              " Græcis

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* Differt. HOMER. vol. ii. diff. 40. p. 216.

" Græcis ducibus virtute et confilio celeberrimis confingi un-
" quam poffit ?"

SEVERAL ancient authors thinking it improbable that HELEN
was in Troy, and feeing the force of the argument againft the
fuppofition of her not having been there, contrived a fiction to
reconcile the two accounts, *viz.* That VENUS had created a fhape
or figure fo exactly like HELEN, that PARIS carried the coun-
terfeit* with him to Troy, believing it to be the celebrated
Beauty herfelf. EURIPIDES's tragedy of HELEN turns entirely
upon this ; and MUSGRAVE, in his notes, conjectures, that the
ftory had been contrived by HELEN, in conjunction with the
Egyptian priefts, to re-eftablifh her character after her return to
Greece. It is plain, however, that, according to the Egyptian priefts
and HERODOTUS, HOMER has falfified the ftory in one material
circumftance ; if fo, it is impoffible to fay where he would ftop.
3*dly*, Although THUCYDIDES, in his introduction, does fup-
pofe the truth of the Grecian expedition againft Troy, and re-
fers to HOMER for feveral particulars, yet he once and again
enters the caveat, " if any credit is to be given to his poems."

Laftly, PAUSANIAS fays, in fo many words, that he gives
more credit to HOMER than the *generality* of people do. The
expreffion in the original † is rather ftronger ; and it is certain,
that feveral ancient authors, whofe works unfortunately have
not reached us, arraigned HOMER of falfehood, in treatifes
written on purpofe to convict him of it §. I will not quote
from LUCIAN, as his levity might be objected to, but only ob-
ferve, that, if the common chronology be juft, he had good
reafon to laugh at the fuppofition of PARIS falling in love with
HELEN, or of her being an object of contention to Afia and
Greece, as it is demonftrable that fhe muft have been about an
hundred years of age when Troy was taken ; for, according to

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* Ἐιδωλον.   † Ὁι λοιποι, p. 160. edit. 1696.

§ See an enumeration of them in the preface to Philoftr. Heroica, p. 603. edit. 1709.

the common chronology, feventy-nine years elapfed between the Argonautic expedition and the taking of Troy; now fhe was the twin-fifter of Pollux, who was one of the Argonauts, and who fought and beat a famous boxer in the paffage to Colchis, and therefore cannot be fuppofed, at that time, under eighteen or twenty. Bayle, in his dictionary, has taken notice of Helen's great age; and a witty author has compared her to the famous Ninon de l'Enclos, who made an affignation on the day fhe entered her eightieth year. But this ridicule ftrikes only againft the common chronology; for Homer fays nothing to afcertain the period of time that elapfed between the two ex-peditions. From a circumftance, however, which he does men-tion, and which will be taken notice of by and by, it appears, that fhe could not be under forty when Troy was taken.

After what has been ftated, I may venture, I imagine, to proceed with lefs timidity than I otherwife could have done, to endeavour to fhew, that the account given by the Greeks of their expedition againft Troy is incredible and inconfiftent with itfelf; and that (if ever there was at all a Trojan war) Troy was not taken by them, but that they were obliged, by thofe who defended it, to raife the fiege, and retire with lofs and difgrace.

Several of the arguments to be urged in the fequel upon this fubject are taken from a very curious differtation by a Greek author, Dio Chrysostomus, who lived in the time of Trajan, and acquired great reputation by his works, from the purity of his ftyle, and the elegance and depth of his fentiments and reflections. He has written two differtations upon Homer; in one of them *, he makes his panegyric as a poet; but, in the other †, takes him feverely to tafk as an hiftorian. The firft mentioned, which is in praife of the poet, is taken notice of by almoft every commentator who has publifhed an edition of his works; but not one of them makes the leaft mention of the other. Hence it is not much known.

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This laſt may be divided into two parts. The firſt part contains an account of the Trojan war, quite oppoſite, in moſt particulars, to that of HOMER ; and this, CHRYSOSTOM ſays, he made up, partly from information, which he too pretends to have obtained from an Egyptian prieſt, and partly from what appeared to him to be moſt probable. The other, and by far the moſt valuable part, is an argument to prove, that HOMER's account muſt appear, when examined with attention, to be falſe, abſurd, and contradictory to itſelf. As the detail which CHRYSOSTOM gives is not vouched or authenticated in any ſhape, I ſhall ſtate no more of it than is neceſſary for underſtanding the argumentative part of his diſcourſe, which merits the greateſt attention. CASAUBON, who writes ſome notes on this author, ſays of this diſſertation ; " Dignus plane liber hic, quem legant " philologi, et quicunque in veterum ſcriptis cum judicio cupiunt " verſari ; quamvis et pro HOMERO multa dici poſſunt."

IT is not, however, my intention to tranſlate this part of the diſcourſe, nor even to abridge it, but only to ſelect from it the arguments that appeared to me the moſt concluſive and ſtriking, to enforce them by ſome additional conſiderations, and to add ſome obſervations that have occurred to myſelf in reading and reflecting on this very important and intereſting article of ancient hiſtory.

ACCORDING to this author, HELEN, the daughter of TYNDARUS, king of Sparta, was, by far, the moſt beautiful woman of her time, and had a great number of ſuitors, amongſt whom were MENELAUS and PARIS. The latter was preferred by the lady to all the reſt, on account of the graces of his perſon and addreſs ; and his magnificent preſents obtained the conſent of TYNDARUS, her father, who beſides was deſirous of connecting himſelf with Aſia. Upon this MENELAUS, and the other Greeks, partly from reſentment of the affront which they thought they had received, and partly from the hope of plunder, invaded

g 2 Troas.

Troas. Many auxiliaries came to the affiftance of Priam, and an obftinate and bloody war enfued, in the courfe of which great numbers fell on both fides ; but the Greeks had all along the worft of it.   They loft a great number of troops, and fome of their braveft commanders. Hector, according to this author, inftead of being flain by Achilles, himfelf flew both Achilles and Ajax ; though Homer, to cover this difgrace, has made the former, who was the braveft of the Greeks, perifh by the hand of Paris, the moft daftardly of the Trojans, the latter by his own.   At laft, after fuffering an infinity of hardfhips and loffes, the Greeks were glad to retire as they beft could. He gives a very long detail of the war ; but, for the reafon already mentioned, I enter not upon it, but proceed to the real evidence he offers of the falfity of the common ftory.

In confidering this matter, it will be proper to view the circumftances and fituations of perfons and affairs, as at four different periods : *1ft*, Before the voyage of Paris to Sparta. *2dly*, As at the time of his arrival there.   *3dly*, During the war. And, *laftly*, After the taking and facking of Troy.

It is, by no means, probable that Paris would fall in love with a woman whom he had never feen ; and ftill lefs fo, that he would form the defperate and nefarious project of carrying her off from her hufband, a powerful king, who lived at a confiderable diftance, and beyond feas.

Chrysostom might have added, that the force of this objection was forefeen ; and that to obviate it, was invented what is called the *judgment of* Paris ; for it was not the fhepherd of Ida that conceived this plan ; he was put upon it by Venus, who promifed him fuccefs in reward of his having adjudged the apple to her.

But further, Paris could not get a fhip, or a crew, without the confent or connivance of his father ; yet it cannot be believed, that Priam, an old, wife and good king, would give any countenance to fuch an undertaking.

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LET it be fuppofed, however, that PARIS, fomehow or other, got a fhip and crew, and arrived at Lacedæmon, when MENELA-us and her brother were abfent, (for it is furely neceffary to fend them away); and let it be ftill further fuppofed, that he had been able to perfuade her to forfake her hufband, her child, and her country, and to follow, to her own eternal difgrace, a young adventurer to a ftrange land; yet ftill infurmountable difficulties ftood in the way of his carrying her off. For it muft be obferved, that Lacedæmon was not a fea-port town, but a mediterranean place, being many miles up the country, as appears from the map; and further, that PARIS did not only carry off HELEN, but her effects, which confifted in bulky goods, fuch as, wearing apparel, carpets, tapeftry, and veffels of different kinds. It was impoffible, therefore, for PARIS to carry her off fecretly. He muft have done it openly and avow-edly, and in the face of the fun; and a number of horfes and carriages were neceffary to tranfport the lady and her baggage from Lacedæmon to the fea-port. Now, fuppofing MENELAUS abfent, is it poffible to believe that his fubjects would have fat with their arms acrofs, and beheld the wife and the wealth of their king carried off by a handful of banditti?

IT is not eafy to figure a tolerable anfwer to this objection. The author of one of the fpurious hiftories of the Trojan war in Latin felt its force, and to avoid it, pretends, that PARIS met with HELEN in the ifland of Cythera, near the coaft of Sparta. But this is inadmiffible; for, in the *firft* place, HOMER exprefs-ly fays, in a variety of paffages, that HELEN was brought from Lacedæmon to Troy; and, 2*dly,* Not only fhe, but all her valu-able effects were carried off; and fhe certainly would not have thefe with her, when upon an excurfion to an ifland in the neighbourhood.

WE come now to the period of the war. It is very furprifing that the Trojans did not deliver up HELEN to the ambaffadors

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sent from Greece, as the demand was not only founded in juftice, but enforced by the threat of an invasion. It is still more surprising, that they should persist in their refusal, when they saw themselves attacked with 1200 ships and 100,000 men. What is most astonishing of all is, that they did not restore her upon the death of PARIS, but married her to his brother DEIPHOBUS. Here CHRYSOSTOM argues, and with great plausibility, that this is perfectly incredible, upon the supposition that PARIS had possessed himself of her by a crime; but by no means so if he obtained her in marriage with her father's consent; for then the grossest injustice was on the side of the Greeks; and it is not at all surprising, that the Trojans should have been willing to suffer the last extremities rather than submit. This last supposition is further confirmed by this circumstance, that CASTOR and POLLUX, the brothers of HELEN, did not go upon this expedition. They both were alive at the time of her pretended elopement *.

TEN years elapsed, after the elopement of HELEN, before the Greeks laid siege to Troy. This we learn from her lamentation over the dead body of HECTOR; for there she is made to say expressly, that she was now in the twentieth year of her absence from her native country †; and as it is agreed, that the siege of Troy lasted ten years, it follows, that the same period had elapsed from her being carried off to the landing of the Greeks in Asia. This circumstance CHRYSOSTOM has overlooked; but it seems to deserve attention. So long a delay cannot well be accounted for.

THE scholiast upon the above passage, who seems to have foreseen the observation, says, that this time was spent in assembling the Grecian army; but as the Grecian princes lived at no great distance from one another, and all their men were accustomed to the use of arms, it could not be difficult to bring them soon together; and if it be supposed, that they came to the place of

rendezvous

* Il. iii. 236.　　　　　　　　† Il. xxiv. 765.

rendezvous at different times during this long period, it is not easy to see how they could be subsisted; besides, it cannot be doubted, that MENELAUS would hasten the invasion as much as possible.

AT this rate, the beauty of HELEN must have been upon the wane when the siege began, and quite over by the time it ended. For which reason, Mr WOOD regrets, that HOMER introduced the circumstance into his poem, as it is far from being agreeable, and not at all material. He might have added, that it is not consistent with the excessive encomiums which even the old men of Troy bestow on her charms, in the tenth year of the siege; or the extravagant compliment they pay her, that it was not at all surprising the Greeks and Trojans should have suffered so much and so long for her. The probability is, that this circumstance was invented by HOMER to give an air of credibility to some others; particularly, to account for the absence of CASTOR and POLLUX. In the third book of the Iliad, HELEN expresses great surprise because she did not see her two brothers among the Grecian commanders. This was in the tenth year of the siege; and HOMER adds, "But they had both died at Lacedæmon a long time before." This proves they were alive at the time of the elopement; and that he thought it necessary to account for their not being at the siege.

THE Greeks, however, did at last make their appearance before Troy; but the town was not taken till after a ten years siege *. This is the most puzzling circumstance of all; especially when it is considered, that HOMER tells us it had been taken formerly by HERCULES with only six ships, and had by him been levelled to the ground.

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* M. FOURMONT, in a dissertation, in tom. 5. *des Mem. de l'Acad. des Inscrip.* pretends, that the siege began only three weeks or a month before the quarrel between AGAMEMNON and ACHILLES, which happened in the beginning of the tenth year; and that the rest of the time had been spent in expeditions against different places in Asia. M. FOURMONT says, unanswerable objections may be made to HOMER's account on the other supposition. The Abbé BANIER has written an answer to this dissertation, in which he proves, from several passages in HOMER, that the siege lasted ten years; but has been, by no means, able to answer the objections that arise from that supposition. See tom. 5.

THE Greeks, by HOMER's account, were always greatly superior in numbers to the Trojans and their auxiliaries; and, for more than nine years, they had ACHILLES with them *, whom HOMER has, on all occasions, reprefented as perfectly irrefiftible to the Trojans. How then came it about that the war lafted fo long?

THE only anfwer that can be made to this is, that the Trojans kept within their walls as long as ACHILLES appeared; and this HOMER himfelf fuggefts †, though it is contradictory to feveral other paffages, where it is faid, that many battles had been fought, and great numbers flain on both fides.

BUT this will not prove fatisfactory, when it is confidered, that ANDROMACHE, in the interview fhe has with HECTOR in the fixth book, tells him, that the city was to be come at, and the wall eafily fcaled ‡; and that AJAX, AGAMEMNON, MENELAUS, and DIOMED, had three times attempted it. If fo, what hindered ACHILLES to ftorm the town the day after he landed? How came AJAX, and the other chiefs, to be fo long in threatening an affault? Madame DACIER, in a note on this paffage, fays, That the art of reconnoitering was not known, at this time, even to the Greeks. The abfurdity of the anfwer fhews the force of the obfervation. A wolf, fox, or other beaft of prey, that wants to get into a fold or clofe where fheep or cattle are confined, would walk round it to difcover at what place the fence was loweft.

BUT further, fuppofing the town to have been impregnable, how came the Greeks not to take it by blockade? They had a powerful fleet, the Trojans none; fo that it was eafy to hinder the town from being fupplied with provifions by fea; and it was equally eafy to have drawn lines around it, which would have cut off all communication between it and the country; the infallible confequence of which would have been, that the Trojans muft have furrendered as foon as their ftock of provifions

* Il. viii. 558.　　　　† Il. vii. 352.; xviii. 287.　　　　‡ Il. vi. 434.

fion was confumed. As the Greeks did not draw lines around the town, whilft, at the fame time, we are told they threw up a rampart before their own fhips, and as the Trojans received fuccours from their neighbours at different times, the fair conclufion is, that the Greeks were not mafters of the country, nor fuperior to the Trojans in the field, but, on the contrary, found themfelves overmatched. If it fhall be faid, that the art of drawing lines was not known to the Greeks, I anfwer, that the method they took to fecure their fhips proves the contrary to be true; and, had they been ignorant of that art, (if fo fimple an operation deferves that name), they never would have thought of the fiege, as they had no artillery or machinery of any kind for making a breach in the walls: Befides, without any art or labour, they could have placed bodies of troops fo as to intercept all the Trojan convoys.

HOMER admits, that the Greeks fuffered more before Troy than any mortal man could relate*: That they loft a great number of men, many excellent officers, and that AJAX, ANTILOCHUS, PATROCLUS, and ACHILLES, the greateft hero of them all, perifhed in the expedition. This, of itfelf, affords a prefumption that they were not fuccefsful. It is very improbable that ACHILLES fell by the hand of PARIS; the truth feems to be, that he died by that of a better man. HECTOR poffeffed himfelf of his armour, which is not at all furprifing, if he flew its owner; but cannot otherwife be explained: For, as to the ftory of PATROCLUS dreffing himfelf in the armour of ACHILLES, and being flain and ftripped by HECTOR, it cannot poffibly be true. ACHILLES was by far the ftrongeft and ftatelieft of the Greeks: HECTOR was nothing to him; and PATROCLUS again was nothing to HECTOR, as is evident from the anxiety with which ACHILLES charges him not to encounter HECTOR. Now, when HECTOR did get ACHILLES's armour, he found he could not ufe it; and, therefore, HOMER † makes

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JUPITER

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* Odyff. iii. 105.   † Book xvii. 210.

JUPITER interpofe to fit it to his body; though, after all, the god did not perform the work fufficiently; for HECTOR owed his death to fighting ACHILLES in that armour, as an aperture ftill remained near the throat, through which ACHILLES drove his fpear. If then the armour of ACHILLES could not be ufed by HECTOR, how is it poffible, that it could be ufed by PATRO-CLUS, who was fo much inferior to him? It is palpable, that he muft have been almoft as ill fitted with it as DAVID was with SAUL's. HOMER himfelf admits *, that PATROCLUS could not wield ACHILLES's fpear, how then could he fupport, not to fay march and fight, under the load of his armour?

IT cannot be denied, that ACHILLES fell during the fiege; and it is evident the Greeks muft have been lefs able to take the town, after this and their other loffes, than before. Ac-cordingly it is admitted by HOMER and his followers, that they did not take it by *force*, but it is pretended they took it by ftra-tagem. HOMER's account of which, is precifely as follows †: EPEUS made a wooden horfe, into which ULYSSES and the Gre-cian chiefs went with a body of troops; the reft of the Greeks burnt their tents, and fet fail. Upon this, the Trojans came down, and, along with them, HELEN. She, attended by DEI-PHOBUS, went three times round the horfe, calling each of the Grecian leaders by his name, and mimicking the voice of his wife. This made them all, except ULYSSES, defirous to get out, or return an anfwer; but he reftrained them, and clapped his hand on the mouth of one of them, who was more eager to fpeak than the reft, and kept him gagged in that manner till HELEN retired. The Trojans then drew up the machine to their citadel, and held a confultation as to what they fhould do with it. Some were for cutting it up; fome for precipitating it from the rock; but others thought it ought to be allowed to remain as a propi-tiatory figure. This laft opinion prevailed, and the Greeks came

out

*. Il. xvi. 140.   †. Odyff. viii. 500.; iv. 271.

out of it, and, after an obstinate struggle, vanquished the Trojans, and plundered the town.

The absurdity of all this is too gross and glaring to need refutation. Virgil saw well the objections to which it is liable, and, to obviate them, has strained his invention to the utmost, but in vain. According to him, this horse was huge as a mountain*; and it was necessary it should, as it was to contain an army in its belly. It fell to the lot of Ulysses, Menelaus, Neoptolemus, the maker Epeus, and five other leaders, to enter this machine; which they did, with a body of armed men that filled it. The rest of the Greeks sailed to Tenedos, which was *in sight* †, and there *hid* ‡ themselves on the desart shore. The Trojans, thinking them gone for good, came down, and consulted about the disposal of the horse, as in Homer. But upon Laocoon, who opposed its introduction into the city, being devoured by two serpents, they put wheels to its feet, and ropes to its neck, and drew it up to the town, through a breach made on purpose in the wall. The Greeks at Tenedos returned at midnight, having the benefit of a bright moon-shine; and those in the horse having descended by means of a rope, opened the gates to them, and the Trojans, being buried in sleep and wine, were easily mastered.

Every person who reads this with the least attention must perceive, that Virgil had better have couched the story in general obscure terms, as Homer does. By being particular, instead of mending the matter, he makes it worse; and there is one striking incongruity, into which it is astonishing he should have fallen. Tenedos, he says, was in sight; and, no doubt, it was; for its distance from the Trojan shore is but forty stadia, or five miles; it was a bright moon-shine, and Troy stood on a hill; how then could a *great* army be *hid* from the Trojans on a *desart* shore? At any rate, it is impossible, that 1200 ships could be concealed from them. They must have seen the fleet

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* Æneid. ii.   † In conspectu.   ‡ Condunt.

at leaft. If fo, it cannot be believed, that they would have made a large breach in their wall, when the enemy was fo near. But it would be improper to dwell longer here. Since the town, it is admitted, was not taken by force, and fince the ftratagem by which it is alleged to have been taken is abfurd and impracticable, the fair conclufion is, that it was not taken at all, and that we fhould have read the repulfe of the Greeks in verfe, if time had not envied us the works of the poets of Troy.

LET us now fee what happened, according to the Greek writers, after Troy was, as they pretend, taken and facked. If the Greeks had been, in reality, victorious, it is natural to fuppofe that they would have returned home in a body, in good order, obferving due difcipline and obedience to their general. But, inftead of doing fo, HOMER tells us *, that they quarrelled among themfelves, differed about the courfe they fhould fteer ; that fome went one way, fome another, and that feveral were fhipwrecked.

BUT this is not all : If the Greeks had been, in reality, victorious, thofe who returned would have been received as conquerors, with open arms by their families, and with acclamations by their fubjects. But the reverfe of this confeffedly happened. AGAMEMNON, their captain-general, upon his arrival, was flain in his own houfe, by a villain who had debauched his wife in his abfence. Would fuch have been his fate, had he appeared at the head of an army of conquerors ? And not only was he himfelf flain, but, according to HOMER, all thofe who returned with him ; yet this exploit was performed, he fays, by ÆGISTHUS, with no more than twenty men ; and he reigned feven years in AGAMEMNON's ftead †, till he was affaffinated, in his turn, by ORESTES. DIOMED was foon driven from his country, and NEOPTOLEMUS from Peloponnefus ; and, according to the account of the former in VIRGIL, all who were concerned in the expedition,

* Odyff. iii. 136.   † Ibid. iv. 530.

expedition againſt Troy were diſperſed over the earth, and ſuf-
fered every where remarkable hardſhips and diſtreſs,

Vel PRIAMO *miſeranda manus* —— Æn. xi. 259.

THE wretched ſituation in which ULYSSES found his affairs
at home is deſcribed, at great length, in the Odyſſey, by HOMER
himſelf. But unleſs it had been well underſtood, that the af-
fairs of the Greeks before Troy were deſperate, no ſet of men
would have dared to have poſſeſſed themſelves of his houſe, in-
ſulted his wife, and devoured his ſubſtance, as he could have re-
turned and puniſhed them in a few days; for we learn from
HOMER * and HERODOTUS †, that the paſſage from Troy to
Pthia and Sparta could be performed in three days, and Ithaca
was not much further off.

ON the other hand, let us take a view of what (it is ſuppoſed)
happened to ſome of the Trojans after the pretended capture
and deſtruction of their town. ÆNEAS ſailed with twenty
ſhips, and a great number of people, to Italy, where he obtain-
ed a very good ſettlement indeed, for himſelf and his follow-
ers. So did ANTENOR ; and, what is ſtill more wonderful, HE-
LENUS goes and occupies a part of Greece, eſtabliſhing himſelf
in Epirus. It certainly never was before heard of, that a con-
quered people ſent out colonies to take poſſeſſion of part of the
country of its conquerors ‡.

I COULD offer many more circumſtances and conſiderations
in ſupport of my propoſition, partly from CHRYSOSTOM, (whoſe
excellent diſſertation I have, by no means, exhauſted) and part-
ly

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* Il. ix. 663.   † Lib. ii. c. 117.

‡ SUCH is the account given by VIRGIL, DIONYSIUS HALICARN. and others ; and it is
generally followed. But it muſt be obſerved, that HOMER ſays nothing of HELENUS's ſet-
tlement in Epirus, or of ÆNEAS's in Italy. On the contrary, he ſays, that ÆNEAS and
his deſcendants reigned over the Trojans. See Iliad, and WOOD's Life of HOMER.
This, however, ſeems as little reconcilable to the Greek account of the capture of the
city as the other.

ly from what I have noted myſelf in the courſe of my re-
ſearches on this queſtion; but, were I to do ſo, this paper
would ſwell to a treatiſe: Beſides, I have ſaid enough, I ima-
gine, to undeceive men as to this matter; at leaſt, enough to
make them think upon it with attention and impartiality;
which, if they do, I have no doubt that they will very ſoon un-
deceive themſelves.

To conclude: As it is a matter of indifference to us now-a-
days, whether the Greeks or Trojans prevailed, there is no rea-
ſon why the foregoing argument ſhould be read with diſlike or
regret: On the contrary, it is the favourable ſide of the que-
ſtion; for, if it leſſens ACHILLES, who had nothing but per-
ſonal courage and ſtrength to recommend him, it exalts HEC-
TOR, whom his enemies admitted to be the beſt and braveſt
man of his nation; and, above all, it does juſtice to HELEN,
the fineſt woman of antiquity, by reſtoring to her that charac-
ter of which poetic calumny has too long deprived her.

Fortunati ambo! ſi quid mea carmina poſſunt.   Æn. ix. 446.

III.

III. *An* ODE *on the* POPULAR SUPERSTITIONS *of the*
HIGHLANDS *of* SCOTLAND, *confidered as the Subject of*
Poetry. Written by the late Mr WILLIAM COLLINS: *And*
communicated to the ROYAL SOCIETY *of* EDINBURGH, *by*
ALEXANDER CARLYLE, D.D. F.R.S. EDIN. *Minifter of*
INVERESK, *and Chaplain in ordinary to his* MAJESTY.

INTRODUCTION TO THE POEM.

AT a meeting of the Literary Clafs of the Royal Society, held
on Monday 19th April 1784, the Reverend Dr CAR-
LYLE read an ode, written by the late Mr WILLIAM COLLINS,
and addreffed to JOHN HOME, Efq; (author of DOUGLAS,
&c.) on his return to Scotland in 1749. The committee ap-
pointed to fuperintend the publication of the Society's Tranf-
actions, having judged this ode to be extremely deferving of a
place in that collection, requefted Mr ALEX. FRASER TYTLER, one
of their number, to procure from Dr CARLYLE every degree of
information which he could give concerning it. This informa-
tion, which forms a proper introduction to the poem itfelf, is
contained in the two following letters.

LETTER *from Mr* ALEX. FRASER TYTLER *to Mr* JOHN ROBISON,
General Secretary of the Royal Society of Edinburgh.

Dear Sir,

AT the defire of the Committee for publifhing the Royal So-
ciety's Tranfactions, I wrote to Dr CARLYLE, requefting of him
an account of all fuch particulars regarding Mr COLLINS's poem
as were known to him, and which were, in his opinion, proper
to be communicated to the public. I received from him the
inclofed

inclofed anfwer, and he tranfmitted to me, at the fame time, the original manufcript in Mr COLLINS's handwriting. It is evidently the *prima cura* of the poem, as you will perceive from the alterations made in the manufcript, by deleting many lines and words, and fubftituting others, which are written above them. In particular, the greateft part of the twelfth ftanza is new-modelled in that manner. Thefe variations I have marked in notes on the copy which is inclofed, and I think they fhould be printed : For literary people are not indifferent to information of this kind, which fhews the progreffive improvement of a thought in the mind of a man of genius.

THIS ode is, beyond all doubt, the poem alluded to in the life of COLLINS by JOHNSON, who, mentioning a vifit made by Dr WARTON and his brother to the poet in his laft illnefs, fays, " He fhewed them, at the fame time, an ode, infcribed to " Mr JOHN HOME, on the fuperftitions of the Highlands, " which they thought fuperior to his other works, but which " no fearch has yet found." COLLINS himfelf, it appears from this paffage, had kept a copy of the poem, which, confidering the unhappy circumftances that attended his laft illnefs, it is no wonder was miflaid or loft ; and, but for that fortunate hint given by JOHNSON, it appears from Dr CARLYLE's letter, that the original manufcript would, in all probability, have undergone the fame fate.

STRUCK with the fingular beauty of this poem, of which, I believe, no man of tafte will fay that Dr WARTON and his brother have over-rated the merit, I could not help regretting the mutilated form in which it appeared ; and, in talking on that fubject to my friend Mr HENRY MACKENZIE of the Exchequer, (a gentleman well known to the literary world by many ingenious productions) I propofed to him the tafk of fupplying the fifth ftanza, and the half of the fixth, which were entirely loft. How well he has executed that tafk, the public will judge ; who, unlefs warned by the inverted commas that diftinguifh

the

the fupplemental verfes, would probably never have difcovered the chafm. Several hemiftichs, and words left blank by Mr COLLINS, had before been very happily fupplied by Dr CARLYLE. Thefe are likewife marked by inverted commas. They are a proof that this poem, as Dr CARLYLE has remarked, was haftily compofed; but this circumftance evinces, at the fame time, the vigour of the author's imagination, and the ready command he poffeffed of harmonious numbers.

<div style="text-align: center">I am, dear Sir,</div>

<div style="text-align: center">Yours, &c.</div>

To ALEX. FRASER TYTLER, *Efq;*

S I R,

I SEND you inclofed the original manufcript of Mr COLLINS's poem, that, by comparing with it the copy which I read to the Society, you may be able to anfwer moft of the queries put to me by the Committee of the Royal Society.

THE manufcript is in Mr COLLINS's handwriting, and fell into my hands among the papers of a friend of mine and Mr JOHN HOME's, who died as long ago as the year 1754. Soon after I found the poem, I fhewed it to Mr HOME, who told me that it had been addreffed to him by Mr COLLINS, on his leaving London in the year 1749: That it was haftily compofed and incorrect; but that he would one day find leifure to look it over with care. Mr COLLINS and Mr HOME had been made acquainted by Mr JOHN BARROW, (the *cordial youth* mentioned in the firft ftanza), who had been, for fome time, at the univerfity of Edinburgh; had been a volunteer, along with Mr HOME, in the year 1746; had been taken prifoner with him at the battle of Falkirk, and had efcaped, together with him and five or fix other gentlemen, from the caftle of Down. Mr BARROW refided in 1749 at Winchefter, where Mr COLLINS and Mr HOME

<div style="text-align: center">*i*</div>

<div style="text-align: right">were,</div>

were, for a week or two, together on a vifit.   Mr BARROW was paymafter in America, in the war that commenced in 1756, and died in that country.

I THOUGHT no more of the poem, till a few years ago, when, on reading Dr JOHNSON's life of COLLINS, I conjectured that it might be the very copy of verfes which he mentions, which he fays was much prized by fome of his friends, and for the lofs of which he expreffes regret.   I fought for it among my papers ; and perceiving that a ftanza and a half were wanting, I made the moft diligent fearch I could for them, but in vain. Whether or not this great chafm was in the poem when it firft came into my hands, is more than I can remember, at this di-ftance of time.

As a curious and valuable fragment, I thought it could not appear with more advantage than in the Collection of the Royal Society.

I am, Sir,

Your moft obedient fervant,

ALEX. CARLYLE.

An

An ODE *on the* POPULAR SUPERSTITIONS *of the* HIGH-LANDS *of* SCOTLAND, *confidered as the Subject of Poetry.*

I.

H———, thou return'ſt from Thames, whoſe Naiads long
   Have ſeen thee ling'ring, with a fond delay,
Mid thoſe ſoft friends, whoſe hearts, ſome future day,
   Shall melt, perhaps, to hear thy tragic ſong.
Go, not unmindful of that cordial youth*,
   Whom, long endear'd, thou leav'ſt by Lavant's ſide;
Together let us wiſh him laſting truth,
   And joy untainted with his deſtin'd bride.
Go! nor regardleſs, while theſe numbers boaſt
   My ſhort-liv'd bliſs, forget my ſocial name;
But think far off how, on the ſouthern coaſt,
   I met thy friendſhip with an equal flame!
Freſh to that ſoil thou turn'ſt, whoſe ev'ry vale
   Shall prompt the poet, and his ſong demand:
To thee thy copious ſubjects ne'er ſhall fail;
   Thou need'ſt but take the pencil to thy hand,
And paint what all believe who own thy genial land.

II.

THERE muſt thou wake perforce thy Doric quill,
   'Tis Fancy's land to which thou ſett'ſt thy feet;
Where ſtill, 'tis ſaid, the fairy people meet
   Beneath each birken ſhade on mead or hill.
There each trim laſs that ſkims the milky ſtore
   To the ſwart tribes their creamy bowl allots;

By

* See the preceding letter from Dr CARLYLE.

By night they fip it round the cottage-door,
    While airy minftrels warble jocund notes.
There every herd, by fad experience, knows
    How, wing'd with fate, their elf-fhot arrows fly ;
When the fick ewe her fummer food foregoes,
    Or, ftretch'd on earth, the heart-fmit heifers lie.
Such airy beings awe th' untutor'd fwain :
    Nor thou, though learn'd, his homelier thoughts neglect ;
Let thy fweet mufe the rural faith fuftain :
    Thefe are the themes of fimple, fure effect,
That add new conquefts to her boundlefs reign,
And fill, with double force, her heart-commanding ftrain.

III.

Ev'n yet preferv'd, how often may'ft thou hear,
    Where to the pole the Boreal mountains run,
Taught by the father to his lift'ning fon
    Strange lays, whofe power had charm'd a SPENCER's ear.
At ev'ry paufe, before thy mind poffeft,
    Old RUNIC bards fhall feem to rife around,
With uncouth lyres, in many-coloured veft,
    Their matted hair with boughs fantaftic crown'd :
Whether thou bid'ft the well-taught hind repeat *
    The choral dirge that mourns fome chieftain brave,
When ev'ry fhrieking maid her bofom beat,
    And ftrew'd with choiceft herbs his fcented grave ;
Or whether, fitting in the fhepherd's fhiel †,
    Thou hear'ft fome founding tale of war's alarms ;
When, at the bugle's call, with fire and fteel,
    The fturdy clans pour'd forth their bony fwarms,
And hoftile brothers met to prove each other's arms.

                                                    'Tis

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* Firft written, *relate.*

† A kind of hut, built for a fummer habitation to the herdfmen, when the cattle are fent to graze in diftant paftures.

IV.

'Tis thine to sing, how framing hideous spells
   In Sky's lone isle the gifted wizzard " sits *,"
" Waiting in" wintry cave " his wayward fits † ;"
   Or in the depth ‡ of Uist's dark forests dwells :
How they, whose sight such dreary dreams engross,
   With their own visions oft astonish'd § droop,
When o'er the wat'ry strath or quaggy moss
   They see the gliding ghosts unbodied troop.
Or if in sports, or on the festive green,
   Their " piercing ||" glance some fated youth descry,
Who, now perhaps in lusty vigour seen
   And rosy health, shall soon lamented die.
For them the viewless forms of air obey
   Their bidding heed **, and at their beck repair.
They know what spirit brews the stormful day,
   And heartless, oft like moody madness stare
To see the phantom train their secret work prepare.

V.

†† " Or on some bellying rock that shades the deep,
   " They view the lurid signs that cross the sky,
" Where, in the west, the brooding tempests lie,
   " And hear their first, faint, rustling pennons sweep.
" Or in the arched cave, where deep and dark
   " The broad, unbroken billows heave and swell,

                                                    " In

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  * Collins had written, *seer.*

  † Collins had written, *Lodg'd in the wintry cave with*—— and had left the line imperfect : Altered and the chasm supplied by Dr Carlyle.

  ‡ First written, *gloom.*

  § First written, *afflicted.*

  || A blank in the manuscript. The word *piercing* supplied by Dr Carlyle.

  ** First written, *mark.*

  †† A leaf of the manuscript, containing the fifth stanza, and one half of the sixth, is here lost. The chasm is supplied by Mr Mackenzie.

" In horrid mufings rapt, they fit to mark
    " The labouring moon ; or lift the nightly yell
" Of that dread fpirit, whofe gigantic form
    " The feer's entranced eye can well furvey,
" Through the dim air who guides the driving ftorm,
    " And points the wretched bark its deftin'd prey.
" Or him who hovers, on his flagging wing,
    " O'er the dire whirlpool, that, in ocean's wafte,
" Draws inftant down whate'er devoted thing
    " The failing breeze within its reach hath plac'd—
" The diftant feaman hears, and flies with trembling hafte.

VI.

" Or, if on land the fiend exerts his fway,
    " Silent he broods o'er quickfand, bog, or fen,
" Far from the fhelt'ring roof and haunts of men;
    " When witched darknefs fhuts the eye of day,
" And fhrouds each ftar that wont to cheer the night ;
    " Or, if the drifted fnow perplex the way,
" With treach'rous gleam he lures the fated wight,
    " And leads him flound'ring on, and quite aftray."
What though far off, from fome dark dell efpied
    His glimm'ring mazes cheer th' excurfive fight,
Yet turn, ye wand'rers, turn your fteps afide,
    Nor truft the guidance of that faithlefs light ;
For watchful, lurking 'mid th' unruftling reed,
    At thofe mirk* hours the wily monfter lies,
And liftens oft to hear the paffing fteed,
    And frequent round him rolls his fullen eyes,
If chance his favage wrath may fome weak wretch furprife.

VII.

Ah, lucklefs fwain, o'er all unbleft indeed !
    Whom late bewilder'd in the dank, dark fen,

Far

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* Firft written, *fad.*

Far from his flocks and fmoking hamlet then !
  To that fad fpot " his wayward fate fhall lead * :"
On him enrag'd, the fiend, in angry mood,
  Shall never look with pity's kind concern,
But inftant, furious, raife the whelming flood
  O'er its drown'd bank, forbidding all return.
Or, if he meditate his wifh'd efcape
  To fome dim hill that feems uprifing near,
To his faint eye the grim and grifly fhape,
  In all its terrors clad, fhall wild appear.
Meantime, the wat'ry furge fhall round him rife,
  Pour'd fudden forth from ev'ry fwelling fource.
What now remains but tears and hopelefs fighs ?
  His fear-fhook limbs have loft their youthly force,
And down the waves he floats, a pale and breathlefs corfe.

VIII.

For him, in vain, his anxious wife fhall wait,
  Or wander forth to meet him on his way ;
For him, in vain, at to-fall of the day,
  His babes fhall linger at th' unclofing † gate.
Ah, ne'er fhall he return ! Alone, if night
  Her travell'd limbs in broken flumbers fteep,
With dropping willows dreft, his mournful fprite
  Shall vifit fad, perchance, her filent fleep :
Then he, perhaps, with moift and wat'ry hand,
  Shall fondly feem to prefs her fhudd'ring cheek ‡,
And with his blue fwoln face before her ftand,
  And, fhiv'ring cold, thefe piteous accents fpeak :
Purfue ‖, dear wife, thy daily toils purfue
  At dawn or dufk, induftrious as before ;

                                           Nor

* A blank in the manufcript. The line filled up by Dr CARLYLE.
† Firft written, *cottage.*
‡ Firft written, *Shall feem to prefs her cold and fhudd'ring cheek.*
‖ Firft written, *proceed.*

Nor e'er of me one haplefs thought renew,
    While I lie welt'ring on the ozier'd fhore,
Drown'd by the KAELPIE's * wrath, nor e'er fhall aid thee more!

IX.

UNBOUNDED is thy range; with varied ftile
    Thy mufe may, like thofe feath'ry tribes which fpring
From their rude rocks, extend her fkirting wing
    Round the moift marge of each cold Hebrid ifle,
To that hoar pile which ftill its ruin fhows † :
    In whofe fmall vaults a pigmy-folk is found,
Whofe bones the delver with his fpade upthrows,
    And culls them, wond'ring, from the hallow'd ground!
Or thither where beneath the fhow'ry weft
    The mighty kings of three fair realms are laid ‡ :
Once foes, perhaps, together now they reft.
    No flaves revere them, and no wars invade :
Yet frequent now, at midnight's folemn hour,
    The rifted mounds their yawning cells unfold,
And forth the monarch's ftalk with fov'reign pow'r
    In pageant robes, and wreath'd with fheeny gold,
And on their twilight tombs aerial council hold.

BUT

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* A name given in Scotland to a fuppofed fpirit of the waters.

† ON the largeft of the *Flannan iflands* (ifles of the Hebrides) are the ruins of a chapel dedicated to St FLANNAN. This is reckoned by the inhabitants of the Weftern Ifles a place of uncommon fanctity. One of the Flannan iflands is termed the *Ifle of Pigmies;* and MARTIN fays, there have been many fmall bones dug up here, refembling in miniature thofe of the human body.

‡ THE ifland of *Iona* or *Icolmkill.* See MARTIN's Defcription of the Weftern Iflands of Scotland. That author informs us, that forty-eight kings of Scotland, four kings of Ireland, and five of Norway, were interred in the Church of St OURAN in that ifland. There were two churches and two monafteries founded there by St COLUMBUS about *A. D.* 565. BED. *Hift. Eccl. l.* 3. COLLINS has taken all his information refpecting the Weftern Ifles from MARTIN; from whom he may likewife have derived his knowledge of the popular fuperftitions of the Highlanders, with which this ode fhows fo perfect an acquaintance.

The HIGHLANDS of SCOTLAND.

X.

But O! o'er all, forget not KILDA's race*,
  On whofe bleak rocks, which brave the wafting tides,
Fair Nature's daughter, Virtue, yet abides.
  Go, juft, as they, their blamelefs manners trace !
Then to my ear tranfmit fome gentle fong
  Of thofe whofe lives are yet fincere and plain,
Their bounded walks the rugged cliffs along,
  And all their profpect but the wintry main.
With fparing temp'rance, at the needful time,
  They drain the fainted fpring, or, hunger-preft,
Along th' Atlantic rock undreading climb,
  And of its eggs defpoil the Solan's neft.
Thus bleft in primal innocence they live,
  Suffic'd and happy with that frugal fare
Which tafteful toil and hourly danger give.
  Hard is their fhallow foil, and bleak and bare ;
Nor ever vernal bee was heard to murmur there !

XI.

Nor need'ft thou blufh, that fuch falfe themes engage
  Thy gentle mind, of fairer ftores poffeft ;
For not alone they touch the village breaft,
  But fill'd in elder time th' hiftoric page.
There SHAKESPEARE's felf, with ev'ry garland crown'd †,
  In mufing hour, his wayward fifters found,
And with their terrors dreft the magic fcene.
From them he fung, when mid his bold defign,
  Before the Scot afflicted and aghaft,

k   The

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* The character of the inhabitants of St Kilda, as here defcribed, agrees perfectly with the accounts given by MARTIN and by MACAULAY, of the people of that ifland. It is the moft wefterly of all the Hebrides, and is above 130 miles diftant from the main land of Scotland.

† THIS ftanza is more incorrect in its ftructure than any of the foregoing. There is apparently a line wanting between this and the fubfequent one, *In mufing hour,* &c. The deficient line ought to have rhymed with *fcene.*

The fhadowy kings of BANQUO's fated line,
    Through the dark cave in gleamy pageant paft.
Proceed, nor quit the tales which, fimply told,
    Could once fo well my anfw'ring bofom pierce ;
Proceed, in forceful founds and colours bold
    The native legends of thy land rehearfe ;
To fuch adapt thy lyre and fuit thy powerful verfe.

XII.

IN fcenes like thefe, which, daring to depart
    From fober truth, are ftill to nature true,
And call forth frefh delight to fancy's view,
    Th' heroic mufe employed her TASSO's art !
How have I trembled, when at TANCRED's ftroke,
    Its gufhing blood the gaping cyprefs pour'd ;
When each live plant with mortal accents fpoke,
    And the wild blaft up-heav'd the vanifh'd fword * !
How have I fat, when pip'd the penfive wind,
    To hear his harp, by Britifh FAIRFAX ftrung.
Prevailing poet, whofe undoubting mind
    Believ'd the magic wonders which he fung !
Hence at each found imagination glows ;
Hence his warm lay with fofteft fweetnefs flows ;
    Melting it flows, pure, num'rous, ftrong and clear,
And fills th' impaffion'd heart, and wins th' harmonious ear †.

ALL

* THESE four lines were originally written thus :
    How have I trembled, when, at TANCRED's fide,
        Like him I ftalk'd, and all his paffions felt ;
    When charm'd by ISMEN, through the foreft wide,
        Bark'd in each plant a talking fpirit dwelt !

† THESE lines were originally written thus :
    Hence, fure to charm, his early numbers flow,
        Though ftrong, yet fweet ———————
    Though faithful, fweet ; though ftrong, of fimple kind.
        Hence, with each theme, he bids the bofom glow,
    While his warm lays an eafy paffage find,
        Pour'd through each inmoft nerve, and lull th' harmonious ear

XIII.

ALL hail, ye scenes that o'er my soul prevail,
  Ye " spacious *" friths and lakes which, far away,
Are by smooth ANNAN fill'd, or past'ral TAY,
  Or DON's romantic springs, at distance, hail!
The time shall come when I, perhaps, may tread
  Your lowly glens, o'erhung with spreading broom,
Or o'er your stretching heaths by fancy led:
  Then will I dress once more the faded bow'r,
Where JOHNSON sat in DRUMMOND's † " social ‡" shade,
  Or crop from Tiviot's dale each " classic flower,"
And mourn on Yarrow's banks " the widow'd maid ‖."
Meantime, ye Pow'rs, that on the plains which bore
  The cordial youth, on LOTHIAN's plains attend,
Where'er he dwell, on hill, or lowly muir,
  To him I lose, your kind protection lend,
And, touch'd with love like mine, preserve my absent friend.

* A blank in the manuscript. The word *spacious* supplied by Dr CARLYLE.

† BEN JOHNSON undertook a journey to Scotland a-foot in 1619, to visit the poet DRUMMOND, at his seat of Hawthornden, near Edinburgh. DRUMMOND has preserved in his works, some very curious heads of their conversation.

‡ A blank in the manuscript. *Social* supplied by Dr CARLYLE.

‖ Both these lines left imperfect; supplied by Dr CARLYLE. This last stanza bears more marks of hastiness of composition than any of the rest. Besides the blanks which are supplied by Dr CARLYLE, there is apparently an entire line wanting after the seventh line of the stanza. The deficient line ought to have rhymed with *broom*.

IV. *An* ESSAY *upon the* PRINCIPLES *of* HISTORICAL COMPOSITION, *with an Application of those Principles to the Writings of* TACITUS. *By* JOHN HILL, M. A. F. R. S. EDIN. *and Professor of Humanity in the University of* EDINBURGH.

PART I.

[Read by the Author, April 19. 1784.]

FEW literary exertions put the author's abilities to a severer test than the composition of history. The poet may create a subject for himself, or he may adopt one that is but imperfectly known. In the composition of an epic poem, he instructs and pleases by exhibiting such a train of actions as might have taken place, and, unless he violates probability, his invention may bid defiance to restraint. If his work be imperfect, he has himself to blame, as those very powers which give the form to his subject, gave it first its existence.

THE orator, again, is more closely circumscribed. Not only is his subject known to have existed, but its circumstances, if not witnessed by his hearers, may, for certain, become matters of proof. In spite of every prejudice upon the part of his audience, he professedly takes a side. He is allowed to suppose, that his opponents either are ignorant of certain facts, or are viewing them in a false light. He applies the address of eloquence to their fancy, and the force of argument to their reason; and reckons every stratagem fair by which he can correct the errors that are involuntary, and confute those that are seen.

THE

THE hiſtorian is in a ſituation more trying, in certain reſpects, than either the poet or the orator. He muſt unite induſtry with genius, as by ſevere labour alone, he has to learn what his ſubject is. He muſt make the moſt of a train of facts too well eſtabliſhed to be altered, and the ſources of his intelligence are generally open to his readers. Having no prejudice to combat, and no ſide to ſupport, he can hardly make the weakneſs of his reader the tool of his addreſs. In the ſtyle of his narration, he muſt exhibit a variety that will ſuit the meaneſt, as well as the moſt ſplendid actions. Though he is not allowed to fabricate, yet he is required to embelliſh. His ornaments, by being the genuine, though the beſt dreſs of his materials, muſt fix the reader's attention, without miſleading his judgment.

FROM the perception of truth with which hiſtorical narration is accompanied, it is of all kinds of writing the moſt inſtructive. Men liſten more ſeriouſly to what they believe, than to the moſt exquiſite fable which fancy can deviſe. The tale pleaſes by a temporary conviction of its truth; but though the moral drawn from it be juſt, yet the impreſſion left behind is eaſily effaced.

HISTORY then is not only a nice, but a dignified ſubject of criticiſm *. It preſents to the race which exiſts, monuments of the wiſdom and the weakneſs of its forefathers. It demands no reverence for its precepts, that is not founded upon a conviction of their propriety. It imparts wiſdom, without expoſing men to thoſe evils which are its ordinary price; and upon every rock that proved fatal to early adventurers, it leaves a beacon for the ſecurity of others.

IN order to eſtabliſh a canon for judging of the merit of every hiſtorical work, we ſhall try to delineate thoſe qualities which ſhould predominate in the hiſtorian's character. Let us
view

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* PULCHRUM imprimis videtur, non pati occidere quibus æternitas debeatur, aliorumque famam cum ſua extendere. PLIN. *lib.* 5. *epiſt.* 8.

view his mind then in refpect to *Feeling*, to *Imagination*, and to *Judgment*; and confider them as the leading powers to which fubordinate ones are to be referred. The due union and the due extent of thefe conftitutes that mental temperament, which, by making beauty the vehicle of inftruction, muft, at once, pleafe the tafte and inform the underftanding.

It may be thought, perhaps, that, as the three powers mentioned cannot be fuppofed requifite in the hiftorian alone, fo no analyfis referring to them can be held truly defcriptive of his character. All the fine arts, however, are clofely allied. " Habent quoddam commune vinculum (fays Cicero), et quafi " cognatione quadam inter fe continentur." Though the conftituents of eminence be the fame in the whole, yet thefe are highly diverfified by the applications and the balance required in each. A flight difference in the leading powers of mind forms all the variety which genius in the different arts exhibits. If thofe principles then that are, at any time, adopted to form a ftandard for juft execution in any one of them be not, in fome degree, general, it may be held as certain that they are not found.

By feeling is to be underftood that nice fenfibility which catches even the flighteft impreffion, and in which there fubfifts a due proportion between the emotion and the caufe of its excitement. Thofe characters of feeling that are adverfe to juft execution in the works of tafte arife both from its deficiency and its excefs. In the one cafe, nature has done too little, in the other fhe has done too much. That calloufnefs which proceeds from the want of feeling excludes impreffions of which others are confcious, and thofe falfe irritations which proceed from its excefs fuggeft emotions which, by the fober, are deemed unnatural, becaufe they were never felt by them. It is in that juft medium, which is equally removed from the extremes mentioned, that feeling becomes the inftrument of genius. The mafterly execution of an able writer pleafes and even improves

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that tafte, in which the balance is not delicate; and the enjoyment of the reader is jointly proportioned to the abfolute juftnefs of the author's feelings, and to the correfpondence between them and his own.

By perceptions thus delicate, the hiftorian's character muft be highly improved. His defcriptions muft be tender, as being founded on thofe nice circumftances that efcape an ordinary eye; and though his fenfibility muft multiply the grounds of defcription, yet the correctnefs of his feeling leads him to fuch only as are juft. Hiftorical narration is more frequently faulty from that bluntnefs of perception, by which the minute qualities of objects are concealed, than from that defect in judgment, by which the leaft proper are felected. The detail often becomes prolix from the dulnefs of the writer. One of true feeling adopts a concife energy, which reaches both the heart and the underftanding. He permits his reader to pafs little that is worthy of his notice, and he with-holds it from that only which is really beneath it.

From an hiftorian of this defcription a delicate fenfe of what he owes to himfelf and to his reader is expected. If the ftrain of his narration ceafes, at any time, to be dignified, it is to remove, by variety, what would otherwife become tirefome. Quaint ornaments in his ftile he rejects as deformities. To the approbation of the judicious, he cannot be fuppofed indifferent; but he fcorns thofe condefcenfions with which the herd of readers is pleafed*. A remark that is obvious and common finds no place in his narration; and, from a fenfe of perfonal dignity, he would rather leave the more ignorant uninformed, than difguft the difcerning. His fenfibility to every moral fentiment, not only detects the leaft fymptom of what is good or bad in human conduct, but is accompanied with an immediate approbation of the one and abhorrence of the other. He records

* Intelliges actum hoc, ut tu fcires quid illi placeret, non ut ille placeret tibi. Sen. *Ep.* 100.

cords the truth as he finds it, without magnifying the virtues of his friend, or extenuating those of his enemy.

Though POLYBIUS repeatedly compares that history in which a due regard has not been paid to truth, to an animal without eyes, yet the comparison does, in reality, suggest less than may be affirmed *. An historian without fidelity is worse than useless; he is injurious to mankind. Upon the credit of his narration, the happiness of future generations may rest. By an error in point of fact, every philosopher may be mortified with circumstances, which, by confuting his theory, limit his usefulness, and impair his fame. In such cases; however, the evil is personal. If society remains unenlightened, it remains also unhurt; while, by an error in the history of men, oppressive establishments may be formed, and the happiness of nations destroyed.

JUST feeling, then, in the mind of an historian is the basis of many excellencies. By means of it, his descriptions become delicate, his narration interesting, his manner dignified, and his fidelity unquestionable.

BUT, besides an acute and judicious sense of things that exist, a lively apprehension of such as are ideal is required of an historian. The intimations of feeling carry along with them a belief of the reality of their objects, while the suggestions of fancy are accompanied with no such sentiment. If judgment is required to correct that sensibility which would otherwise become feverish, it is fully as needful, to correct that vigour of imagination, which would end in extravagance.

FROM the severity of those attentions to truth, which no good historian can sacrifice, it may be understood, perhaps, that imagination is a power, which he ought rarely, if at all, to exert. This, however, is not the case. Imagination may be a dangerous

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* Ὅτι καθάπερ εμψυχ8 σωματος των οψεων εξαιρεθεισων αχρειαται το ὅλον, ὕτως εξ ἱσοριας εαν ἀφης την αληθειαν, το καταλειπομενον αυτης ανωφελες γιγνεται διηγημα.

rous inftrument in the hands of the unwary, but it is a power-
ful one in the hands of the judicious. He who relates thofe
great tranfactions, in which the paffions of men have been in-
terefted, muft enter into the fcenes which he defcribes, and muft
fpeak the language of thofe who bore a part in them. A cold
narrative that is literally true would often be a falfe picture.
Expreffion, befides, is as fufceptible of modifications as the fenti-
ment to which it gives vent. During the influence of paffion,
figurative language indicates the degree of emotion excited in
the fpeaker, and ftimulates the hearer's feelings till they accord
with his own. Even the illiterate fuffer no delufion by that
play of fancy which gives energy to fpeech. They, as well as
the learned, inftinctively ftrip the animated conception of what
is adventitious, and interpret meaning with the moft precife ex-
actnefs.

ALTHOUGH the hiftorian, by the exertions of his fancy, may
often introduce ornament with advantage, yet he muft beware
of employing it to excefs. An impertinent profufion of beau-
ties tallies not with that dignity of manner which he fhould af-
fume and maintain. It is either the fign of that flippant cha-
racter, which is beneath him, or it is the refource of one, con-
fcious of his own coldnefs, and borrowing from art the figns
of that animation which nature has denied him.

BUT imagination is of ufe to the hiftorian, not only when he
is heated with his fubject, and thereby led to adopt figurative
language, but alfo when he means to defcribe. The vivacity
of thofe conceptions which he is able to excite in others may
equal, but will never furpafs the vivacity of his own. By
means of fancy, he can feize the circumftance moft character-
iftic of each object. From a juft confcioufnefs of the laws of
affociation in his own mind, he difcovers what thefe fhould
be in thofe of others who have an equally correct tafte. By
laying hold of one or a few circumftances wifely, he may pro-
duce a very powerful effect. He may give exiftence to ani-
mated defcription, inftead of a lifelefs, becaufe a verbofe detail.

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This double use of imagination in the composition of history is perfectly confistent with the definition at first given of that power. There is always reality in the emotion excited by figurative language; but, at some times, there is none in the subject of it, and, at other times, the qualities of that subject are not perceived precisely as they exist. A description, too, if rigidly interpreted according to the letter, would be virtually deftroyed. Principles ftrictly logical are not to be applied to terms denoting an exertion of fancy; becaufe they carry along with them more or lefs latitude, according to the intention of the speaker at the time. The aggregate of these terms fuggests somewhat different from that which it naturally excites. It only begins the picture which the fancy of the hearer must complete, and leaves that tafk to be performed by this delicate faculty, for which the powers of expreffion fimply are unfit.

By a fine imagination, then, the historian's language acquires energy, and his descriptions livelinefs. The power may improve his expreffion (we have found) without adulterating his matter. It may, in some instances, be too ftrong, and, in others, too weak. In either cafe, the feelings of the writer and the reader may be in unifon, without hitting their due pitch; and the high purpofes of language, as the inftrument of nice interpretation, muft be thereby defeated.

In the account already given of the powers of feeling and imagination, a reference has been made to another one, whofe province it is to control the exceffes of both. When the two former are feeble, the perfon in whom this is the cafe, muft, for ever, keep the rank which nature has affigned him. No provifion is made for multiplying the avenues by which perceptions can enter his mind, nor for increafing his power of forming ideal combinations of such as do. By means of judgment, however, luxuriance may be corrected, though deficiency cannot be fupplied; and such a balance may be eftablifhed among the different powers, as will conftitute the perfection of each.

JUDGMENT

JUDGMENT ſtands oppoſed to feeling, as the operations of the latter are prior in the order of nature; the one paſſing ſentence upon perceptions, which the other has previouſly furniſhed. It ſtands oppoſed to imagination, as there is belief in the reality both of the ſubject and the deciſion. Different, nay oppoſite judgments may be formed of one thing; but, if ſimple apprehenſions be different, their ſubject cannot be the ſame.

TRUE judgment enables men to diſcern both the truth of propoſitions fairly ſtated, and the propriety of ſentiment and conduct in every particular inſtance. As the hiſtorian's judgment is proved, not only by his reflections on the conduct of others, but by what he does himſelf; ſo the firſt indication of the degree in which he poſſeſſes this power is to be ſeen in his choice of a ſubject. The rule in HORACE is alike applicable to writers of every kind:

    —— *Verſate diu, quid ferre recuſent,*
    Quid valeant humeri *.

Real abilities are generally accompanied with a juſt notion of their extent. This conſciouſneſs, at the ſame time, renders neither the poſſeſſor preſumptuous, nor the obſerver jealous. True diſcernment deſtroys every thing like arrogance in the former; and, where there is a clear ſuperiority, men repine not at that ſubordination in talents which nature herſelf has eſtabliſhed.

ALTHOUGH the higheſt abilities will make the moſt of all hiſtorical ſubjects, yet, among theſe, there is ſuch a difference as to give room for a judicious choice. Ordinary genius would be foiled where the moſt diſtinguiſhed can beſt ſhew itſelf. The difficulty of hiſtorical ſubjects depends upon the ſtate of the facts to be recorded. When theſe are of very ancient or of very recent date, it tries the hiſtorian's judgment, upon the one hand, to diſtinguiſh the ſpurious from the genuine, and to make the moſt of information that is perhaps but ſcanty; and, upon the other, to ſhun the odium of parties, without neglect-

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* HOR. de Arte Poëtica, v. 39.

ing what he owes to himself *. He muſt poſſeſs the ſubtilty of
the politician, whoſe tranſactions he relates, ſo as to perceive the
intricacies of his character, and the moſt latent motives of his
conduct. If he does, he will draw the picture with exactneſs;
if he does not, he muſt miſlead poſterity, for whoſe benefit
chiefly he profeſſes to write.

THE judgment exhibited in the choice of a ſubject may be
held a ſecurity for the diſtinct arrangement of all its parts.

> ———————— *Cui lecta potenter erit res,*
> *Nec facundia deſeret hunc, nec lucidus ordo.*

When the hiſtorian exhibits events that took place nearly at the
ſame time in different places, the diſtinctneſs of his detail muſt
become manifeſt as theſe multiply, and the difficulty of main-
taining a due unity in his ſubject is thereby increaſed. The
disjointed record of a journaliſt deſerves not the appellation of
hiſtory. That unity mentioned, too, is alike neceſſary, whether
the ſubject be a ſingle tranſaction in one ſtate, (ſuch as CATILINE's
conſpiracy), or the continued tranſactions of a nation.

THOUGH the cenſure of DIONYSIUS of Halicarnaſſus upon
THUCYDIDES be ſevere, it is not without foundation. In the
opinion of that great critic, the attention of the hiſtorian cannot
be too much turned to this, το τεχνικωτερον μερος, the nice œconomy
and diviſion of his ſubject. For the want of due order, no
compenſation can be made, and every arrangement that breaks
the detail improperly, defeats the purpoſe of all arrangement,
which is perſpicuity. The train of events recorded ſhould be
preciſely that which took place; and the connection between
cauſes

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* Tu tamen jam nunc cogita, quæ potiſſimum tempora aggrediar. Vetera et ſcripta
aliis? parata inquiſitio ſed oneroſa collatio: Intacta et nova? graves offenſæ, levis gra-
tia. Nam præter id, quod in tantis vitiis hominum plura culpanda ſunt, quam laudan-
da, tum ſi laudaveris, parcus: Si culpaveris, nimius fuiſſe dicaris: Quamvis illud pleniſ-
ſime, hoc reſtrictiſſime feceris. PLIN. *lib. 5. ep. 8.*

caufes and effects as difcernible in the hiftory as it before was in the fcenes to which it refers. An hiftorian's bufinefs, according to LUCIAN, is to relate things as they were done.*. The reader's experience is thus increafed, as if he had been actually engaged in the affairs which he contemplates, and he becomes prepared for occurrences by which he would have been otherwife embarraffed †.

THE hiftorian's impartiality, which is a quality of the higheft importance, is always proportioned to the ftrength of his judgment. Fidelity and impartiality are fometimes confounded, though the one is an attribute of the heart, and the other of the underftanding. An hiftorian of fidelity never means to deceive ; an hiftorian that is impartial is not apt to be deceived by circumftances that relate either remotely or immediately to himfelf. In the relations of the former, we look for what is ftrictly true ; in thofe of the latter, for fuch a ftate of facts as exhibits no prejudices into which we and others are unable to enter. We condemn the want of fidelity, as leading to a defigned violation of truth ; but we pity the weaknefs that would miflead involuntarily, and is biaffed by circumftances that are purely perfonal. LUCIAN requires of the hiftorian to diveft himfelf of every poffible ground of partiality ; " to have the in- " difference of a ftranger in judging of his own works ; to be of " no ftate ; to form his own laws ; to acknowledge no king, and " to fpeak the truth without regard to the opinion of parties ‡."

BUT judgment not only divefts the hiftorian of any unjuftifi- able attachment to what concerns himfelf ; but enables him to fee even indifferent objects in their true light. By means of this, he is difpofed neither to depreciate what is really important, nor to over-rate what is really mean. In examining the proba- bility

* Τε δη Συγγραφιως εργον εν, ως επραχθη ειπειν.

† OCCASIONES autem redeunt in orbem, et quod olim erat commodum rurfus adhiberi et prodeffe poteft. BACON *de Aug. Scient. lib.* 2. *c.* 12.

‡ Ξενος εν τοις βιβλιοις, και απολις, αυτονομος, αβασιλευτος, 8 τι τωδε η τωδε δοξει λογιζομενος, αλλα. τι πεπρακται λεγων. Πως δι ιτορ. συγγρ.

bility of dubious events, he is not so credulous as to acquiesce in slight evidence, nor does he stubbornly reject such as should convince him. His mind, like a faithful mirror, reflects every thing precisely as it is seen. As his facts are genuine, so his observations will be pertinent. Knowing, also, that men refuse the praise that is too eagerly courted, he will introduce his own remarks with caution, and will chuse rather to surprise with depth in the body of his detail, than to disappoint expectations that he had formally summoned. My Lord BACON's observation upon this part of the character of an historian is judicious and happily expressed: " Licet enim historia quæque prudentior " politicis præceptis et monitis veluti impregnata sit, tamen " scriptor ipse sibi obstetricari non debet *."

JUDGMENT, then, in the mind of an historian, besides giving the other powers their due value, is itself the foundation of many capital qualities. It enables him to chuse and to arrange his subject, so as to do most justice to his own abilities, and to give most instruction to his reader. It secures the fairness of his decisions, in spite of those personal connections with which most men are blinded. It supposes sagacity in his opinions as to past things that are doubtful, and future things that are contingent. While it makes him view objects as they are, and secures his reader against the impertinence of observations that are either trifling or misplaced, it represses the weak vanity that lessens the merit which it means to exaggerate.

To one or other of the three powers, of feeling, of imagination, or of judgment, (it should seem), all the qualities of a great historian are to be referred. Industry and preliminary information have been allowed to be necessary; but these tend only to do justice to those primary powers. Nothing has been said as to the principle of taste ; because, according to the observation of the ingenious author of The essay upon the sublime and beautiful, this is, in reality, no distinct power, but is the result of the whole of the powers specified when combined.

The

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* BACON de Aug. Scient. l. 2. c. 10.

The characters of an author's style, too, are fixed by thofe of his mind. It is delicate, lively and accurate, according to his fenfibility, his fancy, and his judgment; and its comparative excellence is determined by the abfolute ftrength of each power, and the general balance that fubfifts among the whole.

AFTER attempting to eftablifh a ftandard, by which the merit of any hiftorical work is to be tried, I mean now to apply it particularly to the writings of TACITUS. In doing fo, I propofe to give examples that will indicate the ftrength of the three powers ftated, taken feparately, and in the order in which they have been defined. After contemplating certain inftances, in which our author's fuperiority, with refpect to each, will be evident, others may perhaps be fuggefted, in which his greateft admirers cannot free him from cenfure.

THOUGH it is difficult to determine which of the three powers mentioned predominated in the mind of TACITUS; yet, from the nature of his fubjects, his fenfibility was often exercifed in an uncommon degree. Inftances of this are fo numerous, that we muft felect a few only of the moft ftriking. Let us take that of the death of GERMANICUS, and of the ftate of his widow AGRIPPINA, in the end of the fecond and beginning of the third book of the Annals.

THE fituation of GERMANICUS, juft before his death, (it muft be remembered), was fingular. He had long been the favourite of the Romans, on account of the agreeablenefs of his manners, and the high military character that he had acquired at a very early period of life. He was the adopted fon of TIBERIUS, who, having become jealous of his popularity, had called him from the conqueft of Germany, which he had nearly completed. He was difmiffed from Rome, under pretence of fettling certain differences in the eaft. His conduct there was invidioufly watched by PISO, the governor of Syria, who was in the emperor's confidence. He was certain, when upon his deathbed, that he had been poifoned by PISO; and, while he com-

plains

plains of the hardneſs of his fate, he conjures the friends who ſtood around him to avenge his injuries. " Non hoc præci-
" puum amicorum munus eſt, profequi defunctum ignavo
" queſtu; ſed quæ voluerit meminiſſe, quæ mandaverit exſe-
" qui. Flebunt GERMANICUM etiam ignoti: vindicabitis vos,
" ſi me potius quàm fortunam meam fovebatis. Oſtendite po-
" pulo Romano Divi AUGUSTI neptem, eandemque conjugem
" meam: numerate ſex liberos. Miſericordia cum accuſanti-
" bus erit: Fingentibuſque ſceleſta mandata, aut non credent
" homines, aut non ignoſcent."

OUR author's deſcription is not leſs delicate in the caſe of AGRIPPINA going on board a ſhip for Rome, furrounded with her children, and carrying the aſhes of her huſband. The fight of this ſeems to have affected the ſpectators deeply, and the deſcription is not leſs moving than the ſpectacle. " Miſeran-
" tibus cunctis quod femina nobilitate princeps pulcherrimo
" modo matrimonio inter venerantis gratantiſque aſpici ſolita,
" tunc feralis reliquias ſinu ferret, incerta ultionis, anxia ſui
" et infelici fecunditate fortunæ toties obnoxia." This laſt cir-
cumſtance is very happily laid hold of. The number of AGRIP-
PINA's children, which was once a bleſſing, had now become a curſe. It only enlarged the mark at which the father of her huſband was to direct his malice.

UPON her approach to the coaſt of Italy, another ſcene pre-
ſents itſelf, equally affecting, from the unfeigned ſympathy of the ſpectators, and the deep grief of AGRIPPINA herſelf.
" Atque ubi primum ex alto viſa claſſis, complentur non mo-
" do portus et proxima maris, ſed mœnia, ac tecta, quaque
" longiſſime proſpectari poterat, mœrentium turba, et rogitan-
" tium inter ſe, " Silentione an voce aliqua egredientem exci-
" perent." Neque ſatis conſtabat quid pro tempore foret: Cum
" claſſis paulatim ſucceſſit, non alacri ut adſolet remigio; ſed
" cunctis ad triſtitiam compoſitis. Poſtquam duobus cum li-
" beris feralem urnam tenens egreſſa navi, defixit oculos; idem
" omnium

" omnium gemitus, neque difcerneres proximos, alienos, viro-
" rum feminarumve planctus: Nifi quod comitatum AGRIPPINÆ
" longo mœrore feffum, obvii et recentes in dolore anteibant."

THE death of OTHO, in the 48th chapter of the fecond book
of the hiftory, prefents another fcene, in which the delicacy of
our author's feelings is manifeft. In both cafes, by a previous
narration, in which the art of the writer is judicioufly conceal-
ed, he prepares the reader completely for thofe ftrokes in
which his genius is to break forth. OTHO, after the defeat of
his army, is reprefented as defpairing of future fuccefs, and as
having formed the refolution of putting an end to his exiftence.
He announces this refolution to his friends, with fuch art, as
at once to maintain his own dignity, and to move their compaf-
fion. He reproves his nephew SALVIUS COCCEIANUS for dread-
ing the vengeance of VITELLIUS, upon whofe generofity (he
thought) he might throw himfelf with confidence ; and finifhes
his advice thus : " Proinde erecto animo capefferet vitam, neu
" patruum fibi OTHONEM fuiffe, aut oblivifceretur unquam, aut
" nimium meminiffet."

THE exhortation of ÆNEAS to his fon ASCANIUS has been
much admired :

> *Et te animo repetentem exempla tuorum,*
> *Et pater* ÆNEAS *et avunculus excitet* HECTOR*.

IN point of delicacy, in a fimilar fituation however, the hifto-
rian has got beyond the poet. By the ufe of the adverb *nimium*,
OTHO not only fuggefts to COCCEIANUS what the world would ex-
pect from him as his relation, but delicately infinuates, that the
remembrance of the uncle's virtues would furnifh no apology
for the nephew's defects.

THE ftrength of feeling exhibited by TACITUS always keeps
pace with the trying circumftances in which his characters are
placed. Of this we have a ftriking example in the account
given of the trial of SORANUS and his daughter SERVILIA, in

m   the

* VIRG. Æn. xii. 439.

the 30th chapter of the 16th book of the Annals. During the many unjuft profecutions under Nero, Soranus was accufed of intimacy with Rubellius Plautus, who had been banifh-ed, and alfo of mifbehaviour as a proconful. His daughter, from ftrong affection to her injured father, had fold her clothes and jewels, in order to confult the magicians as to the event of his trial. On this account, fhe, too, was ordered to appear be-fore the fenate. " Igitur accita eft in fenatum, fteteruntque di-
" verfi ante tribunal confulum, grandis ævo parens ; contra fi-
" lia intra vicefimum ætatis annum, nuper marito Annio Pol-
" lione in exilium pulfo, viduata defolataque : Ac ne patrem
" quidem intuens, cujus oneraffe pericula videbatur. Tum in-
" terrogante accufatore, an cultus dotales, an detractum cervici
" monile venum dediffet quo pecuniam faciendis magicis facris
" contraheret ? Primum ftrata humi, longoque fletu et filentio,
" poft altaria et aram complexa ; " Nullos, inquit, impios deos,
" nullas devotiones, nec aliud infelicibus precibus invocavi,
" quam ut hunc optimum patrem, tu Cæsar, et vos Patres fer-
" varetis incolumem. Sic gemmas et veftes et dignitatis infignia
" dedi, quomodo fi fanguinem et vitam popofciffent. Viderint
" ifti, antehac mihi ignoti, quo nomine fint, quas artes exerce-
" ant : Nulla mihi principis mentio, nifi inter numina fuit.
" Nefcit tamen miferrimus pater : Et fi crimen eft, fola deliqui."
" Loquentis adhuc verba excipit Soranus proclamatque, " Non
" illam in provinciam fecum profectam, non Plauto per ætatem
" nofci potuiffe ; non criminibus mariti connexam ; nimiæ tan-
" tum pietatis ream, fepararent a fe quamcunque fortem fubi-
" ret." Simul in amplexus occurrentis filiæ ruebat, nifi inter-
" jecti lictores utrifque obftitiffent."

A beautiful conteft is here prefented between the ftrong-eft parental and filial attachments. The defcription is the lan-guage of nature throughout. Every circumftance is carried its due length, without bordering upon extravagance. No tragic poet, whofe fancy is allowed a latitude which is denied the hi-ftorian,

ftorian, could exhibit even the fcene he had created, with more exquifite delicacy than TACITUS defcribes this that had actually taken place.

BUT the fine feeling of our author is apparent, not only upon fuch gloomy and fuch trying occafions as thofe mentioned, but in the more ordinary tranfactions of life. When HORTALUS, a defcendant of the great HORTENSIUS, applied to the fenate, as mentioned in the 38th chapter of the 2d book of the Annals, for an allowance to enable him to rear that family, which, at the command of AUGUSTUS, he had procreated, even the fervile fenators were fhocked with TIBERIUS's refufal. The emperor perceiving this, agreed to give a paultry donative to his male children. Some of the fenators indeed expreffed their thankful-nefs; but HORTALUS was filent. "Egere alii grates; filuit HOR-" TALUS, pavore, an avitæ nobilitatis etiam inter anguftias for-" tunæ retinens." This laft conjecture, as to the caufe of HORTALUS's filence, could be formed only by a perfon delicately fenfible of what was due to himfelf. More than fufficient vio-lence had been done to the feelings of HORTALUS, when he con-feffed his poverty and begged relief. The niggardly behaviour of TIBERIUS gave him a right to infult the emperor, and, by an expreffive filence, to tell him, in the face of his fenate, that though he had been forced to implore his bounty, yet he de-fpifed his character.

That TACITUS was a ftrictly moral writer, and expreffed, at all times, the ftrongeft love of virtue and deteftation of vice, is evident throughout his works. A fenfe of his duty as an hifto-rian feems often to have forced him to relate what he would have wifhed to conceal. He appears to feel for thofe miferies of others, which, as a rigid moralift, he allows to be the juft confequence of their vices. In the 6th chapter of the 6th book of his Annals, he defcribes TIBERIUS as completely wretched, and agrees with SOCRATES as to the caufe of this unhappinefs. " Neque fruftra præftantiffimus fapientiæ firmare folitus eft, fi

m 2   " recludantur

" recludantur tyrannorum mentes, poffe afpici laniatus et ictus;
" quando ut corpora verberibus, ita fævitia, libidine, malis con-
" fultis animus dilaceretur. Quippe TIBERIUM, non fortuna
" non folitudines protegebant, quin tormenta pectoris fuafque
" ipfe pœnas fateretur."

THE high independence of fpirit poffeffed by TACITUS, may
be inferred from what he fays both of himfelf and of others.
In the 63d chapter of the 2d book of the Annals, he condemns
MAROBODUUS for continuing in exiftence as the prifoner of
TIBERIUS. " Confenuitque multum imminuta claritate, ob
" nimiam vivendi cupidinem."

THIS fame independent fpirit is fometimes feen conjoined
with his love of truth. As the reign of NERO was not very
diftant from the times in which he wrote, of courfe, by attack-
ing the fervility of the fenate, he muft have offended many peo-
ple of the firft rank. Their difpleafure, however, he defpifed,
when put in competition with his own honour and veracity.
" Neque tamen filebimus, fi quod fenatufconfultum adulatione
" novum aut patientia extremum fuit*."

FROM the inftances quoted, it appears, that TACITUS pof-
feffed, in no ordinary degree, thofe qualities of an hiftorian,
that are dependent upon feeling. Few circumftances, from
their minutenefs, could efcape his obfervation. He felt ftrong-
ly the fineft emotions, which the moft trying fituations of his
characters could excite. He was, at all times, the friend of
virtue. A regard for pofterity feems chiefly to have prompted
him to exert his powers as an hiftorian; and, from the fame
benevolent principle, he is always fcrupuloufly careful, not to
affirm with certainty when there could be the leaft reafon for
doubt.

THE power of imagination, as we obferved, enables the hifto-
rian to write with energy, by the proper ufe of figurative lan-
guage, and to felect thofe figures that are the fitteft for defcrip-
tion. Upon examining the ftyle of TACITUS attentively, it
will

* Ann. l. 4. c. 64.

will appear, that he ufes figures more fparingly than is commonly imagined. Though the general train of his narrative be nervous, yet few parts of it are highly embellifhed. The figures that he employs are ufed more frequently with a defign to explain his idea, than to announce the ftrength of his emotion ; and even when he has this laft purpofe in view, he often employs interrogations, and fuch other modes of fpeech, as are the ordinary language of paffion.

FROM the juftnefs of TACITUS's difcernment, his fimiles are remarkably happy. They are, indeed, rarely, but they are always judicioufly introduced. It is, in every inftance, clear, that he had perceived the refemblance ftrongly and diftinctly himfelf; and, by making the allufion, fome good purpofe is completely ferved. Thus, to give a lively idea of the torpid indolence of VITELLIUS, in the 36th chapter of the 3d book of his Hiftory, he compares him to thofe lazy animals, which, when the calls of nature are fatisfied, have no other object of defire. " Sed um- " braculis hortorum abditus, ut ignava animalia, quibus fi ci- " bum fuggeras jacent torpentque ; praeterita, inftantia, futura " pari oblivione dimiferat." The expreffion in the end of this fentence is both bold and happy. The term *dimiferat* intimates a kind of activity even in the indulgence of floth ; and the term *oblivio*, applied to the prefent and the future, infinuates, that both perception and forefight were extinguifhed, like the impreffions of memory when effaced.

ONE of the boldeft, and, at the fame time, one of the happieft figures to be found in TACITUS, is that at the end of his life of AGRICOLA. It is, at once, an inftance of the profopopeia and the apoftrophe, as it fuppofes life in his father-in-law who was dead, and gives prefence to a perfon who was abfent. The high refpect entertained for the memory, and the deep grief felt for the death of AGRICOLA, juftified the ufe of thefe bold figures ; and, as they are introduced with propriety, fo they are fupported with the utmoft art. " Tu vero felix

" AGRICOLA

" Agricola non vitæ tantum claritate, fed etiam opportunita-
" te mortis.　Ut perhibent qui interfuerunt noviffimis fermo-
" nibus tuis, conftans et libens fatum excepifti, tanquam pro
" virili portione innocentiam principi donares.　Sed mihi filiæ-
" que præter acerbitatem parentis erepti, auget mœftitiam, quod
" affidere valetudini, fovere deficientem, fatiari vultu, complexu,
" non contigit.　Excepiffemus certe mandata vocefque, quas
" penitus animo figeremus.　Nofter hic dolor, noftrum vulnus :
" Nobis tam longæ abfentiæ conditione ante quadriennium
" amiffus es.　Omnia fine dubio, optime parentum, affidente
" amantiffima uxore, fuperfuere honori tuo : Paucioribus tamen
" lacrymis compofitus es, et noviffima in luce defideravere ali-
" quid oculi tui."

The delicacy, joined to the ftrength of painting, which is
difcernible in the paffage now quoted, fhows fufficiently, that
though Tacitus employs figures feldom, yet his doing fo arifes
from no defect in his powers.　The frequent ufe of thefe is, in
fact, a ftratagem to which writers of ordinary genius feel
themfelves driven.　They wifh to borrow a device from art, to
conquer a barrier eftablifhed by nature.　For a device of this
kind, Tacitus had no occafion.　The ordinary train of his
narration is fufficiently animated to fummon and to retain his
reader's attention ; and, when he chufes to leave this train, he
knows perfectly how to rife with propriety, and to defcend
without falling.

The inftances of fine defcription are fo numerous in Taci-
tus, that it is not eafy to determine which ought to be fe-
lected.　In all his attempts to defcribe, brevity is ftudied.　When
he defcribes the plague at Rome, in the 13th chapter of the
16th book of his Annals, he employs a few fentences, but
each fentence is full of meaning.　" Omne mortalium genus
" vis peftilentiæ depopulabatur, nulla cæli intemperie quæ oc-
" curreret oculis.　Sed domus corporibus exanimis, itinera fu-
" neribus complebantur.　Non fexus, non ætas periculo vacua.
　　　　　　　　　　　　　　　　　　　　　　　" Servitia

" Servitia perinde ac ingenua plebes raptim extingui, inter con-
" jugum et liberorum lamenta, qui dum affident, dum deflent,
" fæpe eodem rogo cremabantur. Equitum fenatorumque inte-
" ritus, quamvis promifcui, minus flebiles erant, tanquam com-
" muni mortalitate, fævitiam principis prævenirent."

THIS defcription we muft own to be inferior to that of the
plague at Athens by THUCYDIDES. But the Greek hiftorian (it
muft be remembered) had fuffered from the difeafe himfelf;
had feen its direful effects, combined with thofe of war; and
had refolved to enumerate its fymptoms, for the benefit of po-
fterity, in the courfe of fix chapters. TACITUS means to relate
only what he had heard. He does not feem to have copied
THUCYDIDES; though he, too, mentions, that numbers of car-
cafes lay neglected in private houfes, upon the ftreets, at the
fides of fountains, and in the temples. " Ὁ φθορῷ εγιγνετο ꙇδενι κοσμω,
" αλλα και νεκροι επ αλληλοις αποθνησκοντες εκειντο. και εν ταις οδοις εκυλινδουντο και
" περι τας κρηνας απασας ἡμιθνητες τη τꙍ ὑδατος επιθυμια. τα τε ιερα εꙟ οις εσκηνην-
" το νεκρων πλεα ην, αυτꙍ εναποθνησκοντων *."

LUCRETIUS, in the defcription he gives of the plague at the
end of his fixth book, has copied THUCYDIDES clofely, but
feems to have come fhort of the fimplicity and mafterly ele-
gance of the hiftorian.

THE fituation of OCTAVIA, after her divorce from NERO,
forms one of the moft highly finifhed defcriptions in the writings
of TACITUS. After the tyrant had efpoufed POPPÆA, under
the appearance of gratifying the wifhes of his people, whofe re-
fentment he in fact dreaded, he took back his injured wife.
By the arts of POPPÆA, however, which were fkilfully direct-
ed againft his weakneffes, he difmiffed OCTAVIA again, and
bribed one of his minions, to fcreen his injuftice, by declaring
that fhe had been guilty with him. Upon this, the innocent
OCTAVIA was banifhed to the ifland of Pandateria, and the fen-
timents of the fpectators upon this undeferved feverity, are the
ground of the defcription mentioned. " Non alia exful vifen-
" tium

* Θουκυδ. το δευτ. κꙟᴘ. ιᵃ.

" tium oculos majore mifericordia affecit. Meminerant adhuc
" quidam AGRIPPINÆ, a TIBERIO, recentior JULIÆ memoria
" obverfabatur, a CLAUDIO pulfæ. Sed illis robur ætatis af-
" fuerat. Læta aliqua viderant, et præfentem fævitiam me-
" lioris olim fortunæ recordatione allevabant. Huic primus
" nuptiarum dies loco funeris fuit, deductæ in domum, in qua
" nihil nifi luctuofum haberet, erepto per venenum patre, et
" ftatim fratre. Tum ancilla domina validior. Et POPPÆA
" non nifi in perniciem uxoris nupta. Poftremo crimen omni
" exitio gravius *."

THIS defcription is as artful in fact, as it is artlefs in appear-
ance. The circumftances faid to move the compaffion of the
fpectators, are marked with wonderful judgment; and the
beautiful climax exhibited in the arrangement of them, pro-
duces a very uncommon effect. Their feelings firft reft upon
the difference between the fituation of OCTAVIA, and that of
other women of diftinction who had been fubjected to the like
fate. They next reft upon her perfonal difgrace, as an emprefs,
becoming fubject to a fervant; next upon the immediate de-
ftruction threatened her by this marriage of POPPÆA; and laft
of all, upon the falfe accufation of having been unfaithful to
her hufband, and guilty with a mifcreant, which no form of
deftruction could equal. The conditions upon which the fancy
operates fuccefsfully are here fulfilled. It has full room to
work, and its exertions are not clogged by an unmeaning ver-
bofenefs.

FROM fulfilling the conditions now mentioned, THUCYDIDES
has acquired immortal honour by his defcription of the retreat
of the Athenian army, in the 7th book of his Hiftory. The
barbarity of the conquerors and the diftrefs of the vanquifhed
appear equally incredible, though a few circumftances only
are employed to fuggeft thefe. During the paffage of the
Athenians over the river Affinarus, from the extremity of fa-
tigue

* Ann. l. 14. c. 63.

tigue and of thirst, they seem driven to a kind of frantic despair. Though the stream in which they then stood was polluted with mud, and with the blood of their countrymen, yet they are represented as fighting about the water in this corrupted state. " καὶ τὸ ὕδωρ εὐθὺς διεφθαρτο· ἀλλ ὐδὲν ἦοσον ἐπινετο τε ὁμου τῳ πηλῳ ἡματωμε-
" νον καὶ περιμαχητον ην τοις πολλοις *."

Tacitus paints, in the most lively colours, the distress of Vitellius upon the success of the Flavian party, and the distracted state of his mind upon returning to his palace, which he had before left, and then found deserted. " Dein mobilita-
" te ingenii, et quæ natura pavoris est, cum omnia metuenti
" præsentia maxime displicerent, in palatium regreditur, vastum
" desertumque ; dilapsis etiam infimis servitiorum, aut occur-
" sum ejus declinantibus. Terret solitudo, et tacentes loci ;
" tentat clausa ; inhorrescit vacuis : Fessusque misero errore, et
" pudenda latebra semet occultans, ab Julio Placido tribuno
" cohortis, protrahitur. Vinctæ pone tergum manus, laniata ve-
" ste, fœdum spectaculum ducebatur, multis increpantibus,
" nullo illacrymante. Deformitas exitus misericordiam abstu-
" lerat †."

But the uncommon talent for description possessed by Tacitus, is often manifest from his judicious selection of a single anecdote, as explanatory of character. Of this we have a remarkable instance in the 35th chapter of the 1st book of the History. When the old emperor Galba was still sitting in his palace, and hearing expressions of loyalty, which, after the success of Otho, he suspected to be insincere, one Julius Atticus comes up to him, declaring that he had slain the usurper with the bloody dagger which he then held in his hand. The emperor's reply was such as could hardly have been expected. " Commilito, inquit, quis
" jussit ?" This single anecdote is so completely characteristic, as almost to supersede the necessity of the judicious comment that follows : " Insigni animo ad coercendam militarem licen-

n

" tiam,

* Θουκυδ. τὸ ἱᾶδ. κεφ. πδ'. † Hist. l. 3. c. 85.

" tiam, minantibus intrepidus, adverfus blandientes incorrup-
" tus."

In point of imagination, then, the genius of Tacitus is by
no means deficient. Though he ufes figurative language fpa-
ringly, yet he is highly fuccefsful when he does. Many of his
defcriptions may be held perfect in their kind, and will bear a
comparifon with thofe of the moft diftinguifhed hiftorians of
Greece. In all of them brevity is ftudied, and ftriking circum-
ftances judicioufly feized. Thefe are held forth to the reader
with fuch art, as neither to check the operations of his fancy,
by fuggefting too extenfive a fubject, nor to ftop thofe operations
completely, by fuggefting one that is too narrow.

In the fequel of this paper, I fhall produce fome proofs of
that foundnefs of judgment in Tacitus, which is the diftinguifh-
ing quality of a great hiftorian. I fhall afterwards point out
his fuppofed faults, in certain refpects, by an application of that
criterion which may have evinced his merits in others; and
fhall try to mark particular deviations in his ftyle, from that
pure ftandard which was exhibited during the Auguftan age *.

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* See the Second Part of this Paper afterwards.

V.

V. *On the* DRAMATIC *or* ANCIENT FORM *of* HISTORICAL COMPOSITION. *By* WILLIAM RICHARDSON, M. A. F. R. S. EDIN. *and Professor of Humanity in the University of* GLASGOW.

[*Read by Mr* FRASER TYTLER, *Secretary,* June 21. 1784.]

IN comparing ancient with modern historians, we meet with one remarkable circumstance in which they differ. The ancient historians are dramatic, the modern narrative. The ancients exhibit eminent persons delivering long speeches, adorned, as the occasion may require, with all the graces and force of eloquence. This is seldom done by the moderns. If it is ever necessary to give an account of what may have been delivered on an interesting subject by an eminent speaker, they tell us, excepting in such works as may be accounted translations, or in such histories, as those of BUCHANAN and GUICCIARDINI, written manifestly after the models of antiquity, *That* he made use of such or such arguments; and, adhering strictly to the narrative form, they never venture on the bolder task of displaying him in his own person, delivering a long oration.

I. IT is probable, however, that the earliest ancient historians were not induced to a practice so peculiar to themselves by critical considerations. They adopted it without any reasoning about its advantages. They could state no comparison between it and any other form of historical composition. They knew no other, and were led to it, both in its beginnings and continuation, by the particular situation and circumstances in which they were placed. This may be illustrated by a few remarks.

The

The earlieft hiftorians were mere narrators of facts. They were not very anxious either about inveftigating caufes or tracing effects. If they were defirous of inftructing their readers or hearers, (for the earlieft hiftories were often recited to a numerous audience), they were no lefs defirous of amufing them. In fuch compofitions, therefore, they were led to imitate converfation. Their hiftories were, in truth, no other than oral narratives and ftories committed to writing. But, in converfation, the narrator of an interefting ftory becomes animated in his narrative; and if, like the ancient Greeks, he poffefs fenfibility, the fpirit exhibited in his ftory will be proportioned to the vivacity of his feelings. Lively feelings, however, lead perfons, in relating or defcribing the actions or conduct of others, to become dramatic; that is, to tell us the very words or fayings of the perfon they defcribe; and not only fo, but to recite them as if he himfelf were the fpeaker. Now this animated mode is imitated by the earlieft writers who defcribe human actions. They do fo at firft, becaufe it is done in converfation; they continue the practice, becaufe it is lively and interefting. As, in converfation, the fpeeches or fayings attributed to the perfon whofe conduct was delineated, were fhort; they were alfo fhort in the earlieft, and perhaps moft agreeable form of written hiftory. Of this the facred hiftorians and HERODOTUS afford us fufficient proof. It was not till after hiftorical compofition had been fome time in ufe, that it prefented to us long fpeeches and elaborate declamation. Its earlieft fpecies, therefore, may be termed colloquial, as diftinguifhed from that which, belonging to the clafs of dramatic hiftory, followed foon after, and may be termed oratorial. Perhaps there was an intermediate ftep. Poets were earlier than hiftorians; and, in their reprefentations of human actions, were, for the reafons above mentioned, colloquial and dramatic. Such are the poems of HOMER. The propenfity, therefore, which early hiftorians had to affume the dramatic form was, by the practice of their predeceffors,

predeceffors, both juftified and enforced. Hiftorians, from
imitating converfation, came to imitate public fpeaking, and
became oratorial. This change, however, was not merely an
extenfion, fo to fay, of the preceding method. It was produced
by other caufes. The earlieft ancient hiftorians were natives,
or recorded the deeds and revolutions, of independent republics.
In thefe ftates, public fpeaking was very generally practifed,
and was often the caufe of important events. The war between
Athens and PHILIP, promoted by the oratorial powers of DE-
MOSTHENES; and the flight of CATILINE from Rome, occa-
fioned by the eloquence of CICERO, are illuftrious proofs.
But not only did fpeeches, delivered in legiflative or deliberative
affemblies, in the fenate or in the forum, produce important ef-
fects; other fpeeches, funeral orations and allocutions, were
fometimes followed by very fignal confequences. Ancient hi-
ftorians, therefore, were obliged to give us an account of fuch
fpeeches; and, having before them the example of poets and
very early hiftorians, they adopted their method. They had
alfo fome other inducements. In the progrefs of improvement,
the art of public fpeaking came to be highly cultivated. Rhe-
torical talents conferred great reputation, and the ftudy of ora-
tory became univerfal. It is not furprifing, therefore, that hi-
ftorians fhould embrace fuch obvious opportunities as their fub-
jects afforded them, of difplaying their abilities in a fpecies of
compofition fo much efteemed. It has been remarked, that
fymptoms of this paffion for oratory, fo prevalent in Greece
and Rome, may be difcovered, even in fome of their poets.
Such was the origin, and fuch the different kinds of dramatic
or rhetorical hiftory.

II. IT is obvious, that, fo far as amufement is concerned,
the method practifed by LIVY, THUCYDIDES, and other ancient
hiftorians, has great advantages. It is a livelier method. It
brings us, as it were, to the very fcene of action. We are wit-
<div align="right">neffes</div>

neffes of the " very deed ;" we are prefent in the fenate, in the
forum, or on the field of battle.   Nor is this effect wonderful ;
for hiftorians, by adopting the dramatic method, have an op-
portunity of diverfifying their labours, not only with the orna-
ments, but with the impetuofity of rhetorical diction. Some
of the fpeeches in LIVY are as animated and defcriptive as the
pleadings of CICERO.   The advantages of the rhetorical form,
in point of vivacity and amufement, are particularly manifeft,
when an hiftorian, in relating an important event, has occafion
to explain the ftate of parties, with the particular views and in-
tentions of fuch leading men, efpecially in civil diffenfions, as
may have oppofite interefts.   Such detail in modern hiftory be-
comes often very tedious and unengaging, though it may have
coft the writer much laborious refearch, and may be in itfelf
important ; yet the reader very frequently tires, and counts the
pages.   How much more interefting is it, when this informa-
tion is conveyed to us indirectly, in an eloquent fpeech, and
with all the graces of rhetorical expreffion ! It was neceffary for
THUCYDIDES to inform his reader, that the ftate of Athens was
accufed by their neighbours of depredation, and to fet before him
the various interefts, views or condition of thofe Grecian re-
publics that entered early into the Peloponnefian war ; and this
he does in the moft agreeable manner, in the fpeeches he attri-
butes to ambaffadors, or other perfons in high office, among
the Spartans, Corinthians, and Athenians.   How diftinctly, and
with how much fpirit does LIVY fet before us the different
rights, powers and pretenfions of the patricians and plebeians
at Rome, in the orations of APPIUS and CANULEIUS ! Add to
all this, that the dramatic method gives us an interefting difplay
of character.   Who is not more ftruck with the character of a
Lacædemonian, in the following fpeech attributed to STHENE-
LAIDAS *, than if it were defcribed in a more direct, and even
in a more circumftantial narrative ! The Corinthian ambaffadors
at

* THUCYD. lib. 1.

at Lacædemon had reprefented, that the prevailing power of
Athens had rendered it neceffary for the Spartans to interpofe.
The Athenian ambaffadors, then prefent, reply to them in a long
harangue: They wifh to hinder the Lacædemonians from enter-
ing immediately into hoftile meafures; and take occafion to
magnify and enumerate the mighty deeds of the Athenians,
their power, and the fervices they had done to the Greeks.
Thereupon STHENELAIDAS tells them, " I really do not under-
" ftand the long harangue of the Athenians. They expatiate in
" their own praifes; but fay not a fingle word about the wrongs
" they have done to our allies, and to Peloponnefus. If they
" behaved well on a former occafion againft the Medes, they
" behave ill at prefent, and deferve the feverer correction, that,
" having known and practifed what is right, they are now ad-
" dicted to evil. But our conduct has, at all times, been uni-
" form; and, if we act properly at prefent, we fhall neither
" neglect the wrongs fuffered by our friends, nor delay to affift
" them; for, in their fufferings, there is neither delay nor re-
" fpite. Other ftates may have money, and fhips, and horfes;
" but we have good friends, whom we muft not abandon to the
" Athenians. Nor is there any need for enquiries, or difcuf-
" fions in words; it is not by words alone that we and our
" friends are injured. Forthwith, and with all our might, we
" muft give them aid. Nor let any one tell us, when we fuffer
" injury, that we ought to reflect and deliberate. It is the bu-
" finefs of thofe who meditate injury to reflect. Therefore,
" Lacædemonians, let us act confiftently with the dignity of
" Sparta: Let us refolve on war; nor allow the Athenians to
" become too powerful, nor fuffer our allies to be oppreffed;
" but, confident in the favour of Heaven, let us take up arms
" againft the guilty."

III. SINCE, therefore, the dramatic form has fo many advan-
tages; fince it animates a narrative; gives an opportunity to
the

the hiftorian of borrowing affiftance from the graces of elo-
quence; imparts fpirit to details, otherwife unengaging; and
gives an interefting difplay of character; why fhould it be
given up by the moderns? Do they acknowledge themfelves
more deftitute of fancy, fenfibility, and powers of eloquent
diction than SALLUST or TACITUS? Other reafons have been af-
figned, and they deferve to be examined.

" TRUTH," it may be faid, " is the foundation of hiftory.
An hiftorian muft give a faithful account of facts, elfe he is
no hiftorian; he is a novelift, a teller of tales, a romance-
writer, and that of the worft kind; for he would impofe upon
us as actual truth, what is even deftitute of probability. Now,
as it is not probable, that the fpeeches afcribed by ancient hi-
ftorians, to the great perfons of whom they write, were ever
delivered by them in the very form their hiftorians have given
them, they are guilty of deviation from truth and incur the
cenfure we have expreffed. Though CÆSAR and CATO might
have delivered fuch orations as SALLUST has afcribed to them,
it is not very likely that GALGACUS and CORIOLANUS fhould
have delivered the long fpeeches attributed to them by TA-
CITUS and DIONYSIUS. The Romans and Caledonians, at the
period when thefe men appeared, were illiterate and unim-
proved. The practice feems to have arifen among the loqua-
cious Greeks, and to have been copied by the imitative Romans.
It is, as was mentioned, a manifeft violation of truth; and
if an hiftorian, in any cafe whatfoever, appears regardlefs of
veracity, how can we depend upon him on other occafions?
He impairs his own credit, and the whole of his evidence be-
comes fufpected. Therefore, according to this view of the
matter, the felf-denial of modern hiftorians does them great
honour. Rather than trefpafs againft the truth, and weaken
the force of their evidence in matters fo highly important, as
the knowledge of paft events, they deny themfelves all the or-
naments they might derive from the difplay of eloquence;
and,

and, with a manly confcioufnefs of the dignity conferred by their great office, they defpife the praife of rhetorical ingenuity."

This argument feems very weighty. I fhall, therefore, confider, in the *firft* place, How far the dramatic form may be called a deviation from truth or probability ; and, *2dly*, Suppofing it to be fo, whether the feverity of the rule has not been relaxed in other particulars of higher moment, both by ancient and modern hiftorians, but without deftroying, or even weakening their credit.

1. How far, then, may the dramatic form be confidered as a deviation from truth or probability? Were there no public fpeakers in Greece or in Rome? In the deliberations of Athenians and Romans, concerning affairs of the laft importance, were there no public orators? Were there no funeral harangues? And were there no allocutions? Was it not cuftomary for a commander, about to engage in battle, to affemble his army, and pronounce, in their hearing, fuch animated fpeeches as tended to roufe and preferve their fpirit? Did not ambaffadors pronounce elaborate orations? When the Ionians folicited affiftance from the Greeks againft the Perfians, are we not told by HERODOTUS, that PITHERMUS, deputed for that purpofe, arrayed himfelf in purple, and delivered an eloquent oration to the people of Lacedæmon? Ambaffadors among the Romans were originally termed *pleaders* *; they are fo termed by VIRGIL, who never, fo far as I know, deviates from the truth of nature in his delineation of manners. And ILIONEUS, who feems to have been the chief fpeaker among the Trojans, delivers himfelf with great eloquence both at Carthage and to King LATINUS. Or can we fuppofe, that thofe fpeeches, delivered fo frequently, and on fo many occafions, had not very

o   powerful

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* TUM fatus ANCHISA delectos ordine ab omni
  Centum *oratores* augufta ad mœnia regis
  Ire jubet,——   *Æn.* vii. 150.

powerful effects in the great interests of republican states ?
Thefe are facts which cannot be denied. If fo, they ought
certainly to be recorded.   But are they to be recorded in the
very general manner now mentioned ? Is the hiftorian to do no
more than fimply tell us, that certain perfons, upon certain oc-
cafions, delivered fpeeches, on one fide or other, in fome mo-
mentous debate ? A reader, entering with fpirit into the nar-
rative, would be defirous of knowing what arguments were em-
ployed ; for if an effect, worthy of being tranfmitted to pofte-
rity, was produced by fuch fpeeches, the arguments they con-
tained were, without doubt, its efficient caufe.   Therefore, if
they are known, a faithful and intelligent writer will be very
loath to fupprefs them, otherwife he becomes unfaithful. The hi-
ftorian, then, muft give us an account of fpeakers, and of
fpeeches, and of the arguments which they contain ; but muft
he proceed no farther ? The rigid feverity of modern criticifm,
and the laudable love of truth, fo peculiar to the moderns, pro-
nounce an inviolable prohibition.   He muft not pretend to tell
us, nor even to conjecture the method or arrangement obferved
by the fpeaker, and much lefs the words of the fpeech.   It is,
then, about the mere words of the fpeaker, or perhaps his me-
thod, that there is any difpute ; and all the charge brought
againft ancient hiftorians amounts to no more than that they
alter the expreffion, and give the arguments of a fpeaker in the
firft perfon, rather than in the third.   If they had done, as has
been practifed in fome hiftories of England ; if they had told
us, that fome peer or commoner had faid *That* fuch and fuch
were his views and conclufions, there would have been no tranf-
greffion ; and Livy and Thucydides are no otherwife blamed,
than for exhibiting their fpeakers in the firft perfon : Yet, fure-
ly, the faithful hiftorian is a recorder of facts rather than of
words.   Herodotus, in one inftance, has done the very thing
which this criticifm requires.   He has given us the inelegant,
though figurative language, fpoken by fome Perfian ambaffadors
at

at the court of a Macedonian prince*; and has accordingly in-
curred the juſt, but reluctant blame of LONGINUS †. Or would
you have a modern hiſtorian, in giving an account of the
ſpeeches in the Houſe of Commons, give us the Iriſh of one,
the broad Scotch of another, or vulgar Engliſh of a third? Or,
in telling us the converſation of ſome foreign miniſter, ignorant
of the Engliſh tongue, would you have him deliver it in the
original German or Dutch? In ſuch caſes we make uſe of
tranſlation. Yet the idioms of modern European languages are
ſo different from one another, that we ſhall find it, on many
occaſions, utterly impoſſible to give a literal tranſlation of the
very words. We muſt have recourſe to circumlocution, and
to ſuch metaphorical expreſſions, as preſent very different images
from thoſe of the original. HELVETIUS has been charged,
and I think not unjuſtly, with having offered to the public, as
an original poem, a tranſlation of the firſt ſcene of ELFRIDA ‡;
yet the difference between the two performances is much greater
than that between preſenting the views and arguments of a pu-
blic ſpeaker, as delivered by himſelf, or as related by an hi-
ſtorian. Add to all this, that there can be no violation of ve-
racity, when there is no intention of deceiving, much leſs when
the reader is warned of his danger, and, in the very manner
in which ſpeeches are introduced, is guarded by the writer him-
ſelf againſt impoſition. TACITUS introduces the ſpeech of
GALGACUS with the words, " in hunc modum locutus fertur,"
" is ſaid to have harangued after the following manner;" and
the ſpeech of AGRICOLA with " ita differuit," " thought pro-
per thus to addreſs them." THUCYDIDES prefixes to a ſpeech
by the Corinthian ambaſſadors, " ειπον τοιαδε," " they ſpoke ſuch
things;" and to that of STHENELAIDAS, " ελεξε τοις Λακεδαιμονιοις ωδε,"

o 2 " he

* Lib. v. 18.
† De Sublim. ſect. 3.
‡ MASON's Memoirs of the life and writings of Mr GRAY, p. 296. edit. 4to.

" he fpoke to the Lacedæmonians in this manner." SALLUST's introduction to the fpeech of CÆSAR is of the fame kind; and the fame obfervation may be illuftrated in a variety of paffages in LIVY. To what has been offered on this head, I fhall add the following advice from LUCIAN, a writer of confiderable judgment, and who treated fabulous hiftory with very little indulgence. " When it is neceffary to make any one fpeak, you " muft take care to let him fay nothing but what is fuitable to " the perfon, and to what he fpeaks about, and let every thing " be clear and intelligible : Here, indeed, you may be permit- " ted to play the orator, and fhew the power of eloquence."

UPON the whole, therefore, of this argument, I have little difficulty in concluding, that the charge of deviation from truth, in the dramatic form of hiftorical compofition, is ill-founded, or admits of great palliation.

2. BUT, fuppofing the cafe were otherwife, " Has not the ftrict rule of veracity been relaxed in other particulars of higher moment, both by ancient and modern hiftorians, without deftroying or even weakening their credit?" And, if fo, why may not fome indulgence be fhewn to thofe writers who would enliven the detail of facts with the fpirit of oratorial language?

HISTORIANS, very frequently, not only record facts and events, but endeavour to trace and explain their caufes. The caufes, however, of great events often lie in the human mind; in the paffions and judgments of powerful men. It thus becomes neceffary to inveftigate motives, detect inclinations, and explore the labyrinths of the human heart. How difficult a tafk! How difficult, on many occafions, to difcover the motives of our own conduct! How difficult to afcertain the principles of action that inftigate thofe perfons with whom we are daily converfant! How much more difficult to afcertain the motives of men who lived many centuries ago, and with whofe private or peculiar

habits

habits we are little acquainted ! Every inveſtigation of this ſort muſt be attended with uncertainty. Yet hiſtorians have, in this reſpect, been undaunted. They have proceeded boldly in unfolding the mazes of the human heart, in delineating characters, and in explaining great revolutions by the paſſions, deſires, or intereſts of famous men. In ſome caſes, motives are very obvious. When THUCYDIDES tells us, that the Lacedæmonians entered into the Peloponneſian war, not ſo much to protect the other Grecian ſtates, as to hinder Athens from growing powerful, we aſſent very readily to his opinion. In like manner, when a modern hiſtorian, of uncommon elegance, informs us, in his hiſtory of America, that " PIZARRO, intoxi" cated with the ſucceſs which had hitherto accompanied his " arms, and elated with having again near a thouſand men un" der his command, refuſed to liſten to any terms * ;" we give eaſy credit to his account. At the ſame time, the only fact, of which we have ſufficient evidence, is, that PIZARRO refuſed to liſten to any terms. The motives alleged, though probable, are ſuggeſted by conjecture. The ſame obſervation is more fully illuſtrated in the following paſſage from MIDDLETON's life of CICERO, tranſlated almoſt literally from DIO CASSIUS. " JULIUS CÆSAR alſo was a zealous promoter of this law †, " from a different motive than the love either of POMPEY or " of the republic. His deſign was, to recommend himſelf by " it to the people, whoſe favour, he foreſaw, would be of more " uſe to him than the ſenate's, and to caſt a freſh load of envy " on POMPEY, which, by ſome accident, might be improved af" terwards to his hurt ; but his chief view was, to make the " precedent familiar, that whatever uſe POMPEY might make of " it, he himſelf might one day make a bad one." Had this hiſtorian been CÆSAR's father-confeſſor, he could not have been more intimately

* Dr ROBERTSON's Hiſt. of America, vol. ii. p. 255. edit. 4to.
† THE Manilian law.

intimately acquainted with his intentions and inclinations.
Add to thefe illuftrations, the various accounts given us by
different hiftorians, of the motives that influenced LUTHER
in cafting off his allegiance to the pope of Rome. By fome, he
is reprefented as being actuated folely by the love of truth, and,
according to others, by refentment. In thefe, and a variety of
other inftances, we fee hiftorians of the higheft reputation ad-
vancing their own opinions and conjectures, as matters of fact.
This practice, indeed, is much more common, and more unre-
ftrained among modern than among ancient writers, and is
ufually confidered as a great improvement in hiftorical com-
pofition. It is for this, more than for any thing elfe, that
TACITUS is fo much an object of adoration. Yet this prac-
tice, fo very fafhionable at prefent, often leads an hiftorian
into more flagrant violations of truth, and into bolder affump-
tions, than if he pretended to give us the language fpoken by
fome famous fpeaker. The dramatic hiftorian afcribes to his
illuftrious perfons, probable words and phrafes. The narrative
hiftorian, with intrepid boldnefs, afcribes to them probable mo-
tives, paffions and inclinations. The firft indulges conjecture
in thofe things merely that are external, and that regard the
form and manner. The fecond is indulgent to himfelf in thofe
that are material and internal, and advances, as facts, his own
gueffes concerning the moft delicate fprings of action. Since,
therefore, the ftrict rule of veracity is tranfgreffed in this par-
ticular, with fo much applaufe, why, in an inftance of lefs im-
portance, and when the tranfgreffion would be attended with
advantages of another kind, may not criticifm abate fome of
its rigour? Nay, in comparing what was formerly faid with
what has now been obferved, the dramatic hiftorian feems to
have the higher title to this indulgence, that he feems, in truth,
to be the more faithful writer of the two. The narrative hi-
ftorian gives you his facts and conjectures mingled together,
                                                              and

and with equal authority ; fo that it requires more patience and difcernment than belong to a great many readers, to diftinguifh what ought to be received with immediate belief, from thofe things that depend for their evidence on the conjectural judgment of the narrator. Hiftorians of another kind, (and this, in general, is the practice of XENOPHON and LIVY), give you their facts and their conjectures apart. Their facts conftitute the narrative, and their views of characters and motives are thrown into thofe fpeeches, which, as we have feen, are not offered by the writers themfelves as of equal authority with their relation of external events.

I HAVE thus endeavoured to point out the caufe of the difference, ftated at the beginning of this difcourfe, between the ancient and modern forms of hiftorical compofition, and have fuggefted fome confiderations by which the practice of antiquity may be juftified. The fame confiderations do not extend to the hiftory of modern European nations ; for the practice could not be fupported by the fame views of probability. In the revolutions of modern nations, public fpeaking has been of little importance. We have not now any funeral orations for political purpofes ; other circumftances of military difcipline have fuperfeded the ufe of allocution ; our ambaffadors have little occafion for rhetorical powers ; and we may add, that the deliberations of the Britifh parliament are not much influenced by the oratory of even the moft eloquent fpeakers. We may alfo obferve, that the object of modern hiftorians feems a good deal different from that of the ancient: They are become more philofophical ; they difcover more accuracy in explaining caufes, and more penetration in deducing effects. Oratory was the fafhion in ancient times ; philofophy is the fafhion at prefent. The ancient hiftorian was often defirous of exciting fympathetic feelings, and of pleafing the fancy ; the modern hiftorian is chiefly defirous of informing the underftanding. Both methods

are

are liable to perverſion. The ancient hiſtorian was tempted to go too far in queſt of rhetorical embelliſhment; the modern may be equally miſled by the love of philoſophical theory. Great would be the merit of that writer who could unite the elegant graces of the ancient hiſtorian, particularly of the colloquial kind, with the accurate reſearch and comprehenſive diſcernment of the modern.

VI.

VI. *A* Grammatical Essay *on the* Nature, Import, *and* Effect *of* certain Conjunctions; *particularly the Greek* ΔE. *By* John Hunter, *M. A. F. R. S.* Edin. *and Profeſſor of Humanity in the Univerſity of* St Andrews.

[*Read by Mr* Dalzel, *Secretary, June* 21. 1784.]

Levia *quidem hæc, et parvi fortè, ſi per ſe ſpeĉtentur, momenti. Sed ex elementis conſtant, ex principiis oriuntur, omnia : Et ex judicii conſuetudine in rebus* minutis *adhibitâ, pendet ſæpiſſimè etiam in* maximis *vera atque accurata Scientia.*

> Sam. Clarke Præf. ad Hom. Iliad.

IT is a maxim in phyſics, that " an effeĉt ought not to be " aſcribed to the joint operation of many cauſes, if fewer " are adequate to the produĉtion of it." *Fruſtra fit per plura, quod fieri poteſt per pauciora.* This maxim is no leſs juſt when applied to language. It is equally unphiloſophical in grammar and in phyſics, to multiply without neceſſity the principles from which the phænomena are to be explained.

In the Engliſh, however, and in other languages, certain words are claſſed by the grammarians as different parts of ſpeech, according to varieties obſerved in the application of them, even when theſe varieties are merely *accidental.* Thus, in the ſentence, " I came *after his departure,*" the word After is claſſed with the *Prepoſitions;* while, in this other, " I came *after he departed,*" it is claſſed with the *Conjunĉtions.* The word After is, however, the ſame in both ſentences ; its *meaning* is the ſame, and its *effeĉt* preciſely the ſame. The only circumſtance of diſcrimination is, that, in the firſt example, it is prefixed to a noun ſubſtantive,

—*his*

—*his departure*; in the latter, it is prefixed to a nominative and a verb—*he departed*. But even the nominative and verb thus applied do not conftitute a propofition; they do not contain an independent affertion; they exprefs no more than a fpecifying circumftance annexed to the other propofition, "*I came*;" and, whenever they are rightly apprehended by the mind, they are ftript of their propofitionary form, and ftated *abftractly* under a new phafis—*his departure.* Thus confidered, then, the two propofitions are fynonymous in every refpect, excepting the *apparent* grammatical nature of the words—*his departure*, and—*he departed*; and even thefe are reduced to one grammatic form in the mind, whenever the import of the propofitions is rightly apprehended.

FROM thefe obfervations it fhould feem that there is no fufficient reafon for claffing the word AFTER, in the one cafe, with the *Prepofitions*, and, in the other, with the *Conjunctions*; fince, by the feeming change of its regimen, no real change is made, either in its grammatical nature, or in its fignification.

OF this unphilofophical method of arranging the fame words in different claffes, I fhall mention *two* other inftances, chiefly with a view to prepare the way for a conjecture which I am to offer with regard to the nature and import of one of the Greek particles; which inftances will ferve to illuftrate and confirm that conjecture, and will, in their turn, be illuftrated by it *.

I. THE Englifh prepofition TO is very varioufly applied. Being extremely *general* in its fignification, it is confequently capable of various *fpecial* applications. One of its fpecial ufes is to mark *addition* TO. Thus DENHAM,

> " Wifdom he has, and, TO his wifdom †, courage;
> " Temper TO that, and, unTO all, fuccefs."

In this example, every fucceeding circumftance is, by the prepofition

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* IN the progrefs of the effay, it will appear, that the reafoning proceeds upon an analogy much more ftrict and clofe than here it feems to do.

† ΠΡΟΣ τη σοφια.

pofition TO, marked as an *addition to* the preceding. " Wifdom " he has, and courage *additional to* his wifdom," &c. In this acceptation of the word TO, the object which it governs, or to which it marks fomething elfe as *added*, is frequently *not expreffed*, or not formally ftated along with the prepofition. The reafon is, that it readily occurs to the mind, being mentioned in the context immediately before. Thus DENHAM might, with equal propriety, have faid,

" Wifdom he has, and courage TOO," &c.

This mode of expreffion would have been more concife and equally intelligible as the other, " Wifdom he has, and cou- " rage TO *his wifdom*," &c.

NOT only is the object governed by TO omitted, when it is reprefented by a noun fubftantive in the context, but alfo when it is involved in a propofition. Thus Mr POPE,

———— " Let thofe eyes that view
" The daring crime, behold the vengeance TOO."

So " He made him prifoner, and killed him TOO." In the one example, the circumftance of *beholding the vengeance* is ftated as an *addition to* the *viewing the crime;* and, in the other, the *killing him* is ftated as an *addition to* the *making him a prifoner.* In both examples, the object governed by TOO is not formally ftated; and, in both alfo, it is involved in a preceding propofition. It is the *amount* of that propofition taken *abftractly*, or as a *Noun fubftantive.*

ALTHOUGH all thefe ufes of the word TO are really one and the fame, differing in nothing but this, that the object governed by it is, in fome of them, *expreffed*, and, in others, *not expreffed*; yet the grammarians have confidered them as different, and have claffed TO, in the one cafe, with the *Prepofitions*, and, in the other, with the *Conjunctions*, or with the *Adverbs.* This circumftance, together perhaps with the accented pronunciation

of

of TO, when the object governed by it is not expreffed, has given rife to a difference in its orthography, the writing it with two *O*s inftead of one. And the two words have ultimately come to be univerfally confidered as *different*, infomuch that even the fuppofition of their being the *fame* is not likely to be liftened to without prejudice.

IN the parent Saxon language, however, both ufes are comprifed under one form, ʒo ; and, even in the Englifh, as late as the reign of Queen ELIZABETH, they were both written with one *O*. This appears from the fpecimens prefixed to Dr JOHNSON's Dictionary, as a hiftory of our language previous to that period. Thus, Sir THOMAS MORE, fpeaking of fortune and one of her quondam favourites,

> " She glydeth from hym, and her giftes TO ;
> " And he her curfeth, as other fooles do."

And to the accented pronunciation of TO, when its object is not expreffed, that is, by no means, a fufficient reafon, either for claffing or for writing it differently, being a circumftance common to it with every prepofition whatfoever. All of them, when their objects are expreffed, may be accented or not accented, according to the meaning, or fhade of meaning, intended to be conveyed. But, when their objects are not expreffed, they are *commonly* * accented : " To ftand *by*," " to come *on*," " to " run *in*," " to rufh *out*," &c.

FROM thefe obfervations, it fhould feem, that the word TOO, though generally confidered as different, and though ranked by grammarians in a different clafs of the parts of fpeech, is really the fame with the prepofition TO, in its fpecial meaning of *additional to*. This has been fhown from the famenefs of their *meaning* and *effect*, as well as of their *original orthography*, and the

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* IN fact they are *always* accented, though their accent may fometimes be obfcured by an equal or fuperior accent given to an adjoining word, as, " He did not *walk in*, " but *rufhed in*."

the circumſtances of *apparent* diverſity have been accounted for. This, then, I think, may be fairly admitted as one inſtance wherein the various claſſing of the ſame word, founded on imperfect and partial views, tends to deceive, by leading us to ſuppoſe *grammatic* differences which are not real, and to conſider *words* as different, when they are really the ſame.

II. I ſhall ſubjoin a ſimilar example from the Latin language. The Latin prepoſition AD, like the Engliſh TO, is extremely *general*, and conſequently capable of various *ſpecial* applications. One of theſe is to mark one object as *added to* another *. " AD *hoc*, promiſſa barba et capilli efferaverant ſpeci- " em oris †." " *Additional to this*, his long beard and hair " had given a wildneſs to his aſpect."

But the object governed by AD, when uſed in this ſpecial meaning, is often not expreſſed, or not formally ſtated ; and, in that caſe, like the Engliſh prepoſition TO, AD is claſſed with the *conjunctions*, and written differently, AT. Thus, as ABS, compounded with *que*, produces ABS*que*, ſo AD compounded with *que* produces AT*que*, *i. e.* AD*que*. " BRUTUS AT*que* CÆSAR," " BRUTUS and CÆSAR TOO ;" " BRUTUS, and CÆSAR *addi-* " *tional to* BRUTUS." " CÆSAR DUMNORIGEM cepit, AT*que* in- " terfecit." " CÆSAR made DUMNORIX priſoner, and killed him " TOO." In this example, the *killing* DUMNORIX is ſtated as *added to* the *making him a priſoner*. In theſe examples, it is evident, that AT marks one object as *added to* another, and differs from AD, when uſed in the ſame ſpecial meaning, in nothing but the *ſuppreſſing* of the object governed by it.

Even when AT appears by itſelf, and without *que* ſubjoined, it ſeems to be ſometimes uſed in the ſame ſpecial meaning. Thus TERENCE,—" PH. Fac, ita ut juſſi, deducantur iſti.
                                                    " PA.

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* *Added to*—where *accumulation only*, or the increaſe of number or magnitude, is attended to.

† LIVY.

" PA. Faciam. PH. AT diligenter. PA. Fiet. PH. AT ma-
" ture *." By the means of AT, the circumſtances of *dili-*
gence and *haſte* are *ſuperadded* to the action commanded. " PH. It
" is not enough that you do it, you muſt do it carefully TOO.
" PA. Well; it ſhall be carefully done. PH. In good time TOO."

BUT further : *Another* of the *ſpecial* applications of the prepo-
ſition AD, is to mark one object as *united* or *joined to* † another,
and that, too, whatever be the nature of the objects, whether
they be ſuch as are *commonly* united, or ſuch as appear *incongru-*
ous, and whoſe union is contrary to expectation. Of the firſt
kind is this example from LIVY : " AD imperium dictatoris,
" cuncta mota acies ;" " *Joined* TO the command of the dictator,
" the whole army was in motion"—*i. e.* " AT the command,"
&c. In this example, there is nothing incongruous in the ob-
jects united ; their union is even conſidered as neceſſary, the
movement of the army being joined to the *command of the dictator*,
as an *effect* to its *cauſe*. Of the ſecond kind is the following in-
ſtance : " AD imperium dictatoris, diſcedere nolebant ;" " AT
" the command of the dictator, they refuſed to depart." In this
laſt example, the ſentence is conſtructed in the ſame manner as
in the other. Two events are repreſented as *conjoined*, a *refuſal*
to depart and the *command of the dictator* ; and the ſame prepoſi-
tion AD is employed to mark their *union*. From our knowledge,
however, of the power veſted in the Roman dictator, we per-
ceive, that theſe events are, in ſome meaſure, incongruous, and
their union conſequently unexpected. And this perception of
incongruity in the objects united leads us to give to AD the
force, not of TO ſimply, but of TO with emphaſis, or EVEN TO.
" Joined EVEN TO the command of the dictator, they refuſed
" to depart"—*i. e.* " EVEN AT *the command*," &c.

Now it is in this laſt manner, *viz. to mark the unexpected union*
of incongruous objects, that AD, when the object which it governs

is

* *Eun.* Act. ii. Sc. 1.

† *Joined to*, in reſpect of *time*, as *cauſe* and *effect*, &c.

is not formally stated, *i. e.* AT, the *conjunction*, is most common-
ly applied; " Aulam tyranni frequentabat, AT patriam amabat ;"
literally, " He frequented the court of the tyrant ; joined EVEN
" TO that, he loved his country."   " He was a courtier and a
" patriot TOO." By means of AT, the circumstance of *loving
his country* is stated as *united to* the other, *viz. his frequenting the
court of the tyrant.*—The character of a *patriot* is represented as
united to that of a *courtier* in the same person.

CICERO, in his address to CÆSAR in behalf of MARCELLUS*,
has the following sentence : " Nihil est opere aut manu factum,
" quod aliquando non conficiat et consumat vetustas ; AT vero hæc
" tua justitia et lenitas animi florescet quotidie magis." Here first
one truth is stated—" There is nothing made by the labour or
" hand of man which length of time may not waste and destroy."
Then, by means of AT, another circumstance is stated as *joined*
EVEN TO this truth, *viz.* " That CÆSAR's justice and gentleness
" of disposition shall flourish every day more and more."   It
is not *simply* asserted, that " CÆSAR's justice shall flourish," but
that it shall flourish, *conjoined even to* the truth of the other po-
sition—" That every work of the hand must perish"—a position
which we conceive to be almost incompatible with it.   Instead
of AT *vero*, CICERO might have used AT *tamen*.   " Every work
" must perish, *yet* JOINED EVEN TO THAT, your justice shall
" flourish."   The former circumstance shall not prevent the truth
of the latter.   In these, and in all similar examples, the two
objects or events, however incongruous they may *seem* to be,
are actually *united* ; and of their union, AT appears to be the
symbol †.

<div align="right">THE</div>

* Cap. 4.

† THE frequent application of AT, to mark the union of incongruous objects, first gave rise
to the habit of annexing an emphatic meaning to it ; and, when once this habit was form-
ed, the word necessarily raised an expectation of something incongruous to follow.   And
hence it has come at last to be mistaken for a *symbol* of incongruity or opposition.

IT would be difficult to collect examples of *all* the various applications of the word
AT, that may be met with in the Latin authors. In those, however, that most frequently
<div align="right">occur,</div>

THE word **AT** is indeed called an *adverfative*, and is commonly imagined to mark, not the *union*, but the *oppofition* of objects. But,

1. **THE** authority of **QUINCTILIAN** is explicit in favour of our hypothefis. In treating of the Latin orthography, he has the following obfervation : " Illa quoque fervata eft a *multis* " differentia, ut **AD**, quum effet *præpofitio*, **D** literam ; quum " autem

occur, it is evidently expreffive, not of *oppofition*, but of *union*. When there is no incongruity in the objects united, and confequently nothing unexpected in their union, the effect of it will be perceived by rendering it **TO** fimply ; and, when the objects united appear incongruous, by rendering it **TO** with emphafis, or **EVEN TO**.

I. To fimply—as in the form of furrender recorded by **LIVY**, [*Lib.* 1. *cap.* 38.] " Deditifne vos populumque Collatinum in meam populique Romani ditionem ? De- " dimus. **AT** ego recipio ;" " *Joined* **TO** that, I receive them." **ET** might have been ufed in this inftance. In imprecations, and the like, it reprefents the amount of the prayer, as *joined to* an action *mentioned, perceived, dreaded, &c.* 1. To an action *mentioned* ; as in **TERENCE** ; " **CH.** Factum eft hoc, **DAVE** ? **DA.** Factum. **CH.** Hem ! quid " ais, Scelus ? **AT** tibi dii dignum factis exitium duint !" 2. To an action *perceived* ; as in **VIRGIL**, when **PRIAM**, upon *feeing* his fon killed by **PYRRHUS**, exclaims :

" **AT** tibi pro fcelere, exclamat, pro talibus aufis,
" Dî, fi qua eft cœlo pietas, quæ talia curet,
" Perfolvant grates dignas, et præmia reddant
" Digna,—qui nati coram me cernere letum
" Fecifti, et patrios fœdafti funere vultus." [*Æn.* ii. 535.]

II. EVEN TO—as in **TERENCE** ; " Si ego digna hac contumeliâ fum maximè, **AT** tu " indignus qui faceres tamen ;" " Joined **EVEN TO** that, it was unworthy of you to do " it." So when **CHREMES**, after he has heard many circumftances tending to prove that **PAMPHILA** is his daughter, fays, " **AT** mihi unus fcrupulus etiam reftat." " Joined **EVEN** " **TO** [what I have heard] there ftill remains one difficulty." *i. e.* " All I have heard is " not fufficient to remove it." It is ufed precifely in this manner, when it introduces an *objection*, or the *anfwer* to an *objection*. 1. An *objection* ; as in **CICERO** pro **MILONE** ; " **AT** valuit odium, fecit iratus, &*c.*" " Joined **EVEN TO** [what you have faid] his hatred " got the better of him, he acted from paffion :" *i. e.* " For all that you have faid," &*c.* " All that you have faid does not hinder the deed to have proceeded from hatred or paf- " fion." 2. The *anfwer* to an *objection* ; as, " Domus tibi deerat ? **AT** habebas. Pecu- " nia fuperabat ? **AT** egebas." " You will fay you wanted a houfe ; joined **EVEN TO** " that, you had one," &*c.* It is ufed in this manner too, when it introduces the *circum-* *ftances* of an action which tend to heighten our furprife. " Vidit **CLODIUS** neceffe effe " **MILONI** proficifci Lanuvium illo ipfo, quo profectus eft, die ; itaque antevertit. **AT** " quo

" autem *conjunctio*, τ acciperet *." From this paſſage, it is evi-
dent, that the conjunction AT was originally written AD: That
the difference in their orthography, though obſerved by *many*,
was not, at that time, *univerſally* obſerved ; and that this dif-
ference was introduced to diſtinguiſh the conjunction from the
prepoſition. The fortune of the Latin AD appears, therefore,
to have been ſimilar to that of the Engliſh TO. Both of them
are *prepoſitions*, and of the *ſame* ſignification. Both of them,
when the object which they govern is not formally ſtated, have
been reckoned *conjunctions* ; and, in both, a difference of *ortho-
graphy* has at laſt obtained to diſtinguiſh the *conjunction* from
the *prepoſition*.

2. THE propoſitions, whereof AT is ſaid to mark the oppoſi-
tion, are both of them *true*, and they expreſs truths which are
co-exiſtent. They cannot, therefore, be *oppoſite* in one of the
acceptations of that term. They may be *apparently* incompati-
ble, but they are not *really* ſo. Thus, in the example formerly
mentioned, " Aulam tyranni frequentabat ; AT patriam ama-
" bat,"—the two characters of *courtier* and *patriot*, however in-
congruous they may *ſeem* to be, are repreſented as *united* in the
ſame perſon. Conſidering the matter *a priori*, then, it ſeems
reaſonable to imagine, that, on ſuch occaſions, a term would
be employed to mark the *union*, which is *uncommon* and *unexpected*,
rather than the *oppoſition* or *incongruity*, which is *apparent*. Ac-
cordingly, we find, in fact, that thoſe of the conjunctions call-
ed

q

ed

" quo die ? Quo, ut ante dixi, inſaniſſima concio ab ipſius mercenario tribuno plebis eſt
" concitata : Quem diem ille, quam concionem, quos clamores, niſi ad cogitatum facinus
" approperaret, nunquam reliquiſſet ;"—" On what day, τοο ?" *&c.* This is an inſtance
extremely fortunate for our purpoſe ; becauſe, although the *action* of CLODIUS and the
time which he choſe for it appear incongruous, yet the practice of the Engliſh language
admits of our rendering AT literally ; " CLODIUS was beforehand with him, on a day
" τοο when his preſence was neceſſary at Rome."

IN the foregoing examples, which comprehend all the common applications of AT, it
ſeems to mark the *union*, [*expected* or *not expected*], not the *oppoſition*, of the objects con-
nected by it.

* Lib. i. cap. 7.

ed *adverfative*, whofe fignification can be afcertained, are figni-
ficant, not of *oppofition*, but of *union*, or fomething that is equi-
valent. Of this kind are the Greek, ὅμως, accented on the pe-
nult, and δὲ ; the Latin, *etfi, verum, vero, tamen, verum tamen* ;
the French, *cependant*, and perhaps *encore* ; the Englifh, *yet, ne-
verthelefs, notwithftanding*, &c. It might, however, be reckoned
tedious, were I to attempt to ftate the precife import of each of
thefe, and to fhow, that their effect, in a fentence, is confonant
to their fignification, and arifes out of it.

3. THE adverfative *appearance* of AT feems to have arifen
from the circumftance of its raifing an *expectation*, that fome-
thing feemingly oppofite, or incongruous, is to follow. Thus,
when it is faid, " CÆSAR fuit vir fortis, prudens, clemens ;
" AT ———," the word AT is no fooner heard, than an ex-
pectation is raifed, that fomething oppofite to the qualities pre-
vioufly mentioned—fomething difadvantageous to the character
of CÆSAR, is to follow. And hence, from its raifing this ex-
pectation, it has been concluded, that AT itfelf is fignificant of
oppofition : But that this conclufion is by no means *neceffary*,
will appear from the following obfervations.

WHEN objects or qualities, confidered as in their own nature
oppofite or incongruous, are obferved to co-exift, it feems more
neceffary to *intimate their co-exiftence*, than if no fuch oppofition
were felt. The perception of their *natural* incongruity leads
to the giving a *marked* intimation of their *union*, when they
happen to be united. " CÆSAR fuit vir fortis, prudens, cle-
" mens ; AT ambitiofus, patriæ proditor," &c. It might have
been imagined, that fuch oppofite qualities could not unite in
the fame perfon ; and, therefore, it appeared neceffary, that
pointed intimation fhould be given of their union ; and, for
that purpofe, the word AT is employed. The fame circum-
ftance, *viz.* the perception of the incongruity, alfo leads the
hearer to *interpret* the fymbol of union in the fame *emphatic*
manner ; that is, to give to AT the force, not of TO fimply,

but

but of TO with emphafis, or EVEN TO. " CÆSAR poffeffed
" fortitude, prudence, clemency ; joined EVEN TO that, he
" was ambitious, and a traitor to his country."

NOW, this emphatic meaning, which men were *accuftomed* to
annex to AT, in confequence of its being fo very frequently
employed to mark the union of incongruous objects, will fuffi-
ciently account for its raifing an expectation that fomething ap-
parently oppofite, or incongruous, is to follow : For, no foon-
er is this emphatic meaning given to it, than fuch an expecta-
tion is raifed,—and *muft* be raifed, becaufe an emphatic intima-
tion of union *fuppofes* an incongruity in the objects united, and is
given in confequence of a perception of that incongruity. Thus,
" CÆSAR poffeffed fortitude, prudence, clemency ; joined EVEN
" TO that ———." When thefe laft words are heard, we im-
mediately expect that fomething is to follow, apparently oppo-
fite to what is contained in the firft member of the fentence.
We are prepared for fuch attributes as—*ambitious* and a *traitor* to
his country. Thus, then, from the emphatic meaning given
to AT, an expectation was raifed that fomething incongruous
was to follow ; and, from its raifing this expectation, the word
has prepofteroufly been imagined to *exprefs* that incongruity, or
oppofition, which it only *prefuppofes*.

ANY emphatic intimation of union, thrown into a fentence,
will raife an expectation that fomething incongruous is to be
fubjoined ; and the reafon is the fame in them all, namely, that
every fuch intimation is given on the fuppofition, that the ob-
jects are perceived to be naturally incongruous. " CÆSAR was
" brave, prudent, merciful ; *at the fame time*, he was ———."
Or, " CÆSAR was brave, prudent, merciful ; *notwithftanding that*,
" he was ———." In thefe, as well as in the Latin example,
we are led to expect that fome circumftance in the character
of CÆSAR is to follow, which we fhould not have expected to
be united with the qualities, bravery, prudence, and clemency.
Yet the words, *at the fame time*, do *not* exprefs *oppofition*, and *not-*

　　　　　　　　　　　withftanding

withstanding expresses almost the *contrary.* I appeal, then, to the judgment of every candid man, whether the circumstance of AT raising an expectation of something opposite to follow, ought to be considered as sufficient to found the conclusion, that AT itself denotes opposition ; and, if it is not, I know no other ground on which such a conclusion is founded.

WHAT, then, are the *views,* or considerations, upon which the words, *at the same time,* and *notwithstanding,* are used in the preceding examples ? When, in contemplating the various qualities which constitute the character of CÆSAR, we observe them to be such as, from their nature, are generally conceived *not to co-exist,*—*this view* of them leads us to obviate the general prejudice, by intimating that (in this particular instance) they existed *at the same time.* When, again, we consider them as naturally *opposite,* or conceive, that the one class of them has a *natural* tendency to *oppose* or prevent the existence of the other, *this view* of them leads us to intimate, that (in this instance) it did *not oppose* it ; and it is for that purpose that we employ the word *notwithstanding.* In the same manner precisely, when a Roman viewed these qualities as naturally *incongruous,* he was thereby led to give notice that (in this particular instance) they were *united* ; and, for this purpose, the word AT, *i. e.* AD, is employed.

IT should seem, then, that the conjunction AT is an intimation, not of *opposition,* as is generally supposed, but of *union* ; and that the habit of annexing an emphatic meaning to it, is sufficient to account for its raising an expectation, that something apparently opposite or incongruous is to be subjoined.

ACCORDINGLY, if, in any instance, we give to AD, even in its *undisguised* form, the emphatic sense of *even to,* a similar expectation will be raised. " AD imperium dictatoris ——." " EVEN AT the command of the dictator ——." When these words are heard, we instantly expect something to be added, which but ill accords with our notions of a dictator's authority,

whether

whether it be a refusal to depart, or any thing elfe of a like na-
ture. " Ad imperium dictatoris difcedere nolebant." " Even
" at the command of the dictator, they refufed to depart."

Now, in this laft example, and in every other of the fame
kind, by varying the ftructure of the fentence, at may be in-
troduced inftead of ad, without even the flighteft variation in
the meaning. " Dictator imperabat ; at difcedere nolebant."
Wherein, then, does this laft mode of expreffing the idea dif-
fer from the former ? In the former, the dictator's giving the
command is *not afferted ;* it is prefuppofed, and appears only in
the *abftract* form of *imperium dictatoris,* governed by ad ; where-
as, in the latter, it is formally *afferted ;* " *Dictator imperabat ;*"
but the *abftract amount* of the affertion, viz. " *imperium dictatoris,*"
is not repeated as the object governed by at. In the one, the
formal affertion is *omitted,* and the *abftract amount* of the affertion
is *expreffed ;* in the other, the *abftract amount* is *omitted,* and the
formal affertion is *expreffed.* In thefe circumftances, and in thefe
only, the two modes of expreffion feem to differ.

From the preceding obfervations and examples, it appears,
that at is nothing elfe but the prepofition ad, taken in the fpe-
cial meanings—*added to*—*joined to,* and not having the object
which it governs formally expreffed ; and that however oppofite
the objects may appear to be which it unites, yet it does not
exprefs their oppofition.

The word at, as it denotes addition, might, indeed, be con-
fidered as implying *difference ;* for if an object is ftated as ad-
ditional to another, it muft be at leaft *numerically* different from
that other. And, indeed, at agrees with the Greek αλλα, the
Latin *cæterum,* and the French *mais,* in this refpect, that all of
them imply *difference,* but none of them *oppofition.* The laft of
them particularly, *mais, (magis),* like the Latin at, implies
difference, only becaufe it denotes *addition.*

We have now feen, that the Englifh too and the Latin at,
are really the fame with to and ad ; that they are, in truth,

nothing

nothing more than fpecial applications of thefe; and we have
fhown on what thefe fpecialities depend, and that their effect in
a fentence is actually fuch as, by their original fignification,
they may be fuppofed to produce; or, what amounts to the
fame thing, that the effect of them may be fatisfactorily ex-
plained, by reforting to their proper and primitive fignification.

III. Let us next enquire, whether the preceding obfervations
can throw any light on the nature and import of the Greek par-
ticle ΔΕ, for the fake of which, chiefly, they have been premifed.

1. This particle is, not uncommonly, found after the accufa-
tive cafe of *proper* names of places, when motion To thefe places
is expreffed. " Ιλιον ΔΕ,"—" *To* Troy," &c.

2. Not only is it thus affixed to proper names, but alfo to
common, or appellative, nouns, and in the fame fenfe; " οικον ΔΕ,"—
" *To* a houfe." " αγορην ΔΕ,"—" *To* the forum." " αλα ΔΕ,"—
" *To* the fea," &c.

3. It is not affixed to the accufative fingular only, but fre-
quently alfo to the accufative plural, " οικα ΔΕ." When, how-
ever, the accufative plural ends in ς, it is often difguifed by a
tranfpofition, the letters δ and ς being tranfpofed for the fake
of the found. Thus, " Αθηνας ΔΕ,"—" *To* Athens," is com-
monly written " ΑθηναΖΕ." So " χαμαΖΕ,"—" *To* the ground ;"
" Θηβα ΖΕ,"—" *To* Thebes," &c.

4. It is not only applied, in this manner, to the place to
which *real* motion tends, and at which it is conceived to termi-
nate, but alfo to that object, whatever it be, *to* which any ac-
tion is directed as a *final caufe.* Thus Homer *, " Μη αγορευε φοβον-
" Δε,"—literally, " Do not fpeak *to* flight." Let not your fpeech
tend to flight ; let not flight be the *object*, or *final caufe, to which*
it is directed. The Latins ufe *ad*, and the Englifh *to*, in the
fame manner. " Hoc fecit *ad* honorem meum,"—" He did
" this *to* my honour ;" where his *doing this* is, in like manner,
confidered as *tending to* my honour.

The

* Iliad. i'. 252.

THE word ΔE was, indeed, but feldom joined with an accufative cafe by the *Attic* writers, and only in fome expreffions which the grammarians confider as *adverbial*. May we not, however, conclude from the facts juft now ftated, that, with the more early Greeks, and even with HOMER, it was confidered as a *prepofition* governing the accufative, and equivalent to the Latin AD, or the Englifh TO ? It is, indeed, always put *after* the noun which it governs ; but that makes no difference as to its *real* grammatical nature : For though a *pre*-pofition put *after*, is, in truth, a contradiction, yet it is no uncommon occurrence in moft languages. The Latins ufe nobif-*cum*, tantif-*per*, &c. and we there-*to*, where-*to*, and others fimilar. Thefe laft alfo our grammarians confider as *adverbs* ; but they are compound words, in which the prepofition TO is palpably one of the component parts. And the facts before ftated render it, in fome degree, probable, that the Greek ΔE is fometimes, in like manner, a prepofition put after the word which it governs, and equivalent to TO.

ON this hypothefis, then, that ΔE is a prepofition fignifying TO, it is reafonable to imagine—1. That, though it is, in itfelf, extremely *general*, yet, like the correfponding word in other languages, it may be ufed in the *fpecial* meanings of—*added to—joined to*, &c. And—2. That the object, governed by it, may be not formally ftated, but left to be collected from a preceding *noun* or *prepofition*. In fhort, that it fhould follow the fame analogy of application as the Latin AD and the Englifh TO, when they are called *conjunctions*. Accordingly we find, that it does fo in fact. When ULYSSES, in the 9th book of the Iliad, enumerates to ACHILLES the prefents intended for him by AGAMEMNON, he does it in this manner :

———————— " εγω τοι καταλεξω·

" Οσσα τοι εν κλισιησι υπεσχελο δωρ' Αγαμεμνων·

" Επτ' απυρες τριποδας, δεκα ΔE χρυσοιο ταλαντα,

" Αιθωνας ΔE λεβηίας εεικοσι, δωδεκα Δ' ιππυς *.''

In

* V. 265.

In this example, by means of δὲ, each succeeding article is represented as TO, *i. e. additional to* the preceding article. " Se-
" ven tripods—ten talents of gold TOO"—*i. e.* " Ten talents of
" gold *additional to* the seven tripods." This instance is precisely similar to that. formerly quoted from DENHAM, except
that the object governed by δὲ, and to which the succeeding
article is added, is not repeated along with δὲ. In DENHAM
it is,

> " Wisdom he has, and, TO *his wisdom*, courage"—

which, if expressed according to the Greek idiom, in the example quoted from HOMER, would be,

> " Wisdom he has, and courage TOO."

In the above example, then, the word δὲ is used in the special
meaning of *additional to*, and the object which it governs is *not
formally stated*, but is collected from a preceding *noun*.

Again, XENOPHON, describing the Persian polity, says,—
" Διδασκεσι τες παιδας σωφροσυνην· διδασκεσι ΔΕ πειθεσθ τοις αρχεσι."—
" They teach the children temperance ; they teach them, TOO,
" obedience to the magistrates." In this example, by means of
δὲ, their *teaching the children obedience to the magistrates*—is represented as *additional to* their *teaching them temperance*. Here also the
object governed by δὲ is not expressed ; it is collected from the
preceding *proposition*—διδασκεσι τες παιδας σωφροσυνην. It is the *amount*
of that proposition, taken as a *substantive*. So HOMER, in the
beginning of the Iliad, says, that the anger of ACHILLES—

> ———————— " μυρι 'Αχαιοις αλγε' εθηκε,
> " Πολλας Δ' ιφθιμες ψυχας αϊδι προιαψεν
> " Ἡρωων."————

In this passage, first one event is stated, " *The anger of* ACHIL-
" LES *brought numberless woes upon the Greeks* ;"—then another,
" *It*

" *It sent many brave souls to* PLUTO *before their time*;" and, by
the means of δὶ, the last event is represented as *additional to* the
former. " It sent, TOO, to PLUTO many brave souls of he-
" roes." In this example, also, the object governed by δὶ is
not expressed. It is, however, obviously suggested by the con-
text; being the amount of the preceding proposition taken *ab-
stractly*, or as a noun *substantive*. It is unnecessary to multiply
examples. Every page of every Greek author abounds with
them; for of this kind are all those in which the sense leads us
to render δὶ—*and*.

BUT δὶ is often said to denote *opposition*. In truth it *never*
does. In this respect it agrees exactly with the Latin AT. The
events which it unites may appear opposite; but δὶ does not in-
timate their being so: It only marks the one as *added*, or *united*,
to the other. This I am warranted in affirming, by the autho-
rity of the learned, ingenious, and most laborious HOOGEVEEN,
an authority that will not be questioned, at least as to the *facts*
of the Greek language. His words are:—" Δὶ ponitur et pro
" ΑΛΛΑ διαφορικῳ και εναντιωματικῳ, sive MEN præcedit, sive non. vel
" *potius* dicam sententiæ diversæ aut adversanti additur, ita ut
" vicem τȣ ΑΛΛΑ explere *videatur*; *non* enim *ipsi particulæ* δὶ ea
" potestas attribuenda est, sed *sententiæ* cui apponitur *."

FURTHER,—That the same word should be employed to de-
note sometimes the *union*, and sometimes the *opposition* of objects,
is a supposition, in itself, extremely improbable; because, in
that case, the nature of the objects themselves could alone de-
termine which of these significations we ought, in any particu-
lar instance, to affix to it; and, if so, their opposition might
be discovered without the help of this ambiguous symbol of it.
Δὶ, indeed, like the Latin AT, is often employed to mark the
union of incongruous objects; and, like AT too, it has then
been imagined to express that opposition which it only presup-
poses.

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* Doctr. Particul. L. Gr. p. 245.

pofes. Thus, when ORESTES, in EURIPIDES, makes the follow-
ing obfervation—

> " Ονομα γαρ, εργον ΔΕ ουκ εχεσιν οι φιλοι,
> " 'Οι μη επι ταισι συμφοραις ονίες φιλοι *,"—

it is faid, that δὲ ftates an oppofition between the *name* and the
reality of friendfhip : But, when the obfervations formerly made
on AT, and the fignification of δὲ, *afcertained* by the preceding
examples, are taken into confideration, it feems much more
reafonable to fuppofe, that, even here, it retains its proper fig-
nification of *union.* Literally thus—" For the friends that are
" not friends in adverfity have the *name* of friends, not the *reality*
" TOO." " *Nomen*, AT non *rem* habent." Two propofitions
in fact are ftated, *viz.* " That the friends that are not fuch in
" adverfity have the name of friends ;" and fecondly, " That
" they have not the reality :" And, by the means of δὲ, inti-
mation is given, that—(whatever *might* have been expected) the
latter is *united* to the former. This feems to be the precife
meaning of the paffage ; and it is elicited without depart-
ing from the *known* fignification of δὲ. Let us take an exam-
ple ftill more ftriking. Suppofe that it is faid of a perfon—
" εςιι μεν νεος, εςιι ΔΕ σοφος"—" He is young, but he is wife."
The fame perfon is reprefented as poffeffing *at once* the two
feemingly incongruous qualities of *youth* and *wifdom.* Can any
perfon allege, that, in this example, it is reafonable to depart
from the *known* fignification of δὲ, and to confider it as denoting
oppofition? The oppofition between *youth* and *wifdom* is fufficient-
ly apparent, without any expreffed fymbol of it. Is it not
more reafonable to fuppofe δὲ to give notice, that—(whatever
might have been expected—however oppofite or *incongruous* thefe
qualities may *feem* to be) they are (in this particular inftance)
united : That *his being wife* is reprefented as joined EVEN TO his
being young? This, at leaft, is the intimation that every perfon

feels

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* Oreft. 455.

feels himself prompted to give, when he obferves the *union* of fuch incongruous qualities.

IT fhould feem, then, that the conjunction δὲ, even when it is faid to mark oppofition, and tranflated *but*, ftill retains its genuine fignification of *union*,—with this variation, however, that from the perceived incongruity of the objects, and the unexpectednefs of their union, we ought to give it, in fuch inftances, the force, not of TO fimply, but of TO with emphafis, or—EVEN TO.

BUT δὲ, when it appears in the form of a *prepofition* governing the accufative, is not accented,—κλυμπονΔE—κλισινΔE, &c. ; whereas δὲ the *conjunction* is always accented. If they are one and the fame, whence arifes this difference? This circumftance, among others, has led the very learned and ingenious author quoted above, to imagine them to be altogether different, and of different origin. His words are:—" Cæterum quoties ΔE εγκλινεῖαι; " non conjunctio eft, fed fyllabica adjectio, nec *quicquam* cum " particula δὲ *commune* habet *. But, notwithftanding this feeming difference between them, and notwithftanding the great authority now quoted, we cannot hefitate to regard them ftill as the *fame* word. For, if rightly confidered, this difference as to accent, in the pronunciation at leaft †, inftead of being an objection, is really a confirmation of our hypothefis ‡. We have feen already, that the prepofitions, when the object which they govern is expreffed, are commonly *not* accented,—" He came *to* " Rome." In like manner δὲ, when its accufative is expreffed, ought, upon this analogy, *not* to be accented,—" κλυμπονΔE :" That, on the other hand, when the object governed by them is not expreffed, or not formally ftated, the prepofitions are then *accented*, " Wifdom he has, and courage *too*." Δὲ, therefore, when

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* Doctr. Particul. L. Gr. p. 262.

† WITH regard to the accentual *marks*, they feem to have owed their origin to an unfuccefsful attempt to perpetuate a particular *mode* of pronunciation.

‡ As far at leaft as a thing fo little known as the nature of Greek accent can be allowed to have weight in the prefent cafe.

the object which it governs, or to which it marks something as *united* or *added*, is not expressed,—that is, δὶ the conjunction—ought, upon the same analogy, to be then accented. Were this a proper occasion for such a discussion, it might even be shown, that this analogy, in giving and with-holding the accent, is not arbitrary, but founded on principle.

MAY we not then conclude, with some degree of probability, that δὶ the *conjunction* is not a different word from δὲ the *preposition*, or *post-fix*, but only a special application of it? If this conclusion be admitted, it appears, that the conjunctive use of the Latin *Ad* and the English *To* illustrates the nature and use of the Greek conjunction δὶ; and that *it*, in its turn, serves to illustrate and confirm the account that was given of *them*. All of them represent the *same idea*; and, in the three taken together, there appears a beautiful gradation in the application of it. The English *Too* being applied as a *simple* intimation of union, is accounted an *additive* only; the Latin *At*, giving commonly an *emphatic* notice of *unexpected* union, is considered as an *adversative*; and the Greek δὶ, being applied in *either* way indifferently, will appear *additive* or *adversative*, according to the *degree of emphasis* given to it, that is, according to the *nature of the objects* which it unites.

BUT what real knowledge have we gained in the progress of this long enquiry? The answer is,—That the *classing disparate phænomena*, and referring them to one common principle, is held to be *science* in *Physics*,—and why should it not also be accounted *science* in *Grammar**? But, not to give an answer which may seem captious, we have seen——

I. THAT

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* THE observation in the text, although extremely common, appears to mistake the *half of science* for the *whole*. It is undoubtedly the part of science to investigate what, in dissimilar objects, is *generic*, or common to the whole: But to discern and to mark what is *specific*, or peculiar to each, is no less the business of science; and, as it is commonly of greater difficulty, so it is at least of equal importance. The author, therefore, has attempted, whether successfully or not, to ascertain what is peculiar with regard either to *grammatical nature*, or to *signification*, in the various applications of the words he has discussed.

1. THAT *Prepofitions*, in various languages, govern not only nouns fubftantive, but alfo claufes of fentences bearing the form of propofitions; but that fuch claufes are then equal to nouns in their *effect*, the *abftract amount* of them only being regarded : And, confequently, that, by this *feeming* change of their regimen, no *real* change is made, either in the grammatical nature, or in the fignification of the prepofitions themfelves.

2. THAT, whether the object governed be a noun fubftantive, or the amount of a propofition taken as a noun fubftantive, that object is often not formally ftated, being obvious from the context; but that neither does the *formal ftatement*, or the *omiffion* of the governed object, make any change, either in the grammatical nature, or in the fignification of the prepofitions.

3. THAT the fpecialities attending thefe *prepofitions*, when they are called *conjunctions*, depend, in as far as the *expreffion* is concerned, on one or other, or both of the following circumftances, *viz.* the governed objects *being involved in a propofition*, or its *not being formally ftated*.

4. THAT the adverfative *appearance* of *fome* of the conjunctions called *adverfative*, arifes folely from the *emphatic* meaning given to them, when employed to mark the union of objects *feemingly* oppofite or incongruous; but that, though they may *prefuppofe*, they do not *exprefs* fuch incongruity or apparent oppofition.

5. BY having fhown that the conjunctions *Too, At,* and Δὲ, are the fame with the prepofitions *To, Ad,* and Δὲ, we have difcovered their ftrict and proper fignification, and are thereby enabled to annex to each of them a *precife idea*, inftead of having a vague and confufed *feeling* of their *effect*.

Laftly, BY having afcertained the grammatical nature of *certain* conjunctions, we have advanced *one* ftep towards the developement of the nature of the *Conjunction* itfelf,—I mean the

part

part of fpeech fo called,—which is ftill a *Defideratum* in gram-
mar, the nature of it being, perhaps, lefs underftood than
that of any other of the parts of fpeech *.

* THE author is fully fenfible that, in feveral places of this effay, he has ufed expref-
fions which, to an Englifh reader, muft appear extremely uncouth. Convinced as he is,
that the word AD or AT, and ΔΕ, however varioufly applied, are always reprefentative
of the *fame idea*, he has attempted to *hold that circumftance up to view*, by ufing always
the fame Englifh word, ἰο, in tranflating them. Now, in this attempt, fuch uncouth-
nefs was unavoidable; for it happens that the Greek, Latin and Englifh languages have
not followed always the fame range in the *application* of thefe words, although they are
in *themfelves* ftrictly fynonymous. And whenever the ufage of our language does not
correfpond with that of the Greek or Latin, a literal tranflation cannot be attempted,
without a manifeft violation of the propriety of the Englifh idiom:—In truth, it frequent-
ly happens that words of the *fame generic meaning* are found in very *different fpecial appli-
cations*, in different languages. For example, the Greek prepofition ANTI, and the Latin
ANTE, not only reprefent the *fame idea*, viz. priority, but they are really the *fame word;*
and yet the fpecial applications of them are by no means correfpondent with each other,
ANTE, in Latin, never marking oppofition, nor ANTI, in Greek, priority in refpect of
time.—On the other hand, words that are very different in their original import, fre-
quently produce the fame ultimate effect. Thus the words AD and EX are not only of
different, but nearly of oppofite meaning; and yet, of the two expreffions, " AD fuam
" naturam fingere cæteros," and " EX fua natura fingere cæteros," the effect is ulti-
mately the fame.

VII.

VII. Essay *on the* Origin *and* Structure *of the* European Legislatures. *By* Allan Maconochie, *Esq; Advocate,* F. R. S. Edin. *and Professor of Public Law in the University of* Edinburgh.

PART II.

Section I. *Of the Legislature of the German Nations during the first Ages after their Establishment in the Roman Provinces* *.

[*Read by the Author,* July 19. 1784.]

IT is reasonable to suppose, that the founders of the European states would, at least for some time after their conquests, retain much of their former political arrangements. The idea, therefore, which I have formed of their legislatures in their new situation may, in a great measure, be anticipated from the observations contained in the preceding part of this paper. At the same time, the change from the wilds of Germany to the cultivated provinces of the empire was very great : And it is necessary to survey, in general, the aspect which, on this event, the German governments might be expected to exhibit, in order, either to form an accurate conception of the general hypothesis I have adopted, or to perceive the propriety and application of those discussions which are intended for its support.

At the close of an expedition of a German confederacy which had been crowned with conquest, I apprehend that their general, or common leader, would not lay down his authority as in ordinary cases, where victory, rather than new settlements,

formed

* See Part I. at the beginning of Papers of the Literary Class in this Volume.

formed the object of the war. The influence he muſt have acquired in the courſe of the conqueſt, and a general ſenſe that the ſecurity of the new acquiſitions depended on preſerving the union which had gained them, would neceſſarily perpetuate his office, and render it regal. The confederated tribes, again, in accommodating themſelves to their new ſituation, would adhere as much as poſſible to their ancient habits. The conquered country would like their old domains be parcelled out, *gentibus cognationibuſque hominum*; and theſe tribes would, of courſe, give their names to their new ſettlements, and would arrange themſelves into thoſe diviſions and ſubdiviſions, *pagi* or ſhires, hundreds and tithings, by means of which alone their civil, political, and military affairs had formerly been tranſacted. The old aſſemblies would ſtill be celebrated, the old military parade exhibited, and the old religious rites ſolemnized.

As the conquerors were generally much inferior in numbers to thoſe they had ſubdued, and as their habits of independence, and their contempt for the mercenary troops which they had been accuſtomed to vanquiſh, muſt have rendered it impracticable to keep on foot a ſtanding army, the importance of preſerving military ſubordination and arrangement among themſelves was, without doubt, univerſally perceived, and the meaſures that appeared eſſential for this purpoſe muſt, therefore, have been adopted, whatever might be the inconveniences with which they were attended. On this account, not only the military exerciſes and evolutions, formerly practiſed at the aſſemblies of each *pagus* and its ſubdiviſions muſt have been continued, but it would be univerſally found neceſſary to have once a-year at leaſt a general muſter of the whole confederacy, and to attribute to their general or king the right of calling forth the nation in arms when he ſaw cauſe, and of enforcing the obſervance every where of thoſe regulations which had been made at their general meetings, by common conſent.

AT

At such general musters, the king would hold a council, with the chiefs of the different tribes, about such affairs as could not be transacted without the national concurrence; and what they resolved on would, when proposed to the multitude, be in general approved of: But, on some singular occasions, the people might entertain different sentiments from their chiefs; and instances, therefore, may have occurred, not only of such proposals being rejected, but of opposite resolutions being embraced.

The power by which the king exercised his new authority would naturally be founded in the influence of his old retainers, and in the habits of the vanquished natives, which must have universally disposed them to attribute to him the prerogatives of the imperial crown. From this last source, the forms of official business, which, as far as preserved, were necessarily conducted by the vanquished, would, wherever the king was concerned, retain the language of despotism: And in this way, likewise, as the conquerors would, at their first settlement, have more lands than they could well occupy, the greater part of the imperial fiscs (those vast domains which monopolized the Roman provinces) would remain to the king: And, without doubt, the right of distributing the lands at the sojourning of the tribe, which was the known and ancient prerogative of the German chiefs, would greatly facilitate his acquisition of the fiscs, without envy or dispute. Thus the king would become the most considerable proprietor in the nation, and his vast possessions would enable him to multiply exceedingly the ancient numbers of his retainers, and to afford them, in return for their services, more valuable rewards than the battle-horse, or the conquering spear.

The retainers of the subordinate chiefs would, in like manner, be multiplied and rewarded with lands. Under the empire, the municipia, as well as the emperor, had their proper domains, from the produce of which they defrayed the public expences of the community. Besides these domains, there were

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large commons allotted for the promiſcuous uſe of the inhabitants of particular diſtricts; and the devaſtations of the conqueſt left large tracts of land deſtitute of proprietors. Now, independently of the grants which the ſubordinate chiefs might ſpare from their own large eſtates, they muſt evidently have had great influence in the diſpoſal of ſuch public, common or waſte lands. Poſſeſſed of the prerogative of diſtributing the lots of the citizens; inheriting, for the moſt part, a conſiderable family-intereſt, which the wealth of the conqueſt had confirmed; entruſted, in the firſt inſtance, with the care of the public treaſure and the public ſafety, and free from the jealous factions of an independent ſtate, it muſt ſoon have become a matter of courſe for them to make grants of ſuch lands to their favourites and retainers*. The conditions of the grants were, no doubt, various. Some, we know, were like the lots of the citizens conferred in full property; but, among people who had acquired wealth by conqueſt, before either laws or government were ripe to guard it, the natural and ordinary terms of all ſuch tranſactions muſt have been military ſervice, yielded on the one hand, and lands and protection conferred in return. Theſe grants were termed benefices, and the grantees beneficiaries; and, in this way, a great number of the more enterpriſing and better ſort of people were not only diſtinguiſhed, as before the conqueſt, by their particular attachment and fidelity to certain chiefs, but came to be ſubjected to the ſpecific obligation of yielding to the king, or to other great men, an extent of military ſervice, much beyond what they owed to their country, in common with the reſt of the nation.

But however much this practice may have added to the powers of the magiſtracy, or whatever revolutions in government it afterwards produced, there is no reaſon to imagine, that, in early

* In Sweden, the towns, hundreds, and provinces had each of them commons, bearing reſpectively the technical names of lamſalt, haradzalmaining, and land almaining, grants of which were obtained from the chief magiſtrates, *viz.* lagman, hereda, &c.; and ſuch public and common lands are natural appendages to all rude communities.

early times, it affected, in any shape, the structure of the legislature. As attendance around their chiefs at the national assemblies was a condition by which benefices were held, the beneficiaries would be more punctual than others in frequenting the diets; but it is not to be thought, that, on such occasions, the royal beneficiaries were either admitted into the council of the king and chiefs of *pagi*, or deliberated apart from other freemen.

I LIKEWISE apprehend that there is no sufficient reason for conceiving, that either the acquisition of the Roman towns by the conquest, or the embracing of Christianity after it, would make any material innovation in the form of the original German legislature. The government of the Roman towns was well suited to combine with the German political arrangements. Most of them had, in fact, been originally *pagi* *, and still retained vestiges of their primary structure; and those that had been founded in civilized times were, modelled after Rome, herself unquestionably a production of rude ages. The curiales, or ancient burgesses, were every where arranged into wards or tithings under headsmen elected by them, called *decuriones*. The curiales formed a popular assembly; the decuriones a senate. Magistrates chosen by them, and holding their offices for a limited time, exercised a subordinate jurisdiction; and, like those of Rome, judges, selected from the order of decuriones, tried lawsuits. Besides, each considerable town usually chose a great man to be its protector and patron, and was likewise subjected to one or more magistrates, invested with military and civil powers, and appointed by the emperor.

NOTHING, then, could be more natural than that the municipia should, immediately on the conquest, acquire the aspect of the German *pagi*. The new settlers naturally mixed with

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* THERE were above an hundred sovereign states in Gaul, and many more in Spain, when subdued by the Romans; and there were 115 free cities in Gaul under the empire.

the curiales, tranfacted the affairs of the community, and yielded military fervice, under their tithing men or decuriones, led by a common chief, called a *graff*, *burgraff*, or *count*, in the fame way as the inhabitants of the country diftricts.

THE converfion to Chriftianity was, however, an event that, though it created no change in the general ftructure of the legiflature, muft have naturally augmented the numbers of the deliberative body which prefided in it. As Chriftianity incapacitated the leaders of tribes from officiating as chief priefts at thofe religious rites which were ufually celebrated at the opening of public affemblies, the bifhops and abbots came naturally to difcharge this duty on fuch occafions. In this way, they muft have fhared in the rank, by fharing in the functions of the chief; and the fituation in which they thus appeared at the opening of all political conventions, would enable them to join, with much effect, in the deliberations which enfued; and their fuperior knowledge, their facred character, and their influence with the people, would foon acquire them power equal to their rank. They muft, therefore, have been well entitled to demand admiffion into that council, which was formed by the king and the lay chiefs at the national affemblies; and, as they balanced the authority of thofe chiefs, we cannot doubt, that the king would be difpofed to give the utmoft effect to their claim. Accordingly, we every where find the dignified clergy prefiding along with the lay magiftrates, in the provincial affemblies of every degree in all the Gothic nations, and enjoying every advantage, in point of rank and authority, in their national diets. —As to the inferior clergy, they muft long have continued blended with the body of the freemen. It was by degrees only that ecclefiaftics were at firft exempted, and afterwards prohibited from yielding military fervice; and we may be fure, that, in a rude age, the clerical character muft be unable to extinguifh fuddenly that of the warrior.

THE

THE leading propofition in the foregoing hypothefis is, that the diets of the European ftates were originally national affemblies, containing, *de jure,* the whole warriors belonging to them, conducted by their local chiefs or magiftrates, who, together with the king and dignified ecclefiaftics, formed a fenate or council that, in general, directed the common refolves. I propofe, in this part of the paper, to confider the grounds of this propofition, in the firft place; and then, chiefly with a view to our own country, examine the evidence relative to the deliberative council which I have afcribed to the diets, and to the fituation of towns, in order to juftify the hypothefis, in ftating that the former was an affembly of the magiftracy, and that the latter reforted to the diets, in the fame manner as the country diftricts.

CONSIDERING how certainly we know, that the warriors or *liberi homines* of every tithing and hundred were bound to attend perfonally, not only on the meetings of thefe diftricts, but in the general meetings of the province or fhire, where they not only were reviewed by the chief magiftrate, but affifted in the judicial and political deliberations which the bufinefs of their quarter required; it might have been imagined, that a natural analogy would have led authors to agree in the fuppofition, that the national diet was nothing more than an aggregate of the provincial diets, in the fame manner as the provincial diets were aggregates of thofe of leffer diftricts. The difficulty we feel in accommodating our reafonings to a period, when both the bufinefs and the amufement of a freeman confifted in making war, and when the habits of the migratory life of fhepherd tribes were ftill recent, and rendered the manners of fociety extremely different from our own, is the only reafon I can offer for this opinion having met with little attention or regard. Strong arguments in favour of it, from the hiftory of the ancient German nations, I flatter myfelf, will be fuggefted from what has been ftated in the former parts of this paper. Thofe

from

from the hiſtory of latter times, I hope, will be found equally ſatisfactory.

We have no details reſpecting the diets on the continent, previous to the riſe of the houſe of Martel. GREGORY of TOURS, in a paſſage formerly quoted, mentions the Franks aſſembling in their *champ de mars* " per phalanges * ;" in other places, he calls their national council an *exercitus ;* and we have frequent mention of ſimilar conventions †, before as well as after DAGOBERT I. when the power of the mayors of the palace came to engroſs that of the crown. The champs de mars were fields belonging to the great cities of Gaul, allotted for the recreation of the inhabitants, and named after the *campus martius* in Rome. And, as the aſſemblies of citizens and reviews of the troops were held in them, it was natural they ſhould likewiſe be choſen for the meetings of the diets of the Franks, whether general or provincial. We uſually find mention made of theſe aſſemblies as celebrated

* THUS he mentions a placitum, in which GONTRAN appointed CHILDEBERT the heir of his kingdoms ; and tells, that there " GONTRAN cohortabatur omnem *exercitum,*" and feaſted them for three days. *Lib.* 7. § 33. In the ſame way, when CLOTAIRE marched againſt the Saxons, and they offered terms of accommodation, which the king approved of, and propoſed to his people, he relates, that they (Franci) repeatedly rejected them ; and when CLOTAIRE declared to them, " Si abire volueritis, ſpontanea voluntate " non ſequar," that " ipſum vi detrahentes interficere voluerunt, ſi cum illis abire dif- " ferret." *Lib.* 4. § 14. See alſo *lib.* 6. § 45. An ancient author writes, " Franco- " rum regibus moris erat kal. Maii, præſidere coram *tota gente,* et ſalutare et ſalutari, ob- " ſequia et dona accipere. SIGEBERT ad ann. 662 pontan. orig. Franc." *Lib.* 6. *p.* 485.

† WHEN, in *A. D.* 575, SIGEBERT wanted to dethrone his brother CHILPERIC, he was aſ- ſaſſinated by two *pueros Tarvuanenſes,* who had been hired by the wife of CHILPERIC, and aſſiſted at his election to the throne with this view. The election was like that of CLOVIS, by the nation aſſembled. " Collectus eſt ad eum *omnis exercitus,* impoſitumque " ſupra clypeum, regem eum *ſuper ſe ſtatuunt* : —— dixitque Fredegundis (*ſciz.* pueris.) " Ite ad cuneum SIGEBERTI, et adſimulate ut eum ſupra vos in regem elevare debeatis." *Geſta Francor.* § 32. ; and GREG. *lib.* 4. § 46. When, about *A. D.* 612, THEUDEBERT claimed ALSACE from THIERRI, the hiſtorian relates, " Unde placitum inter hos duos re- " ges ut Francorum judicio finiretur in Saloiſſo (Seltz.) *caſtro* inſtituunt. Ibique THEU- " DERICUS (or THIERRI) cum SCARITIS tantum decem millibus acceſſit, THEUDEBERTUS " vero cum magno exercitu Auſtraſiorum." *Fredeg. Chron.* § 37. When BRUNEHAUT, the JEZEBEL of the North, was put to death by CLOTAIRE, it was " *advocato agmine* " Francorum et Burgundiorum, et omnibus vociferantibus Brunihildum morte urpiſſi- " ma eſſe condignam." *Geſta Francor.* § 40. Again ; " Cum autem denunciatum fuit " *placitum* qua die ad *præliandum* convenire deberent." § 30.

celebrated in the spring, previous to a military expedition ; to which, I apprehend, they, in the same manner as in the most ancient times, were a neceffary prelude *. On thefe occafions, the name of *placitum exercitale* is often afcribed to them, while the term *placitum* fimply is attributed to all diets without exception, where judicative and political authority was exercifed. This circumftance itfelf looks as if thefe affemblies had differed only in their object. The power and means of convoking them, and the perfons that they confifted of, muft have been the fame in both ; and, without deliberative powers, we cannot conceive any thing more abfurd than to have beftowed the name of *placitum* on an affembly of the national force.

But, though we have no particular defcription of the Merovingian placita, or malla †, we find every where evidence, that all affairs of confequence were tranfacted in them. The mayor of the palace was chofen in them ‡ ; differences among the royal family, and with foreign nations, were decided in them ‖ ; and the Salic law feems to have owed to them its fanction §.

UNDER

* See PEPIN's Expediton to Italy. *Fredeg. Chron. Contin.*

† MAEL, in German, an affembly or convivium.

‡ Fredeg. Chron. cap. 43. et 89. And, I apprehend, the kings themfelves likewife. In a difpute between CLOTAIRE II. and the children of THIERRI, CLOTAIRE makes this reply to an embaffy from the latter : " *Judicio* Francorum *electo*, quicquid precedente domino a Francis inter eofdem judicabitur, pollicetur fe implere." *Ibid.* § 40. In the fame way, the conftant expreffion ufed in the Chronicles to record a fucceffion to the crown, is, " Et filium ejus Franci fuper fe regem ftatuunt." *Geft. Franc.* § 43. The very ceremony of the coronation of the French kings, as practifed in modern times, is that of an election by the grandees, affembled within the church of Rheims, and an approbation of the people affembled without. In fact, however, the Chronicles often mention elections in exprefs terms.

‖ Thus AISTULFUS, king of the Lombards, engaged, " Ut omnia per judicium Francorum emendaret ;" and it was " per facerdotes et optimates Francorum," that he obtained peace. *Fredeg. Chron. Continuat.* In the fame way, " GUNTRAN et CHILPERIC " pacem fecerunt, pollicentes alter alterutrum, ut quicquid facerdotes vel feniores popu- " li judicarent, pars parti componeret quæ terminum legis excefferat." GREG. *Tur. lib.* 6. § 31.

§ In the preamble of the compilation of it, as corrected under CLOTAIRE II. the authority it proceeded from is thus defcribed : " Temporibus CLOTARII regis, una cum " principibus

UNDER the Carlovingians, we have much more particular accounts of thefe affemblies. The moft unambiguous expreffions of hiftorians indicate that they were national*.

HINCMAR relates, that, at the placita, the " Epifcopi abbates, " vel hujufmodi honorificentiores clerici, fibimet honorificabiliter " a cætera multitudine primo mane fegregarentur ;" and that a fimilar feparation took place, as to the comites, " vel hujufmodi " principes." Thefe, he fays, formed two councils, which met together in one, when the affairs under deliberation required it. Here, then, we have the magiftracy, or governors of towns and counties, and the dignified clergy, forming a fenate, and feparated from the multitude of which the reft of the diet was compofed. And it will be particularly obferved, that this multitude were, by no means, as has often been pretended, a rabble of attendants and fpectators ; for it is related, that no " inferiores perfonæ" were admitted among them ; and that their functions were to hear the refolves of the lay and ecclefiaftical magiftracy ; and fometimes (in cafes, I fuppofe, of very general intereft) deliberate on them, and confirm them, not by their power in executing them, but by their fuffrage in approving of them †.—There is alfo a leffer diet mentioned by

HINCMAR,

" principibus fuis, id funt, 33 epifcopis, 34 ducibus, et 79 comitibus, vel cætero populo " conftituta eft." And HINCMAR, archbifhop of Rheims, under LOUIS LE DEBONNAIRE, a well informed author, and anxious to preferve information of the conftitution of his country, feems to hold it as a thing perfectly notorious, that, in all times, the national confent had been given to the promulgation of laws. " Habent enim reges," fays he, " et reipublicæ miniftri, leges quibus, in quacunque provincia degentes regere debent " habent capitula Chriftianorum regum, ac progenitorum fuorum, quæ generali confen- " fu fidelium fuorum tenere legaliter promulgaverunt." *Vol.* ii. *p.* 204. The capitularies are exprefs on this fubject. One of them runs as follows : " Per capitula avi et pa- " tris noftri, quæ Franci pro lege tenenda judicaverunt et fideles noftri, in generali pla- " cito noftro confervanda decreverunt." *Capit. Carol. Cal. tit.* 39. *cap.* 8.

* IT is related under the year 767, " Ibi fynodicum fecit (*fciz.* PIPINUS) cum *omnibus* Francis in campo Bertini. *Annales Francor.*

† IT is thus I underftand the following paffage. It begins with mentioning, that there were two diets in the year, one of the general kind I am treating of, in which the

HINCMAR, which, he fays, confifted only of the *feniores* and *præcipui conciliarii*, *i. e.* " the magiftracy and principal officers of the crown," and was deftined for the purpofe of making prefents to the king, and confulting on fuch affairs refpecting the bufinefs of the enfuing year, as required early deliberation.

OF this period, as well as the former, it is alfo to be remarked, that we find the term *placitum* applied indifcriminately to the affembly fummoned for immediate war, and to that where deliberation rather than action was its object *.

THE ancient German diet, under the houfes of Saxony and Franconia feems to have retained precifely the form which HINCMAR afcribes to it under CHARLEMAGNE. At the election of CONRAD II. *A. D.* 1024, we find the nation affembling in the plains between Worms and Mentz ; the Franks on the weft, the Saxons, Carinthians, and Bavarians, on the eaft. The dignified clergy, and the dukes, counts, and marquiffes, retired to an ifland on the Rhine, and agreed, that two perfons, named CONRAD, fhould be the candidates. The archbifhop of Mentz propofed the eldeft firft. The dignified clergy gave him their fuffrages, then the dignified laymen, and, in fine, the multitude of the nobility, diftributed into national battalions, gave their confent by cries and acclamations †. PFEFFEL, *vol.* 1. *p.* 180.

I NEED fcarce obferve, that this form of the diet under the houfe of MARTEL affords the ftrongeft indication of its form under that of CLOVIS ; for it is clear from the Capitularies, that the feus had

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whole bufinefs of the year was arranged, fo as not to be altered : . " Nifi fumma necef-
" fitas quæ toto regno incumbebat ;" and thus proceeds, " In quo placito generalitas
" univerforum majorum, tam clericorum quam laicorum, conveniebat ; feniores, propter
" concilium ordinandum ; minores, propter idem concilium fufcipiendum et interdum pa-
" riter tractandum, et non ex poteftate, fed ex proprio mentis intellectu vel fententia
" confirmandum." *Vol.* 2. *p.* 211.

* SEE paffage in the preceding note, as an example of the latter ; and for the former, fee *Capit.* paffim. Thus, *cap.* 2. *Car. Mag. cap.* 9. where the bifhops, counts and abbots are required to have people, " Qui, *&c.* ad diem denunciati placiti veniant, et ibi " oftendant quomodo fint parati. Habeant loricas vel galeas et temporalem hoftem."

† THE election of LOTHARIUS II. *A. D.* 1125, was decided againft the inclination of the fenate, by the will of the multitude, of which, as the accurate PFEFFEL obferves,
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not as yet affected the general structure of the legislature ; and
we know of no other source from which any great change in it
could have proceeded.   Besides, the form of the Polish diet coin-
cides so exactly with that above described, while Poland, at the
same time, was never feudalized, as greatly strengthens the con-
clusion, that it preserved much of the original structure of the Eu-
ropean diets ; especially as the singular tenaciousness of the Poles
to ancient customs, and their seclusion from many of the sources
of political innovations, render it otherwise highly probable, that
they must retain more of the arrangements of ancient Europe than
are to be found in other nations.   In the diet of Poland, the senate,
consisting of the bishops, and of the provincial magistrates, pala-
tines, and castellans, *i. e.* governors of counties or fortresses, assem-
ble within an inclosure, called the *szopa*. The king presides, and,
in his absence, or during an interregnum, the archbishop of
Ghesna.   The noblesse are arranged without, under the banners
of their palatinates, and approve, or reject, by exclamations,
such propositions as the senate think proper to make to them *.
And it is to be remarked, that descent alone, without any estate in
land, is sufficient to constitute a person a member, either of
the provincial or national diets †.

WHAT

" Les historiens font monter le nombre à plus de soixante mille hommes, tous rangés
" sous leurs drapeaux et divisés en six brigades." *Vol.* 1. *p.* 242.

* INSTEAD of the noblesse of the palatinates in the ordinary diets, only deputies at-
tend ; but this is known to be merely a modern invention, and that still it is competent
to assemble the whole body of the nobility, which is actually done when a comitia palu-
data, or an assembly more destined for action than deliberation is convoked.

† THE account SHERNHOOK gives of the ancient Swedish diet shows, that it was also
a national assembly of confederate tribes arranged by the districts to which they belong-
ed : " Hæ provinciæ," says he, " parvum quoddam reipublicæ corpus sibi fecisse vi-
" dentur, non alias in communi cum reliquis consulentes, quam cum aut de hoste pel-
" lendo, aut rege eligendo vel sustentando ageretur : Non enim ut hodie separati ordi-
" nes erant sed provinciæ ; ubi mixti nobiles, clerici, cives, milites, rustici provinciatim,
" et pro communi habitationis loco responderent : Quod et antea dictum est, et inter
" se ordines magis quam provincias conjunxit." *P.* 47. As to the term *rustici*, it may
be observed, that only the peasants of the domains send the representatives which form
the house of peasants in the modern diet. The crown continuing elective, they had
become freemen and proprietors in early times.

WHAT we know of the Spanish diets before the invasion of the Saracens, is also agreeable to the same notions of the ancient legislatures. We have evidence, that both the grandees and the populace gave their suffrages at the elections of the Gothic kings *. It is certain, that their cortes, or councils, were attended by the dignified clergy, and by the palatines, or great provincial magistrates, comprehending *duces, comites et gardingi,* who had the right of summoning and leading forth the national militia †. We have likewise evidence, that this militia, when in actual service, formed occasionally what might be called a *placitum exercitale* ‡. It seems highly probable, therefore, that this militia likewise attended the cortes, which we find always accompanied with a multitude, to whom the resolutions of the deliberative body of it were communicated for approbation ‖ ; a circum-

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* IN the history of the election and expedition of WAMBA into Gaul, published by an archbishop of Toledo, it is not only said of him, " Quem totius gentis et patriæ " communio elegit," and that at his election " Populi acclamatio extitit," but also that he had the " anhelantia *plebium* vota ;" and that a duke, by menaces, compelled him to accept of the crown. *Apud du Chesne, vol.* I.

† *Vide* L L. Visigoth. et Concil. Tolet. Can. passim.

‡ WE have a very curious record of the trial and judgment of PAULUS, and his associates, for revolting in Narbonne against WAMBA, in *A. D.* 673. It bears, that, after they were vanquished and taken captive, " Convocatis adunatisque omnibus nobis, itidem " senioribus cunctis palatii, Gardingis omnibus, omnique palatino officio, seu etiam ad- " stante exercitu universo in conspectu gloriosissimi nostri domini, PAULUS cum prædic- " tis sociis suis judicandus assistebat." It does not certainly appear who the *nobis omnibus* were, for there are no subscriptions preserved ; but, I imagine, the enumeration which succeeds that expression is the true interpretation of it. Accordingly, sentence seems to have been pronounced by the whole assembly, " Ob hoc secundum latæ legis " edicta, hoc *omnes communi definivimus sententia.*" The punishment was " mors tur- " pissima," with a reservation, that the king might spare their lives, " Sed non ali- " ter quam evulsis luminibus." The proceedings at the trial are highly curious. The king first asked the rebels if he had done them any injury. They confessed he had not. Then the record of their having joined in the king's election, and sworn fealty to him, authenticated by their subscriptions, was produced. Then followed the record of PAULUS having accepted of their fealty ; and, in fine, two laws of the councils of Toledo against rebellion were read. The first of these steps was probably necessary, be- cause the Gothic kings at their election " fidem populis reddiderant." *Apud du Chesne, vol.* I. *p.* 831.

‖ *E. G.* THE speech of St LEANDER, when the cortes renounced Arianism, in the reign of RECAREDO, in the end of the sixth century.

ftance which well explains why, on a vacancy of the throne, after a fucceffor was named by the palatines, it was always efteemed neceffary to affemble a folemn diet, in order to have their appointment confirmed, and the right of the new king recognized by the nation.

IF we turn our refearches more homeward, we fhall find, that every thing, in the like manner, indicates, that the legiflature was a national affembly.

THE very places of meeting, in the open air, and in great plains afford reafon to fuppofe, that the diets of the Anglofaxons were very popular affemblies; and all the expreffions of hiftorians, in mentioning them, likewife eftablifh that fuch was the fact *. Even after the conqueft, the Englifh diets were ftill at times very numerous. In an affembly under WILLIAM RUFUS, *A. D.* 1094, almoft all the nobility of England are faid to have been prefent †; and it appears, that, befides them and the dignified clergy, a great crowd of both clergy and laity attended; and that a miles, *unus de multitudine*, made a fpeech, encouraging Archbifhop ANSELM in the conduct he was purfuing ‡. Accordingly, even the laws of the Conqueror bear to have been enacted, " Per commune concilium totius regni ‖." And the

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* THE council, or diet, in which EDGAR was to be abfolved from penance, in *A. D.* 973, is defcribed thus: " Adunatis epifcopis, abbatibus, et cæteris principibus, " cum tota regni ingenuitate, coram eis adftante innumera populi multitudine." The council of *A.D.* 697, affembled at Berghamfted, enacted fundry laws, or canons, which bear that they were decreed by the clergy; " Viris utique militaribus et communi omnium " confenfu." Earl GODWIN purged himfelf of the murder of the king's brother AL-FRED, " coram rege et univerfa gente." *Saxon Chron.* 1052. MATTHEW of Weftmin-fter fays, " Maxima pars regni, tam clericorum quam laicorum, in unum congregati " pari confenfu KNUTONEM in regem elegerunt." The Saxon Chronicle relates, that, on HAROLD's death, " Populus univerfus elegit EDWARDUM in regem."

† EADMERUS calls it fimply, " totius regni adunatio." *P.* 39.

‡ *Ibid.* p. 26.

§ THE election of the dignified clergy was anciently in parliament; and I fee a record in Madox, where STEPHEN, in vefting the bifhop of Bath with the temporalities of

<div align="right">his</div>

ancient entry in the journals of the House of Lords fuggefts the idea of the nation having been affembled along with them : " Præfente etiam *toto* populo, et plebe de domo communi." The laft words, *et plebe de domo communi*, muft evidently have been added after the admiffion of the reprefentatives of trading incorporations among the milites, or proper citizens of the nation.

WE alfo find the fame indifcriminate application of the diet to civil and military purpofes as in the continent. So low down as 23d HENRY II. *A. D.* 1177, mention is made of an extraordinary parliament being affembled at Windfor, attended by all the earls, barons, and almoft the whole military tenants of the king, with their horfes and arms, prepared to go wherever he fhould command them *.

IN Scotland, alfo, we have full evidence of the ancient diets being a national affembly. BENEDICTUS Abbas, under the year 1188, mentions, That the bifhop of Durham, and others, were fent by HENRY II. to WILLIAM, king of Scotland, to collect tithes : That WILLIAM, being defirous to get back certain caftles that had been taken from him, agreed, provided the confent of his fubjects could be obtained : That the ambaffadors came accordingly, " In LEONEIS ad locum quæ dicitur " Brigeam ; — et ipfe rex Scotorum, cum omnibus fere epifcopis " et comitibus et baronibus terræ fuæ, et cum infinita homi- " num fuorum multitudine, ad locum præfixum venerunt ; et " audita adventus nunciorum regis caufa, et eorum petitione,
" habito

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his fee, addreffes the grant, " Archiepifcopis, epifcopis, abbatibus, comitibus, baroni- " bus, *et omnibus fidelibus*, per totam Angliam, conftitutis ;" and adds, that the grant proceeded, " Canonica prius electione præcedente, et communi veftro concilio, voto et " favore profequente." This charter is tefted in a general council at Weftminfter ; " Audientibus et collaudantibus omnibus fidelibus," *&c.*

* BENEDICT. Abb. apud LITTELTON, HEN. II. vol. 3. p. 290. Even under HENRY III. *an.* 1223, " Natali domini," fays the Chronicle of Dunftaple, " venit rex Northamp- " ton, et cum eo D. Cant. archiepifcopus, et tot epifcopi, et comites et barones, et " milites *armati*, quod nec in diebus patris fui, nec poftea, dignofcitur tale feftum in " Anglia celebratum." *Ap. Hody, p.* 300. See alfo note below, on p. 150.

" habito cum fuis concilio, refpondit, fe non poffe animos eo-
" rum inclinare ad decimam dandam.   Et ipfi pro fe refponde-
" runt, fe nunquam decimam daturos; nec etiam fi rex An-
" gliæ, et dominus eorum, rex Scotiæ, juraffent fe illam habi-
" turos, unquam illam darent *."   In the laws of WILLIAM,
we find fome introduced as follows : " Affifa regis WILLIELMI
" facta apud Perth, quam epifcopi, abbates, comites, barones,
" thani, et tota communitas regni tenere firmiter juraverunt,"
&c. †.   " Statuit rex WILLIELMUS apud Sconam, de commu-
" ni concilio et deliberatione prælatorum, comitum, et baro-
" num, ac libere tenentium," &c. ‡.   Nothing, however, is
extant which communicates more fatisfactory evidence of the
ancient diet being an affembly of the nation, than the indenture
entered into between ROBERT BRUCE and his people, in the year
1326.   It proceeds on the narrative, that the king, holding his
full parliament, where were affembled the earls, barons, bur-
geffes, and all the other freeholders of his kingdom, made a
propofal to them, which they approved of, and the perfons ap-
proving are enumerated in the following explicit manner : " Qui
" omnes et finguli comites, barones, burgenfes, et libere te-
" nentes, tam infra libertates quam extra, de domino rege, vel
" quibufcunque aliis dominis infra regnum, mediatè vel imme-
" diatè tenentes, cujufcunque fuerint conditionis ||, confide-
" rantes et fatentes præmiffa effe vera, &c. habito fuper præ-
" miffis communi ac diligenti tractatu, &c. unanimiter concef-
" ferunt," &c. §.   This very curious record, the original of
                                                          which

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* Vol. 2. p. 515.   † Cap. 7.   See alfo general title.   ‡ Cap. 32.

|| THE ecclefiaftics feem to have been omitted in this enumeration, becaufe the grant
in agitation regarded only laymen.   In the parliament, or affembly of the ftates at Ayr,
A. D. 1315, where the fettlement of the crown was made on ROBERT I. the enumera-
tion is as follows : " Epifcopi, abbatcs, priores decani, archidiaconi, et cæteri eccle-
" fiarum prælati, comites, barones, et cæteri de communitate regni Scotiæ, tam
" clerici quam laici." *Ap.* ANDERSON's *Independence, Appendix*, No. 24.

§ THE diet which HENRY I. of England fummoned in 1115 or 1116, to recognize the
fucceffion of his fon WILLIAM, feems to have contained vaffals of fubjects.   MALMSBURY
                                                          fays,

which is ſtill extant in the Advocates Library, proves, that, not-
withſtanding the feudal ſubordination which was then taking
deep root in Scotland, the loweſt military tenants in the king-
dom aſſembled in the national diet, and ſtill retained ſo much
of their *original independence,* as to exerciſe a right of ſuffrage
there, in common with their feudal ſuperiors *. I expreſs my-
ſelf in this manner, becauſe, I imagine, every perſon acquaint-
ed with the hiſtory of the progreſs of ſociety, or with the ge-
nius of the feudal ſyſtem, muſt perceive, that the admiſſion of
vaſſals to the exerciſe of any of the functions of ſovereignty,
in common with their lords, under the predominancy of that
ſyſtem, could never have been the reſult of it, but muſt have
been the remaining effect of a ſituation of things anterior to
that inequality which the feudal arrangements of landed pro-
perty had introduced or confirmed.

THIS principle, likewiſe, leads me to obſerve, that the hiſtory
of the repreſentation in parliament of the counties, whether in
Scotland or England, does, in fact, contain evidence, that the
freeholders in both were originally members of that legiſlature,
from attendance on which they were excuſed, only on condition
of conveying their powers to delegates officiating in their ſtead.
In

ſays, " Ei (*viz.* WILLIAM) vix dum 12 annorum eſſet, omnes liberi homines Angliæ
" et Normanniæ, cujuſcunque ordinis et dignitatis, *cujuſcunque domini fideles,* manibus
" et ſacramento ſe dedere coacti ſunt." See HODY, *p.* 198.

* THE iter juſticiarii proves, that ſubvaſſals were anciently ſectatores of the king's
court : " Primo vocentur ſectatores, et eorum domini ; quia tametſi ſectatores compa-
" rent, tamen eorum domini obligantur ad comparendum, coram juſticiario in ſuo iti-
" nere." Again ; " Sectatores curiæ iterum vocari debent ſinguli bis, cum ipſorum
" dominis." It appears, too, from *cap.* 15. *Quon. Att.* That a vaſſal of a baron was
probably, at the period of the regulation there mentioned, ſtill a ſectator curiæ viceco-
mitis. Poſſibly, *cap.* 67. *ejuſd.* may have been the origin of their being excluded the
county courts of freeholders. It is there provided, that a baron cannot be judged by a
vavaſor, nor a vavaſor by a burgeſs ; but that a lower perſon might be judged by a
higher. In the decline of the feus again, *viz.* in 1593, all landed men were found by
the court of ſeſſion to be pares curiæ, and competent to ſit as jurymen, even in the trial
of peers before the juſticiar, MACK. *Crim. part.* 2. *tit.* 8.

In Scotland, we know, that it was not till the latter part of the sixteenth century, that freeholders were excluded from sitting along with their representatives; and though, during the period of domestic troubles that occurred between the reigns of Robert I. and James I. the feeblenefs of the crown appears to have permitted such an usurpation of sovereignty in the subject-superiors, as to deprive their military vassals of the title and rights of freeholders, the indenture I have quoted proves that they originally possessed them. And the analogy of England, where they never lost them *, but retain, at this day, the name and privileges of freeholders, in common with the tenants *in capite*, confirms powerfully the evidence which that indenture affords.

It may further be remarked, as a circumstance extremely favourable to the hypothesis I have offered, not only that all freeholders owed military service, but that, in Saxon times, the *expeditio militaris* formed an article of the trinoda necessitas incumbent

* I KNOW English antiquaries suppose there was a time when the vassals of subjects were *admitted* to the privileges of freeholders. But there is no vestige of evidence that such an event ever took place, or that there was room for it, by their ever having been destitute of those privileges. The fact, I apprehend, was, that the vigorous administration of the Anglo-Norman princes prevented, in a great measure, that usurpation of sovereignty in the subject-superiors, which occurred in other countries. Hence, though property was arranged in England according to feudal ideas, the vassal preserved much of his public privileges and natural equality as a citizen. Thus the *valvasor*, or powerful vassal of a feudal lord, was regarded as a superior person to a simple *miles*, or petty tenant *in capite*. Thus, the sheriff alone could levy a distress from vassals, to compel them to fulfil their obligations to their superiors. Thus the first peer of the realm is not only, in all civil cases, subject to the jurisdiction of a jury of commoners, who may be vassals of subjects, but, in criminal cases, is subject to the grand jury, and, on an appeal of felony or murder, may be convicted capitally by a petty jury of them. And thus, too, the king always might have required the council of any freeholder, by writ, commanding his attendance in parliament, where he consequently might have sat and voted as an equal with his feudal lord. The statute HEN. III. *an.* 9. *cap.* 14. seems to have arisen from the distinction of ranks which the feudal law had then rivetted. In the mandamus of that prince to the itinerant justices, he directs them to amerce all liable to be amerced, except earls and barons, "Qui coram concilio "nostro amerciandi sunt." By § 27. *Mag. Chart.* they could be amerced only " per " pares suos."

cumbent on every free citizen, and that the poffeffion of a fword and a lance was fuch a characteriftic of freedom, that the ceremony of emancipating a villein confifted in beftowing them on him.

I DO not mean to contend, that every degree of emancipation, though creating an obligation to ferve in war, conferred a right of entry into the courts of the hundred and fhire. I rather incline to believe, that, in general, the emancipated remained fubject to various burdens in favour of their patrons, and reforted to that domeftic jurifdiction which their patrons exercifed in their own domains; and that, in turbulent times, many of the original freemen were either compelled by their more powerful neighbours, or found it convenient, for the fake of protection, to fubmit to fimilar burdens, and to a fimilar degradation. But, on the other hand, we find the Saxon Ceorls entering into *fodalitia* with the moft confiderable perfons in the ftate: We find fokemen, in the oldeft times, members of the county-courts; and Doomfday proves, that even thofe fokemen, who probably had no entry there, and were transferable by their lords, retained fo much of the characters of the ancient independence of freemen, that they exercifed the functions of fuitors of courts, and were capable of enjoying the emoluments of jurifdiction *.

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* IN enumerating the lands of ROGERUS comes, it is faid in Doomfday-book; " Hanc terram tenuerunt 6 foccomanni, et dare et vendere terram fuam potuerunt. " Unus eorum homo regis EDWARDI fuit, et Invuardam invenit vicecomiti. Tres iftorum " Soccomannorum accommodavit PICOTUS (the vicecomes), ROGERIO comiti, *propter pla-* " *cita fua tenenda.* Sed poftea occupaverunt eos, homines comitis et retinuerunt cum terris " fuis fine liberatione, et rex inde fervitium non habuit, nec habet. Sic ipfe vicecomes dicit." P. 193. 2. Again, when defcribing Herftingeftan hundred; " Ibi eft terra Soccoman- " norum 5 hid. ad geld. Terra 8 carruc. et 6 bov. Ifti foccomanni dicunt, fe habuiffe le- " grevitam, blodevitam, latrocinium fuum, ufque ad 4 denar. et poft 4 denar. habe- " bat abbas forisfacturam latrocinii." In the remarks at the end of the furvey of the fhire, it is faid, that a jury informed that, as to thefe 5 hides, " Terra foccomannorum fuit " tempore regis EDWARDI; fed idem rex dedit *terram* et *focam* de eis fancto Bene- " dicto de RAMSEY, propter unum fervitium quod abbas ALVINUS fecit ei in Saxonia, " et poftea femper habuit." *Huntingtonfhire.*

FROM all this combined evidence, derived from the history of so many countries, I think myself entitled to conclude, that the European diets were, in their origin, national assemblies of the warriors of each country, in the same manner as the provincial diets consisted of the posse comitatus, or military force of each district. I am aware it may be objected, that many of the facts I have founded on are extraordinary events, which, it may be said, ought not to be considered as indicating the true constitution of a country. I think, however, there is a solid answer to this objection. It will be observed, that I am reasoning from occurrences among nations practising agriculture, with a view to discover what constitution they possessed on their first establishment, when war and a pastoral migratory life had formed their opinions and habits. I am, therefore, entitled to suppose, that their ancient and most sacred functions would become unsuitable to their new situation, and be neglected, as inconvenient and burdensome, except when great occasions excited a general interest, which overcame the natural unwieldiness of an agricultural nation, where the powers of government are little felt or acknowledged. In this view, therefore, the examples above quoted, of immense numbers assembling in a military form in the German and British diets, ought not to be considered as insulated events, but as instances marking the genuine structure of the nation : For it will be remarked, that they were not the consequences of revolutions, but only of important occurrences, that must naturally have inclined people to overlook private inconveniences, and, from a regard to the public interest, exert their ancient and known political rights.

I SHALL make only one observation more in favour of my opinion ; and it is this, That it fully explains a great variety of circumstances in the history of the middle ages, and, during the reign of the feus, altogether adverse to what was the spirit of those institutions, and the temper of those times. Such are the

the formidable and frequent demands made to the Norman princes for the reftoration of the Saxon laws; the regard paid by magna charta to the rights of the commons, as much as of the peerage; the facility with which deputies from the lefser freeholders were admitted into parliament, fo that no cotemporary hiftorians take any notice of the event; the numerous veftiges of an ancient equality of ranks among thofe who may juftly be termed the warrior caft of the nation*; the privileges of the noblefse on the continent, and the fpirit of the common law in England, fo favourable to the rights of the commons and adverfe to feudal ufurpation: Thefe are a few of the particulars which, I think, have never received any fatisfactory explanation on the fyftem of thofe authors who hold, that all our inftitutions are to be confidered as originating in feudal times.

PART II.

SECTION II. *Of the deliberative Body in the Anglo-Saxon and Scottifh Diets; and whether or not they contained Reprefentatives of Towns.*

THERE are two points in the hypothefis maintained in the preceding fection that feem to demand feparate confideration. Thefe are the members afcribed to the deliberative body in the European diets in general, and in the wittenagemot in particular; and the denial of any reprefentation having belonged to the commons in the Gothic ages.

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* THUS, in Scotland, where the greater and lefser barons fat together in one houfe of parliament, we find commoners holding the higheft offices in the ftate, and fitting along with peers in juries and in trials in parliament.

As to the former of thefe circumftances, it will not have efcaped attention, that many of the facts already quoted ftrongly confirm the general idea, that there was a prefiding body in the national diets, confifting chiefly of the ecclefiaftical and lay magiftracy. HINCMAR's defcription of the placita under CHARLEMAGNE; what we know of the diets in Germany under his fucceffors, and of thofe of the Vifigoths before the Saracen conqueft, and the ftructure of thofe of Poland and Sweden, are all agreeable to this opinion. The queftion, however, who the wites were, from which the Anglo-Saxon diet, or micelmot, derived fometimes the name of *wittenagemot*, has been a matter of fo much difcuffion, the opinion I offer is fo adverfe to what the greateft of our hiftorians have entertained on the fubject, and is itfelf fo material in explaining the origin and functions of the peerage and titled nobility of modern Europe, that I flatter myfelf fome obfervations, particularly directed to this fubject, will not be unacceptable.

IN the *firft* place, it is to be noticed, that many of the expreffions of our ancient hiftorians and records indicate, that the Saxon diet confifted of two bodies. This feems to be implied even in the common enumeration, which begins with the dignified clergy, and ends with fome term denoting a great multitude of people, fuch as *tota ingenuitas*, or *populus*; but there are not wanting more explicit expreffions. Thus, WILLIAM of Malmfbury, who flourifhed only fixty-nine years after the conqueft, makes HAROLD, when reproached for affuming the crown contrary to his oath, give the following anfwer to WILLIAM the Norman: " De regno prefumptuofum fuiffe, quod " abfque generali *fenatus et populi* conventu et edicto, alienam " illi hæreditatem juraverit," *&c.* *.

<div align="right">Mr</div>

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* ANALOGOUS expreffions are ufed with refpect to the diets of the continental nations. As to the northern nations, Poland, Sweden, Denmark, and Norway, the fact, with regard to two bodies, a fenate and people, compofing their ancient diets, admits of no difpute.

Mr HUME, obferving that vaft numbers of members were always afcribed to the Saxon diet, has thought it neceffary to fuppofe, that the principal proprietors of land were entitled to feats in it; and he, at the fame time, rejects the notion of the commons fitting, or being reprefented in it, becaufe he finds no mention of reprefentatives in Saxon times; and becaufe, from the nature of the thing, a deliberative council could not contain a whole nation. But, if the diet was a military review, the leaders might naturally form a council far from being too numerous for deliberation; and the body which approved or rejected their refolutions might be fuppofed to confift of almoft any given numbers without confufion. The feparation of the diet into two bodies is, no doubt, irreconcileable with Mr HUME's fyftem; but it feems to obviate the difficulties that induced him to adopt it.

In the *next* place, I apprehend the following paffages clearly point out, that the eldeft wites, or *fapientes natu majores*, were the lay and ecclefiaftical magiftrates, and, by no means, merely confiderable landholders. INA reigned in Weffex in the end of the feventh and beginning of the eighth century. His laws are

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difpute. As to thofe of Spain, there feems to be no room for fuppofing them different : " Tandem unus ex primatibus," fays an ancient chronicle, " nomine CHINDASINTHUS, " collectis plurimis fenatoribus Gothorum, cæteroque populo in regno Spaniæ fublima- " tur. TOLOGANEM degradatum ad honos CLERICATI tonforare fecit." FREDEG. § 82. The fame conftitution among the Lombards feems to be implied in the expreffion of the chronicle : " Langobardi una cum concilio procerum fuorum DESIDERIUM in fedem reg- " ni inftituunt." DU CHESNE, *tit.* I. *p.* 775. As to France, again, under the firft Race, we frequently meet with fuch language as this : " CHILPERICUS rex, convocatis " melioribus Francis, reliquifque fidelibus, nuptias celebravit filiæ fuæ." GREG. *Tur.* *lib.* 6. § 45. " Ille vero congregatis fenioribus fecum, præparatis epulis," &c. *Lib.* 4. § 27. And FREDEGARIUS writes, " Confilio fapientum ufus pagos et civitates, " quod fratri fuo CHARIBERTO ad tranfigendum ad inftar privato habitu vivendum, " potuiffet fufficere nofcitur conceffiffe." *Cap.* 57. In the fame way, the legiflature of the Saxons, when conquered by CHARLEMAGNE, confifted of a fenate and people : " Cum in Saxoniam CAROLUS perveniffet totum perfidæ gentis *fenatum ac populum,* " quem ad fe venire jufferat, morigeram ac fallaciter fibi devotam invenit." EGINHAR- TUS *in actis ann.* 777.

are extant; and the preamble of them bears, that they were enacted with the advice of his father, &c. and the eldest wites of his people. One of these laws provides, that, if any person fights in an alderman's house, or in other (oþner) illustrious wite's house, he must pay, &c. Dr HENRY* has translated the passage thus: " If any man fights in an alderman's house, or " in the house of one of the famous wise men." It is evident, that here the Doctor makes the passage express a distinction between an alderman and a wite, while the Saxon relative oþner manifestly implies, that aldermen were wites, though there were wites that were not aldermen.

ASSERUS, in his life of ALFRED, mentions the attention of that prince to the distribution of justice, and his rebuking his judges for assuming the rank and functions of wites, " Gradus " et ministerium sapientum," while they neglected " sapientis " studium et operam;" and commanding them, therefore, to lay aside " terrenarum potestatum ministeria." This passage proves, that the wites, or sapientes, were possessed of the powers of magistrates. The sequel of it is, however, still more explicit, and, as I apprehend, obviates every doubt; for, in mentioning the effect of the rebuke, ASSERUS names particularly the persons reformed by it: " Perterriti veluti pro maxima vin- " dicta correcti comites et præpositi ad equitatis discendi stu- " dium totis viribus se vertere nitebantur; ita ut mirum in " modum illiterati ab infantia comites, pene omnes præpositi " ac ministri, literatoriæ arte studerent," &c. †.

THESE passages scarce require a commentary. In the law of INA, aldermen are mentioned as a considerable class of wites. The rebuke of ALFRED relates only to laymen; and the sapientes laici are there specified under the Latin names universally used to denote chiefs of counties and towns. The lay wites were certainly, therefore, the chiefs of districts, by whatever name those chiefs were called, heretoges, aldermen, or gerefas:

And

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* Hist. of Gr. Brit. vol. 2. p. 246.   † P. 21.

And the ecclefiaftical wites, were, without doubt, the dignified
clergy whom we find enumerated at the head of thofe of whom
the diets were compofed. In the laws of ALFRED, it is faid ;
" Sancti epifcopi et fapientes laici ftatuerunt." KINEWOLF, king
of Weffex, in writing about religious affairs, fays ; " Una cum
" epifcopis meis, nec non cum caterva fatraparum ;" or, more fim-
ply, " Cum confenfu epifcoporum, atque fatraparum meorum."
The term *fatrap* here, and in other places, ufed by the Anglo-
Saxon writers was certainly, of all others, the moft proper to
denote thofe powerful provincial magiftrates who were, in fact,
petty kings, and united, like them, the civil and military
powers. And it will, likewife, be noticed, that this term is ufed
by KINEWOLF, as corresponding to that of fapientes laici in the
laws of ALFRED *.

IT may be tedious to add further authorities ; but I will ven-
ture to fay, that, if any perfon takes the trouble to look into
the Saxon writers, he will, I believe, find, that the common
expreffions ufed by them are more juft, if interpreted according
to the fyftem I have offered, than in any other way. Thus, for
inftance, the current phrafe, " Confidentibus totius Angliæ fe-
" natoribus," or, " Totius Angliæ majoribus natu," could,
with no propriety, be ufed to exprefs, as is manifeftly intended
by it, that the fenate was full and general; unlefs all the parts
of England had fenators peculiar to them ; that is, that the fe-
nators were the provincial magiftrates. If they had been either
the judges of a royal court of juftice, or had been confiderable
proprietors without functions, then the phrafe would naturally
have run, " *Omnibus Angliæ fenatoribus,*" or, " *Omnibus Angliæ*
" *majoribus*

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* IN the fynod of *A. D.* 694, affembled chiefly on religious affairs, the enumeration of the
members is more full ; firft, the archbifhop of Britain and the bifhop of Rochefter are
mentioned, and then it proceeds as follows : " Cæterifque abbatibus, abbatiffis, prefby-
" teris, diaconibus, ducibus, fatrapis, in unum glomeratis." See alfo enumeration of
the diet which abfolved EDGAR, quoted above in note. p. 148.

" *majoribus natu confidentibus*." And many examples of a like nature might be quoted *.

I⊤ will naturally occur, that the opinion of a qualification in landed property having been neceſſary to confer a ſeat in the wittenagemot, is adverſe to the concluſion which is meant to be ſuggeſted by the above obſervations. But it is to be remarked, that what Dr HENRY has laid down on this ſubject as a matter of certainty, was offered by Mr HUME merely as a conjecture. The only foundation, as far as I know, for this doctrine is a paſſage in the Hiſtoria Elienſis †, where mention is made of land being alienated from a convent, in order to make up an eſtate of 40 hides for a friend of the abbot, that he might be reckoned among the nobles, "proceres." We know, that more anciently a king's thane muſt have had five hides of land, a chapel and a hall. Hence, as Mr HUME ſuppoſed, the great proprietors of land, or king's thanes, were the wites, he conjectured reaſonably enough from the above paſſage, that, in later times, the qualification of a wite had been advanced to 40 hides ‡. It is manifeſt, however, that, till it is proved that the thanes were ſenatores Angliæ, a doctrine which, by the by, would render the ſenate too numerous for deliberation, there is no evidence whatever, that a qualification in land had any connection in law with the wittenagemot, farther than that we may conjecture, that proprietors who held lands free from ſervile conditions alone would be eſteemed companions in arms for each other,

and

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* " GLORIOSUS rex OFFA cum ſenatoribus terræ, *&c.* Hæc decreta ſenatoribus et " ducibus et populo terræ propoſuimus." SPELMAN's *Councils.* A charter of EDWARD the Confeſſor runs thus : " EDWARDUS R. Salutem dicit HERMANNO epiſcopo, HAROLDO " comiti, et omnibus ſuis *agri Dorſetenſis miniſtris.*" HODY, *p.* 64.

† Lib. 2. cap. 40.

‡ I⊤ is remarked in Doomſday, that a thane who had more than ſix manors in Nottingamſhire, paid 8 pounds relief to the *king*; but, if he had ſix or fewer manors, he paid 3 merks to the *ſheriff,* whether he lived *in burgo* or *extra.*

and, of courfe, alone would attend the provincial and national diets *.

As to Scotland again, there feems to be every reafon to believe, that its ancient diet was conftituted in a manner very fimilar to that of the Anglo-Saxons. We find the country divided, like England, into fhires and wapontacks. We know, that the Saxons and Danes gave their language and cuftoms to the fouth-eaftern parts of Scotland; and what is tranfmitted to us of the Irifh and Welfh cuftoms feems to differ from the arrangements of the Anglo-Saxons, only as having belonged to a more rude and uncultivated people. On thefe accounts, I think it reafonable to fuppofe, that the great men, mentioned in the enumeration of the members of the ancient Scottifh diets, were the magiftracy of the nation. I know a learned author †, in a late work, feems inclined to difpute that ever earls were official in Scotland. But, fo late as the laws of DAVID II. ‡, earls are mentioned as provincial judges; and the ancient Scottifh ftatutes cannot be looked into without finding the term *judices* applied to earls, and others, with the fame general impropriety as in the reft of Europe, where it was conftantly employed to denote magiftrates rather than judges. When, therefore, in an affembly at Perth, fines for non-performance of military fervice are faid to have been afcertained, " Coram rege per omnes judices Scotiæ ‖," we ought to be at no lofs to difcover, that it was the fenators, or the magiftracy of the nation, that formed the body here meant §.

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* I SHALL afterwards, in confidering the innovations in the ftructure of the ancient legiflatures, have occafion to treat of this qualification in land.

† Mr WALLACE.

‡ Cap. 8. and 9.

‖ Stat. ALEX. cap. 15. Stat. WILLIEL. cap. 3.

§ IT is curious to find GREGORY of Tours ufing a fimilar mode of expreffion, " Poft " hæc edictum *a judicibus* datum, ut qui in hac expeditione tardi fuerant damnarentur." *Lib.* 7. *c.* 42.

It is worthy of remark, that the record mentions the fines awarded to have been such as had not been adjudged at the army, where the attendance should have been given. This must be acknowledged to look as if a placitum exercitale was not unknown in Scotland.

I HAVE been able to discover no vestige in Scotland of any particular quantity of land-estate being anciently required to qualify a person to be a member of the national diet. Dr STUART, indeed, has laid it down in his work on the public law of Scotland, that the possession of a knight's fee was necessary for this purpose * ; and he has thought proper to treat Dr ROBERTSON with much asperity for holding, that the lesser tenants, *in capite*, were members of it. It does not, however, appear, that even the national force was ever called forth, according to any distribution of the country into knights fees. The statute of WILLIAM the Lion, *c.* 23. proves the contrary, as far back as his reign. There is, therefore, as little probability as evidence, that this species of estate was employed to form the qualification of a seat in the national diet.

EVEN in England, where knights fees were of such important use, the possession of an entire knight's fee does not appear to have ever been considered as, in the least, connected with a vote in the legislature. By Magna Charta, all tenants *in capite* †　were, without distinction, to be summoned to parliament ‡ ; and, if we look to foreign countries, we shall find, that it was always noble blood alone, or a fee held by a noble tenure, conjoined

joined

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* Page 290.

† WHETHER holding by one species of tenure, or another ; and whether holding large estates, or only fractions of knights fees. See also L L. GUL. I. and L L. HEN. I. ap. Lambard.

‡ " ET præterea faciemus summoneri in generali, per vicecomites et ballivos nostros, " omnes illos qui de nobis tenent in capite." *Mag. Chart.* § 14. I must here remark, that this expression is not adverse to my opinion, that freeholders, not holding in chief, were

joined with noble blood, and by no means the quantity of the fee, that afforded a qualification for the diet.

BESIDES, Dr STUART has inferted, in an Appendix to his work, the indenture of ROBERT I. where all the free tenants, " of whatever condition," and whether holding of king or fubject, belonging to liberties, or not belonging to them, are mentioned as affembled and deliberating in parliament.

ONE obfervation more is neceffary on the prefiding body of the Britifh diets, *viz.* that both in England and Scotland, it appears to have affembled in the fame manner as the autumnal placita of the Franks, though no general diet of the nation had been convoked. The Saxon hiftorians often mention affemblies where only fenators in general, or, more particularly, bifhops, abbots, or feniores, are fpecified as attending ; and we find the Saxon monarchs trying great law fuits in fuch conventions. Thus, fays the Hiftory of Ely, " Edicitur generale placitum " apud Lundoniam," where the duces, principes, fatrapæ, rhetores, and caufidici, affembled ; and there a queftion of property was decided by them, in which the bifhop of Winchefter was concerned *. In the fame way, in Scotland, the remains of our

x 2 ancient

were originally entitled to attend at the diets. The tenants *in capite* owed their attendance as the condition of their eftates, and were compelled to give it accordingly, while other freemen were more apt to neglect a burdenfome and inconvenient duty, which was not, in their cafe, often enforced by immediate forfeitures. Accordingly, the bold inventor of the treatife Mod. Tenen. Parl. makes the tenants in chief attend parliament by neceffity of their tenure, while others only might be afked to attend. The real foundation, however, of this provifion in Magna Charta was, I apprehend, no more than this, that the tenants in chief were, agreeably to the feudal arrangements, the leaders and magiftrates of their vaffals. Hence it was incumbent on the king to fummon only his immediate vaffals, each of whom was, in virtue of fuch fummons, obliged to attend, " cum hominibus fuis." Accordingly we find, that, in Scotland, certain of the vaffals owed only prefence, and not fuit, at the king's courts ; and that it was neceffary to enforce the obligation of fuit by various regulations. *Stat.* 1. ROB. I. *cap.* 2. &c. 4. et 5.

* Lib. 1. cap. 10. See for more fuch affemblies, *cap.* 14. 45. 46. 60. This piece of hiftory is the more remarkable, that it affords a ftrong indication of the original independence

ancient laws take notice of ordinances and judgments decreed
in fimilar conventions. One GYLASPIC MACSCOLANE we
find ordered to give fureties, or furrender himfelf, by an affem-
bly of all the judices Scotiæ and Galividiæ. A judgment re-
fpecting the widows third of lands, rendered by the king in
his court, is marked by having been pronounced when many mag-
nates were prefent, and, therefore, no doubt of the greater au-
thority; and ALEXANDER II. iffues ordinances, fometimes
" communi confilio comitum fuorum," and fometimes along
with the " comites barones et judices Scotiæ;" or, more general-
ly, as in a cafe formerly quoted, " Recordatio facta coram do-
" mino rege per omnes judices Scotiæ †."

* * * *

THE opinion, that the towns had reprefentatives, in the an-
cient European diets, deferves particular examination, not fo
much on account of any argument or evidence produced in its
favour, as becaufe men of ingenuity have maintained it, and
that the difcuffion of the merits of it tends to throw light
on the fources from which this privilege was, in after ages, de-
rived.

AND confidering, that the fupporters of this opinion gene-
rally hold, that the vaffals of fubjects, and even thofe tenants
in capite, whofe property was lefs than a knight's fee, had no
<div align="right">place</div>

pendence of the counties. For, after relating the judgment of the generale placitum,
it thus proceeds : " Poft hæc, infra octavum diem convenerunt iterum ad Northampton,
" et congregata ibi tota provincia five vicecomitatu, coram cunctis iterum caufam fu-
" pradictam patefecerunt. Qua patefacta ac declarata, ut præjudicatum erat apud
" Lundoniam, judicaverunt et ifti apud Northampton."

† IT is natural to confider, as the remains of this ancient inftitution, the known
royal prerogative in England, of holding conventions of peers, though no parliament
is in exiftence ; and the practice which appears from the Scots ftatutes to have obtained
in Scotland, of the peers iffuing ordinances without the concurrence of the other eftates
of parliament.

place in the diet * ; and that the reprefentation by knights of the fhire in Britain, and deputies of nobleffe on the continent, was a modern inftitution, the æra of which is nearly afcertained ; it furely may be fairly urged, that a hypothefis is, at leaft, improbable which thus fuppofes, that, in rude and warlike times, the owners of fmall eftates, who formed fo large a portion of the feudal militia, had no accefs to the national council, while plebeian burgeffes had, in all times, been admitted into it, and even, according to fome, formed the wites, from which, among the Anglo-Saxons, it derived its name.

But though it were permitted us to fuppofe, that reprefentatives from counties, as well as from towns, had been delegated to the national diets, neither the diforderly and calamitous ftate of fociety in the Gothic ages, nor the feudal ufurpations to which they gave birth, nor the feeble and disjointed condition in which they left the European nations, can fuffer us to attribute to fuch times an inftitution which our own experience of it has proved to be the powerful guardian of civil liberty, the fureft fource of equal and general laws, and the efficacious bond which unites a widely extended country into one great community, cemented by the fame public interefts, and

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* The Abbé Mably, however, thinks, that the Commons, or Tiers Etat, formed a third chamber in the diet of the Carlovingians, becaufe the *Capit.* of *A. D.* 819, *art.* 2. requires *each* comes to bring with him to the diet, " 12 fcabinos, fi tanti " fuerint, fin autem de melioribus hominibus comitatus fuppleat numerum ;" and that the advocati of the dignified clergy fhould alfo attend. But the fcabini were always chofen " de nobilioribus ;" and, at any rate, it is evident, the 12 beft people of a county can, by no means, be reckoned as of the Tiers Etat. Befides, Hincmar's defcription of the affembly gives no countenance to the notion of a chamber of delegates. The regulation in queftion, I apprehend, was deftined to remedy, in part, that neglect of attendance on the diet, which, at laft became fo fatal to its authority ; or, perhaps, for fome particular purpofe, like what we read in Hoveden, of William the Conqueror ; " Willielmus rex, anno quarto regni fui, confilio baronum fuorum, fecit " fummonari per univerfos confulatos Angliæ *Anglos nobiles* et fapientes, et fua lege " eruditos, ut eorum jura et confuetudines ab ipfis audiret. Electis igitur de fingulis " totius patriæ comitatibus viri duodecim," &c. And they are faid to have reported the laws upon oath.

and actuated by the fame national fpirit. It is ftrange, that thofe who profefs to be the moft zealous friends of the Houfe of Commons fhould adopt a fyftem, according to which a le-giflature by reprefentatives, even when eftablifhed among a people uncorrupted by luxury, and trained to arms, proved in-fufficient to anfwer the moft effential purpofes of government. The multiplied oppreffion, the turbulency of powerful indivi-duals, the national debility, the diverfity of local cuftoms, which, it is not to be difputed, were the refult, as well as the at-tendants of the Gothic governments, are furely the ftrongeft evidence of a conftitution intrinfically bad, or grofsly inade-quate to the circumftances of the people to whom it belonged.

Besides, if it be confidered, that each diftrict had conftitu-tionally the election of its own chief magiftrate *, who, it can-not be queftioned, was a member of the diet, it will be dif-ficult to conceive, how the meafure of fending any other re-prefentative to fuch affemblies fhould have been adopted. A perfon with fuch a character would have appeared to be ano-ther

* " Audiens autem Chilpericus omnia mala, quæ faciebat Leudaftes ecclefiis Turo-" nicis et omni populo, Ansualdum illuc dirigit. Qui veniens, ad feftivitatem Sancti " Martini, *data nobis et populo optione*, Eunomius in comitatum erigitur. Denique Leu-" daftes cernens fe *remotum*," &c. Greg. *Tur. lib.* 5. § 48. " Præcipientes jubemus, " ut in ipfo pago Cenomanico accipere non debeant, ducem aut comitem, nifi per elec-" tionem ipfius pagi, pontificis et pagenfium." Bouquet, *tom.* 4. *ad ann.* 698. The emperor Henry II. recognized, that it had been the right of the Bavarians, at all times, to chufe their dukes. Again, "Ut judices, vicedomini, præpofiti, advocati, centenarii " boni et veraces, cum comite et populo, eligantur." *Capit. ad ann.* 809. See alfo L L. Edwardi, cap. 35. and L L. Boior. tit. 2. cap. 1. The kings, as prefiding ma-giftrates, had naturally the nomination of dukes and counts ; and the people had the appointment or rejection. The kings feem to have interfered in prejudice of the peo-ple, by transferring the election into the general affembly of the magiftracy, and then by affuming it altogether. Thus we have frequent mention of the " electiones " de palatio" as to bifhops, and they are marked in the edict of Clotaire II. ann. 615, as an alternative to elections " clero et populo." I have quoted a char-ter in Madox, that proves a bifhop of Bath was elected in parliament in Stephen's time ; and we find dukes and counts fometimes fent " e palatio," and fometimes chofen, as in the above cafe of Tours. See alfo, lib. 8. § 42.

ther chief magiftrate, and muft have been confidered as a rival and a foe to the natural head of the community.

Very ftrong arguments have been derived from the progrefs of the Houfe of Commons to its political confequence ; and, from its rank and functions, when firft found acting in the legiflature, to fhow, that it was, by no means, a body coeval with the conftitution. Thefe, however, are well known, and need not be infifted on.

But, independently of the foregoing obfervations, which, however they may produce conviction on people accuftomed to eftimate the force of political reafonings, will poffibly be little relifhed by others ; I apprehend we have evidence of a more direct nature againft the antiquity of the reprefentation of towns. *If, previous to the æra of charters of incorporation, towns were governed precifely in the fame manner as the country,* it is manifeft, that nothing can be more improbable, than that they reforted to the diet in any other way than the reft of the nation ; and an examination of the ftate of the Anglo-Saxon towns, compared with that of thofe on the continent, both proves, that *they contained the fame orders of perfons, and the fame political arrangements as the country* ; and even points out the circumftances, in their fituation, which led them to exchange their ancient ftructure for their prefent conftitutions.

In the *firft* place, it is evident from Doomfday, (which, it will be remembered, mentions the ftate of things under Edward the Confeffor, as well as their fubfequent ftate under the Conqueror, when the furvey was taken), that the towns were univerfally comprehended under the divifions of the country, by counties, hundreds, and tithings, and were fubjected to certain public burdens, in proportion to the divifion at which they were rated *. And we accordingly find, that,

<div align="right">when</div>

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* " Burgum de Grentbrige pro uno hundret. fe defend." *Grentebrefcire.* " Bede-
" ford, tempore regis Edwardi, pro dimidio hundret. fe defendeb. et modo facit in
<div align="right">" expeditione.</div>

when the towns, in the fucceeding centuries, purchafed charters, erecting them into little communities, it was neceffary to feparate them from the ancient fyftem of fubordination to which they belonged. Thus, thofe charters contained, among other privileges, exemptions from owing fuit to the county, and even hundred courts * ; exemptions from the ancient authority of the fheriff, as collector of the revenues of the fhire ; and provifions, that burgeffes fhould not be tried by a jury of the county, unlefs one half of the jurymen were taken from their corporation. It is fcarce neceffary to add, that feveral of the towns which obtained charters were, at the conqueft, nothing more than manors belonging to the king, or other great proprietors. ATKYNS, in his *Lex Parlamentaria*, has long ago mentioned feveral ancient vills of the domain that afterwards became royal boroughs.

2*dly*, DOOMSDAY exhibits the government of towns as the fame with that of the country. Thus, it mentions the comes, vicecomes, and their fubftitutes, *viz.* præpofiti, majores, *&c.* as the perfons who had authority in towns † : And thofe that ranked as hundreds are defcribed not only as fubdivided into

<div align="right">wards</div>

" expeditione et in navibus." Of Exon,(Exeter) it is faid,"Serviebat hæc civitas quantum " 5 hidæ terræ." *P.* 100. " Huntedun. Burg. defendeb. fe ad geld. regis, pro quar" ta parte Herftingeftan hundred." Of Clifford, it is remarked, " Iftud caftellum eft " de regno Angliæ. Non fubjacet alicui hundret. neque in confuetudine. GISLIBET " vicecomes tenet illud ad firmam et burgum et carucat." (village and plowgate), *&c. &c.*

* IN the charter of Portfmouth, RICHARD I. grants; " Quod prædicta villa, et " omnes burgenfes in ea, et tenentes de ea, fint quieti —— de fciris et hundredis, et " de fectis fcirarum et hundredorum, et de fummis et auxiliis vicecomitum, et fervien" tibus et de placitis et querelis omnibus." BRADY *on Bor. App. p.* 14. In the charter of Dunwich, King JOHN grants; " Quod nullam fectam faciant comitatum vel " hundredorum, nifi coram jufticiariis noftris : et cum fummoniti fuerunt effe coram " jufticiariis, mittant pro fe, duodecim legales homines de burgo, qui fint pro omni" bus :" And, if they were to be amerced, " Amercientur per 6 probos homines " burgi, et 6 extra burgum." See others in MADOX Hift. Excheq.

* OF Huntedun, it is faid ; " De toto hoc burgo exib. temp. Reg. EDW. de Landga" ble 10 lib. ; inde comes terciam partem habeb. rex duas, &c. ; præter hæc habeb.

<div align="right">" rex</div>

wards or tithings, but as containing lagmen *, who, we know, were a certain number of the moſt diſtinguiſhed perſons of a diſtrict, named in the aſſembly of it, in order to enquire into crimes and miſdemeanors, and who decided cauſes on oath, if that mode of trial was preferred to the judgment of the aſſembly itſelf. Thoſe towns that belonged to manors were no doubt governed indiſcriminately with the reſt of the territory of the manors. A manor formed a tithing within itſelf; and the officers of the proprietor, as præpoſitus, ſeneſcallus, major domo, foreſtarius, viarius (radman), bedellus, &c.†, by whatever name

<center>*y*</center>

<center>they</center>

" rex 20 lib. et comes 10 lib. de firma burgi." The cenſus of a mill of the burgh-lands, of 3 piſcatores, and 3 monetarii, was divided by the ſame proportions. " Burgenſes " de Hanton redd. vicecomiti p. ann. 30 lib. et 10 ſol. Burgenſes de Grentebrege, " T. R. E. accommodabant vicecomiti carucas ſuas, ter in anno; modo novem vicibus " exiguntur; nec averas nec car. T. R. E. invenieb. quæ modo faciunt per conſuetud. " impoſitam. Reclamant autem, ſuper Picotum vicecomitem, communem paſturam ſibi " per eum ablatam." Of Hereford T. R. E. " Si quis burgenſium voluiſſet recedere " de civitate, poterat conceſſu præpoſiti domum ſuam vendere, &c. et habebat præ-" poſitus tertiam denarium hujus venditionis;" and, if a poor man abandoned his houſe, " Præpoſitus providebat, ne domus vacua remaneret, et ne rex careret ſervitio." In the ſame city, " unaquaque maſura" yielded 11 denar. et obol.; and, during 3 days in Auguſt, " Secabat ad maurdine, et una die erat ad fenum congregandum ubi vicecomes " volebat, &c. De hac civitate reddit præpoſitus 12 lib. regi, et 6 lib. comiti.".

* " In hoc burgo (Grentebrige) fuerunt decem cuſtodiæ, &c. De hareta Lageman-" norum habuit ipſe picot. (vicecomes of Grentebrige) 8 lib. et un. palfred, et unius " militis arma. ALWRIC GODRICSON, quando fuit vicecomes, habuit harietam unius " iſtorum 20 ſolidos." Grentebrege was ranked as an hundred. *Vide ſupra.* Lag-men are mentioned in Warwick having ſac. et ſoc. See alſo LINCOLN, &c.

† " In hoc manerio (Biſelie) una hida. Et in dominio ſunt 2 caruc.; et 4 villani, " et 8 bordarii, et præpoſitus et bidellus. Inter omnes habent 4 carucatæ. Ibi 8, in-" ter ſervos et ancillas, et vaccar. et daiar. Ibi foreſtarius tenet. dimid. virg. terræ." P. 180. 2. " WILLIELMUS comes miſit, extra ſuos manerios, 2 foreſtieros, propter " ſilvas cuſtodiendas, unum de Hanlie, unum de Biſelie," (2 royal manors). There is often mention made of the vaſſals belonging to manors. *Vide* Arkenfelde in Here-fordſcire. The government of manors is to be found in all inſtitutions of the law of England. The comes had ſuperintended, in ancient times, thoſe of the king. In the ſurvey of Herefordſcire, " *Comes* poſuit foris de hoc *manerio* unam virgatam, et dedit " cuidam burgenſi de Hereford. Anſchetel tenet 40 acras, inter planam terram et " pratam quas *præpoſitus* regis EDWARDI præſtavit ſuo parenti."

they were diftinguifhed, performed the functions of magiftrates over it, while the tenants or vaffals of the manor compofed the judges of the manor court, or hallmote, whofe fentences thefe magiftrates carried into execution.

3*dly*, THE ranks and privileges of the inhabitants appear to have been the fame in town and country. Befides, lagmen, as already noticed, we find mention made of thanes in general, as refiding in towns, and performing the fame duties with thofe of the country *. Next to the thanes, burgeffes are enumerated, and thefe appear to have been in very different fituations. Some of them are defcribed as poffeffing lands and houfes in full property with jurifdiction, and fubject to no rent or cenfus to any perfon ; others of them as proprietors of manfes fimply, and ftill enjoying jurifdiction, even within this fmall property † ; and others, without this advantage, being fubjected to the jurifdiction of particular perfons, and yielding to them, or to others, a cenfus or a confuetudo. In fine, others are mentioned, whofe manfes belonged in property to individuals, to whom they yielded rent and fervices ‡ : And, in fome cafes, thefe different fituations appear to be more or lefs blended together ‖. Befides thefe

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* SEE note, p. 160. ; and the evidence abounds in Doomfday, and elfewhere. WILLIAM of Malmfbury fpeaks of country barons admitted, long before his time, into the community of London. *Hift. Novor. lib.* 11. § 10. *f.* 106.

† IN Warwick, it is faid, there were 19 burgenfes, " qui habent 19 mafuras, cum fa-" ca et focha, et omnibus confuetudinibus, et ita habebant temp. Reg. ED." The bur-genfes of Exon, it is faid, " Habent extra civitatem, 12 carucat. terræ, quæ nullam " confuetud. reddunt, nifi ad ipfam civitatem." A manfe in France denoted not only a houfe, but 12 bonnés of land belonging to it. In Doomfday, however, mafura and domus feem to be fynonymous. In Norwich, fome burgeffes enjoyed jurifdiction and patronage over other burgeffes.

‡ IN Warwick, the king had, *in dominio*, 113 manfes, and the barones regis 112, which likewife paid geld to the king, and were appendages of their eftates that lay *ex-tra burgum.*

‖ IN Hereforde, " HERALDUS comes habeb. 27 burgenfes, eafd. confuet. hab. quas " alii burgenfes." The præpofitus, however, " Habeb. in fuo cenfu fupra dictas om-" nes confuetudines. Rex vero habebat in fuo dominio tres forisfacturas. Hoc erat " pacem

thefe burgeffes, notice is taken of bordarii foccomanni, &c. as affifting the burgeffes to pay the cuftoms or rents due by them *. The burgeffes indifcriminately are every where mentioned as yielding military fervice, and fubject to the burdens attending it, according to a certain modus, eftablifhed, as it fhould feem, by cuftom chiefly †.   And citizens likewife partook of the fports and amufements of the nobleffe of the country ‡.

In the country, the fame ftate of perfons appears.   We do not, indeed, find the term *burgeffes* applied to them.   But there are numbers of people mentioned among the inhabitants of the country, that feem to differ in no refpect from burgeffes, except in wanting that name, which, it is evident, the nature of their place of refidence could not admit of giving them.   Thus, we

<div align="center">y 2</div>

<div align="right">find</div>

" pacem fuam infractam, heinfaram et foreftellum. Quicunque horum unum feciffet, " emendab. 100 fol. regi, cujufcunque homo fuiffet." Every mafura, likewife, was obliged to fend a man to attend when the king hunted. In defcribing the royal manor of Suchlie, it is faid, " In Wireceftre unus burgenfis, fed nil reddit."

* In Huntedone, it is faid, " T. R. E. fuerunt et funt modo 116 burgenfes, confue- " tud. omnes et geld. regis reddentes; et fub eis funt 100 bordarii, qui adjuvant eos ad " perfolutionem geldi. De his burgenfibus habuit fanctus Benedictus de Ramsey, 10 " cum fac. et foc. et omni confuet." *Borde* or *borderie* is an old French word, fignify- ing a " domain aux champs, deftiné pour le menage, labourage, et culture." Hence *bordelage* in the French law. Argou. *lib.* 2. *cap.* 4.

† Of the burgeffes of Hereforde, it is faid, " Qui equum habebat ter in anno, per- " gebat cum vicecomite ad placita, et ad hundrez. ad Urmelavia." Again, " Burgen- " fis cum caballo ferviens cum moriebatur, habeb. rex equum et arma ejus. De eo qui " non habeb. equum, fi moreretur, habeb. rex aut 10 folid. aut terram ejus cum do- " mibus. —— Si vicecomes iret in Wales cum exercitu, ibant hi homines cum eo. " Quod fi ire juffus, non iret, emendab. regi 40 folid." Exon tantum geldab. quando London, York, et Winton, geldab. " et hoc erat dimid. mark. argenti ad opus mili- " tare. Quando expeditio ibat per terram, ferviebat hæc civitas quantum 5 hidæ " terræ." Warwick fent a contingent of 10 burgeffes to affift in a war at land, and 4 boatfwains, or 4 lib. of pence in a war at fea. " Qui monitus, non ibat," paid 100 folidi. Wilton fent a man for every five hides, Ledeceftre fent 12 as a contingent, &c. &c.

‡ " Et cives Londoniæ habeant fugationes fuas ad fugandum, ficut melius et plenius " habuerunt anteceffores eorum fcilicet in Chiltre, et Middlefexe, et Surreie." *Char- ter by Infpeximus of* Hen. I. *and* Hen. II. *and* Rich. I.

find there people poffeffing fingle manfes, or fingle roods or half
roods of land, and fometimes larger quantities, as ploughgates,
and yielding military fervice, and various cuftoms, to the king
or individuals. The rights of the owners of thefe lands like-
wife appear to have differed in the fame way as thofe of bur-
geffes, and to have been fubjected to a fimilar diverfity of bur-
dens *.   I need not add, that we find the whole country a-
bounding with foccomanni, bordarii, porcarii, bovarii, who ap-
pear to have been in fome degree of fervile condition, and di-
ftinguifhed from each other chiefly by names derived from the
particular fpecies of rent or fervice yielded by them, or other
fuch little circumftances.

THE above particulars, and the authorities on which they are
ftated, appear to me, when maturely confidered, to leave no rea-
fonable doubt, that the towns enjoyed no peculiar fyftem of ad-
miniftration, but were diftinguifhed merely as places of fome
ftrength, where authority was better enforced, and where the
fmaller proprietors, and perfons of fervile condition, who had
preferved or obtained a degree of liberty, reforted in numbers,
for the fake of mutual protection.   If the town belonged to an
individual, it was governed in the fame manner as the reft of
his eftate.   If the town belonged to different people, it formed,
along with what was afterwards called its *liberty* (*i. e.* the ban-
lieue or territory adjoining and belonging to it), a divifion of
the country, or a political community, and was ranked and go-
verned accordingly.

AUTHORS feem, in general, to have fteered very wide of this
fimple and natural conclufion.   Some, ftruck with the oppreffive

reftraints

* IN the furvey of a manor, it is faid, " ANSGOT, homo comitis, tenet dimid. virg.
" terræ. Et ULVIET unam hidam liberæ terræ." *P.* 180. In the manor of Arken-
felde, the king had 96 men, who, with their men, held 76 caruc. " et dant de con-
" fuetud. 4 fextar. mellis, 20 fol. pro ovibus, quas foleb. dare, et 10 fol. pro fumagio;
" nec dant geld. aut aliam confuet. nifi quod pugnant in exercitu regis, fi juffum eis
" fuerit." If a villein died in this manor, the king had an ox; if a freeman, his horfe
and arms. But a page of Doomfday cannot be perufed without perceiving abundant
evidence of the affertion in the text.

reſtraints and burdens to which the more ancient charters of in-
corporation, as well as Doomſday, prove that the inhabitants of
towns were ſubjected, have inferred, that they were no better
than ſlaves, and never could have had ſufficient conſequence to
reſort to the diet. Other authors, again, have maintained, that
the miſerable ſituation of towns aroſe only in the corruption of
the feudal ſyſtem, and that charters conferred on them no more
than a reſtoration of their ancient liberties. Both appear to
have been partly miſtaken in theſe opinions, and partly in the
right.

THE *nobleſſe citadins* certainly once abounded in the greater
towns, both in Britain and on the continent. And it was na-
tural it ſhould be ſo, as long as towns were places of defence,
and not manufacturing communities. In Germany, we have
frequent mention of city nobles, under the name of patricians,
or of hauſſegenoſſen and muntzer (confreres and monnoyers),
from being united into a ſociety, to which the care of the coin-
age or mint was committed. In that country, it is well known
that this order flouriſhed long before the twelfth century, when
HENRY V. emancipated the ſervile artiſans, and LOTHAIRE II.
granted charters of incorporation; that it long afterwards pre-
ſerved ſcrupulouſly a ſeparation of blood from the ſimple free
burgeſſes, endeavouring, as formerly, to monopolize the offices
of lagmen, echevins or jurats; and that, from a remote anti-
quity till about the times of CONRAD IV. it maintained its rank,
and yielded military ſervice on the ſame footing with the nobles
of the country, from whom there is evidence that many belong-
ing to it were deſcended *. In Italy, again, it cannot be diſputed,
that, long before the reign of HENRY V. the cities were bodies
politic, of much conſequence: And the ariſtocracy which an-
ciently prevailed in all of them, as well as in Germany, of which

Switzerland

* IN 928, the emperor HENRY I. cauſed a ninth part of the country nobleſſe to reſide
in the towns on the eaſtern frontier of Germany, in order to guard it againſt the
Sclavonic nations.

Switzerland was a part, proves, that they contained, in remote times, perſons of family, and men better acquainted with arms than induſtry. In Spain, alſo, as far back as the *fueros* of the towns, the principal inhabitants of them were cavalieros and eſcuderos, and yielded military ſervice like the nobility of the country *. In the ſame way, in France, we find, during the firſt and ſecond Race, the towns of a warlike character having counts, ſcabini, *&c.* at their head †: And the Franks, who conquered Paleſtine in the early times of the third Race, aſſumed arrangements which prove, that a city nobleſſe was ſufficiently agreeable to their domeſtic cuſtoms ‡. It is certainly in the ſame way alone, that we can explain how, in Britain, the citizens

* MANY of the principal Spaniſh towns long preſerved independence of the Goths; and it appears from a law of CHINDASINTHUS, who reigned about *A. D.* 650, that, notwithſtanding the ſubmiſſion of the towns, on the renunciation of Arianiſm, the diſtinction between the curiales and plebeians of the Roman municipia remained in force. *L L. Viſig. lib.* 5. *tit.* 4. *cap.* 19. The ſame law likewiſe proves, that the juriſdiction of the comes obtained in the Spaniſh towns, as well as in the country diſtricts; and Dr ROBERTSON, in his Hiſtory of CHARLES V. *v.* 1. *p.* 345, &c. ſhows, That the towns made a diſtinguiſhed figure, as far back as there are any accounts of the kingdoms which aroſe on the ruins of the Arabian powers. It is certain, that the principal inhabitants of towns enjoyed the honours of the country nobleſſe; and this will hardly appear extraordinary, when it is conſidered, that, during the long warfare with the Moors, towns were the natural bulwarks to which the inhabitants of the country muſt have reſorted in times of danger.

† GREGORY of Tours, *lib.* 4. § 30.; *lib.* 6. § 11. *verb. ſeniores civium*; and *lib.* 8. § 18. 21. 45.; *lib.* 10. § 5. And many other authors might alſo be quoted to the ſame effect.

‡ THE principal inhabitants of Jeruſalem, Napoli, Acre, and Sur, furniſhed 666 knights, and the ſimple burgeſſes furniſhed, together with the churches, 5075 ſergens to the army; and theſe knights ſeem to have been, in no reſpect, inferior to thoſe furniſhed by the country barons. *Aſſiſes de Jeruſalem, cap.* 326. &c. In the time of St LEWIS, Paris contributed to the war of Flanders 400 cavalry and 200 infantry. The fine for abſence was 60 ſolidi. Fines of this nature were levied on burgeſſes in very ancient times. Every perſon, without diſtinction, having 4 manſes in property, or benefice, was obliged to attend in war. BALUZ. *tom.* 1. *p.* 489. And we have burgeſſes particularly mentioned as ſubject to this duty. *Edict of* CHARLES LE GROS, *ad ann.* 880.

zens of certain of the principal towns, as London and the Cinque Ports, were named barons or thanes, and mentioned as reforting in an aggregate body to the national diet, and there poffeffing much influence*.

Again, though we fometimes find inhabitants of towns deftitute of the right of alienating their property ; that the crown was their heir inftead of their children ; and that fervices of all forts, or compofitions in lieu of fervices, were exacted from them in the moft oppreffive manner ; it neither follows, that all the inhabitants of towns were in this fituation, nor that the inhabitants of the country were in happier circumftances. Various caufes tended to create a multiplicity of reftraints and fervices. The German kings fubfifted chiefly by gifts from the freemen of the nation, and, like the heads of all paftoral tribes, received from them lodging, forage, and attendance when they journeyed. After the conqueft of the Roman provinces, thefe voluntary aids degenerated into a variety of cuftomary taxes, uncertain fervices, and oppreffive compofitions. Fines alfo were prefcribed for all manner of delinquencies, and feem to have been employed as an inducement to the execution of the law, by rendering every proprietor a profiter from it. Perfonal protection, likewife, was not only to be paid for by a yearly rent to the king, or potent individual who afforded it, but became the condition of various reftraints as to marriage, alienation, fucceffion, &c. over thofe who received it. Befides, the imperfections of agriculture, and the diforders arifing from the weaknefs of government, often reduced even freemen to the greateft hardfhips ; and it was lawful for them to fell themfelves into flavery ; and it was alfo lawful to purchafe emancipation or relief, by fubmitting to various burdens affecting their pofterity, as well as themfelves. In fine, the jealoufy

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* On the death of CANUT, the Saxon Chronicle relates, that HAROLD was chofen king by Earl LEOFRIC, *and the mariners of London*, and almoft all the thanes north of the Thames. " Major Londoniæ, et alii barones Londoniæ attornaverunt," &c. 6. HEN. III. *Rot.* 5. BROMPTON, and the Norman writers ufe *baro* to denote thane ; and the records for feveral reigns after the conqueft employ both terms promifcuoufly. MADOX. *Hift. Exch.* BOULAINVILIERS *Etat de la France, v.* 3. *p.* 56.

and exclufive fpirit natural to rude communities, and the powers
of proprietors to make particular regulations, and eftablifh
tolls, and other cuftoms, within their eftates, produced re-
ftraints, from which again the crown fold exemptions. Now,
all thefe fources of perfonal reftraints reached equally to
the country and to the towns, and appear accordingly from
Doomfday, not to mention other evidence, to have overwhelm-
ed both*. The towns, indeed, were early in condition to ob-
tain freedom from them by actual purchafe and by fpecial
grants ; and, accordingly, their former ftate under them has
drawn more attention ; while the country, obliged to wait for
the gradual influence of political advancement, has derived its
freedom flowly and infenfibly, fo that its ancient oppreffions
have attracted lefs obfervation.

NOR is there any reafon for fuppofing, that towns were, in
remote times, poffeffed of thofe liberties, and of that conftitu-
tion, which was conferred on them by the charters of incor-
poration. Even among the Romans, manufactures were not
carried on in great towns. The manners of their conquerors
were certainly little fitted to make any innovation in this re-
fpect ;

* I HAVE abundance of evidence to offer of the particulars in the text. *It*, however,
is voluminous ; and *they*, in general, are well known. I fhall, therefore, quote only
two very curious paffages from Doomfday. " Northamptonfcire redd. firmam trium
" noctium, 30 lib. ad pondus. ad canes 42 lib. alb. de 20 in ora. De dono reginæ et
" de feno, 10 lib. 5 oras. De Accipitre, 5 lib. De Summario, 20 fol. De Elemos,
" 20 fol. De eq. venator, 20 fol." See alfo Ledeceftre and Warwick, &c. In defcribing
the cuftoms of Arkenfelde in Herefordefcire, it is faid ; " Si quis Wallenfium occid. ho-
" minem regis, et facit heinfaram, dat regi 20 fol. de folut. hominis, et de forifac.
" 100 fol. Si alicujus Taini hom. occiderit, dat 10 fol. domino hominis mortui. Quod
" fi Wallenfis Wallenfem occiderit, congregantur parentes occifi, et prædantur eum
" qui occidit, ejufque propinquos, et comburunt domos eorum, donec in craftinum circa
" meridiem corpus mortui fepeliatur. De hac præda, habet rex terciam partem. Illi
" vero totum aliud habent quietum. Si vicecomes eos evocat ad Sciremot. meliores ex
" eis 6 aut 7, vadunt cum eo. Qui vocatus non vadit, dat 2 fol. aut unum bovem re-
" gi. Qui de hundret. remanet, tantumdem perfolvit. Similiter emendat qui, juffus
" a vicecomite fecum ire in Wales, non pergit. Nam fi vicecomes non vadit, nemo
" eorum ibit. Cum exercitus in hoftem pergit, ipfi faciunt avantwarde in reverfione
" rerewarde. Hæ confuetud. erant Wallenfium." *T. R. E. in Arkenfelde.*

fpect; and it accordingly appears from the domeftic regulations of CHARLEMAGNE, that the manufactures, confumed by the royal houfehold, were ftill prepared in the ancient manner, in his fifcs or domains. It is, therefore, extremely improbable, that any merchants, or artifans, that may have belonged to great towns, in the middle ages, were perfons of confequence; and it is equally improbable, that, if they had been fo, and been poffeffed of property and arms, and been formed into corporate bodies, they fhould have become the flaves or dependants of a few owners of land in their neighbourhood. But, if the ancient towns were nothing elfe than fortified *pagi*, to which the great proprietors around them reforted *; and, if the reft of the inhabitants confifted either of clients, or dependants of thefe proprietors, fubfifting by cultivating little portions of land, and fighting under their banners, or of perfons of fervile condition, who had obtained, or who fought for fome degree of liberty, and earned their living by exercifing crafts, or affifting the burgeffes in their duties; the whole hiftory of towns becomes perfectly natural, and the origin of that fituation which led to incorporations is explained.

BEFORE incorporations were erected, there muft have been focieties, refulting from voluntary confederations, which found it defirable to obtain the fanction of law to their union. But it is in times of trouble and oppreffion that people have recourfe to private affociations, and to the patronage of individuals, for that fupport and protection which government is unable to afford them; and government, fenfible of its debility, willingly gives its countenance to any meafures that have the appearance

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* LONG before charters of incorporation, WILLIAM the Conqueror confidered them in this light: "Nullum mercatum vel forum fit, nec fieri permittatur, nifi in civitati- "bus, et in burgis et muro vallatis, et in caftellis, et in locis tutiffimis, ubi confue- "tudines regni noftri —— deperiri non poffunt, nec defraudari nec violari. — Et ideo "caftella, et burgi, et civitates fitæ funt, et fundatæ, et ædificatæ, *fciz.* ad tuitionem "gentium et populorum regni, et ad defenfionem regni, et idcirco obfervari debent, "cum omni libertate et integritate et ratione." *L L.* GUL. I. *c.* 61. Saxon hiftory juftifies the affertion; and the laws of ATHELSTAN, c. 12. and 13. furnifh the regulation. The *burghbotam*, or expence of repairing the fortifications of towns, affected according- ly every land-eftate in the kingdom.

of promoting a degree of public order, or affording shelter against private wrongs. We find accordingly, in the Saxon times, voluntary affociations entered into by men of different ranks, with a view to afford fecurity to each other, and government approving of the regulations to which they had fubjected themfelves *. National induftry, however, was not then fo far advanced as to permit us to fuppofe, that mere artifans were of fufficient confequence to eftablifh fuch focieties. The only embryo that can be difcovered of a fraternity for a commercial purpofe, is the gilda, which belonged to certain towns, and appears to have been an inftitution fomewhat refembling the German muntzer †; and poffibly, like thofe fraternities, to have had fome charge of the coinage, and of receiving the king's revenue in good money ‡.

In all probability, however, this inftitution fuggefted to the reft of the inhabitants the idea of forming fimilar affociations. We know, that, in Germany, the fimple burgeffes affociated in this way, and, becoming wealthy and confiderable, obtained a fhare of the privileges of the muntzer ; and the bordarii and cottagers, who originally inhabited only the fuburbs of towns, (*extra murum*),

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* In Canterbury, " Burgenfes habeb. de rege 33 acras prati in gildam fuam."

† The mint of a diftrict was, no doubt, originally under the care of the magiftrate. The following grant of the year 955 fhows that this was the cafe, and that towns in Germany were very fimilar to what they were in England at the time of the furvey : " Concedentes, &c. omnem burgum, et univerfa quæ ibidem ad dominationem et pote- " ftatem comitis pridem pertinuiffe vifa funt, forum fcilizet, teloneum, *monetam*, et " omnem diftrictum, cum terra et manfionibus ipfius burgi." Bouquet, *tit.* 9. *p.* 618.

‡ The burgh of Huntedun, which was ranked as the fourth part of a hundred, " pro 50 hidis defendeb. fe ad geld. reg. *Sed modo non geldab. in illo hund.* poftquam " Rex Ws. gildum monete pofuit in burgo." The monetarii appear to have paid double the heriot, or relief, and fometimes quadruple the cuftom of the fimple burgeffes. It was probably the lucrative nature of the bufinefs that made it an object for the city nobleffe in Germany to take charge of it. The monetarii in England had " faccam et " focham fuam." L L. Athelstani, c. 14. provide, That every burgh was to have at leaft one ; and when exemptions from the county jurifdictions were beftowed on incorporations, there is very commonly a refervation as to the monetarii : " Exceptis mo- " netariis et miniftris noftris." *Charter of* John *to London.* In Scotland, at this day, the guild brethren, as they are called, are diftinguifhed as fuperior to the handycraftfmen, or trades.

rum), and came there to be called *cives opifices*, or *artifans*, foon followed the example of the francs burgeois, and, forming opulent fraternities, compelled them, in their turn, to allow of a participation of the municipal government. It was from this revolution that the German towns became diftinguifhed by induftry and wealth; for the muntzer found it neceffary to have recourfe to commerce, and to join the free burgeffes in trading adventures, if they did not chufe to be eclipfed, in point of fortune, by their inferiors.

THERE is every reafon to conclude, that fimilar events in Spain, France, Britain, and other countries, were produced from fimilar caufes. The turbulence of the middle ages every where enabled the more wealthy, or the more fortunate, to reduce their neighbours under different degrees of fubjection. Towns afforded an opportunity to the better fort to form, for mutual fecurity, leagues or focieties, which counteracted the progrefs of this calamity. Princes countenanced thefe affociations, and fuch as were formed by the inferior inhabitants in imitation of them; and thefe bodies again, either by purchafe, by force, or by growing cuftoms, eftablifhed municipal governments, that maintained exemptions from the ancient fyftem of fubordination, which was naturally detefted by the induftrious as burdenfome, tumultuary, and unfuitable to their habits. The towns accordingly ceafed to refort to the diets. Their warlike gentry, the companions of the fovereign, either left them, or mingled in thofe focieties of commerce or manufacture which governed them. Becoming, therefore, affemblages of manufacturers, rather than national bulwarks, they neceffarily appeared degraded in the eyes of an age which was the fource of chivalry and the offspring of the feus.

BUT that fecurity which municipal governments afforded, foon rendered the towns wealthy and formidable. Kings, then, applied to them for aid, and offered them privileges and beneficial laws in return. Hence the towns came to negotiate by means

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of delegates with their fovereigns, and with each other ; and, from little detached dependent plebeian republics, came to form a body which reforted to the diets, as a third and an ignoble eftate, formerly unknown in the European conftitutions.

THESE obfervations, it is hoped, are fufficient to juftify the pofition, That the fame fimple arrangements of government pervaded the whole of a German nation, at its eftablifhment in a Roman province ; and that it was only in confequence of a revolution, the fteps of which may, in general, be diftinguifhed, that we are entitled to fuppofe that the idea of affembling a nation by its reprefentatives was fuggefted or realized *.

* IT is fcarce neceffary to remark, that the claims of one or two Englifh boroughs for the privilege of electing members of parliament, on the ground that they had reforted to the Saxon diets, is rather explained by, than repugnant to the above hypothefis. The evidence that was offered of the grounds of claim has not been preferved ; and the age in which it was offered is diftinguifhed by having been impofed upon by the groffeft forgeries. The tradition, however, of anciently reforting to the diets in the manner I have ftated, may naturally, both have fuggefted the claim, and rendered it fuccefsful.

VIII.

VIII. *An* Essay *upon the* Principles *of* Historical Composition; *with an Application of those Principles to the Writings of* Tacitus. *By* John Hill, M. A. F. R. S. Edin. *and Professor of Humanity in the University of* Edinburgh.

PART II*.

[*Read by the Author, Feb.* 21. 1785.]

THE proofs of found judgment in the writings of Tacitus are extremely numerous. From the choice of his subjects, he appears to have been perfectly acquainted with the nature and the extent of his own powers. Though he was considerably advanced in life before he began to write history, yet the closeness of his application enabled him to unfold that wisdom which his experience had furnished. In spite of an ardent love of fame, he avoided the rock upon which most authors split, and wisely forbore to solicit the attention of the public, till he could for certain command its respect.

WHILE he was governor of Belgium, he did not waste his time in idleness, nor in devising plans for the increase of his fortune. The generosity of his spirit made him abhor that cruelty with which other Prefects oppressed their subjects. When the concerns of his government did not engage his attention, he viewed the rude manners of the Germans with an attentive eye ; and the acuteness of the observer was happily suited to the nicety of the subject. The discussions of the philosopher were, with him, a relaxation from the cares of the statesman.

* See Part I. p. 76. of Papers of the Literary Class.

ſtateſman. During his abode in Belgium, he collected mate-
rials relating to the firſt ſtage of human ſociety, which form
the moſt valuable treatiſe that is even yet to be found upon the
ſubject.

HE next wrote the life of his father-in-law AGRICOLA. In
this treatiſe, we have reaſon to admire the qualities of an af-
fectionate heart as much as the accompliſhments of an able
writer. As a piece of biographical writing, it may be deemed
a ſtandard. Nothing needful to be known is ſuppreſſed, and
nothing ſuperfluous is admitted. AGRICOLA is made ſo com-
pletely reſpectable as a ſoldier, and amiable as a man, that the
character drawn may ſeem perhaps too near to perfection. It
does not appear, however, that the contemporaries of TACITUS
ever accuſed him of partiality.

AFTER the life of AGRICOLA, he compoſed his hiſtory,
which begins at the death of NERO, and ends with the reign of
TITUS. It is unfortunately ſo much mutilated, that it compre-
hends little more than a twentieth part of its ſubject. That our
author knew preciſely the nature of the period he had choſen,
is evident from his own words : " Opus aggredior (ſays he)
" opimum caſibus, atrox prӕliis, diſcors ſeditionibus, ipſa etiam
" pace ſӕvum *." Throughout the work, a moſt exact unity
is preſerved, in the midſt of a multiplicity of facts. The views
of VESPASIAN in the eaſt are ſuggeſted before the diſpute be-
tween OTHO and VITELLIUS had come to a concluſion, and
the reader is thus prepared for contemplating a new ſtruggle.
The diſturbances in Germany and in Britain ſolicit his atten-
tion when they occur ; but ſo as not to break in upon the main
ſtory. Foreign and domeſtic occurrences find a place ſuited to
their reſpective importance ; and the account of the war in
Germany, and that of the expedition of TITUS in Judea are
kept completely diſtinct, and made clearly intelligible.

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* Hiſt. lib. 1. cap. 2.

IN the annals of TACITUS, which were the laſt of his works, though their ſubject be prior to that of his hiſtory, a more diſtinct arrangement is to be found than could well be expected from their title. From the author's ability, the narration in them is better conducted than that in eaſier ſubjects is by the generality of thoſe who have wiſely adopted them. He was, at the ſame time, thoroughly aware of the difficulties he encountered. He inſinuates, that the period choſen preſents a multiplicity of facts too inconſiderable to be the foundation of a legitimate hiſtory; and that thoſe great events no longer exiſted, which as often hide the hiſtorian's defects, as they receive embelliſhment from the force of his talents. "Nobis in " arcto, et inglorius labor. Immota quippe aut modice laceſſita " pax, mœſtæ urbis res, et princeps proferendi imperii incurio- " ſus erat. Non tamen ſine uſu fuerit, introſpicere illa primo " aſpectu levia, ex quîs magnarum ſæpe rerum motus oriun- " tur *."

As an impartial hiſtorian, TACITUS is, without doubt, entitled to high praiſe. He arraigns the conduct of the undeſerving, without regard to their rank; and appears to have been, in every caſe, devoid of prejudice. At the beginning of his hiſtory, he lays down a rule for other writers, to which he gives reaſon to think that he himſelf will rigidly adhere. " Mihi GALBA, OTHO, VITELLIUS, nec beneficio nec injuria " cogniti. Dignitatem noſtram a VESPASIANO inchoatam, a " TITO auctam, a DOMITIANO longius provectam non abnu- " erim; ſed incorruptam fidem profeſſis, neque amore quiſ- " quam, et ſine odio dicendus eſt †." A beautiful ſtruggle is here exhibited between the emotions of his gratitude and his ſenſe of what was right; but he holds it diſhonourable even to be grateful at the expence of truth.

THAT the views of TACITUS upon human affairs are profound and juſt, muſt be obvious to every perſon who has judgment

* Ann. lib. 4. cap. 32.   † Hiſt. lib. 1. cap. 1.

ment to follow him. The perufal of his works requires more than an ordinary exercife of attention. They are fitted to inftruct rather than to amufe. Their choiceft beauties lie hid from vulgar obfervation ; and the longer they are contemplated, even by the difcerning, the higher is the pleafure they afford. If ever any hiftorian underftood the fprings of human action thoroughly, it was TACITUS. His penetrating eye never refted upon the furface of objects, but fearched their inmoft recefs. His mind feems to have been formed for catching thofe peculiarities in character, which, though not eafily difcerned, have no fmall effect upon the conduct of men. Of this we have an inftance in the cafe of CÆSONIUS PÆTUS, who had been improperly appointed by NERO for the defence of ARMENIA, and who rejected the advice of his experienced counfellors. " Ve- " rum ubi a viris militaribus adverfus urgentes cafus firmatus " erat, rurfus ne alienæ fententiæ indigens videretur, in diver- " fa ac deteriora tranfibat *." An ordinary writer would have either told the fact fimply, or have miftaken its caufe ; but it became the fubtilty of TACITUS to expofe the falfe pride which made PÆTUS reject the counfel which he needed, and add obftinacy to ignorance.

THE obfervations of TACITUS fometimes illuftrate not only the characters of the perfons to whom they are applied, but the nature of the times in which they lived. He is, indeed, as fparing of his expreffion as he is profufe of his matter. This appears upon many occafions ; and particularly in the account given why POPPÆUS SABINUS had been raifed from a very ordinary ftation to offices of truft and diftinction. " Fine " anni POPPÆUS SABINUS conceffit vita, modicus originis, " principum amicitia confulatum ac triumphale decus adeptus: " Maximifque provinciis per quatuor et viginti annos impofi- " tus ; nullam ob eximiam artem, fed quod par negotiis, neque " fupra erat †." The elevation of this SABINUS (it fhould

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* Ann. lib. 15. cap. 10.　　　　† Ibid. lib. 6. cap. 39.

feem) was owing, not to the precife extent of his abilities alone, but to the fentiments which his jealous fuperiors entertained of them. From the meafure of talents which he poffeffed, they perceived, that the bufinefs of the public would not be neglected; and, from the mediocrity of thofe talents, that its tranquillity would not be difturbed.

OUR author's obfervation upon the fall of SALLUSTIUS CRISPUS is alfo worthy of himfelf. When this perfon was advanced in life, he loft the favour of TIBERIUS, which he had long enjoyed; and TACITUS hazards a conjecture as to the fate of courtiers in general. The mutability of their fituation is often afcribed to the caprice of their patrons alone; but our author, with much ingenuity, and perhaps equal juftice, afcribes this to a capricious levity both in the patrons and in the objects of their beneficence. " Ætate provecta fpeciem magis " in amicitia principis quam vim retinuit. Idque MÆCENATI " acciderat, fato potentiæ raro fempiternæ : An fatias capit, aut " illos cum omnia tribuerunt; aut hos, cum jam nihil reliquum " eft quod cupiant *."

BUT almoft the whole account of the reign of TIBERIUS contains the expofition of a character not more odious than it was fingular. An ordinary writer might have marked fome of its general features, but fuch a writer as TACITUS alone could unfold its intricacies. In almoft every action, and every fpeech, the tyrant had fomething to conceal. Under the veil of moderation, he was ever anxious to undermine the liberties of his people. Flattery, however artfully adminiftered, was, from the fufpicioufnefs of his nature, apt to give him offence; and, though he was provoked with the fervility of his fubjects, yet he would not permit them to be free. This ftruggle between contending humours, together with its effects upon thofe around him, is beautifully infinuated in the following words. " Acer- " beque increpuit eos, qui divinas occupationes, ipfumque do-

a a " minum

* Ann. lib. 3. cap. 30.

" minum dixerant.   Unde angufta et lubrica oratio fub prin-
" cipe, qui libertatem metuebat, adulationem oderat *."

IN unfolding the character of SEJANUS, who was long the
favourite, and even the director of TIBERIUS, no lefs art is
difplayed than in unfolding that of the emperor himfelf. Along
with many bad qualities, this SEJANUS had poffeffed the moft
wonderful addrefs.   While the other fubjects of TIBERIUS
dreaded the violence and the caprice of his humours, he had
art enough to render both the inftruments of his elevation.
He could make even the tyrant conceal his lufts, through a fear,
or an attachment, of which he was the object. " Obtectis libidi-
" nibus, dum SEJANUM dilexit, timuitve †."   By an unfortu-
nate chafm in the writings of TACITUS, the hiftory of the fall,
and the full expofition of the character of SEJANUS are now
loft.   His daring ambition, and almoft unfathomable fubtilty,
prefent a fubject that fuits the hand of an able artift ; and fome
of the great outlines ftill remaining fhew clearly the value of
the picture when complete.

· BUT, although TACITUS draws his characters in ftrong co-
lours, yet there is nothing in them bordering upon extravagance.
The fingularity of their conduct juftifies that of the view held
forth.   Though many foul paffions deformed the character of
TIBERIUS; yet our author is candid enough to point out in it
the fmalleft fymptom of virtue.   He repeatedly frees him from
the imputation of avarice.   He even feems happy in extolling
the merit of his reply to ADGANDESTRIUS, who offered to de-
ftroy ARMINIUS, if the fenate would fend him poifon for the
purpofe.   " Refponfum effe, non fraude neque occultis, fed pa-
" lam et armatum populum Romanum hoftes fuos ulcifci.
" Qua gloria æquabat fe TIBERIUS prifcis imperatoribus, qui
" venenum in PYRRHUM regem vetuerant, prodiderantque ‡."

As the character of TIBERIUS is not held forth as complete-
ly abandoned, fo neither is that of GERMANICUS held forth as
completely

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* Ann. lib. 2. cap. 87.   † Ibid. lib. 6. cap. 51.   ‡ Ibid. lib. 2. cap. 88.

completely virtuous. TACITUS fhows that partiality to virtue
which becomes its friend ; but his judgment was too ftrong to
be mifled, even by a venial bias. In fpite of the amiablenefs
of GERMANICUS, in almoft every fituation, he difcovers, upon
one occafion, the frailties of a man.   At the interview between
him and PISO, they met " Firmato vultu, PISO adverfus me-
" tum, GERMANICUS ne minari crederetur.   Poftremo paucis
" familiarium adhibitis fermo cœptus a CÆSARE, qualem ira
" et diffimulatio gignit *."

THOUGH the obfervations of TACITUS be profound, yet he
rarely fhows any anxiety, or employs any artifice to fet them
off to advantage.   The current of his narration runs often fo
fmooth, that the treafures with which it is impregnated are apt
to efcape unnoticed.   He wrote for thofe only who had acute-
nefs to catch his hints, and ability to apply them as they de-
ferve.   A profound obfervation often prefents itfelf unexpected-
ly ; and the reader's admiration is beftowed the more willingly,
becaufe the hiftorian's fenfe of dignity made him averfe from
courting it.   The caufe of RUFUS's feverity is beautifully paint-
ed at the end of the following fentence, by the ufe of four
words.   " Quippe RUFUS diu manipularis, dein centurio, mox
" caftris præfectus, antiquam duramque militiam revocabat,
" vetus operis ac laboris, et eo immitior quia toleraverat †."

THE defperate fituation of the old emperor GALBA, who
was employed in offering a facrifice, even after the fchemes of
OTHO his fucceffor had begun to take effect, is alfo delicately
expreffed in a few fimple words.   " Ignarus interim GALBA et
" facris intentus, fatigabat alieni jam imperii deos ‡."

WITH much judgment, alfo, and, at the fame time, with
great fimplicity of expreffion, he affigns the reafon why ANI-
CETUS, who had been employed by NERO, firft to attempt
drowning his mother, and afterwards to flay her, incurred the
emperor's difpleafure.   " Levi poft admiffum fcelus gratiâ, dein

a a 2   " graviore

* Ann. lib. 2. cap. 57.   † Ibid. lib. 1. cap. 20.   ‡ Hift. lib. 1. cap. 29.

" graviore odio, quia malorum facinorum miniſtri quaſi ex-
" probrantes aſpiciuntur *."

SUCH ſtriking and deep remarks ſeem to ſpring ſpontaneouſly
from the mind of TACITUS. They are, for moſt part, made
without any ſeeming effort, and without oſtentation. Though
replete with inſtruction to the moſt intelligent reader, yet they
often teach without mortifying him, and excite no diſguſt at
the hiſtorian's arrogance.

THE judgment of TACITUS is remarkable, not only in thoſe
ſingle ſtrokes, by which he unexpectedly, and at once, unfolds
ſomething not underſtood, but alſo when he warns his reader
that he is to do ſo, and ſolicits his attention. In his deſcriptions
of character, there is none of that ſpurious ſubtilty which ba-
lances circumſtances not duly oppoſed. Every antitheſis ſtated
has its foundation in nature, and beſpeaks that ſolid acuteneſs
which is above affectation. Of this, the character drawn of
GALBA, in the 49th chapter of the 1ſt book of the Hiſtory,
furniſhes one out of many inſtances. " Hunc exitum habuit
" SERGIUS GALBA tribus et ſeptuaginta annis, quinque prin-
" cipes proſpera fortuna emenſus, et alieno imperio felicior,
" quam ſuo. Vetus in familia nobilitas, magnæ opes : ipſi
" medium ingenium, magis extra vitia quam cum virtutibus.
" Famæ nec incurioſus, nec venditator. Pecuniæ alienæ non
" appetens, ſuæ parcus, publicæ avarus. Amicorum liberto-
" rumque, ubi in bonos incidiſſet, ſine reprehenſione patiens :
" ſi mali forent, uſque ad culpam ignarus. Sed claritas nata-
" lium, et metus temporum fuit obtentui, ut quod ſegnitia
" erat, ſapientia vocaretur. Dum vigebat ætas, militari laude
" apud Germanias floruit. Proconſul Africam moderate : jam
" ſenior, citeriorem Hiſpaniam pari juſtitia continuit : major
" privato viſus, dum privatus fuit, et omnium conſenſu capax
" imperii, niſi imperaſſet."

FROM

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* Ann. lib. 14. cap. 62.

FROM all the obfervations made, and all the paffages quoted, we may infer, that TACITUS was eminently endowed with that judgment, which, befides giving the feeling and the fancy of the hiftorian their due value, is itfelf the foundation of many capital qualities. This enabled him, we find, to chufe and to arrange his fubject, fo as to do moft juftice to his own abilities, and to give moft inftruction to his reader. It fecured the fairnefs of his decifions, in fpite of thofe perfonal connections with which moft men are blinded. It made him fagacious in his opinions as to paft things that are doubtful, and as to future things that are contingent. While it enabled him to fee objects as they were, and infured his reader againft the impertinence of obfervations that are either trifling or mifplaced, it alfo repreffed the weak vanity, which leffens the merit that it means to exaggerate.

As the power of judgment comes late to maturity, both in the individual and in the ftate, fo hiftory, in its moft improved form, is never one of the earlieft efforts of national genius. The perfection of the poet's art depends chiefly upon the acutenefs of his feeling and the vivacity of his fancy. In the improvement of thefe powers, little or nothing is left to the poffeffor's induftry, while judgment is fortified by the recollection of paft errors, and ftrengthens flowly by repeated trials. As the improvement of national wifdom, too, is the fruit of national experience; fo hiftory cannot flourifh but where interefting facts prefent themfelves, and where their value is diftinctly feen. Though thofe powers which ferve to embellifh truth muft not be extinguifhed in the hiftorian, yet judgment muft prefcribe the laws by which they are to be controlled. Between the emotions of mind, and the refpective impulfe that is the caufe of each, a fteady proportion is thus preferved. As too much brilliancy in any object prevents it from being diftinctly feen; fo the brightnefs of the reader's fancy muft illu-

minate

minate the fubject of narration, without dazzling the reader's eye.

THE pofition now advanced, as to the period in fociety at which hiftorical narration appears in its moft improved form, will be found to be juftified by facts. In every literary æra, the poet has been the firft to offer the fruits of his genius, and to court the difpofers of that approbation which is the reward of his excellence. Before even the remoteft period to which any human record reaches, HOMER had difplayed the wonderful powers of the Greek language ; and, by his own practice, had fixed thofe principles upon which future artifts were to perform, and future critics to judge. At Rome, the poems, not only of LIVIUS ANDRONICUS, ACCIUS, and PACUVIUS, but of PLAUTUS and TERENCE, had attracted the notice of their countrymen, before any tolerable profe compofition appeared. Upon the revival of letters, when thofe arts were cherifhed at Florence, which the Turks had banifhed from Greece, the hiftory of literature prefents the fame appearances. The Genius of Italy, after flumbering for ages, was firft awakened by DANTE and PETRARCH. In France, a tafte for the beauties of profe was ufhered in by the poems of MALHERBE. In Britain, too, that elegance which has diftinguifhed the compofitions of fome of our countrymen, was firft difcernible in the works of our poets. The affertion, then, as to the period of hiftorical genius, feems juftified by facts. In every region in which literature has as yet flourifhed, capital productions in hiftory have announced the maturity, though they could not fecure the continuance of claffical tafte. Like a bird of paffage, impatient of the rigours of every climate, this is ever ready to change its abode.

THOSE paffages, produced now and formerly from TACITUS, though fraught with beauties of the firft order, enable us to form but an imperfect judgment of his merits. We are, indeed, fairly entitled to infer, that the genius which gave ex-

iftence

iſtence to thoſe beauties is no ordinary one ; but, before we de-
cide as to its preciſe extent, we muſt mark the inſtances in
which that genius has failed, as well as thoſe in which it has
been ſucceſsful. The proſpect upon which we have hitherto
dwelt, though rich, is, in ſome degree, deluſive. An eulogy
that acknowledges no fault can alſo confer no praiſe ; and that
approbation only is to be valued which reſts on the balance of
beauties that have been oppoſed to defects.

THE ſtyle of TACITUS has been juſtly condemned as being,
in ſome places, harſh, and not fitted to allure the attention of
the reader, by gratifying his taſte. This fault is the leſs par-
donable, as it ſprings from intention, and not from careleſſneſs.
From wiſhing to ſhun that ſervile vanity, by which moſt wri-
ters court the admiration of their readers with exceſſive eager-
neſs, TACITUS has fallen into a contrary extreme.

In vitium ducit culpæ fuga ſi caret arte*.

He ſometimes throws out his deepeſt reflections with an indiffer-
ence that is ſuſpicious, ſo that the abſence of parade is not always
an indication of his modeſty. The abruptneſs of his manner bor-
ders upon a ſtudied ſententiouſneſs ; and, from being too conſci-
ous of his own depth, he is apt to diſguſt as being dogmatic
and oracular. He writes like a perſon confident that his opinions
are ſound, regardleſs of thoſe of his reader, and unwilling to wait
till the capacity of ordinary men permits them to follow him.

FROM the abruptneſs of the ſtyle of TACITUS, ſome critics
of reſpectable authority have aſſerted, that he had made SALLUST
his pattern. With all deference for their opinion in other caſes,
we muſt in this differ from them. If the originality of the
genius of TACITUS has permitted him to copy any writer, it is
THUCYDIDES. In the uſe of certain words and forms of con-
ſtruction, he may have copied SALLUST ; but few hiſtorians
are more nearly oppoſite in their manner. In the ſtyle of SAL-
LUST, there is a ſtudied elegance, at which his ſuppoſed imi-
tator

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* HOR. de Arte Poet. v. 31.

tator never aimed; and, in the fentiment of TACITUS, there is a depth which SALLUST could never rival.

TACITUS is accufed of being vain of his erudition, and of feizing even the flighteft opportunities of difplaying it. He is faid to be at too much pains to give the origin of cuftoms, both foreign and domeftic, and to make too frequent references to the more remote events in the hiftory of his country. This accufation I hold to be groundlefs. A philofophic mind, like that of TACITUS, muft have feen a value in certain facts that efcapes common obfervers. His benevolence, too, may have urged him to ftimulate the remaining virtue of his contemporaries, by recalling to their remembrance the merits of their anceftors. As the empire declined, he perceived, that the materials of hiftory were the more likely to perifh; and, happily for fociety, he poffeffed both that precifion, by which the antiquary eftablifhes fingle facts, and that power of arrangement, by which the hiftorian ftates a number in that order which is to form his detail.

THE energy of the ftyle of TACITUS has been condemned as romantic. This may appear to be the cafe to thofe who never felt that enthufiafm which warmed his breaft. The glowing language of an elevated mind tallies ill with the cold propriety of vulgar criticifm. The learned Bifhop of Worcefter, in his notes upon HORACE's art of poetry, tells us, that figurative expreffion became the dignity of the hiftoric character and genius of TACITUS; but that, had his contemporary SUETONIUS ufed the fame language, he would have fet his readers a-laughing *.

OUR hiftorian's defcriptions have been charged with inconfiftency; but this is owing to the inconfiftency of thofe characters that are their fubjects. A more fuperficial obferver would have prefented a picture lefs juft, though more uniform in its parts; yet the merit of an hiftorian is to be tried by the confonancy of his relation with what exifted, not with what

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* Vol. I. p. 75.

may be fuppofed. The fingular duplicity of many of the cha-
racters in TACITUS furnifhes a full vindication of him in the
refpect mentioned. His fagacity had efcaped his critics, who,
by charging him with the want of penetration, have unluckily
difcovered their own.

BUT the moft partial admirers of TACITUS cannot deny,
that his writings are fometimes deformed with pieces of conceit
and affectation. A certain quaintnefs and minute elegance in
fome parts of his works ftands oppofed to the manly beauties
of others. Though this affectation in our author be real and
highly culpable, yet it is fometimes complained of when it does
not exift. He is accufed of exceffive refinement in his views,
and of affigning motives for conduct, of which even the agents
were unconfcious. But it may be eafier for a weak mind to de-
ceive itfelf than an obferver of fuch deep penetration. In nice
cafes, he generally fuggefts a variety of motives, and leaves it
to his reader to felect the moft probable. Where judgment
alone is concerned, no writer, perhaps, was ever lefs apt to err.
As foon as the difcernment of his critics fails, their candour
fails along with it; and they chufe rather to attribute the ob-
fcurity of the author to his weaknefs, than to their own want
of penetration. The mind of the emperor CLAUDIUS, for ex-
ample, feeble as it was, made a fubject of obfervation that was
fortunate both for the hiftorian and his reader. A great ana-
tomift only can mark minute deviations in nature from her or-
dinary procefs; and, by ftating flight deficiencies or exceffes
in certain parts, can explain irregularities that are glaring in the
fyftem.

WHEN the judgment of TACITUS operates in the way of con-
trolling his feeling and imagination, certain failures may be de-
tected, which are not vifible when that power operates by itfelf.
That vigour in each, which is the general caufe of his excel-
lence, renders the balance more delicate, and becomes, at times,

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the neceffary caufe of his defects. His errors proceed from the exuberance, not from the want of genius.

THE imagination of TACITUS had certainly got beyond due bounds, when he told us, that the rednefs of DOMITIAN's face was ufeful to him in fuppreffing the figns of fhame. " Sævus " ille vultus et rubor, a quo fe contra pudorem muniebat *." The character of DOMITIAN was fo completely abandoned, that we muft fuppofe him deftitute of every fentiment like modefty ; and, at any rate, it is abfurd to talk of a perfon thus ftifling the figns of emotions of which he was actually confcious.

OUR author alfo fpeaks of the Germans as feparated from the Dacians, " Mutuo metu *aut* montibus †." When two fubjects fo completely different as fear and mountains, are ftated as operating in the production of one common effect, we are apt to imagine, that the hiftorian had forgot his dignity, and aimed at a fpecies of wit.

THE fame unmeaning quaintnefs appears when TACITUS tells us of the confirmed jealoufy that fubfifted between the Lugdunenfes and Viennenfes. " Unde æmulatio, et invidia, " et uno amne difcretis connexum odium ‡." That the vicinity fhould infure the difagreement of thefe two nations is highly probable ; but, in order to announce this fentiment, there was no need to go in queft of the pointed antithefis involved in the two terms *difcretis* and *connexum*.

THE fact is, that the writings of PLINY, QUINCTILIAN, and the other contemporaries of TACITUS, do all carry the fymptoms of declining tafte. That period had arrived, at which, as the ingenious critic ‖ before quoted obferves, the writer muft find means to ftrike and to furprife. Antithefis, remote allufions, and the double fenfe of words, are the tools by which he does fo. In thefe artifices, fuited to pleafe the falfe tafte of his
                                                    countrymen,

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* Vit. AGRIC. cap. 45.   † De Mor. Germ. cap. 1.
‡ Hift. lib. 1. cap. 65.   ‖ Bifhop of Worcefter.

countrymen, TACITUS was often eminently fuccefsful. Thus, in telling us, that AGRIPPINA was able to give the empire to her fon CLAUDIUS, but was unable to fubmit to his fovereignty, he makes one word denote both the power and the abfence of it. " Truci contra ac minaci AGRIPPINA, quæ filio dare im-" perium, tolerare imperitantem nequibat *." The verb *nequi-bat* is equally connected with the two infinitives *dare* and *tole-rare*; but it muft be decompounded, before it is applied to the firft of them, fo as to bring forth the hiftorian's meaning.

FROM the charge of affectation and conceit, in certain inftances, then, our author cannot be freed. It is the prerogative of criticifm to cenfure without fear, to defpife the authority of names, and to decide upon principle. TACITUS, perhaps, expected, that the luftre of his uncommon accomplifhments would deftroy the ridicule that is aimed at common defects; that even the luxuriant play of his genius would extort that refpect which is due to its moft correct productions.

MANY of the impurities that occur in the ftyle of TACITUS are to be imputed to the times in which he lived, and not to any careleffnefs, or to any ignorance of his. The contemporaries of CICERO himfelf fometimes attacked that orator's ftyle. From jealoufy of his reputation, perhaps, they were difpofed to reject even terms, " græco fonte cadentia et parce detorta." In judging of the legitimacy of expreffion in a dead language, the moft ignorant are often the moft prefumptuous. The influence of analogy is held to be more extenfive than it is; and a high degree of uniformity is fuppofed to exift in a fubject of all others the moft eccentric. TACITUS, then, may have had authorities for thofe expreffions which we hold to be the moft irregular. From the boldnefs and originality of his views, at the fame time, we may fuppofe, that he would be apt to bend the language of his country to his own conceptions, and to fpurn at the fetters of ftrict grammatical authority.

b b 2 . TACITUS,

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* Ann. lib. 12. cap. 64.

TACITUS, doubtlefs, feems attached to expreffions more commonly to be met with in writers of poetry than of profe. Expreffions more fimple, at the fame time, might have produced an equal, if not a fuperior effect. By means of thofe Grecifms, in which he abounds, he feldom prefents an idea with more energy than CÆSAR and LIVY could have done without them. Though high poetical authority often fcreens his ftyle from the imputation of being impure, yet its general character becomes artificial and too much his own. When the barrennefs of language, befides, does not call for innovations, the writer is blamable who makes them.

UPON examining the ftyle of TACITUS, we fhall find, that he employs fome terms that are either peculiar to himfelf, or fupported by authority not ftrictly claffical. The term *diffugium* *, though expreffive of the idea it prefents, is fupported by no other authority. By being compounded, it heightens the original notion of a rapid departure from an object fuppofed dangerous. The term *fuftentaculum* † is alfo fingular. It clearly fuggefts the idea of a neceffary fupport. As a derivative from *fuftento*, the frequentative from *fuftineo*, it denotes the conftant preffure of one body upon another immediately under it. *Auctito*, alfo, is a verb that is to be found in no other claffic, though, at the fame time, it is highly expreffive of the conception which the hiftorian means to prefent by it. " Qui pecunias fœnore " *auctitabant* ‡." As a double frequentative from *augeo*, it expreffes ftrongly the eagernefs of ufurers to enrich themfelves. The verb *reftaurare*, though not peculiar to TACITUS, refts upon authority that is not to be trufted. JUSTIN and ULPIAN ufe it ; but the purer writers employ *inftaurare* in its ftead.

WE may, befides, difcover in TACITUS fingular ufes of terms that are to be feen in the works of the beft claffics. He takes the adjective *avarus*, and the abftract noun *avaritia*, in a fenfe very

different

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* Hift. lib. 1. cap. 39. † Ibid. lib. 2. cap. 28. ‡ Ann. lib. 6. cap. 16.

different from what is common. The latter term is made by him to denote an article of praife in AGRICOLA as a judge. "Ubi officio fatisfactum, nulla ultra poteftatis perfona. Tri- "ftitiam et arrogantiam et *avaritiam* exuerat *." CICERO's de- finition of the vice fixes the precife force of the term. "Ava- "ritia (fays he) eft injuriofa appetitio alienorum." But no affection that is injurious can be meritorious in any perfon, far lefs in a judge; and the moft rigid affertor of public rights cannot, in juftice, invade thofe of individuals. Both the cha- racter and the object, then, of this *appetitio,* employed by CI- CERO in the definition of *avaritia,* are reverfed by TACITUS. That defire which he applauds muft have been more than in- nocent; and its objects muft have been the property of that community in behalf of which AGRICOLA acted as a judge.

THE ufe made by our author of the adjective *avarus* corre- fponds entirely with the ufe now ftated of the abftract noun *avaritia.* He tells us of GALBA, that he was, "Pecuniæ ali- "enæ non appetens, fuæ parcus, publicæ *avarus* †." The term *avarus,* in this acceptation, expreffes all that infatiable thirft for poffeffion, in behalf of the public, which the avaritious have for themfelves. It denotes an inflexible keennefs in GALBA to fupport every claim of the ftate he governed, in fpite of thofe temptations to which the virtue of other emperors had yielded.

THE word *gnarus,* which is properly applicable to the perfon who knows, TACITUS applies to the thing known. "Gnarum "id TIBERIO fuit ‡." Again, in the 45th chapter of the 12th book of the Annals, he fays, "Nihil tam *ignarum* barbaris "quam machinamenta et aftus oppugnationum; at nobis ea "pars militiæ maxime *gnara* eft." SALLUST had applied the term *ignarus* to the thing unknown, as well as to the perfon ignorant; as, when he fays, "Mare magnum et *ignara* lingua "commercia

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* De vita AGRIC. cap. 9. † Hift. lib. 1. cap. 49.
‡ Ann. lib. 3. cap. 6.

" commercia prohibebant * ;" and, " Regio hostibus *ignara* †."
TACITUS, who frequently imitates particular expressions of
SALLUST, not only takes this seeming liberty with the com-
pounded, but assumes a corresponding one with the radical
word.

IT is, by no means, common to find the word *obsidium* taken
to denote, " in the way of a hostage." " MEHERDATES *obsidio*
" nobis datus ‡." *Obsidium* properly denotes the act of invest-
ing a fortified place ; but, instead of this act, there is here sub-
stituted the manner in which a person is delivered up as a secu-
rity, that a stipulation made to those who raise the siege will
be performed.

BUT the irregularities in the style of TACITUS may, perhaps,
appear more striking in his use of certain particles than of the
terms mentioned.   Let us attend, then, to his use of these four,
Alias, *An*, *Et*, *Penes*, and observe, first, the radical power, and
then the ordinary applications of each.

ALIAS, in its primary meaning, refers to an event as taking
place occasionally, or at times both prior and posterior to that
at which the term is used.   The occasional occurrence of the
event is signified when the verb appears in the aorist of the
indicative ; so that the time at which the proposition is an-
nounced, is comprehended by that in which the fact affirmed
takes place.   Thus, " Mutantur sæpe hominum mores, *alias*
" adversis rebus, *alias* ætate ingravescente ‖."   The future ex-
istence of the event supposes the time of affirmation prior to
that at which the fact is to take place, and the past supposes
this posterior to that at which it actually did ; and they ap-
pear in such instances as the two following : " Sed hæc ad te
" scribam *alias* subtilius §."   " Quibus de rebus et *alias* sæpe
" nobis multa quæsita et disputata sunt **."

ALIAS,

* Bell. Jug. cap. 18.   † Ibid. cap. 52.
‡ Ann. lib. 11. cap. 10.   ‖ CIC. de Orat.
§ CIC. Ep. ad ATT. lib. 1. cap. 11.   ** CIC. Acad. Quæst. lib. 4. cap. 4.

ALIAS, then, is originally an adverb of time, and is applied indifferently to the paſt, the preſent, and the future.

UPON authority leſs to be truſted than that of CICERO, we find *Alias* transferred from time to place. Thus, " Idæus rubus " appellatus eſt, quoniam in Ida non *alias* naſcitur *." " Nuſ- " quam *alias* tam torrens fretum †."

But TACITUS does more than transfer *Alias* from time to place, which two furniſh mutual analogies in language, by ap- plying it to the idea of cauſe. Thus, when he talks of the pain which TACFARINAS's meſſage gave TIBERIUS, " Non " *alias* magis ſua populique Romani contumelia indoluiſſe CÆ- " SAREM ferunt, quam *quod* deſertor et prædo hoſtium more " ageret ‡." The circumſtance of time, which, upon CICERO's authority, is the radical and the proper one, is here deſerted, and the character and conduct of TACFARINAS are held forth as a cauſe of which the emperor's diſtreſs was the effect. We are called to attend, not to the degrees of diſtreſs which the mind of TIBERIUS had undergone, at different times, that were paſt, but to the comparative efficacy of the cauſes of its excitement. The amount of that part of the expreſſion, then, in which *Alias* is concerned, is as if it had been ſtated thus: " Non ob aliam magis quam hanc cauſam," nempe, " quod de- " ſertor, et prædo hoſtium more ageret."

THE primary power of the particle *An* is that of interroga- tion upon the part of ſome perſon who wiſhes to be informed. Thus, in TERENCE, PYTHIAS aſks, " *An* abiit jam a milite ?" To which CHREMES anſwers, " Jamdudum, ætatem ‖."

AN is ſometimes employed, not for the purpoſe of gaining information, but for that of expreſſing contempt towards the perſon interrogated. A pretended ſubmiſſion is made upon the part of the enquirer, in order to bring the perſon interrogated to the neceſſity, either of condemning himſelf, or of being filent.

* PLINY, lib. 24. cap. 14.   † JUSTIN, lib. 4. cap. 1. 8.
‡ Ann. lib. 3. cap. 73.   ‖ EUN. lib. 4. cap. 5. 7.

filent. Thus, " *An* nefcis longas regibus effe manus *?" Ci-
cero, too, employs *An* in the fame way, when he perfonifies
his country, and makes it reafon with him as to the propriety
of perfecuting Catiline ; " Quid tandem impedit te ? *An* in-
" vidiam times ?"

An fometimes does not operate as an interrogative particle at
all, but only expreffes doubt, or ignorance, upon the part of
the fpeaker. Thus Sallust fays of Sylla, " Multique du-
" bitavere fortior *an* felicior effet †." So alfo, " Haud fcio *an*
" nemini magis quam tibi faciendum ‡"

Upon the beft authority, then, (it fhould feem) *An* deviates
from its original power, which is purely interrogative. It, in
the firft place, ftates a queftion to which no anfwer is expected ;
and, in the next, it prefents the mind of the fpeaker as unable
to fatisfy itfelf, but, at thc fame time, as requiring no informa-
tion from others.

Tacitus ufes *An*, in the fenfe laft mentioned, in a way that
is peculiar to himfelf. In ufing it, he profeffes his ignorance
as to the manner in which certain facts took place, but he fup-
preffes the term that announces the uncertainty. Thus, " Ar-
" chelaus finem vitæ fponte *an* fato implevit ∥." He records
the fact, that this king did die ; and the particle *An*, befides
fuggefting two ways, in one of which he might have died, is,
without the aid of an *incertum eft*, a *dubito*, or *haud fcio*, made
to intimate alfo his ignorance, whether he perifhed by a volun-
tary or by a natural death. There is clearly hefitation upon
the part of the hiftorian, otherwife he would have been abfurdly
reducing all the modes of death to two, and ufing *An* as equiva-
lent to *Vel*. In the fame way, he talks of the feeming modera-
tion of Germanicus after the defeat of the Germans, " De fe
" nihil addidit, metu invidiæ, *an* ratus confcientiam facti fatis
" effe §."

SOME

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* Ovid, Ep. 17. 166.   † Bell. Jug. cap. 95.
‡ Cic. de Off. lib. 3. cap. 2.   ∥ Ann. lib. 2. cap. 42.
§ Ann. lib. 2. cap. 22.

SOME paſſages in CICERO may, at firſt ſight, ſeem to ſupport that uſe of *An* now condemned in TACITUS. The former ſays, for inſtance, " Nos hic te ad menſem Januarium expectamus, " ex quodam rumore, *an* ex literis tuis ad alios miſſis *. In ſuch a caſe as this, however, the ſpeaker's heſitation as to the opinion to be adopted, is but an inconſiderable circumſtance. He juſt ſuggeſts, without wiſhing to remove his doubt. The expectation of ſeeing ATTICUS is the leading idea in the ſentence ; and the origin of this expectation is regarded as unworthy of the attention that is neceſſary to trace it. So alſo ; " Summa ſenectute CATO orationem in origines ſuas retulit, " paucis antequam mortuus eſt, *an* diebus, *an* menſibus †." The orator knew not whether CATO tranſcribed his oration a few days or a few months before his death ; but, feeling that either alternative did not affect the leading circumſtance, which was his great age, he only ſtates the queſtion which he had no deſire to reſolve.

IN ſome other paſſages, TACITUS uſes *An* and *Sive* together, as if they were ſynonymous particles. He tells us, that no ſolicitations of PLAUTUS's friends could prevail upon him to fly from the deſtruction threatened by NERO. " Sed PLAUTUM " ea non movere. *Sive* nullam opem providebat inermis atque " exul ; *ſeu* tædio ambiguæ ſpei ; *an* amore conjugis et libero- " rum, quibus placabiliorem fore principem rebatur, nulla ſoli- " citudine turbatum ‡."

AN and *Sive* are analogous only when the former expreſſes doubt, and not when in its interrogative and ironical acceptations. With all the ſeeming likeneſs, however, that occaſionally takes place between them, *Sive* requires no term to intimate doubt upon the part of the ſpeaker, becauſe no doubt exiſts. Thus, LIVY tells us, " Tum dictator cenſuram minuere parat : " *ſeu* nimiam poteſtatem ratus, *ſeu* non tam magnitudine ho- " noris quam diuturnitate offenſus ‖."

c c   AN

* CIC. Ep. ad ATT. lib. 1. cap. 2.   † CIC. in BRUTO, 89.
‡ Ann. lib. 14. cap. 59.   ‖ LIV. lib. 4. cap. 24.

An and *Sive* agree in fuggefting ignorance in the fpeaker in refpect to the fuitablenefs of an affirmation, applicable to one of two or more alternatives, to the exclufion of the reft.   But *An* fuppofes, that fomething, though not enough, is known with regard to each of the whole.   Thus, they who doubted whether SYLLA owed moft to his valour or his good fortune, poffeffed facts that tended to eftablifh both opinions, though neither preponderated.   The mind is thus exhibited as balancing circumftances, and terminating in doubt from the fcantinefs of that information which *An*, as an interrogative, ferves originally to furnifh.   *Sive*, again, fuppofes complete ignorance as to all the alternatives ftated, fo as to preclude that doubt, of which the act of balancing probabilities is the fign.   In the cafe of *An*, (we have found), fomething is known with refpect to all of them; in the cafe of *Sive*, nothing is known in refpect to any one; and the whole fubject is held forth as either, in its nature, infcrutable, or as induftrioufly and effectually concealed. Thus TIBULLUS fays;

> *Vivite felices, memores et vivite noftri*
> *Sive erimus, feu nos fata fuiffe velint* *.

TERENCE alfo fays;

> —— *Hæc* ANDRIA
> *Sive ifta uxor, feu amica eft, gravida e* PAMPHILO *eft* †.

In the firft of thefe inftances (it is clear) that heaven only could know which of the alternatives was to take place; and, of courfe, the matter was infcrutable.   In the fecond, DAVUS virtually acknowledges, that he was not fo much in the young man's confidence as to know whether he was married or not; and, of courfe, that matter, though perhaps known to others, was effectually concealed from him.

     IF the account given of *An* and *Sive* be juft, TACITUS is fingular, either in taking them as fynonymous particles, or in employing

* Lib. 3. el. 5. 31.   † AND. act. 1. fc. 3. 11.

ploying the former in such a way as to lead his reader, in the instance quoted, to suppose, that the truth of the last alternative might have been explored, while that of the two former was incapable of being so. All the three appear to be equally the subjects of conjecture. By changing the particle, the historian meant, perhaps, to insinuate, that he reckoned the last cause the most probable; and it was, at least, worthy of his candour, to ascribe most probability to that which was most for the honour of PLAUTUS.

That TACITUS had some such purpose in view, by changing the particle, may be inferred from a similar passage, in which, after employing the *Sive* twice, he lays hold of the conjunction *Vel.* " Agitasse LACO, ignaro GALBA, de occidendo TITO VI- " NIO dicitur, *sive* ut pœna ejus animos militum mulceret, *seu* " conscium OTHONIS credebat, ad postremum *vel* odio *." LACO's purpose is represented as arising from one of three motives; but the two first are not to each other as both are to the third. The historian knew not whether it sprang from wishing to do what was agreeable to the soldiers, or from jealousy of an undue attachment to OTHO; but he affirms, that, if from neither of these, it certainly sprang from hatred.

TACITUS employs the conjunction *Et* as synonymous with *Cum,* and as expressive of time. He says, " Nondum quartus a " victoria mensis, *et* libertus VITELLII vetera odiorum nomina " æquabat †." Though this use of *Et* may be subservient to the purposes of description; yet, from its novelty, it must be regarded as a grammatical licence. The will of the speaker is, indeed, absolute, in uniting by this, and other conjunctions, what objects it pleases; yet a certain degree of similarity is expected in those that form the assemblage. *Et* is here made to unite a period of time and a state of political corruption; and the writer's intention is to mark the rapidity of the growth of the latter, by conjoining, and, of course, contrasting it with

c c 2   the

* Hist. lib. 1. cap. 39.   † Ibid. lib. 2. cap. 95.

the fhortnefs of the former.   Such ufes of *And* in Englifh, and και in Greek, are frequent; but an inftance precifely fimilar to that mentioned will hardly be found in Latin.

THE ufe which TACITUS makes of the prepofition *Penes* is not to be juftified by any good authority.   He tells us, that TIBERIUS was offended becaufe the practice of marrying by the *Confarreatio* had fallen into difufe.   " Plurefque ejus rei " caufas adferebat; potiffimam *penes* incuriam virorum femi- " narumque *."

THE prepofition *Penes* denotes the relation which an object bears to a perfon, as being in his power and under his direc- tion †.   Thus,

> *Me* penes *eft unum vafti cuftodia mundi* ‡.

A CERTAIN vicinity is fuppofed to exift between the mafter and that which is fubject to his dominion.   Within a limited fphere, accordingly, he is underftood to have the merit of what is laudable, and the demerit of what is the contrary.   So, " *Pe-* " *nes* aliquem laudem effe ‖ ;" and, " Illorum effe hanc culpam " credidi quæ te eft *penes* §."   The term *illorum*, in the laft in- ftance, denotes the relation between the blame, and a number upon whom it was not chargeable; but the term *Penes* denotes the relation between the blame, and one at whofe door it actually lay, as being in a fphere within which that perfon had an ex- clufive right to exercife authority.

IN the expreffion, " potiffimam *penes* incuriam virorum fe- " minarumque," the prepofition is evidently employed, as in the paffage quoted from TERENCE, to ftate the relation between

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* Ann. lib. 4. cap. 16.

† I MIGHT here ftate the precife meaning of *Penes* at greater length, by fhewing the difference between it and *Apud*, with which it is fometimes confounded; but I referve an analyfis of the Latin prepofitions as the fubject of future confideration.

‡ OVID, Faft. 1. 119.   ‖ CIC. de Cl. Or. 142.

§ TER. HEC. act. 4. fc. 1. 20.

a certain degree of blame, and the persons supposed culpable.
The idea of blame in TACITUS, however, is got by implication;
that is, from knowing that TIBERIUS disapproved of the modes
of marrying by the *Coemptio* and the *Usus*, which were different
from that before mentioned. The word *incuria*, besides, which
expresses the carelessness, that is, the culpable circumstance, is
under the government of the preposition, instead of being a
correlative term to those expressing the persons upon whom the
blame is laid. This word, also, as denoting only the absence
of thought, is too specific to act as a correlative to those de-
noting the persons. In proportion as the power of the noun
is, in this situation, more than ordinarily particular, that of
the preposition becomes more than ordinarily general. The
latter is not limited to the conception of blame in agents, as
usual, but denotes the relation between one object and another,
acting as its immediate cause, and may be translated " owing
" to." Had the general term *culpa* been used, the expression
" penes viros feminasque" would have been legitimate; but
the " causa penes incuriam virorum feminarumque" is certainly
singular.

IF we had leisure to examine the modes of construction in
TACITUS, as minutely as we have the terms, the former, per-
haps, would, on some occasions, appear as singular as the latter.
He sometimes puts a genitive after a verb that usually governs
an accusative. " Nihil abnuentem dum *dominationis* apisce-
" retur *." We find, also, an accusative coming after a verb,
which other writers make govern a dative. " *Sua facinora* ad-
" versari deos lamentantur †. The verb *præsideo*, besides, is
sometimes made to govern a dative, as usual, and, at other
times, an accusative, which will hardly be seen in any other
author. " Præsidere *ludis* ‡." " Præsidere *Pannoniam* ‖."

TACITUS

* Ann. lib. 6. cap. 45.   † Ibid. lib. 1. cap. 28.
‡ Ibid. lib. 3. cap. 64.   ‖ Ibid. lib. 12. cap. 29.

Tacitus, alfo, often imitates Sallust, in adopting ufes of terms, and modes of conftruction, that are properly Greek. Thus, " Memoriæ Drufi eadem quæ in Germanicum decernuntur, plerifque additis ut ferme *amat* pofterior adulatio *." As the Greek verb φιλεω often denotes ordinary and natural occurrence in certain cafes, fo does the Latin verb *amo* here.

—— Φιλεει δε τε κερτομα βαζειν †.

—— *Amatque convicia loqui.*

So alfo, " Οπερ εν τοις τοιστοις φιλει." The attachment to a fpecified action, fuggefted by the two verbs in the different languages, is made to denote its frequency even among inanimate objects. Tacitus alfo fupprefles the governing prepofition, after the manner of the Greeks. Thus, as they faid, " Ρωμαιος πατριδα," for " Ρωμαιος κατα την πατριδα ;" fo he frequently adopts fuch poetical expreffions as, " Clari genus ‡," " Animum vultumque " converfi ||."

From the view now taken of the ftyle of Tacitus, it fhould feem, that it will not bear a comparifon with that of the writers during the reign of Augustus. The age of high claffical purity was, in his days, paft ; and, of courfe, the grammatical ftandard eftablifhed by practice had altered. As the firft wifh of our author muft have been to pleafe his contemporaries, fo he would naturally adopt thofe modes of expreffion that were moft agreeable to them ; and we cannot fuppofe him able, though he had been difpofed, to refift that progrefs towards corruption which had already commenced. The impurities of his ftyle, at the fame time, can never cancel the dignity of his fentiment. In the one, we fee the Roman language, in fome degree, corrupted ; but, in the other, we fee human reafon proportionably improved.

THE

* Ann. lib. 4. cap. 9.   † Hesiod. Ep. 5. 788.
‡ Ann. lib. 6. cap. 9. || Hift. lib. 1. cap. 85.

THE character of TACITUS as an hiftorian, though, upon the whole, defervedly high; yet cannot, in every refpect, efcape our cenfure. He poffeffed powers perfectly adequate to the tafk of fpeculating upon the affairs of men, as becomes a philofo- pher. His fenfibility catched thofe delicate fhades in the hu- man character, of which ordinary obfervers lofe fight amidft its great outlines. His fancy fuggefted the precife emotions moft likely to arife in a trying fituation; led him to adopt that language by which fuch emotions feek vent; and to feize the circumftances, in every object defcribed, which ftrike the ob- ferver firft, and bring the reft along with them. His judgment difcriminated the genuine from the fpurious, however artfully embellifhed; and, in the action even of complicated caufes, could affign the exact influence of each in the production of their common effects. But the ardour of his feeling, and the quicknefs of his fancy, fometimes betrayed him into errors. Strong as his judgment was, it did not always watch and con- trol their exceffes. The elegance of his ftyle and fentiments, accordingly, degenerates, at times, into affectation, and their animation into extravagance. From the general vigour of his powers, he has thrown beauties into many paffages which few writers, in any age, have rivaled, and which none have fur- paffed; but, from an undue balance, occafionally exifting among thefe powers, certain paffages are overwrought, and deformed by thofe attentions that were meant to improve them.

SHAKESPEARE and TACITUS are, perhaps, the two writers who leave upon the minds of their readers the ftrongeft impref- fion of the force of their genius. Splendid beauties in each are but eclipfed by faults which would have cancelled the merit of ordinary performers. We fhould, indeed, have no ftandard for meafuring their excellence, did not the poet fometimes fhock us with his extravagancies, and the hiftorian with his conceits.

THE

THE opinions of the beſt modern critics confirm the favourable judgment given upon the writings of TACITUS. They were rated beneath their value by thoſe who pretended to judge of them in the laſt century. Mere philologiſts might, indeed, detect impurities in our author's ſtyle, and falſely aſcribe that obſcurity to a fault in his diction, which, in fact, had its ſeat in the depth of his thought. Being void, however, of that ſcience which alone makes literature reſpectable, no words could unfold to them thoſe beauties upon which he meant that his reputation ſhould reſt. Monſieur D'ALEMBERT *, and other French critics, whoſe merit entitled them to direct literary opinions, ſaw the value of his works, and removed, in ſome degree, the prejudices that had ſubſiſted againſt them. The elegant Mr GIBBON tells us, " That, if we can prefer per- " ſonal merit to accidental greatneſs, we ſhall eſteem the birth " of the emperor TACITUS more truly noble than that of kings : " That he claimed his deſcent from the philoſophic hiſtorian, " whoſe writings will inſtruct the laſt generations of mankind †." That the emperor did not feel himſelf diſhonoured by the connection, appears from his giving orders, that ten copies of TACITUS ſhould be annually tranſcribed, and placed in the public libraries. From the works of his immortal anceſtor, he expected, that his ſubjects would learn the hiſtory, not of the Roman conſtitution alone, but of human nature itſelf. By reſcuing even a part of theſe from deſtruction, he acquired a right to the gratitude of poſterity ; becauſe he thereby preſerved a mine, in which, the longer and the deeper we dig, we ſhall find the richer ore.

HOWEVER feeble this attempt to trace the principles of hiſtorical compoſition may have been, it may perhaps ſhew, that TACITUS, and all ſucceſsful hiſtorians, have pleaſed, not by accident, but by rigidly adhering to a ſtandard which
they

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* Melanges de Litterature, tom. 3. Morceaux de TACITE.
† Hiſt. vol. 1. p. 325.

they muſt have previouſly diſcerned. In ſpite of thoſe diverſities in point of manner, and gradations in point of merit, which neceſſarily take place among a number of writers, the leading characters of this ſtandard muſt be the ſame to them all. A new proof may be thus had, that there is as certainly, in the nature of things, an immutable difference between beauty and deformity, as between truth and falſehood; that the principle of taſte is more conſiſtent in its deciſions than is generally ſuppoſed; and that, in all the fine arts, this principle is gratified when we obſerve, and offended when we neglect, certain laws which are the baſis of juſt execution, and of ſound criticiſm in each.

END OF THE FIRST VOLUME.

1 — 28

July '81.

ERRATA.

Phyf. Cl. page 98. *line* 12. *for* and *x read* and *z*.

——————— 213. *line* 5. *for vis incita read vis infita*.

——————— 314. *line* 4. *from the bottom, for* greater *read* lefs.

——————— 324. *The Author finds, on refuming the computations, that the error in latitude is but half a minute. Since this article was printed off, he has feen, in the Memoirs of the Academy of Berlin, Elements of this Orbit, by* P. FIXLMILNER, *and a comparifon of them with a great number of Obfervations. There is fome miftake in this article of the Memoirs; for the mean diftance and diurnal motion fet down in thofe Elements, are inconfiftent with each other, and both of them are incompatible with the Obfervations. The Author will juft obferve, that the* form *of the Ellipfe is precifely the fame with that deduced by him from the fecond fuppofition refpecting the fecond differences of the arches, and mentioned at the bottom of p*. 322.

——————— 327. *Tab*. I. *col*. 3. *line* 2. *for* 10. 23. 06. 26 *read* 11. 23. 06. 26.

——————— 332. *Tab*. V. *col*. 1. *lines* 14, 15. *for* 01. 02 *read* 19. 20.

Lit. Cl. page 65. *line* 25. *for* Mr JOHN BARROW *read* Mr THOMAS BARROW.

——————— 116. *line* 16. *for* And to *read* And as to

——————— 119. *The four firft lines of the note fhould be a feparate note on* page 123. *taken off at the end of the* 2d *paragraph, at the word* prefuppofes.

——————— 127. *line* 25. *for* prepofition *read* propofition.

——————— 206. *Note* †, *for* Ep. *read* Εϼγ. καὶ ἡμεϼ.

DIRECTIONS FOR THE BINDER.

The Binder is defired to obferve that the VOL. confifts of Three Sets of Pages, to be arranged in the following order, immediately after the TABLE of CONTENTS, *viz*. PART I. containing THE HISTORY OF THE SOCIETY: PART II. containing, I. PAPERS OF THE PHYSICAL CLASS; II. PAPERS OF THE LITERARY CLASS: And to place the two Plates, entitled *Theory of the Earth*, to front page 304. of Papers of the Phyfical Clafs, and the other Plates (which fold out) according to the references marked upon them.