S4-C1

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. I.



EDINBURGH:

PRINTED FOR J. DICKSON, BOOKSELLER TO THE ROYAL SOCIETY.

SOLD IN LONDON BY T. CADELL, IN THE STRAND.

M.DCC.LXXXVIII.


BRITISH MUSEUM
NATURAL HISTORY



TO THE

KING.

SIR,

I AM desired 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, ſhould be preſented.

IF they ſhall be found worthy of the approbation of a MONARCH, who has diſtinguiſhed His Reign by the utility of His Inſtitutions for improving the elegant Arts, as well as by the ſplendour and ſucceſs of His undertakings to extend the knowledge of Nature, The Royal Society of Edinburgh may hope to occupy a reſpectable place among thoſe Bodies of learned Men, who, by their united efforts, have contributed,

buted, ſo eminently, to the progreſs of Science and of Taſte in Europe. I am, with the higheſt reſpect,

Your MAJESTY's dutiful ſubject,

and devoted ſervant,

BUCCLEUGH.

CONTENTS

OF THE

FIRST VOLUME.

PART I.*

HISTORY of the SOCIETY.

INTRODUCTION, - - Page 3.

Charter of the Society, - - 7.

Laws of the Society, - - 11.

Account of Experiments on Antimony, by Mr James Ruſſell, - 16.

Dr Roebuck *on the filling of Corn,* - - 17.

The Earl *of* Dundonald *on Sea-Salt,* - - 19.

Dr Anderſon *on Caſt Iron,* - - 26.

Caſe communicated by Dr Andrew Duncan, - 27.

Mr Wilſon *on the Solar Syſtem,* - - 28.

Dr Blane's *Account of the Hurricane at Barbadoes,* - 30.

Count de Windiſchgratz's *Problem,* - - 37, 45.

Mr Smellie *on Inſtinct,* - - 39.

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

APPENDIX.

MEMBERS DECEASED, - - Page 46.

I. *Biographical Account of* William Lothian, D. D. - 47.

II. *Biographical Account of* Sir George Clerk-Maxwell, *Baronet*, 51.

III. *Biographical Account of* Matthew Stewart, D. D. - 57.

LIST *of* DONATIONS *presented to the* ROYAL SOCIETY *of Edinburgh*, 77.

LIST *of all the* MEMBERS *or* FELLOWS *of the* ROYAL SOCIETY *of Edinburgh*, - - 83.

Office-Bearers of the SOCIETY, - - 98.

PART II.

PAPERS READ BEFORE THE SOCIETY.

I.

PAPERS OF THE PHYSICAL CLASS.

I. *Experiments on the Motion of the Sap in Trees. By* Dr John Walker, 3.

II. *The Theory of Rain. By* Dr James Hutton, - 41.

III. *On the Causes which affect the Accuracy of Barometrical Measurements. By* Mr John Playfair, - - 87.

IV. *On the Use of Negative Quantities in the Solution of Problems by Algebraic Equations. By* Mr William Greenfield, - 131.

V. *Experiments and Observations upon a remarkable Cold which accompanies the Separation of Hoar Frost from a clear Air. By* Mr Patrick Wilson, - - - 146.

VI. *An Account of the Method of making a Wine, called by the Tartars* Koumiss; *with Observations on its use in Medicine. By* Dr John Grieve, - - - 178.

VII. *An Improvement of the Method of correcting the obſerved Diſtance of the Moon from the Sun or a Fixed Star. By the Reverend* Mr Thomas Elliot, - Page 191.

VIII. *Account of a remarkable Agitation of the Waters of Loch Tay: in a Letter from the Reverend* Mr Thomas Fleming *to* Mr John Playfair, - - 200.

IX. *Abſtract of a Regiſter of the Weather, kept at Branxholm for ten years. Communicated by the Duke of* Buccleugh, - 203.

X. *Theory of the Earth. By* Dr James Hutton, - 209.

XI. *The Orbit and Motion of the* Georgium Sidus, *determined directly from Obſervations. By* Mr John Robiſon, - 305.

XII. *Abſtract of a Regiſter of the Weather, kept at Hawkhill from* 1771 *to* 1776. *Communicated by* Mr John Macgowan, 333.

II.

Papers of the Literary Class.

I. *Eſſay on the Origin and Structure of the European Legiſlatures. By* Mr Allan Maconochie. *Part* I. - 3.

II. *A Diſſertation to prove that Troy was not taken by the Greeks. By* Mr John Maclaurin, - - 43.

III. *An Ode on the Popular Superſtitions of the Highlands. Written by the late* Mr William Collins: *And communicated by the Reverend* Dr Alexander Carlyle, - 63.

IV. *An Eſſay upon the Principles of Hiſtorical Compoſition, with an Application of thoſe Principles to the Writings of* Tacitus. *By* Mr John Hill. *Part* I. - - 76.

V. *On the Dramatic or Ancient Form of Hiſtorical Compoſition. By* Mr William Richardſon, - - 99.

VI. *A Grammatical Eſſay on the Nature, Import and Effect of certain Conjunctions; particularly the Greek* ΔΕ. *By* Mr John Hunter, - - - 113.

VII. *Eſſay on the Origin and Structure of the European Legiſlatures.* *By* Mr Allan Maconochie. *Part* II. - - Page 135.

VIII. *An Eſſay upon the Principles of Hiſtorical Compoſition, with an Application of thoſe Principles to the Writings of* Tacitus. *By* Mr John Hill. *Part* II. - 181.

*** *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 inſtitution of Societies of learned men, who have united their labours for the cultivation of Philoſophy, or of Literature, is of an ancient date in ſeveral poliſhed nations of Europe. It is, however, for the honour of Great Britain to have ſet the firſt example of an inſtitution for theſe purpoſes, incorporated by charter from the Sovereign, and carrying on its reſearches 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 baſilica*, the eſtabliſhment of Academies or Societies of learned men, who ſhould give, from

* 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 inſtituted in 1731, for the improvement of medical knowledge, by collecting and publiſhing Eſſays and Obſervations on the various branches of Medicine and Surgery, written by the members themſelves, or communicated to them. The Secretary of this Society was the elder Dr Alexander Monro, the firſt profeſſor of Anatomy in the Univerſity of Edinburgh, and the founder of the medical ſchool which has ſince attained to ſuch eminence and celebrity. Under his care, the Tranſactions of this Society were publiſhed at different periods, in five volumes 8vo, with the title of *Medical Eſſays and Obſervations*, &c. ; a work which has undergone many editions, which has been tranſlated into many foreign languages, and is honoured with the encomium of Haller, as one of the moſt uſeful books in the ſciences of Medicine, Anatomy and Surgery.

Soon after the publication of the above mentioned volumes of Medical Eſſays, *viz.* in 1739, the celebrated Mr Maclaurin, profeſſor of Mathematics in the Univerſity of Edinburgh, conceived the idea of enlarging the plan of this ſociety, by extending it to ſubjects of Philoſophy and Literature. The inſtitution was accordingly new-modelled, by a printed ſet of laws and regulations, the number of members was increaſed, and they were diſtinguiſhed, from that time, by the title of *The Society for improving Arts and Sciences*, or, more generally, by the title of *The Philoſophical Society of Edinburgh*. They choſe for their Preſident James Earl of Morton, afterwards Preſident of the Royal Society of London : Sir John Clerk of Pennycuik, one of the Barons of Exchequer, and Dr John Clerk, were elected Vice-preſidents ; and Mr Maclaurin and Dr Plummer Secretaries of the inſtitution. The ordinary members were ſome of the moſt diſtinguiſhed 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 conſiderable ſpace of time, by the

the diſorders of the country during the rebellion in 1745; and no ſooner was the public tranquillity re-eſtabliſhed, than it ſuffered a ſevere loſs by the death of Mr MACLAURIN, whoſe comprehenſive genius, and ardour in the purſuits of ſcience, peculiarly qualified him for conducting the buſineſs of an inſtitution 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 preſs ſuch papers as were judged worthy of being ſubmitted to the public eye. The firſt volume of the Tranſactions of the Philoſophical Society of Edinburgh was accordingly publiſhed in 1754, under the title of *Eſſays and Obſervations, Phyſical and Literary*; the ſecond volume was publiſhed in 1756, and the third in 1771.

IT has been always obſerved, that inſtitutions of this kind have their intervals of languor, as well as their periods of brilliancy and activity. Every aſſociated body muſt receive its vigour from a few zealous and ſpirited individuals, who find a pleaſure in that ſpecies of buſineſs, which, were it left to the care of the members in general, would be often reluctantly ſubmitted to, and always negligently executed. The temporary avocations, and, ſtill more, the deaths of ſuch men, have the moſt ſenſible effect on the ſocieties to which they belonged. The principle of activity which animated them, if not utterly extinguiſhed, remains long dormant, and a kindred genius is required to call it forth into life.

FROM cauſes of this kind, the Philoſophical Society of Edinburgh, though its meetings were not altogether diſcontinued, appears to have languiſhed for ſome time, till about the year 1777, when its meetings became more frequent, and, from the uncommon zeal and diſtinguiſhed abilities of the late HENRY HOME, Lord KAIMES, at that time elected Preſident of the inſtitution,

ſtitution, its buſineſs was conducted with renewed ardour and ſucceſs.

About the end of the year 1782, in a meeting of the Profeſſors of the Univerſity of Edinburgh, many of whom were likewiſe members of the Philoſophical Society, and warmly attached to its intereſts, a ſcheme was propoſed by the Reverend Dr Robertson, Principal of the Univerſity, for the eſtabliſhment of a New Society on a more extended plan, and after the model of ſome of the foreign Academies, which have for their object the cultivation of every branch of ſcience, erudition and taſte. It appeared an expedient meaſure to ſolicit the Royal Patronage to an inſtitution of this nature, which promiſed to be of national importance, and to requeſt an eſtabliſhment by charter from the Crown. The plan was approved and adopted; and the Philoſophical Society, joining its influence as a body, in ſeconding the application from the Univerſity, his Majeſty was moſt graciouſly pleaſed to incorporate The Royal Society of Edinburgh, by the following Charter:

GEORGIUS, *Dei Gratia, Magnæ Britanniæ, Franciæ, et Hiberniæ Rex, Fidei Defenſor, OMNIBUS probis hominibus, ad quos præſentes Literæ noſtræ pervenerint, Salutem. QUANDO QUIDEM, Nos conſiderantes quod Petitio humilis Nobis oblata fuerit, a* Henrico *Duce de* Buccleugh, Roberto Dundas *Armigero, Domino Præſide Curiæ Seſſionis;* Jacobo Montgomery *Armigero, Domino Capitali Barone Curiæ Scaccarii in Scotia;* Thoma Miller *Armigero, Domino Juſtitiario Clerico;* Joanne Grieve *Armigero, Domino Præpoſito Civitatis Edinenſis; Domino* Alexandro Dick *Baronetto; Domino* Georgio Clerk *Baronetto; Reverendo* Gulielmo Robertſon, *S. S. Theologiæ Doctore, Academiæ Edinenſis Præfecto;* Gulielmo Cullen *et* Alexandro Monro, *Medicinæ Doctoribus;* Hugone Blair *et* Joanne Walker, *S. Theologiæ Doctoribus;* Adamo Ferguſon, *Legum Doctore, et* Andrea Dalzel, Joanne Robiſon, *et* Allano Maconochie, *in Academia Edinenſi Profeſſoribus;* Ilay Campbell

Campbell *Armigero, Solicitatore noſtro Generali pro Regno Scotiæ;* Jacobo Hunter-Blair *et* Adamo Smith, *Armigeris, et* Joanne Maclaurin, Gulielmo Nairne, *et* Roberto Cullen, *Armigeris, Advocatis; ab iis ſcilicet, atque in eorum nomine: In qua Petitione enarratur, Eruditorum hominum Societates uſu compertas eſſe admodum idoneas ad promovendam Scientiam, et bonum de re Literaria Judicium, ubicunque gentium inſtitutæ fuerint; Atque adeo multos eſſe homines, aut Loco aut Literis eminentes, qui votum diu extulerint, ut Societas Literaria Edinburgi inſtitueretur, ad Statum illius partis Imperii noſtri qnæ Scotia vocatur accommodata, perſuaſiſſimum habentes ejuſdem Labores et Indagationes emolumento Reipublicæ haud aſpernando futuras: Quem ad finem Petitores ſupradictos ſpectantes Societatem inter ſe, ſi modo Patrocinio noſtro digni haberentur, inire conſtituiſſe, eoſdemque ſubmiſſe ſperare Nobis pro gratia noſtra placiturum, ut eos in unum Corpus formemus, una cum aliis quicunque in eorum numerum ſint cooptandi, ad Societatem conſtituendam, quæ non ſolum in Scientiis Matheſeos, Phyſices, Chemiæ, Medicinæ et Hiſtoriæ Naturalis, verum etiam in iis quæ ad Archæologiam, Philologiam et Literaturam ſpectant, verſetur: Precantes igitur, ut iis concedamus regiam noſtram Cartam, ſeu Literas patentes, ſub Sigillo intus ſcript. Nominantem, Conſtituentem, Erigentem, et Incorporantem dictos Petitores, et alios quales poſtea aſſumentur ſeu eligentur Socii, In unum Corpus Politicum et Corporatum, ſeu legalem Incorporationem, per Nomen et Titulum, et ſub Ordinationibus in his poſtea dictis: ET NOS certiores facti Conſilium Petitorum eſſe laudabile et dignum quod promoveatur: IGITUR Conſtituimus, Ereximus et Incorporavimus, ſicuti Nos, regia noſtra prerogativa, et Gratia ſpeciali, pro Nobiſmetipſis noſtriſque regiis Succeſſoribus, per has præſentes, Conſtituimus, Erigimus, et Incorporamus PRÆFATOS* Henricum *Ducem de* Buccleugh; Robertum Dundas *Armigerum, Dominum Præſidem Curiæ Seſſionis;* Jacobum Montgomery *Armigerum, Dominum Capitalem Baronem Curiæ Scaccarii in Scotia;* Thomam Miller *Armigerum, Dominum Juſtitiarium Clericum;* Joannem Grieve *Armigerum, Dominum Præpoſitum Civitatis Edinenſis; Dominum* Alexandrum

Alexandrum Dick *Baronettum; Dominum* Georgium Clerk *Baronettum; Reverendum* Gulielmum Robertſon, *S. S. Theologiæ Doctorem, Academiæ Edinenſis Præfectum;* Gulielmum Cullen *et* Alexandrum Monro, *Medicinæ Doctores;* Hugonem Blair *et* Joannem Walker, *S. Theologiæ Doctores;* Adamum Fergusſon, *Legum Doctorem, et* Andream Dalzel, Joannem Robiſon *et* Allanum Maconochie, *in Academia Edinenſi Profeſſores;* Ilay Campbell *Armigerum, noſtrum 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 poſtea aſſumentur ſeu 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 exiſtens, et per tale nomen Perpetuitatem habeat et Succeſſionem; atque ut potens et capax ſit capere, tenere et frui proprietate reali ſeu perſonali, et petere, Cauſas agere, defendere et reſpondere, et conveniri in Jus, trahi, defendi et reſponderi in omnibus ſeu ullis noſtris Curiis Judicaturæ: ET NOS poteſtatem damus Petitoribus primum eorum Congreſſum tenendi, quarto die Lunæ menſis Junii proximi, in Bibliotheca Academiæ Edinenſis, hora duodecima meridiana, cum poteſtate comperendinandi, atque, vel ad dictum Congreſſum, vel ad tempus in quod idem, per majorem Suffragiorum numerum eorum qui aderunt, comperendinatus fuerit, eligendi Præſidem et tot Socios quot idoneos ad complendam Societatem judicaverint; ibique, necnon ad eorum Congreſſus ſubſequentes, ordinandi Canones, ad quos Res Societatis ſint adminiſtrandæ, Præſeſque et Socii ſint eligendi; qui, tamen, Canones mutari vel augeri poſſint, majore ſuffragante numero Sociorum qui ad ullum Congreſſum Societatis aderunt, ſi modo quæ ſunt mutanda vel adjicienda, propoſita fuerint in Congreſſu habito uno menſe ante illum Congreſſum ubi de his judicandum ſit: ET NOS ordinamus, ut cunctæ Res antiquæ, Tabulæ publicæ, Librique Manuſcripti, quos acquiſiverit dicta Societas, deponantur in Bibliotheca Facultatis Juridicæ,*

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, 1783. *anno Domini milleſimo ſeptingenteſimo et octogeſimo tertio, Regnique noſtri anno vigeſimo tertio.*

Per Signaturam Manu S. D. N. Regis ſupraſcript.

June 23. 1ſt General Meeting of the Royal Society.

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.

THE

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

THE Society having met, in terms of the adjournment, the Secretary gave in a liſt of thoſe noblemen and gentlemen who had accepted of the invitation to become members. He alſo informed the meeting, that he had been directed by the Vice-Preſident and members of the Philoſophical Society of Edinburgh, to deliver their minute-book, and all ſuch diſſertations 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. Auguſt 4. 2d General Meeting.

THE members then conſidered anew the ſtatutes and regulations which had been propoſed at laſt meeting, and enacted a body of fundamental laws, aſcertaining their conſtitution, and directing their future proceedings. Laws of the Society.

IT is judged unneceſſary to give a minute account of theſe laws. The public is intereſted only in what relates to the ſcientific proceedings of the Society, the general duties of its members, and the election of candidates.

THE Royal Society of Edinburgh conſiſts of *Ordinary* and *Honorary* members; and the honorary places are reſtricted to perſons reſiding out of Great Britain and Ireland.

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

A CANDIDATE for the place of an ordinary member muſt ſignify, by a letter addreſſed to one of the members, his wiſh to be received into the Society. He muſt then be publicly propoſed at leaſt a month before the day of election. If the propoſal be ſeconded by two of the members preſent, his name is to be inſerted in the liſt of candidates, and hung up

in the ordinary place of meeting. The election is made by ballot, and is determined in favour of a candidate, if he ſhall have the votes of two thirds of thoſe preſent, in a meeting conſiſting of at leaſt twenty-one members.

THE general buſineſs of the Society is managed by a Preſident, two Vice-Preſidents, with a council of twelve, a General Secretary, and a Treaſurer. Theſe officers are choſen by ballot, annually, on the laſt Monday of November. All public deeds, whether of a civil or of a literary nature, are tranſacted by this board, and proceed in the name of the Preſident or Vice-Preſident.

IT is requeſted and expected of each of the members, that he will favour the Society, from time to time, with ſuch eſſays or obſervations on ſubjects of ſcience, literature, or other uſeful knowledge, as his leiſure and opportunities may render convenient.

The Society divided into two Claſſes.

As it was thought that the members would have a greater inducement to punctual attendance on the meetings of the Society, if they had ſome general intimation of the nature of the ſubjects which were to be conſidered, and made the topics of converſation, it was therefore reſolved, to divide the Society into *Two Claſſes*, which ſhould meet and deliberate ſeparately.

The Phyſical Claſs.

The one of theſe claſſes is denominated the PHYSICAL CLASS, and has for its department the ſciences of Mathematics, Natural Philoſophy, Chemiſtry, Medicine, Natural Hiſtory, and whatever relates to the improvement of Arts and Manufactures.

The Literary Claſs.

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

EVERY

EVERY member is desired, at his admission, to intimate which of those classes he wishes to be more particularly associated with; but he is, at the same time, entitled to attend the meetings of the other class, and to take part in all its proceedings.

EACH of the classes has four Presidents and two Secretaries, who officiate by turns.

Times of meeting.

THE meetings of the Physical Class are held on the first Mondays of January, February, March, April, July, August, November and December; and the meetings of the Literary Class are held on the third Mondays of January, February, March, April, June, July, November and December, at 7 o'clock afternoon.

Business of the Meetings.

AT these meetings, the written essays and observations of the members of the Society, or their correspondents, are read publicly, and become the subjects of conversation. The subjects of these essays and observations are announced at a previous meeting, in order to engage the attendance of those members who may be particularly interested in them. The Author of each dissertation is likewise desired to furnish the Society with an abstract of it, to be read at the next ensuing meeting, when the conversation is renewed with increased advantage, from the knowledge previously acquired of the subject.

AT the same meetings are exhibited such specimens of natural or artificial curiosities, such remains of antiquity, and such experiments, as are thought worthy of the attention of the Society. All objects of natural history presented to the Society, are ordered by the Charter of the Institution to be deposited, on receipt, in the Museum of the University of Edinburgh, and all remains of antiquity, public records, or ancient manuscripts, in the Library belonging to the Faculty of Advocates at Edinburgh.

THE

THE ordinary members, whoſe uſual reſidence 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 inſtitution. The members who reſide at ſuch a diſtance from Edinburgh, that they cannot enjoy the advantages ariſing from a regular attendance on the meetings of the Society, are not ſubjected to any contribution for defraying its expences, but have a right to attend thoſe meetings when occaſionally in Edinburgh, and to take part in all their proceedings.

Committee for Publication.

THE compilation of the printed tranſactions of the Royal Society of Edinburgh, is to be made in the following manner: The papers read at the monthly meetings, and depoſited in the hands of the Secretaries of the two claſſes, are ſubjected to the review of *the Committee for publication*, which conſiſts of the Preſident, Vice-Preſidents and Council, the General Secretary and Treaſurer of the Society; together with the Preſidents and Secretaries of the two claſſes. This Committee makes a ſelection of papers, and determines the order in which they are to be publiſhed. It is not, however, to be underſtood, that thoſe papers which do not appear in the Tranſactions of the Society, are thought unfit for the public eye. Several papers have been communicated with the ſole view of furniſhing an occaſional entertainment to the members; and that end being anſwered, have been withdrawn by their authors: Eſſays, obſervations, and caſes, are often read at the meetings of the Society, in order to obtain the opinions of the members on intereſting or intricate ſubjects: Some papers intended for a future publication have been withdrawn for the preſent by their authors, in order to profit by what has occurred in the converſations which the reading of the papers has ſuggeſted; and others, of acknowledged merit, the Committee has found it neceſſary to reſerve for

for a ſubſequent volume. Nor is the publication of any paper to be conſidered as expreſſing 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 uſeful information it contains, the hints which it may ſuggeſt, or the ingenuity which it diſplays. 1783.

AFTER the enactment of the Laws of the Society, the meeting proceeded to the election of the office-bearers of the enſuing year. [See the Liſt ſubjoined to Part firſt of this volume.] Auguſt 4. Election of the Office-bearers.

THE *Phyſical Claſs* of the Royal Society of Edinburgh met, for the firſt time, on the 4th of November 1783; and Dr WILLIAM CULLEN, Profeſſor of Medicine in the Univerſity of Edinburgh, was requeſted to take the chair. The meeting then proceeded to the election of four Preſidents and two Secretaries, for directing and recording the proceedings of this Claſs. [See the Liſt of the office-bearers ſubjoined to Part firſt of this volume.] The meeting then appointed a Committee for framing regulations for conducting the buſineſs of the Phyſical Claſs. Nov. 4. 1ſt Meeting of the Phyſical Claſs of the Royal Society.

THE *Literary Claſs* of the Royal Society of Edinburgh met, for the firſt time, on the 17th of November 1783, and the Reverend Dr ROBERTSON, Principal of the Univerſity, was requeſted to preſide. The firſt buſineſs of the meeting was the election of four Preſidents and two Secretaries, for directing and recording the proceedings of this Claſs. [See the Liſt of the office-bearers ſubjoined to Part firſt of this volume.] The meeting then appointed a Committee for framing regulations for conducting the buſineſs of the Literary Claſs. Nov. 17. 1ſt Meeting of the Literary Claſs.

Phyſ. Cl. AT a meeting of the Phyſical Claſs of the Royal Society, the Reverend Dr WALKER read the firſt part of a paper, Dec. 8. Paper by Dr Walker.

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

Account of experiments on Antimony by Mr Ruſſell.

AT the ſame meeting, Mr JAMES RUSSELL, ſurgeon, read an account of ſome experiments made by him on antimony. The object of theſe experiments was to find an eaſy and a cheap method of obtaining a ſolution of regulus of antimony in the muriatic acid, with a view to the preparation of tartar emetic, according to the directions in the laſt edition of the Diſpenſatory of the Royal College of Phyſicians in Edinburgh; the uſe of butter of antimony, as there directed, implying a very tedious, complicated, and expenſive proceſs. Mr RUSSELL endeavoured to obtain pure dephlogiſticated muriatic acid in a fluid form, by adding to it the black calx of manganeſe, (freed from particles of iron by digeſtion with vitriolic acid, and afterwards calcined by heat,) and then diſtilling it: But he found it impoſſible to condenſe the fumes of the muriatic acid when thus dephlogiſticated, (as it appeared to be by the black calx of manganeſe becoming white,) though he uſed a very long-necked retort, and had the receiver, containing water, immerſed in ſnow; for this acid, contrary to what happens to all the others, becomes much more volatile on being dephlogiſticated.

HE then tried the effect of the vapours of this dephlogiſticated muriatic acid on regulus of antimony placed in the receiver, and in the neck of the retort. This ſucceeded to his wiſh; the regulus diſſolving quickly and copiouſly. As regulus of antimony is an expenſive preparation, he made a trial of crude antimony inſtead of it; and he found that the muriatic vapours very ſoon diſſolved the metallic parts of it, and at laſt began to decompoſe the ſulphur, as, on trial, he found they did pure flowers of ſulphur. This he judged to be of little conſequence to the ultimate object, as the affinity of the muriatic acid to antimony is much ſtronger than that of the vitriolic.

vitriolic. From a retort with ſome manganeſe in it, he diſtilled five ounces of muriatic acid on two ounces of crude antimony, moiſtened with water, raiſing the heat towards the end of the proceſs, to make the ſand-pot red-hot. After the proceſs, there were found in the receiver ſome ſulphur, ſome undecompoſed antimony, and a complete ſolution of the metal in the muriatic acid. This ſolution had all the properties of butter of antimony; and its precipitate, either by means of water or alkalis, was exactly ſimilar 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 muſt be perfectly free from all mixture of a mercurial ſalt or corroſive ſublimate, which, it has been ſuſpected, may be found in the common preparation. It may likewiſe be obtained with much more eaſe, and at leſs than a tenth part of the expence. 1783.

Lit. Cl. Mr ALLAN MACONOCHIE, Advocate, read the firſt part of a Diſſertation on the Origin and Structure of the ancient European Legiſlatures. The Diſſertation is printed in this volume. [No. I. *Lit. Cl.*] Dec. 15. Diſſertation by Mr Maconochie.

1784.

Phyſ. Cl. Dr WALKER read the continuation of his paper on the motion of the Sap in Trees. [No. I. *Phyſ. Cl.*] Jan. 5. Dr Walker on the ſap of Trees.

Dr ROEBUCK read ſome Obſervations on the ripening and filling of Corn.

SUMMER 1782 having been remarkably cold and unfavourable, the harveſt was very late, and much of the grain, eſpecially oats, was green even in October. In the beginning of October, the cold was ſo great, that, in one night, there was produced on ponds near Kinneil, in the neighbourhood of Borrowſtounneſs, Dr Roebuck on the filling of corn.

1784. ſtounneſs, 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 aſcertain this point, Dr ROEBUCK ſelected ſeveral ſtalks of oats, of nearly equal fulneſs, and immediately cut thoſe which, on the moſt attentive compariſon, appeared the beſt, 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 ſtanding in the field, were found to be equal in weight to thirty of the grains which had been cut a fortnight ſooner, though even the beſt 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 obſerved every day at 8 o'clock in the morning and 6 in the evening, was a little above 43. Dr ROEBUCK obſerves, that this ripening and filling of corn in ſo low a temperature, ſhould be the leſs ſurpriſing to us, when we reflect, that ſeed-corn will vegetate in the ſame degree of heat; and he draws an important inference from his obſervation, *viz.* That farmers ſhould be cautious of cutting down their unripe corn, on the ſuppoſition, that, in a cold autumn, it could fill no more.

Jan. 5. Dr Blane on the diſeaſes of the fleet.

Mr Profeſſor DUGALD STEWART read the firſt part of a paper, communicated by Dr BLANE, Phyſician to the Fleet lately in the Weſt Indies, giving an account of the Diſeaſes in that fleet in 1782 and 1783. It is unneceſſary to give here any abſtract of this paper, as the ſubſtance of it is publiſhed by Dr BLANE in his *Obſervations on the Diſeaſes of Seamen.*

Jan. 23. Mr T. Robertſon on inflection in languages.

Lit. Cl. The Reverend Mr THOMAS ROBERTSON, miniſter of Dalmeny, read the firſt part of a Diſſertation on the Theory of

of Inflection in Languages. This paper, and its continuation, which was read at the next meeting of the Literary Claſs, forming a detached chapter of a work compoſed by Mr ROBERTSON on the *Theory and Hiſtory 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 preſent it here in a mutilated or imperfect form. 1784.

A GENERAL meeting of the Royal Society was held for the election of Members. Jan. 26. Gen. Meeting.

Phyſ. Cl. Mr Profeſſor DUGALD STEWART read the remainder of Dr BLANE's Paper on the Diſeaſes of the Fleet in the Weſt Indies in 1782 and 1783. [See *ſupra*, Jan. 5. 1784.] Feb. 2. Dr Blane on the diſeaſes of the fleet.

Dr HUTTON read the firſt part of a Diſſertation, entitled, The Theory of Rain, which is printed in this volume. [No. II. *Phyſ. Cl.*] Dr Hutton's theory of rain.

Dr WALKER read a paper, communicated by the Earl of DUNDONALD, containing an account of a new method, invented by his Lordſhip, for purifying ſea-ſalt. His Lordſhip, who was preſent, added, *viva voce*, ſome obſervations on the ſubject, which the Society requeſted he would communicate in writing at a ſubſequent meeting. Earl of Dundonald on ſea-ſalt.

THE Earl of DUNDONALD's proceſs for purifying ſea-ſalt proceeded upon this obſervation, That the common ſea-ſalt poſſeſſes a conſiderable mixture of ingredients, which render it, in a great degree, unfit for preſerving victuals. Theſe ingredients appear, by experiment, to be nauſeous, bitter and cathartic ſalts, having an earthy baſis, (magneſia ſalita and magneſia vitriolata or Epſom ſalt) which are intimately mixed with the proper ſea-ſalt.

To purify common ſalt, by diſſolving it in water, decompounding the bitter ſalts, and precipitating their earthy baſis, by adding a fixed alkali, whether foſſil or vegetable, is a tedious proceſs, and by far too expenſive to be employed for œconomical or mercantile purpoſes. It is even imperfect; as it is almoſt impoſſible, after that proceſs, to ſeparate from the ſea-ſalt the Glauber ſalt, or vitriolated tartar, or ſalt of Sylvius, which are produced according as the foſſil or vegetable alkali is uſed.

Lord DUNDONALD obſerved, That hot water ſaturated with ſea-ſalt, will ſtill diſſolve a great part of the bitter earthy ſalts. His method, therefore, of purifying the common ſalt from theſe bitter ſalts is, To take a conical veſſel, having a hole in the ſmall end of it, which is to be undermoſt; to place it, filled with common ſalt, in a moderate heat; to take one twentieth part of the ſalt contained in it, and putting it in an iron pan, to diſſolve it in its proper proportion of water, ſo that the water ſhall be completely ſaturated with the ſalt; and then to pour this ſolution boiling hot on the ſalt in the conical veſſel, which is to be purified. The boiling water being already ſaturated with ſea-ſalt, will diſſolve no more of it, but will diſſolve much of the bitter earthy ſalts; and this ſolution will gradually drop out at the hole in the bottom of the cone. When it ceaſes to drop, the ſame proceſs is to be repeated by means of freſh portions of the ſame parcel of ſalt, already partly purified, till it be brought to the required degree of purity. Lord DUNDONALD reckons, that three ſuch waſhings make the common ſalt of this country purer than any foreign ſalt; that each waſhing makes it $4\frac{1}{2}$ times purer than before; ſo that (diſregarding fractions) after the ſecond waſhing it will be 20 times, after the third 91 times, after the fourth 410 times, and after the fifth 1845 times purer than at firſt.

THE ſuperiority of ſalt thus purified to common ſalt, is equally obvious to the taſte, and by its effect in preſerving fiſh, flesh

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. 1784.

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. Feb. 16. Mr T. Robertſon on 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.*] Mr Maclaurin on the ſiege of Troy.

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.*] March 1. Mr Playfair on barometrical meaſurements.

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. March 15. Mr D. Stewart on cauſe and effect.

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 Biographical account of Dr Lothian.

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.

1784.

TABLE.

	Salt employed. lb.	oz.		Purified Salt. lb.	oz.		Magnesia salita. Magn. vitriol. lb.	oz.		
Salt hot from the pan first drawn,	56	00	contained of	49	00	and of	6	05	which is equal nearly to	$\frac{1}{9}$ of salt employed.
Salt hot from the pan last drawn,	56	00		33	09		22	06		$\frac{2}{7}$ 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 first drawn, dripped 24 hours,	56	00		52	12		3	00		$\frac{1}{18}$ Ditto.
Salt last drawn, dripped 24 hours,	56	00		44	08		11	00		$\frac{2}{7}$ Ditto.
Medium of the two last,	56	00		48	10		7	00		$\frac{1}{8}$ Ditto.
Spanish great Salt,	10	00		9	$15\frac{1}{2}$		00	$00\frac{1}{2}$		$\frac{1}{640}$ Ditto.
Basket fine Salt,	3	00		3	00		00	00		

Books from Dr Samoilowitz.

Dr CULLEN delivered to the Society five volumes written by Dr SAMOILOWITZ of St Petersburg, presented at the request of the Author, to the Royal Society of Edinburgh. The titles of these are to be found in the list of Donations, at the end of Part I. of this volume.

April 19. Dr Anderson on the English genitive.

Lit. Cl. Dr JAMES ANDERSON read observations on a peculiarity in the English language, usually called a *Genitive* Case.

Dr ANDERSON is of opinion, that the English noun admits of no inflection by cases, and therefore that the term *genitive case* is improper. He contends that the addition of the letter *s* with an apostrophe, to a noun, as *John*'s *staff*, is not an inflection of the noun, and therefore cannot be termed a Case. He affirms that when a noun undergoes a change of this sort, it ceases to be itself a noun, and becomes immediately a definitive; the office of which is to limit and render more precise the general meaning of another noun, with which it is necessarily connected. Thus the general word *staff* has its meaning limited, by the prefixing

1784. prefixing of the definitive *John*'s. He further obſerves, however, that all Engliſh nouns do not admit of this converſion into definitives. The names of animated beings, or corporeal objects, he conſiders as readily ſuſceptible of ſuch a change; but ſuch nouns as ſignify abſtract ideas, as *holineſs*, *diligence*, *whiteneſs*, he conſiders as incapable of being thus convertible into definitives. He concludes, by recommending to grammarians, as an object worthy of inveſtigation, the aſcertaining the difference betwixt ſuch definitives and adjectives, to which they bear a near reſemblance.

Mr Hill's eſſay on hiſtorical compoſition.

Mr Profeſſor JOHN HILL read the firſt part of an Eſſay on the Principles of Hiſtorical Compoſition; with an Application of theſe Principles to the Writings of TACITUS. The Eſſay is printed in this volume. [No. IV. *Lit. Cl.*]

Ode of Collins on the ſuperſtitions of the Highlands.

THE Reverend Dr ALEXANDER CARLYLE read a Poem compoſed by the late Mr WILLIAM COLLINS, on the Superſtitions of the Highlands of Scotland, addreſſed to JOHN HOME, Eſq; author of *Douglas*, *&c.* being the Ode mentioned by Dr SAMUEL JOHNSON in his life of COLLINS, which the biographer there gives up for loſt. An authentic copy of this beautiful Poem, from the manuſcript in Mr COLLINS's hand-writing, is printed in this volume, preceded by a particular account of the manner in which it has been preſerved and diſcovered. [No. III. *Lit. Cl.*]

June 5. Mr Wilſon's experiments, *&c.* on cold.

Phyſ. Cl. Dr WALKER, one of the Secretaries of the Phyſical Claſs, read a paper by Mr PATRICK WILSON, Profeſſor of Aſtronomy in the Univerſity of Glaſgow, containing Experiments and Obſervations on a remarkable Cold which accompanies the Separation of Hoar-froſt from a clear Air. The paper is publiſhed in this volume. [No. V. *Phyſ. Cl.*]

Mr

1784.

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.

Biographical account of Sir George Clerk, Baronet.

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.*]

June 21. Mr Richardſon on hiſtorical compoſition.

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.*]

Mr Hunter on certain conjunctions.

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.

June 28. General meeting.

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.*]

July 12. Dr Grieve on Koumiſs.

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

Medical caſes.

1784. complete and permanent Cure in Aſcites; the other, A Caſe of ſevere nervous ſymptoms occurring from a ſlight ſuperficial wound.

July 19. Mr Maconochie on the European legiſlatures.

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

Auguſt 2. Dr Anderſon on caſt iron.

Phyſ. Cl. Dr JAMES ANDERSON read a paper on ſome œconomical uſes to which caſt iron may be applied. He obſerved, That, in ſeveral mechanic arts, maſſes of great weight, ſize and ſtrength, are required for bruiſing or grinding various ſubſtances; that it is often difficult to procure ſtones of ſufficient ſize and ſtrength for theſe purpoſes; that caſt iron, though proper in point of ſtrength, and eaſily made of almoſt any ſize or ſhape, is ſometimes inconvenient from its weight, and is, for many purpoſes, too expenſive. He propoſed, therefore, that, inſtead of pure iron, the moulds in which ſuch maſſes are to be caſt ſhould be nearly filled with ſtones, or what would be ſtill better, with bricks, as theſe could be eaſily moulded into the exact ſhape required; a proper ſpace being left for an axle where needed, and an interſtice between the outermoſt of them and the mould; that then melted iron ſhould be poured in to fill up every chink. This iron, cooling and conſolidating, will unite or cement the ſtones or bricks firmly together, and cover them with an uniform ſurface of metal. Thus, Dr ANDERSON thinks, that maſſes of any ſize, ſhape and weight, and of ſufficient ſtrength, may be procured at a cheap rate; as a very ſmall quantity of metal would be ſufficient for a cement and coating to the ſtones or bricks.

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

poſe of bridge-building, where very large ſtones are often required for the conſtruction of arches. Inſtead of ſuch large ſtones, he propoſes to uſe compound maſſes, ſuch as thoſe above deſcribed, cemented with iron, and exactly moulded, ſo as to form, if required, an entire rib of an arch without a fiſſure; and he thinks that, in this way, a number of arches might be accurately and firmly put together. 1784.

Mr Elliot's aſtronomical problem.

Mr ROBISON, General Secretary, read a paper, communicated by the Reverend Mr THOMAS ELLIOT, Miniſter of Cavers, containing an Improvement on the Method of correcting the obſerved Diſtance of the Moon from the Sun or a Fixed Star. The paper is publiſhed in this volume. [No. VII. *Phyſ. Cl.*]

Medical caſes.

THERE was likewiſe read an account, by Dr ANDREW DUNCAN, of a caſe of obſtinate *ſingultus*, in which the beſt effects had been produced by the uſe of vitriolic acid. A gentleman, in the 73d year of his age, was ſeized with a violent hiccough, which continued without intermiſſion for ſeveral hours. Dr DUNCAN preſcribed for him a mixture containing a drachm of *acidum vitriolicum tenue*, united with four ounces of mint-water, of which a table-ſpoonful was to be taken every half hour. The firſt doſe put a ſtop to the *ſingultus*. About twelve hours afterwards, there was a return of the fit; which, however, yielded inſtantly to a ſecond ſpoonful of the mixture; nor was there afterwards any occaſion to repeat the doſe.

Nov. 15. Dr Gregory's eſſay on cauſe and effect.

Lit. Cl. Dr GREGORY read the Introduction to an Eſſay towards an Inveſtigation of the exact Import and Extent of the common Notion of the Relation of Cauſe and Effect in Phyſics, and of the real Nature of that Relation. Parts of the Eſſay itſelf were afterwards read by him at ſeveral ſubſequent meetings of the Literary Claſs; but he did not incline, that either the

1784. Eſſay itſelf, or any abſtract of it, ſhould appear in this volume of the Society's Tranſactions.

Nov. 29. General meeting. 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.]

Dec. 6. Dr Walker on the ſap of trees. *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.*]

Mr Fleming on Loch Tay. 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 Wilſon on the ſolar ſyſtem. 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 of

of the fixed ſtars indicated the proportion between the orbital volocity of the earth, and the velocity of light in the vitreous humour of the eye. This opinion ſoon led him into various diſcuſſions, and, in particular, made him ſuppoſe, that the aberration of the fixed ſtars, when determined by obſervations made with a teleſcope filled with water, would be different from the aberration determined by obſervations made with a common teleſcope. Mr WILSON has given an account of ſome important and unexpected conſequences reſulting from theſe ſpeculations, in the Philoſophical Tranſactions of London. About the year 1775 or 1776, Mr WILSON began to entertain an opinion that the centre of the ſolar ſyſtem was in motion, and in 1777, communicated to Mr ROBISON, and others, a paper on this ſubject. The water-teleſcope was, by this time, become familiar to his thoughts; and it occurred to him, that it might be employed for deciding this queſtion, and even for determining the direction and velocity of this motion; by means of the difference between the obſerved aberration of the fixed ſtars and the aberration which ſhould reſult from the earth's orbital motion alone. But various objections and difficulties occurred in the proſecution of this attempt, and Mr WILSON ſoon after thought of another method.

IF the earth be carried, with a great velocity, towards a fixed ſtar, whoſe rays are made to deviate a little by an achromatic priſm, it will follow, that a conſtant 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,

1. LET the teleſcope of a meridional quadrant be furniſhed with a priſm, refracting a few degrees in altitude. Search, by meridional obſervations, for ſuch ſtars as exhibit altitudes inconſiſtent with Dr BRADLY's aberrations: The differences will indicate an aberration cauſed by a motion of the earth, different from its orbital motion round the ſun.

2. FURNISH

1784. 2. FURNISH a teleſcope with a plain mirror, inclined to its axis in an angle of 45°, and a ſeries of achromatic priſms refracting 90°. Suppoſe the teleſcope to be directed to a point of the heavens, 90° diſtant from a ſtar which is viewed through it. Suppoſe alſo the earth to be at reſt, and the images of this ſtar, formed by the refracted and by the reflected light, to coincide. Then ſuppoſe the earth to be in motion towards this ſtar: The images will ſeparate, both on account of a change in the total deviation of the refracted light, and alſo on account of a tranſverſe aberration, to which the refracted image is liable, by the motion of the teleſcope.

3. IF a long achromatic teleſcope be directed to a fixed ſtar, towards which the earth is moving, the focal diſtance of the teleſcope will be lengthened. The augmentation will indeed be very ſmall, but Mr WILSON has fallen upon very ingenious methods of increaſing it, ſo as to make it become ſenſible.

Dec. 20. Eſſay by Mr Dalzel.

Lit. Cl. Mr Profeſſor DALZEL read an Eſſay towards an Explanation of the Pleaſure ariſing from certain Scenes, Repreſentations and Deſcriptions of Diſtreſs: But he did not incline that the Eſſay, or any account of it, ſhould be given in this volume.

1785. Jan. 3. Mr Playfair on barometrical meaſurements.

Phyſ. Cl. The Reverend Mr JOHN PLAYFAIR read the ſecond part of his Paper, on the Cauſes that affect the Accuracy of Barometrical Meaſurements, publiſhed in this volume. [No. III. *Phyſ. Cl.*]

Dr Blane's account of the hurricane at Barbadoes.

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, ſo that the

the inhabitants began to think themſelves exempt from ſuch calamities, and accordingly had no edifices of ſufficient ſtrength to withſtand the force of a hurricane.

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

At 8 o'clock it began to make impreſſion on the houſes, by tearing off the roofs, and overthrowing ſome of the walls. The hurricane was thought to be at its greateſt height at midnight, but did not abate conſiderably 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 diſtinction of age, ſex, or condition, were driven from their houſes, for fear of being buried in the ruins of them, and were obliged to paſs the night in the fields, expoſed to the impetuous wind, to the cold, which was very remarkable, conſidering the climate, to inceſſant torrents of rain, and to the terrors of thunder and lightning, which were violent and almoſt conſtant.

Multitudes periſhed, either by clinging too long to the buildings for ſhelter, in attempting to ſave what was valuable, or by unavoidable accidents from the falling of walls, roofs, and furniture, the materials of which were projected to great diſtances. The number of lives loſt was eſtimated from returns made to the Governor, at more than 3000; but ſeveral pariſhes 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 ſeveral yards.

All the fruits of the earth then ſtanding were deſtroyed, moſt of the trees on the iſland were torn up by the roots, and many of them were ſtripped of their bark.

All

ALL the houſes on the iſland ſuffered more or leſs. Many of the private houſes were levelled with the ground, all of them unroofed, and the whole of their carpenter-work and furniture deſtroyed. The large elegant church of Bridgetown was reduced to a heap of ruins.

THE ſea roſe ſo high as to deſtroy the Fort, carrying the great guns many yards from their platform, and demoliſhing the houſes near the beach. A ſhip was driven on ſhore againſt one of the buildings of the naval hoſpital, which, by this ſhock, and the impetuoſity of the wind and ſea, was entirely deſtroyed and ſwept away. The Mole-head was ſwept away, and ridges of coral rock were thrown up, which ſtill remain above the ſurface of the water: But the harbour and road have, upon the whole, been improved, being deepened in ſome places ſix feet, in others as many fathoms; and the anchoring ground in the road is much better, by the cruſt of coral, which had been the growth of ages, being torn up, and leaving a ſoft oozy bottom. Many ſhells and fiſh were thrown on ſhore, which had been heretofore unknown.

THE ſufferings and loſſes by ſea were alſo great and calamitous. The wind was too violent for any ſhip to ride it out, and they all puſhed to ſea, where moſt of them periſhed by the mere violence of the weather, without being driven any where on ſhore. Out of twelve of his Majeſty's ſhips of war that were expoſed to it, five have been totally loſt; and out of the crews of theſe, not more than ten or twelve perſons have been ſaved.

Dr BLANE was ſatisfied, both from what he had an opportunity of obſerving himſelf, and from the teſtimony of thoſe who had been preſent during the hurricane, that an earthquake attended it; and he is convinced that it is not a vulgar prejudice or error to ſuppoſe, that in hurricanes a concuſſion 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,

at

at Bridgetown were ſet at angles to each other, though they were ſheltered from the wind, and nothing had fallen on them that could produce ſuch an effect; caſks had changed their poſition in cellars below ground; maſſes of rock were removed, which the mere force of air and water did not ſeem capable of effecting; and there were chaſms in the earth, which ſeemed to indicate ſome internal agitation. The inhabitants, both of Barbadoes and St Lucia, felt the earthquake plainly; and at St Lucia the earthquake happened ſome hours after the greateſt ſeverity of the gale.

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

THE extent of this hurricane, from north to ſouth, was pretty well aſcertained by the accounts from the different iſlands already mentioned. But there were no means of aſcertaining, with equal accuracy, how far it extended from eaſt to weſt. A ſhip that arrived at Barbadoes ſix 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 compaſs; a circumſtance which diſtinguiſhes the hurricane from all other gales within the tropics; the courſe of nature being ſo far inverted, that the direction of the trade-winds, at other times conſtant, is not then obſerved. 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

time, due W. and was more or leſs from all the intermediate points. In places but a few miles diſtant, people diſagreed in their accounts of its violence and direction at the ſame point of time. It was very irregular in theſe reſpects at other places; for on the iſland of St Lucia they had it not at any time from the weſt; but the Montague and Ajax, the ſhips that were driven from that iſland, had it from all points.

THE progreſs of it weſtward was very ſlow, conſidering 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 ſo violent. At St Domingo they had it in a ſtill leſs degree on the 13th and 14th of October. It has ſince appeared, that there was in England the moſt violent ſtorm that has been known for many years, the very day of the hurricane at Barbadoes.

IT was remarked, that the ſhips 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-ſhip, with the crew on board, was driven from her anchors at Barbadoes, all the compaſſes were broken, and, after toſſing about for two days and two nights, the people found themſelves at the mouth of Carliſle bay, the very point whence they ſet out, at a time when they might reaſonably have ſuppoſed themſelves 100 leagues from it.

THERE was much lightning during the hurricane, chiefly in large ſheets and ſteady 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 ſuppoſes to be the *ignis fatuus.*

THERE was in the N. E. an Aurora Borealis, an unuſual appearance in the Weſt Indies.

DURING

DURING the whole night, a rumbling noiſe was heard in the ſky, now and then interrupted by a momentary pauſe. There were no obſervations 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 iſland, the barometer, near the level of the ſea, fell to $27\frac{2}{18}$. It is known, that, in the Weſt Indies, the barometer ſtands, with little variation, ſomewhere between 29 and 30.

THE influence of the hurricane on peoples health was very remarkable. Inſtead of producing ſickneſs, it ſeemed to have the very oppoſite effect. There was leſs ſickneſs after, than there had been before it; and moſt of thoſe who were ſick at the time of it were benefited by it, except the very old and delicate, who ſuffered, either from mechanical violence, or the ſubſequent want of ſhelter. It had a viſible good effect on the diſeaſes of the climate, fevers and fluxes. Chronic diarrhœas, the conſequence of dyſenteries, were alſo cured by it. But the diſeaſes on which it operated moſt viſibly and ſenſibly were pulmonic complaints. Some recent caſes of phthiſis, and even the acute ſtate of pleuriſy, were cured by it. Nay, in the more advanced and incurable ſtate of phthiſis, the hectic fever was, in a great meaſure, removed, and a temporary alleviation at leaſt procured. Dr BLANE mentioned particularly the caſe of a lady of his acquaintance, who was ill of a pleuriſy at the time of the hurricane, and paſſed more than ten hours in the open air, ſitting generally in a plaſh of water from the rain that fell; ſhe had no more of her complaint, nor any return of it; and Dr BLANE ſaw her a few weeks after in better looks and in a better general ſtate of health than ſhe had enjoyed for a great while before. It was a general obſervation, that people had remarkably keen appetites for ſome days after the hurricane; and many people, who uſed to be thin and ſallow, Dr BLANE ſaw looking freſh and plump a few weeks after it,

1784. though the unhealthy rainy ſeaſon was there hardly over. Theſe facts, which appear ſo very wonderful, Dr BLANE mentions with confidence, they being confirmed by a concurrence of teſtimony, and, in ſome meaſure, by his own obſervation.

Regiſter of the weather at Branxholm.

Dr WALKER preſented and read the title of a paper, communicated by his Grace the Duke of BUCCLEUGH, Preſident of the Society, containing a Regiſter 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 Regiſter is publiſhed in this volume. [No. IX. *Phyſ. Cl.*]

1785.

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

Lit. Cl. Mr ALEXANDER FRASER-TYTLER read a Diſſertation on the Character, Manners and Genius of the Ancient Scandinavian Nations. He did not incline that the Diſſertation, or any abſtract of it, ſhould be publiſhed.

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 ſpecimens of natural hiſtory, and other curioſities, which had been preſented to the Royal Society. Theſe are enumerated in the Liſt of Donations, printed at the end of Part I. of this volume.

Feb. 21. Mr Hill on hiſtorical compoſition.

Lit. Cl. Mr Profeſſor JOHN HILL read the remainder of his Eſſay on Hiſtorical Compoſition, publiſhed in this volume. [No. IV. and VIII. *Lit. Cl.*]

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

Phyſ. Cl. Dr BLACK, in the abſence of the Author, read the firſt part of Dr HUTTON's Theory of the Earth, which is publiſhed in this volume. [No. X. *Phyſ. Cl.*]

Lit.

1785.

March 21. Dr Gregory on cauſe and effect.

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.]

April 4. Dr Hutton's theory of the earth.

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

May 27. Donations.

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.

June 20. Dr Macfarlan on manufactures, &c.

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.

June 27. General meeting.

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.

July 4. Dr Walker on muſcous plants.

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.

July 9. Count de Windiſchgratz's problem.

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

reſtraints 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 poſſibili inſtrumentorum ſpecie, quibus quis ſe " obſtringere, ſuumve dominium in alterum, quibuſcunque " ex motivis, et quibuſcunque ſub conditionibus transferre " poteſt, formulas tales invenire, quæ omnibus caſibus indivi- " duis conveniant, atque in quovis caſu ſingulis duntaxat termi- " nis, iiſque pervulgatis expleri opus habeant, qui termini, " æque ac ipſæ formularum expreſſiones ejuſmodi ſint, ut quem- " admodum in matheſi, nullum dubium, nullum litigium lo- " cum, habeat."

A PRIZE of a thouſand ducats is offered to any perſon who ſhall furniſh a complete ſolution of this problem. Should there be no complete ſolution, a prize of five hundred ducats is offered to the author of that ſcheme, which ſhall be judged to approach the neareſt to a ſolution. The Count propoſes, in the printed *programma*, that all writings which ſhall be offered in the competition for theſe prizes, ſhall be judged of by three of the moſt diſtinguiſhed Literary Academies in Europe. In his letter to Mr SMITH, he informs him, that the three learned bodies which he has choſen for that purpoſe are: The Royal Academy of Sciences at Paris, the Royal Society of Edinburgh, and one of the Academies of Germany or Switzerland, which he ſhall afterwards name. As a recompence for the trouble they may be put to in this deciſion, he offers the ſum of 50 *louis d'or* to each of theſe learned bodies, to be aſſigned by them as a prize for the ſolution of any queſtion which they ſhall propoſe. Count de WINDISCHGRATZ intimates, that the Academy of Sciences at Paris has accepted of the office required of them; and he deſires that Mr SMITH will communicate his requeſt to the Royal Society of Edinburgh, and inform him whether that body is willing to undertake the office of deciding

ding in the competition along with the Academy of Sciences, and the other Academy to be yet named. 1785.

Mr SMITH ſignified to the meeting, that although he entertained great doubt whether the problem of the Count de WINDISCHGRATZ admitted of any complete and rational ſolution, yet the views of the propoſer being ſo highly laudable, and the object itſelf of that nature, that even an approximation to its attainment would be of importance to mankind; he was therefore of opinion, that the Society ought to agree to the requeſt that was made to them. He added, that it was his intention to communicate his ſentiments on the ſubject to the Count, by a letter, which he would lay before the Council at a ſubſequent meeting.—The Council were of opinion, That the Society ſhould acquieſce in the Count de WINDISCHGRATZ's propoſal, but ſhould decline to accept of the recompence offered. The farther conſideration, however, of the affair was poſtponed, till Mr SMITH ſhould communicate to the Council the draught of his intended letter to the Count, on the ſubject of his problem.

Phyſ. Cl. Dr GREGORY read a paper communicated by Dr HOPE, giving an account of a remarkable caſe, attended with anomalous ſymptoms, and terminating fatally; in which, on diſſection, the diſeaſe appeared to have proceeded from a large gall-ſtone ſticking in the neck of the gall-bladder. Aug. 1. Caſe communicated by Dr Hope.

Lit. Cl. Dr GREGORY read a continuation of his Eſſay on Cauſe and Effect. [See *ſupra*, Nov. 15. 1784.] Nov. 21. Dr Gregory on cauſe and effect.

Phyſ. Cl. Mr WILLIAM SMELLIE read an Eſſay on Inſtinct. As this Eſſay makes a part of a larger work, which the author is preparing to lay before the Public, he did not wiſh it ſhould appear at full length among the Diſſertations printed in this volume. Dec. 5. Mr Smellie on Inſtinct.

lume. The following abſtract, however, is given of its principal contents.

MANY theories have been invented with a view to explain the inſtinctive actions of animals, but none of them have received the general approbation of Philoſophers. This want of ſucceſs may be referred to different cauſes; to want of attention 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 diſtinguiſh inſtinctive from rational motives. Mr SMELLIE endeavours to ſhew that no ſuch diſtinction exiſts, and that the reaſoning faculty itſelf is a neceſſary reſult of inſtinct.

HE obſerves, that the proper method of inveſtigating ſubjects 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 exhibits 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 inſtruction 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 inſtincts. 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 mother'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.

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 inſtincts receive improvement from experience and obſervation, and are capable of a thouſand modifications. One inſtinct counteracts and modifies another, and often extinguiſhes the original motive to action. The inſtinct of fear is often counteracted by ambition and by reſentment: The inſtinct of anger, by fear, by ſhame, by contempt, by compaſſion. Of modified, compounded, and extended inſtincts, there are many examples. Devotion is an extenſion of the inſtinct of love, to the firſt Cauſe or Author of the univerſe. Superſtition is the inſtinct of fear extended to imaginary objects of terror. Hope is the inſtinct of love directed to future good. Avarice is the inſtinct of love directed to an improper object. Fear is likewiſe an ingredient of this attachment. Envy is compounded of love, avarice, ambition, and fear. Sympathy is the inſtinct of fear transferred to another perſon, and reflected back upon ourſelves. In this manner all the modified, compounded or extended paſſions of the human mind, may be traced back to their original inſtincts.

The inſtincts of brutes are likewiſe improved by obſervation and experience. Of ſuch improvement, the dog, the elephant, the horſe, the camel, afford numerous and ſtrong inſtances.

From theſe and other examples, given of the different claſſes of inſtincts, Mr Smellie argues, that inſtinct 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 ſentient principle or mind. Whatever feels, therefore, is mind. Of courſe, the loweſt ſpecies of animals is endowed with mind. But the minds of animals have very different powers; and theſe powers are expreſſed by peculiar actions. The ſtructure 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 inſtincts, however, of animals, appear often previouſly to the expanſion of thoſe inſtruments which nature intended they

ſhould employ. This view of inſtinct is ſimple: It removes every objection to the exiſtence of mind in brutes, and unfolds all their actions by referring them to motives perfectly ſimilar to thoſe by which man is actuated. There is perhaps a greater difference between the mental powers of ſome animals, than between thoſe of man and the moſt ſagacious brutes. Inſtincts may be conſidered as ſo many internal ſenſes, of which ſome animals have a greater, and others a ſmaller number. Theſe ſenſes, in different ſpecies, are likewiſe more or leſs ductile; and the animals poſſeſſing them are, of courſe, more or leſs ſuſceptible of improving, and of acquiring knowledge.

THE notion that animals are machines, is therefore too abſurd to merit refutation. Though not endowed with mental powers equal to thoſe of man, they poſſeſs, in ſome degree, every faculty of the human mind. Senſation, memory, imagination, the principle of imitation, curioſity, cunning, ingenuity, devotion, or reſpect for ſuperiors, gratitude, are all diſcoverable in the brute-creation. Every ſpecies too has a language, either of ſounds or geſtures, ſufficient for the individuals to communicate their wants to each other; and ſome animals underſtand in part the language of man. The language of infants is nearly on a par with that of brutes. Brutes, without ſome portion of reaſon, could never make a proper uſe of their ſenſes. But many animals are capable of balancing motives, which is a pretty high degree of reaſon. Young animals examine all objects they meet with, and in this inveſtigation they employ all their organs. The firſt periods of their life are dedicated to ſtudy. When they run about and make frolicſome gambols, it is nature ſporting with them for their inſtruction. Thus they gradually improve their faculties, and acquire an intimate knowledge of the objects that ſurround them. Men who, from peculiar circumſtances, have been prevented from mingling with companions, and engaging in the different amuſements and exerciſes of youth, are always awkward in their movements,

movements, cannot uſe their organs with eaſe or dexterity, and often continue, during life, ignorant of the moſt common objects. 1785.

Dec. 13. Count de Windiſchgratz's problem.

AT a meeting of the Council of the Royal Society, the ſubject of the Count de WINDISCHGRATZ's Problem was reſumed, and Mr Commiſſioner SMITH read to the Meeting the draught of a letter written by him to the Count, ſtating objections to the poſſibility of a complete ſolution of his problem, but intimating, at the ſame time, that the Royal Society of Edinburgh had agreed to co-operate with the other two Academies, in deciding on the merit of all Eſſays or Diſſertations which ſhould appear in the competition for the prizes propoſed, 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 requeſted of the Author, in order to be preſerved among their papers, as he did not incline that it ſhould be publiſhed in the Tranſactions of the Society.

APPEN-

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

I. Account *of* *William Lothian*, D. D.

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

THE cuſtom adopted by ſeveral learned Societies or Academies abroad, which requires, that a profeſſed panegyric on every one of the Members, after his death, ſhould firſt be read before the Academy, and then printed in the hiſtory of their tranſactions, has not met with a general approbation, either in England or in this country. For although characters have frequently appeared in the republic of Letters, whoſe ſhining talents have, with ſufficient propriety, employed the power of eloquence in their praiſe, every Member of an Academy cannot be deemed the proper ſubject of a laboured encomium. The Britiſh character, naturally ſhy and reſerved, is apt to look with an eye of ſuſpicion, upon any diſcourſe that comes decorated with the pompous title of *Eloge*.

But though to write a profeſſed panegyric on every deceaſed Member of our Society might, with reaſon, be thought oſtentatious and improper; yet ſuch is the merit and juſtly acquired literary fame of ſome of our number, that, to permit them to ſink into the grave, without any public teſtimony of our regard, would argue a culpable degree of inſenſibility and reſerve. There are names in our catalogue, whoſe praiſe will be publicly celebrated, and whoſe fame will deſcend to poſterity, in ſpite of the ſilence which we might think proper to obſerve; and as they muſt ſtand forward in the Biographical Annals of Great Britain, where can an authentic memorial of them be ſo properly preſerved as in the Regiſters of this Society?

It ſeems proper alſo, that, at the death, even of every one of the Members, a ſhort notice of him ſhould be inſerted 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; ſuch a ſhort and ſimple account having been previouſly read at a meeting of the Claſs to which he more particularly belonged.

But whoever has diſtinguiſhed himſelf in a ſuperior degree in the republic of Letters ſeems to have a claim to higher and more public honours. Nor could the moſt faſtidious reſerve be offended, if the memory of ſuch a character were celebrated at an aſſembly of the whole Society.

These obſervations have been ſuggeſted by the recent loſs of a worthy Member of our Literary Department. And as the omiſſion of this firſt opportunity of introducing a practice, which ſeems ſo laudable, might be aſcribed to negligence, or to an imperfect diſcharge of that truſt with which the Society has honoured its Secretaries, I flatter myſelf the Meeting will hear, with indulgence, the following ſhort and ſimple account of the perſon to whom I have alluded.

Account of Dr Lothian.

WILLIAM LOTHIAN, D. D. *ſenior* Miniſter of Canongate, and Member of this Society, was born in the city of Edinburgh on the 5th of November 1740. Before he was ſix years old, he loſt his father Mr George Lothian, a reſpectable Surgeon; and his mother alſo having died when he was an infant, the charge of his education devolved on other relations.

He had his academical education in the Univerſity of Edinburgh; and both during the uſual courſe of Literature and Philoſophy, and during his application to the ſtudy of Theology, he was diſtinguiſhed for diligence and promiſing talents.

The

Account of Dr Lothian.

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.

Account of Dr Lothian.

As a member of the Church of Scotland, Dr LOTHIAN followed, with firmneſs, that courſe of conduct which ſeemed to him to be the moſt proper. And the appearances which he made in the Eccleſiaſtical Courts exhibited ſuch marks of ſound underſtanding, and ſuch firmneſs of mind, as procured him great reſpect. Indeed, his contemporaries and younger brethren, among whom his acquaintance was very extenſive, always repoſed the higheſt confidence in his judgment, his honour and his integrity, and ſpoke in the ſtrongeſt terms of the ſincerity and warmth of his friendſhip.

WHEN this Society was honoured with a Royal Charter of Incorporation, Dr LOTHIAN was naturally thought of as a proper perſon 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 Hiſtory, he publiſhed two Sermons, which are to be found in the ſecond volume of a Collection, entitled, *The Scotch Preacher*, printed at Edinburgh in the year 1776.

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 Preſidents of the Phyſical Claſs of this Society, was born at Edinburgh on the laſt day of October 1715. He was the fourth ſon 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 ſtudies were carried on at the Univerſity of Edinburgh, under the eye of his father, who was himſelf a man of letters, and from whom he appears very early to have caught a ſtrong taſte for Natural Hiſtory, Antiquities and the Theory of Commerce, particularly in ſo far as theſe branches of knowledge related to his own country. He afterwards went to Leyden, where he finiſhed his ſtudies under the immediate inſpection of the celebrated Boerhaave, who had been the friend of his father; and, before his return home, he viſited ſeveral parts of France and Germany.

After ſettling in his native country, his turn of mind led him to ſtudy, with great diligence, the commercial intereſts of Scotland, and to be zealous and active in promoting them. He applied himſelf to the introduction and encouragement of various home-manufactures. In particular, he eſtabliſhed, at a conſiderable expence to himſelf, the Linen Manufactory at Dumfries. He likewiſe ſet on foot many different projects for working lead and copper mines. In theſe laudable undertakings, the public advantage outweighed with him every other

Account of Sir George Clerk.

conſideration; for his ſchemes were proſecuted frequently to the detriment of his private fortune.

In 1755, he addreſſed *two Letters* to the Truſtees for Fiſheries, Manufactures and Improvements in Scotland, containing Obſervations on the common mode of treating Wool in this country, and ſuggeſting a more judicious ſcheme of management. Theſe were publiſhed, by direction of that Board, in 1756: And the method there recommended having been univerſally followed in practice, has been of real advantage to the public, by improving the quality of Scottiſh wool. He likewiſe, in 1761, wrote a paper on the Advantages of Shallow Plowing, which was read to the *Philoſophical Society*, and is publiſhed in the third volume of their Eſſays.

In 1741, Mr Clerk was appointed Lord Treaſurer's Remembrancer in Exchequer; and, when the forfeited eſtates were put under the management of Commiſſioners in 1752, he was fixed on as a proper perſon to fill a place at their Board. In 1760, he was named one of the Truſtees for Fiſheries, Manufactures and Improvements: And in 1763, Commiſſioner of the Cuſtoms in Scotland.

His conduct in the diſcharge of the public truſts thus committed to him, was ſuch as gained him the eſteem and confidence of his colleagues. The two Boards of Truſtees, in particular, often committed affairs of importance to his ſole management; and he never failed to acquit himſelf to their entire ſatisfaction. Nor was his ability in their buſineſs more remarkable than his delicacy: For ſo ſcrupulous was he, that though he had juſtly acquired conſiderable influence at thoſe Boards, he was never ſuſpected of having once employed it in improper endeavours to ſerve his perſonal friends. In the courſe of his duty as a Commiſſioner of the Cuſtoms, he faithfully improved every opportunity of doing ſervice to the Revenue.

One inſtance, among many, deſerves particular notice, both as being a proof of the confidence repoſed in him by the Board of Cuſtoms,

Account of Sir George Clerk.

Cuſtoms, and as a remarkable public event, in which he was, though not oſtenſibly, 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

ſmuggling

Account of Sir George Clerk.

ſmuggling trade, though it ſtill ſubſiſts, is now confined to thoſe who are poſſeſſed of extenſive capitals; whereas, before this act of Parliament, every farmer's ſervant who could purchaſe half a caſk of ſpirits, was engaged for his ſhare. The conſequence is, that the whole inhabitants on the ſouth-weſt coaſt, who had followed ſcarcely any other employment than this pernicious traffic, to the entire neglect of their huſbandry and manufactures, now earn their ſubſiſtence by a more honeſt application of their induſtry. The face of the country, which formerly never could raiſe a ſufficient quantity of grain to ſupport its own inhabitants, is totally changed, and every year it affords a plentiful ſupply to the neighbouring counties.

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

HE was likewiſe a ſkilful engineer and draughtſman, 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 deſigning confined to this more mechanical ſpecies of drawing. He could ſeize and delineate, with uncommon ſpirit, every ludicrous expreſſion of character; and his drawings in this line are in great requeſt with the curious. His mind had likewiſe 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 aſſociation of gentlemen, named *the Yorkſhire Hunters*, who attended the royal army; and he was, on different occaſions, employed by the Duke of CUMBERLAND, (who knew him well) and, in particular, to conduct the forces to the proper ground for opening the ſiege of Carliſle.

Mr

Account of Sir George Clerk.

Mr CLERK had an excellent taſte for the fine arts, and was ſolicitous to encourage them. As one inſtance of this, he had the principal concern in eſtabliſhing and procuring an endowment for the drawing-ſchool in the Univerſity of Edinburgh, where twenty pupils are inſtructed *gratis* in the art of deſigning. Theſe are ſelected from among ſuch young people, of either ſex, as give ſigns of genius, who are deſtined to apply to thoſe profeſſions in which a ſkill in that art is requiſite. This inſtitution has contributed more than any other circumſtance, to the great improvement of ornamental manufactory, which this country has made during the laſt twenty years. And whoever recollects the old patterns of carpet, damaſk, gauze, and other manufactures of that ſort, and compares them with thoſe of the preſent day, muſt allow the ſuperior elegance of deſign now exhibited in thoſe productions, and which may reaſonably be aſcribed, in a great meaſure, to the happy effects produced by the inſtitution we have mentioned.

HE married, at a very early period of life, his couſin-german DOROTHY CLERK-MAXWELL, heireſs of Middlebie in Dumfries-ſhire, by whom he had ſix ſons and ſeven daughters, of whom only two ſons and two daughters ſurvived him. He ſucceeded 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 conſtitution and ſpirits ſuffered many ſevere ſhocks from family misfortunes. He loſt, within a ſhort time, three ſons, a daughter, and a grandſon, all of whom had arrived at years of maturity, and promiſed to be the comfort of his old age. Of theſe, his third ſon GEORGE, who had been ſome years at the Bar, died in 1776. WILLIAM, his fifth, a Lieutenant in the 1ſt regiment of foot; ROBERT, his ſixth, a Lieutenant in the 56th, and GEORGE CRAIGIE younger of Glendoick, his grandſon, a Captain in the 40th regiment, all periſhed in the ſervice of their country, within the period of a few months. The laſt mentioned of theſe, in the end

Account of Sir George Clerk.

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 Univerſity of Edinburgh, was the ſon of the Reverend Mr DUGALD STEWART, Miniſter of Rothſay in the Iſle of Bute, and was born at that place in the year 1717. After having finiſhed his courſe at the grammar-ſchool, being intended by his father for the Church, he was ſent to the Univerſity of Glaſgow, and was entered there as a ſtudent in 1734. His academical ſtudies were proſecuted with diligence and ſucceſs; and he was ſo happy as to be particularly diſtinguiſhed by the friendſhip of Dr HUTCHESON and Dr SIMSON. With the latter, indeed, he ſoon became very intimately connected; for though it is ſaid, that his predilection for the Mathematics did not inſtantly appear on his application to the ſtudy of that ſcience, yet the particular direction of his talents was probably obſerved by his maſter before it was perceived by himſelf. Accordingly, after being the pupil of Dr SIMSON, he became his friend; and during all the time that he remained at the Univerſity of Glaſgow, purſuing the ſtudies of Philoſophy and Theology, he lived in the cloſeſt intimacy with that excellent Mathematician, and was inſtructed by him in, what might not improperly be called, the *arcana* of the ancient Geometry. That ſcience was yet involved in ſome degree of myſtery; for though the extent of its diſcoveries was nearly aſcertained, its analyſis, or method of inveſtigation, was but imperfectly underſtood, and ſeemed inadequate to the diſ-

Account of Dr Stewart.

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 ſucceſs. Dr SIMSON was now engaged in perfecting what they had begun, and in reſiſting the encroachments, which he conceived the modern analyſis to be making upon the ancient. With this view, he had already publiſhed a treatiſe of Conic Sections, and was now preparing a reſtoration of the *Loci Plani* of APOLLONIUS, in which that work was to reſume its original elegance and ſimplicity. To theſe, and other ſtudies of the ſame kind, he conſtantly directed the attention of his young friend, while he was delighted, and aſtoniſhed at the rapidity of his progreſs.

Mr STEWART's views made it neceſſary for him to attend the lectures in the Univerſity of Edinburgh in 1741; and that his mathematical ſtudies might ſuffer no interruption, he was introduced by Dr SIMSON to Mr MACLAURIN, who was then teaching, with ſo much ſucceſs, both the Geometry and the Philoſophy of NEWTON. Mr STEWART attended his lectures, and made that proficiency which was to be expected from the abilities of ſuch a pupil, directed by thoſe of ſo great a maſter. But the modern analyſis, even when thus powerfully recommended, was not able to withdraw his attention from the ancient Geometry. He kept up a regular correſpondence with Dr SIMSON, giving him an account of his progreſs, and of his diſcoveries in Geometry, which were now both numerous and important, and receiving in return many curious communications with reſpect to the *Loci Plani*, and the Poriſms of EUCLID. Theſe laſt formed the moſt intricate and paradoxical ſubject in the hiſtory of the ancient Mathematics. Every thing concerning them, but the name, had periſhed. PAPPUS ALEXANDRINUS has made mention of three books of Poriſms written by EUCLID, and has given an account of what they contained; but this

this account has ſuffered ſo much from the injuries of time, that the ſenſe of one propoſition only is complete. There was no diagram to direct the Geometer in his reſearches, nor any general notion of the ſubject, or of the form of the propoſitions, to ſerve as a rule for his conjectures. The taſk, therefore, of reſtoring theſe ancient books, which Dr SIMSON now impoſed on himſelf, exceeded infinitely the ordinary labours of the Critic or the Antiquary; and it was only by uniting the learning and diligence of theſe two characters, with the ſkill of a profound Geometer, that he was at laſt ſucceſsful in this difficult undertaking. He had begun it as early as the year 1727, but ſeems to have communicated the whole progreſs of his diſcoveries to Mr STEWART alone. Account of Dr Stewart.

WHILE the ſecond invention of Poriſms, to which more genius was perhaps required than to the firſt diſcovery of them, employed Dr SIMSON, Mr STEWART purſued the ſame ſubject in a different, and new direction. In doing ſo, he was led to the diſcovery of thoſe curious and intereſting propoſitions, which were publiſhed, under the title of *General Theorems*, in 1746. They were given without the demonſtrations; but did not fail to place their Diſcoverer at once among the Geometers of the firſt rank. They are, for the moſt part, Poriſms, though Mr STEWART, careful not to anticipate the diſcoveries of his friend, gave them no other name than that of Theorems. They are among the moſt beautiful, as well as moſt general propoſitions known in the whole compaſs of Geometry, and are perhaps only equalled by the remarkable *Locus* to the circle in the ſecond book of APOLLONIUS, or by the celebrated theorem of Mr COTES. The firſt demonſtration of any conſiderable number of them, is that which was lately communicated to this Society *, though I believe there are few Mathematicians, into whoſe hands they have fallen, whoſe ſkill they have not often exerciſed. The unity which prevails among them is a proof, that a ſingle, though ex-

* By the Reverend Dr SMALL.

Account of Dr Stewart.

tenſive view, guided Mr STEWART in the diſcovery of them all. It ſeems probable, that, while he aimed at extending Geometry 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 whatever 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, accordingly, were the propoſitions which Mr STEWART now communicated to the world. He ſuppreſſed his inveſtigations, however, 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 patronage of the Earl of BUTE and the Duke of ARGYLE, had obtained the living of Roſeneath. It was in that retired and romantic ſituation, that he diſcovered the greater part of the propoſitions 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 *.

IN

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

Account of Dr Stewart.

In the ſummer of 1746, the Mathematical Chair in the Univerſity 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 reſided at Leadhills, and who was well known in the mathematical world. He, however, declined appearing as a candidate for the vacant chair; and ſeveral others were named, among whom was Mr Stewart. In the end of this year, the *General Theorems* were publiſhed, and gave to their Author a decided ſuperiority above all the other candidates. He was accordingly elected Profeſſor of Mathematics in the Univerſity of Edinburgh, in the beginning of September 1747.

The duties of this office gave a turn ſomewhat different to his mathematical purſuits, and led him to think of the moſt ſimple and elegant means of explaining thoſe difficult propoſitions, which were hitherto only acceſſible to men deeply verſed in the modern analyſis. In doing this, he was purſuing the object which, of all others, he moſt ardently wiſhed to attain, *viz.* the application of Geometry to ſuch problems as the algebraic calculus alone had been thought able to reſolve. His ſolution of Kepler's problem was the firſt ſpecimen of this kind which he gave to the world; and it was impoſſible to have produced one more to the credit of the method he followed, or of the abilities with which he applied it. When the Aſtronomer, from whom that problem takes its name, diſcovered the elliptical motion of the planets, and their equable deſcription of areas round the ſun, 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 ellipſe, that ſhould divide the area of the ſemi-ellipſe in a given ratio. It was ſoon found, that this problem did not admit of an accurate ſolution; and that no more was to be expected, than an eaſy and exact approximation. In this, ever ſince the days of Kepler, the Mathematicians

Account of Dr Stewart.

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 theſe,

theſe, Mr STEWART lays down the doctrine of centripetal forces, in a ſeries of propoſitions, demonſtrated (if we admit the quadrature of curves) with the utmoſt rigour, and requiring no previous knowledge of the Mathematics, except the elements of plain Geometry, and of Conic Sections. The good order of theſe propoſitions, added to the clearneſs and ſimplicity of the demonſtrations, renders this Tract the beſt elementary treatiſe of Phyſical Aſtronomy that is any where to be found. Account of Dr Stewart.

IN the three remaining Tracts, our Author had it in view to determine, by the ſame rigorous method, the effect of thoſe forces which diſturb the motions of a ſecondary planet. From this he propoſed to deduce, not only a theory of the moon, but a determination of the ſun's diſtance from the earth. The former is well known to be the moſt difficult ſubject to which Mathematics have been applied. Though begun by Sir ISAAC NEWTON, and explained, as to its principles, with ſingular ſucceſs; yet, as to the full detail and particular explanation of each irregularity, it was left by that great Philoſopher, leſs perfect than any other of his reſearches. Succeeding Mathematicians had been employed about the ſame ſubject; the problem of the *Three bodies* had been propoſed in all its generality, and in as far as regards the motion of the moon, had been reſolved by a direct and accurate approximation. But the intricacy and length of theſe calculations rendered them intelligible only to thoſe, who were well verſed in the higher parts of the Mathematics. This was what Dr STEWART propoſed to remedy, by giving a theory of the moon that might depend, if poſſible, on Elementary Geometry alone, or which ſhould, at leaſt, be the ſimpleſt that the nature of things would allow. The Tracts were deſtined to ſerve as the baſis of this inveſtigation. We are not, however, to imagine, that Dr STEWART intended to proceed in the ſame direct manner that CLAIRAULT, and ſome other Geometers, had done. It is not probable, that he believed this to be within

Account of Dr Stewart.

in the power of pure Geometry. His deſign undoubtedly was, to purſue that method of approximation which Sir ISAAC NEWTON had begun, and which CALLENDRINI, MACHIN and WALMSLEY had greatly improved; and, by uſing the methods of Geometry, he hoped to reduce the problem to its ultimate ſimplicity. Such an undertaking was worthy of a great Geometer, and of a Philoſopher, who conſidered that one of the chief obſtructions to the advancement of knowledge, is the difficulty of ſimplifying that knowledge, which has already been acquired. We muſt regret, therefore, that the decline of Dr STEWART's health, which began ſoon after the publication of the Tracts, did not permit him to purſue this inveſtigation.

THE other object of the Tracts was to determine the diſtance of the ſun, from his effect in diſturbing the motions of the moon. The approach of the tranſit of Venus, which was to happen in 1761, had turned the attention of Mathematicians to the ſolution of this curious problem. But when it was conſidered, of how delicate a nature the obſervations were from which that ſolution was to be deduced, and to how many accidents they were expoſed, it was natural, that ſome attempt ſhould be made to aſcertain the dimenſions of our ſyſtem, by means leſs ſubject to diſappointment. Such accordingly was the deſign of Dr STEWART; and his enquiries into the lunar irregularities had furniſhed him with the means of accompliſhing it.

THE theory of the compoſition and reſolution of forces enables us to determine what part of the ſolar force is employed in diſturbing the motions of the moon; and, therefore, could we meaſure the inſtantaneous effect of that force, or the number of feet by which it accelerates or retards the moon's motion in a ſecond, we ſhould be able to determine how many feet the whole force of the ſun would make a body, at the diſtance of the moon, or of the earth, deſcend in a ſecond, and, conſequently, how much the earth is, in every inſtant,

Account of Dr Stewart.

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 meaſured; and that it is only the effect of that force, continued for an entire revolution, or ſome conſiderable portion of a revolution, 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 motions of the latter are diſturbed, the farther off the ſun is ſuppoſed, 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 quantity, 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. Indeed, 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 longer axis of that orbit has an angular motion, by which it

Account of Dr Stewart.

goes back about three degrees in every lunation, and completes an entire revolution in nine years nearly. This motion, though very remarkable and eaſily determined, has the ſame fault, in reſpect of the preſent problem, that was aſcribed to the other irregularities of the moon; for a very ſmall part of it only depends on the parallax of the ſun; and of this Dr STEWART, as will afterwards appear, ſeems not to have been perfectly aware.

THE propoſitions, however, which defined the relation between the ſun's diſtance and the mean motion of the apogee, were publiſhed among the Tracts in 1761. The tranſit of Venus happened in that ſame year: the Aſtronomers returned, who had viewed that curious phænomenon from the moſt diſtant ſtations; and no very ſatisfactory reſult was obtained from a compariſon of their obſervations. Dr STEWART then reſolved to apply the principles he had already laid down; and, in 1763, he publiſhed his eſſay on the ſun's diſtance, where the computation being actually made, the parallax of the ſun was found to be no more than 6″. 9. and his diſtance, of conſequence, almoſt 29875 ſemidiameters of the earth*.

A DETERMINATION of the ſun's diſtance, that ſo far exceeded all former eſtimations of it, was received with ſurpriſe, and the reaſoning on which it was founded was likely to be ſubjected to a ſevere examination. But, even among Aſtronomers, it was not every one who could judge in a matter of ſuch difficult diſcuſſion. Accordingly, it was not till about five years after the publication of the *Sun's Diſtance*, that there appeared a pamphlet under the title of *Four Propoſitions*, intended to point out certain errors in Dr STEWART's inveſtigation, which had given a reſult much greater than the truth. A diſpute in Geometry was matter of wonder to many, and perhaps

* About 118,541,428 Engliſh miles.

Account of Dr Stewart.

perhaps of ſatisfaction 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

Account of Dr Stewart.

given riſe. In this laſt, however, he has not completely ſucceeded; and that, too, by committing a miſtake ſimilar to that which he cenſured in Dr STEWART, and by rejecting quantities not leſs than ſome which he retained. He obſerved, however, what produced the compenſation that has been taken notice of, *viz.* the immenſe variation of the ſun's diſtance, which correſponds to a very ſmall variation of the motion of the moon's apogee. It is doubtful, whether Dr STEWART was fully appriſed of this circumſtance; becauſe the geometrical method, elegant and beautiful as it is, rarely preſents a general view of the relations, which the magnitudes it treats of bear to one another; and many of theſe relations may, therefore, eſcape the moſt profound Geometer, which an Algebraiſt, of more ordinary abilities, would not have failed to diſcover.

THERE are other of this Author's ſtrictures, which we cannot admit as juſt, but which we will not attempt here, either to enumerate or refute. Yet it were doing great injuſtice to his remarks not to acknowledge, that, beſides being juſt in the points already mentioned, they are, every where, ingenious, and written with much modeſty and good temper. The Author, who concealed his name, and permits it now, for the firſt time, to be publicly mentioned, was Mr DAWSON, a ſurgeon at Sudbury in Yorkſhire; a man, as it ſhould ſeem, who might have enjoyed more of the fame, had he been leſs ſatisfied with the poſſeſſion of knowledge.

A SECOND attack was ſoon after this made on the *Sun's Diſtance*, by Mr LANDEN; but by no means with the ſame good temper which has been remarked in the former. He fancied to himſelf errors in Dr STEWART's inveſtigation, which have no exiſtence; he exaggerated thoſe that were real, and ſeemed to triumph in the diſcovery of them with unbecoming exultation. If there are any ſubjects on which men may be expected to reaſon diſpaſſionately, they are certainly the properties of number

Account of Dr Stewart.

number and extenſion; and whatever pretexts Moraliſts or Divines may have for abuſing one another, Mathematicians can lay claim to no ſuch indulgence. The aſperity of Mr LANDEN's animadverſions muſt not, therefore, paſs uncenſured, though it be united with ſound reaſoning and accurate diſcuſſion. The error into which Dr STEWART had fallen, though before taken notice of by Mr DAWSON, was firſt exactly determined in the work before us *. But Mr LANDEN, in the zeal of correction, brings many other charges againſt Dr STEWART, the greater part of which ſeem to have no good foundation. Such are his objections to the ſecond part of the inveſtigation, where Dr STEWART finds the relation between the diſturbing force of the ſun, and the motion of the apſides of the lunar orbit. For this part, inſtead of being liable to objection, is deſerving of the greateſt praiſe, ſince it reſolves, by Geometry alone, a problem which had eluded the efforts of ſome of the ableſt Mathematicians, even when they availed themſelves of the utmoſt reſources of the integral calculus. Sir ISAAC NEWTON, though he aſſumed the diſturbing force very near the truth, computed the motion of the apſides from thence only at one half of what it amounts to in reality; and ſo, had he been required, like Dr STEWART, to invert the problem, he would have committed an error, not merely of a few thouſandth parts, as the latter is alleged to have done, but would have brought out a reſult double of the truth †. MACHIN and CALLENDRINI, when commenting on this part of the *Principia*, found a like inconſiſtency between their theory and obſervation. Three other celebrated Mathematicians, CLAIRAULT, D'ALEMBERT and EULER, ſeparately experienced the ſame difficulties,

* IT is but juſtice to remark, that Mr LANDEN had probably never ſeen Mr DAWSON's Propoſitions at the time his own were publiſhed, the whole impreſſion of them, almoſt, having been burnt by a fire which conſumed the warehouſe where they were lodged.

† Prin. Math. lib. 3. prop. 3.

Account of Dr Stewart.

ficulties, and were led into an error of the ſame magnitude. It is true, that, on reſuming their computations, they found, that they had not carried their approximations to a ſufficient length, which when they had, at laſt, accompliſhed, their reſults agreed exactly with obſervation. Mr WALMSLEY and Dr STEWART were, I think, the firſt Mathematicians, who, employing in the ſolution of this difficult problem, the one the algebraic calculus, and the other the geometrical method, were led immediately to the truth; a circumſtance ſo much for the honour of both, that it ought, by no means, to be forgotten. It was the buſineſs of an impartial critic, while he examined our Author's reaſonings, to have remarked, and to have weighed theſe conſiderations.

WE may add, that the accurate meaſurement of the ſun's diſtance, and the complete theory of the moon's motions, with which ſcience has been enriched, ſince the time to which we now refer, ſufficiently vindicate the principle of Dr STEWART's inveſtigation, and ſhow how much reaſon he had to expect, that the former might be inferred from the latter with conſiderable exactneſs. M. MAYER, from one of the lunar irregularities, computes the ſun's parallax to be 7″. 8, nearly a mean between the parallax already mentioned, and that which has been deduced from the tranſit of Venus in 1769 *.

ON the whole, therefore, while it muſt be acknowledged, that Dr STEWART's determination of the ſun's diſtance is, by no means, free from error, it may ſafely be aſſerted, that it contains a great deal which will always intereſt Geometers, and always be admired by them. Few errors in ſcience are redeemed by the diſplay of ſo much ingenuity, and what is more ſingular, of ſo much ſound reaſoning. The inveſtigation is every where elegant, and will, probably, be long regarded as a ſpecimen of the moſt arduous enquiry which has been attempted by mere Geometry; at the ſame time, the miſtake into which the geometrical method has betrayed this great Mathematician, will ſerve

* Theoria Lunæ, ſect. 51.

ſerve as a proof that it is not equal to ſuch difficult reſearches; and that in thoſe caſes, eſpecially, where approximation is to be uſed, it is neceſſary to ſacrifice the rigour of the ancient demonſtration for the accuracy of the modern analyſis. Account of Dr Stewart.

THE *Sun's Diſtance* was the laſt work which Dr STEWART publiſhed; and though he lived to ſee the animadverſions made on it, that have been taken notice of above, he declined entering into any controverſy. His diſpoſition was far from polemical; and he knew the value of that quiet, which a literary man ſhould rarely ſuffer his antagoniſts to interrupt. He uſed to ſay, that the deciſion of the point in queſtion was now before the public; that, if his inveſtigation was right, it would never be overturned, and that, if it was wrong, it ought not to be defended.

A FEW months before he publiſhed the Eſſay juſt mentioned, he gave to the world another work, entitled, *Propoſitiones Geometricæ More Veterum Demonſtratæ.* This title, I have been told, was given it by Dr SIMSON, who rejoiced in the publication of a work ſo well calculated to promote the ſtudy of the ancient Geometry. It conſiſts of a ſeries of geometrical theorems, for the moſt part, new; inveſtigated, firſt, by an analyſis, and afterwards ſynthetically demonſtrated by the inverſion of the ſame analyſis. In the former, the propoſition to be inveſtigated is ſuppoſed true; from thence conſequences are deduced, and the reaſoning is carried on till ſome conſequence is drawn that is already known to be true. A neceſſary connection is thus traced between the propoſition that was ſuppoſed true, and another that is certainly known to be ſo; and, thus, an ingenious method is laid down for making the knowledge of any truth ſubſervient to the diſcovery of its demonſtration. This method made an important part in the analyſis of the ancient Geometers; but few examples of it have been preſerved in their writings, and thoſe in the *Propoſitiones Geometricæ*, are, on that account, the more valuable.

Dr

Account of Dr Stewart.

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 STEWART 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

Account of Dr Stewart.

conſolation to ſee a laſting monument raiſed to the fame of his friend, by the munificence of Lord STANHOPE, who, by the publication of Dr SIMSON's poſthumous works, has obliged the world with a *reſtoration* of the moſt curious fragment of the Greek Geometry.

SOON after the publication of the *Sun's Diſtance*, Dr STEWART's health began to decline, and the duties of his office became burdenſome to him. In the year 1772, he retired to the country, where he afterwards ſpent the greater part of his life, and never reſumed his labours in the Univerſity. He was, however, ſo fortunate as to have a ſon, to whom, though very young, he could commit the care of them with the greateſt confidence. Mr DUGALD STEWART, having begun to give lectures for his father from the period above mentioned, was elected joint Profeſſor with him in 1775, and gave an early ſpecimen of thoſe abilities, which have not been confined to a ſingle ſcience.

AFTER mathematical ſtudies (on account of the bad ſtate of health into which Dr STEWART was now falling) had ceaſed to be his buſineſs, they continued to be his amuſement. The analogy between the circle and hyperbola had been an early object of his admiration. The extenſive views which that analogy is continually opening; the alternate appearance and diſappearance of reſemblance in the midſt of ſo much diſſimilitude, make it an object that aſtoniſhes the experienced, as well as the young Geometer. To the conſideration of this analogy, therefore, the mind of Dr STEWART very naturally returned, when diſengaged from other ſpeculations. His uſual ſucceſs ſtill attended his inveſtigations; and he has left, among his papers, ſome curious approximations to the areas, both of the circle and hyperbola. For ſome years toward the end of his life, his health ſcarcely allowed him to proſecute ſtudy even as an amuſement. He died January 23. 1785, at the age of 68.

Account of Dr Stewart.

THE habits of ſtudy, in a man of original genius, are objects of curioſity, and deſerve to be remembered. Concerning thoſe of Dr STEWART, his writings have made it unneceſſary to remark, that, from his youth, he had been accuſtomed to the moſt intenſe, and continued application. In conſequence of this application, added to the natural vigour of his mind, he retained the memory of his diſcoveries in a manner that will hardly be believed. He rarely wrote down any of his inveſtigations, till it became neceſſary to do ſo for the purpoſe of publication. When he diſcovered any propoſition, he would put down the enunciation with great accuracy, and, on the ſame piece of paper, would conſtruct very neatly the figure to which it referred. To theſe he truſted for recalling to his mind, at any future period, the demonſtration, or the analyſis, however complicated it might be. Experience had taught him, that he might place this confidence in himſelf without any danger of diſappointment; and for this ſingular power, he was probably more indebted to the activity of his invention, than the mere tenaciouſneſs of his memory.

THOUGH he was extremely ſtudious, he read few books, and verified the obſervation of M. D'ALEMBERT, that, of all the men of letters, Mathematicians read leaſt of the writings of one another. His own inveſtigations occupied him ſufficiently; and, indeed, the world would have had reaſon to regret the miſapplication of his talents, had he employed, in the mere acquiſition of knowledge, that time which he could dedicate to works of invention.

IT was his cuſtom to ſpend the ſummer at a delightful retreat in Ayrſhire, where, after the academical labours of the winter were ended, he found the leiſure neceſſary for the proſecution of his reſearches. In his way thither, he frequently made a viſit to Dr SIMSON at Glaſgow, with whom he had lived from his youth in the moſt cordial and uninterrupted friendſhip.

ſhip. It was pleaſing to obſerve, in theſe two profound Mathematicians, 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 enquiries of the moderns. Dr STEWART, in particular, had remarked 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 occaſions, may be given of the moſt difficult propoſitions, inveſtigated 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 analyſis. But, if it be confeſſed, that Dr STEWART rated, in any reſpect too high, the merit of the former of theſe ſciences,

Account of Dr Stewart.

* 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 Glaſgow, an intimate friend of Dr SIMSON, and a great admirer of the ancient Geometry:

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

Account of Dr Stewart.

this may well be excuſed in the man whom it had conducted to the diſcovery of the *General Theorems*, to the *ſolution of* KEPLER's *Problem*, and to an *accurate* determination of the *Sun's diſturbing force*. His great modeſty made him aſcribe to the method he uſed, that ſucceſs which he owed to his own abilities.

DONATIONS

DONATIONS presented to the ROYAL SOCIETY *of Edinburgh.*

[*N. B.* The numbers refer to the order in which the articles are depoſited in the Muſeum of the Univerſity of Edinburgh.]

By his Grace the Duke of *Buccleugh.*

The Head, Horns and Bones of the BISON *Scoticus*, found in a peat-moſs upon the Duke's eſtate in Roxburghſhire. No. 1.—4.

By Dr *Alexander Monro.*

Thirty-eight coloured Drawings of Birds, of the ſouthern hemiſphere. No. 5.—42.

The Head and Horns of the *Arnee*, from Bengal. No. 43.

By the Honourable Lord *Dunſinnan.*

A painting in oil, of the Head and Horns of an Elk, found in a marl-pit in Forfarſhire. No. 44.

By the Honourable Lord *Hailes.*

A large Maſs of the Rock at Gibraltar, containing Bones. No. 45.

The Ear of a Whale, from Greenland. No. 46.

The Head of a Fiſh, petrified. No. 47.

The *Vertebræ* of three different ſpecies of animals, petrified. No. 48. 49. 50.

Gloſſopetræ, belonging to two different ſpecies of Shark. No. 51. 52.

Two cruſtaceous animals petrified. No. 53. 54.

Three

List of Donations.

Three different ſpecies of *Echinus* petrified. No. 55. 56. 57.
Four different ſpecies of *Nautilus* petrified. No. 58.—62.
Six different ſpecies of turbinated Shells petrified. No. 63.—68.
Ten ſpecies of turbinated Shells petrified. No. 69.—78.
Three ſpecies of Shells. No. 79.—81.
Four ſpecies of *Madrepore*. No. 82.—85.
Red Coral from the Mediterranean. No. 86.
Six ſpecies of *Gorgonia*. No. 87.—92.
SPONGIA *Aculeata*. LIN. No. 93.
OSTREA *Folium*. LIN. No. 94.
Two Indian Arrows poiſoned. No. 95.

By Captain *Fairfax* of the Navy.

Five ſpecies of Fiſhes from the Spaniſh main. No. 96.—100.

By the Reverend Dr *Bowmaker*, Miniſter of Dunſe.

Two ſpecies of Serpents from Florida. No. 101. 102.

By the Right Honourable Lord *Daer*.

A collection of Indian Arms, Apparel and Utenſils, from the South Seas; made during Captain *Cook's* laſt voyage. No. 103.—177.

A collection of Indian Arms, Apparel and Utenſils, and of Natural Productions, made in the South Sea iſlands, and on the weſt coaſt of America, by Mr *Anderſon*, Surgeon to Captain *Cook*. No. 178.—274.

By the Earl of *Hopetoun*.

A cabinet of Foſſils, containing the following articles:
Fifty-five ſpecies and varieties of antique Marbles. No. 275.—338.
Six ſpecies of Florentine Marbles and other Landſcape Stones. No. 339.—344.
Seventeen ſpecies and varieties of the *Phengites*, or antique Oriental Alabaſter. No. 345.—411.

Thirty

Thirty-five ſpecies and varieties of thoſe antique Stones which are called by the Italians *Pietre dure*. They all belong to the ſiliceous claſs, and to the following genera:

Jaſper, *Heliotrope*, *Petroſilex*, *Sinople*, *Lazuli*, *Chalcedony*, *Agate*, *Mocho*, *Jaſper Agate*, *Egyptian Pebble*, *Onyx*, *Sardonyx*, and *Camea*.

Nine ſpecies of antique *Porphyry*, *Serpentine*, and *Granite*. No. 539.—554.

Earths, three ſpecies. No. 555.—557.

Cryſtallized *Shorls*, two ſpecies. No. 558.—565.

Garnets, three ſpecies. No. 566.—569.

Semipellucid Gems, five ſpecies. No. 570.—574.

Steatitical Stones, ſix ſpecies and varieties. No. 575.—583.

Amiantus, two ſpecies. No. 584. 585.

Zeolitical Stones, four ſpecies. No. 586.—598.

Verd d'Ecoſſe, Davila, cat. 2. p. 125. n. 4. No. 599.

Nickel and Cobalt, two ſpecies. No. 600.—605.

Cubical Marcaſite. No. 606.

FERRUM *Hæmatites*. β nigrum, LIN. No. 607.

Grey, black and yellow Ores of Copper. No. 608.—616.

Eight ſpecies and varieties of Lead Ores. No. 617.—636.

Varieties of Copper Ore. No. 637.—643.

Varieties of Silver Ores. No. 644.—660.

A large maſs of green antique Jaſper poliſhed. No. 661.

An Axe of black Whinſtone, ſuppoſed to have been uſed by the Druids in their ſacrifices. No. 662.

Petrified Corals from Weſt Lothian. No. 663. 664. 665.

An ancient Amulet, called by the vulgar an *Adder Stone*. No. 666.

Three ſpecies of Indian Nuts. No. 667. 668. 669.

Two *Goa* Stones. No. 670. 671.

By *John Macgowan*, Eſq; Edinburgh.

GORGONIA *Norvegica*, the great Norway Sea Shrub. No. 672.

CROTALUS *Dryinas*. LIN. No. 673.

Two

List of Donations.

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*, Eſq; 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, relative 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.*

Obſervations on the Diſeaſes of Seamen. 8vo. *Lond.* 1785.

By Dr *Robert Boyd.*

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

By *H. F. A. De Rouſſel*, M. D. and Profeſſor of Medicine in the Univerſity of Caen.

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

By *Joannes-Franciſcus Coſte, &c.*

De Antiqua Medico-Philoſophia Orbi novo adaptanda, Oratio habita in Comitiis Univerſitatis 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 Céleſtes. Tom. 1. 4to. Paris 1786.

By *M. l'Abbé Treſſan, (à Rouen.)*

Eſſai ſur la Fluide Electrique, par feu M. le Comte de Treſſan, (ſon Pere.) 2 toms. 8vo. *

* Other Donations have been received, a Liſt of which is reſerved for Vol. II.

January 1. 1788.

LIST of all the MEMBERS *or* FELLOWS *of the* ROYAL SOCIETY *of Edinburgh.*

I.

MEMBERS upon the Liſt at the firſt 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 deceaſed. *P* added denotes of the PHYSICAL CLASS, and *L* of the LITERARY CLASS.]

1. RESIDENT MEMBERS.

A.

Alexander Abercrombie, Eſq; Advocate. *L.*

* *James Anderſon*, LL. D. *P.*

B.

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

* *Joſeph Black*, M. D. Profeſſor of Medicine and Chemiſtry in the Univerſity of Edinburgh. *P.*

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

Robert Blair, Eſq; Advocate. *L.*

John Bruce, M. A. Profeſſor of Logic in the Univerſity of Edinburgh. *L.*

† *Robert Bruce*, Eſq; of Kennet, one of the Senators of the College of Juſtice. *P.*

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

Reſident Members.

C.

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

John Campbell, Eſq; of Stonefield, one of the Senators of the College of Juſtice. *L.*

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

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

John Clerk, Eſq; of Eldin. *P.*

William Craig, Eſq; Advocate. *L.*

* † *Andrew Croſbie*, Eſq; Advocate. *P.*

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

Robert Cullen, Eſq; Advocate. *L.*

* *William Cullen*, M. D. Profeſſor of the Practice of Phyſic in the Univerſity of Edinburgh. *P.*

D.

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

Andrew Dalzel, M. A. Profeſſor of Greek in the Univerſity of Edinburgh. *L.*

John Davidſon, Eſq; Clerk to the Signet. *L.*

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

* *Andrew Duncan*, M. D. Phyſician to his Royal Highneſs the Prince of Wales.

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

† Right Hon. *Robert Dundas* of Arniſton, Lord Preſident of the Court of Seſſion. *L.* ‖

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

E.

James Edgar, Eſq; Commiſſioner of the Cuſtoms. *L.*

David Erſkine, Eſq; Clerk to the Signet. *L.*

Colonel *James Edmondſtoune*, of Newton.

Adam

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

Reſident Members.

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

Reſident Members.

* † *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

Reſident Members.

William Morehead, Eſq; *L.*

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

N.

William Nairne, Eſq; of Dunſinnan, Advocate; now one of the Senators of the College of Juſtice. *L.*

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

P.

* *John Playfair*, M. A. now Profeſſor of Mathematics in the Univerſity of Edinburgh. *P.*

John Pringle, Eſq; Advocate. *L.*

Mark Pringle, Eſq; Advocate. *L.*

R.

David Rae, Eſq; of Eſkgrove, one of the Senators of the College of Juſtice. *L.*

James Robertſon, D. D. Profeſſor of Oriental Languages in the Univerſity of Edinburgh. *L.*

William Robertſon, D. D. Principal of the Univerſity of Edinburgh. *L.*

William Robertſon, Eſq; Advocate. *L.*

* *John Robiſon*, M. A. Profeſſor of Natural Philoſophy in the Univerſity of Edinburgh. *P.*

Adam Rolland, Eſq; Advocate. *L.*

* Mr *James Ruſſell*, Surgeon. *P.*

* *John Ruſſell*, Eſq; Clerk to the Signet. *L.*

* *Daniel Rutherford*, M. D. now King's Botaniſt in Scotland, and Profeſſor of Medicine and of Botany in the Univerſity of Edinburgh. *P.*

S.

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

* *Adam Smith*, LL. D. F. R. S. LOND. Commiſſioner of the Cuſtoms in Scotland. *L.*

John

Reſident Members.

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

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

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

* *Dugald Stewart*, M. A. formerly Profeſſor of Mathematics, now of Moral Philoſophy, in the Univerſity of Edinburgh. *P.*

* † *Matthew Stewart*, D. D. Emeritus Profeſſor of Mathematics in the Univerſity of Edinburgh. *P.*

* *Alexander Fraſer-Tytler*, Eſq; Advocate, Profeſſor of Civil Hiſtory, and of Greek and Roman Antiquities, in the Univerſity of Edinburgh. *L.*

William Tytler, Eſq; of Woodhouſelee, Clerk to the Signet. *L.*

W.

* *John Walker*, D. D. M. D. Regius Profeſſor of Natural Hiſtory, and Keeper of the Muſeum in the Univerſity of Edinburgh. *P.*

George Wallace, Eſq; Advocate. *P.*

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

V.

James Veitch, Eſq; of Elliock, one of the Senators of the College of Juſtice. *L.*

2. Non-resident Members.

A.

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

* *John Amyatt*, Eſq; King's Chemiſt, London. *P.*

John Anderſon, M. A. F. R. S. Lond. Profeſſor of Natural Philoſophy in the Univerſity of Glaſgow. *P.*

Mr

Non-Reſident Members.

* 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 Philoſophy, 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, Aberdeen. *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 Univerſity 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.*

Non-Reſident Members.

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

Non-Reſident Members.

I.

George Jardine, M. A. Profeſſor of Logic in the Univerſity of Glaſgow. *L.*

† *William Irvine*, M. D. Lecturer on Chemiſtry in the Univerſity of Glaſgow. *P.*

L.

John Leſlie, A. M. Profeſſor of Greek, King's College, Aberdeen. *L.*

* *James Lind*, M. D. Haſlar Hoſpital. *P.*

* *James Lind*, M. D. Windſor.

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

* *Andrew Lumiſden*, Eſq;

M.

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

Hugh M'Leod, D. D. Profeſſor of Church Hiſtory in the Univerſity of Glaſgow. *L.*

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

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

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

* *John Mudie*, M. D. Montroſe. *P.*

O.

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

R.

William Richardſon, A. M. Profeſſor of Humanity in the Univerſity of Glaſgow. *L.*

Thomas Reid, D. D. Emeritus Profeſſor of Moral Philoſophy in the Univerſity of Glaſgow. *L.*

Non-Reſident Members.

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 Univerſity 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 Univerſity of St Andrew's. *P.*

W.

James Williamſon, D. D. Profeſſor of Mathematics in the Univerſity 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.

Non-Resident Members.

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.

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.

II.

MEMBERS chosen since the first Meetings of the Classes.

Members chosen, Jan. 26. 1784.

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 Drysdale, 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. 1784, all Ordinary Members : Members choſen, June 28. 1784.

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. 1785, all Ordinary Members : Members choſen, June 24. 1785.

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, Eſq; of London. *P.*
George Young, M. D. Phyſician to the Military Hoſpital in the Weſt Indies. *P.*
James Hare, M. D. Eaſt Indies. *P.*

Members choſen, Jan. 23. 1786.

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

1. RESIDENT.

Robert Blair, M. D. Regius Profeſſor of Practical Aſtronomy in the Univerſity of Edinburgh. *P.*
Alexander Millar, Eſq; 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 Aſtle, Eſq; F. SS. R. & A. LOND. Keeper of the Records in the Tower of London. *L.*
Charles Hutton, LL. D. F. R. S. LOND. Profeſſor of Mathematics in the Military Academy at Woolwich. *P.*
Handyſide Edgar, M. D. Jamaica. *P.*

Members choſen, Jan. 22. 1787.

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

1. RESIDENT.

William Stewart, Eſq; Advocate. *L.*
George Brown, Eſq; Commiſſioner of the Cuſtoms. *L.*
James Home, M. D. Edinburgh. *P.*

James

James Finlayſon, A. M. Profeſſor of Logic in the Univerſity of Edinburgh. *L.*

2. NON-RESIDENT.

James Playfair, D. D. Miniſter at Meigle. *L.*
Adair Crawford, M. D. Phyſician to St Thomas's Hoſpital, London. *P.*
Thomas Percival, M. D. F. R. S. LOND. at Mancheſter. *P.*
John Haygarth, M. B. F. R. S. LOND. at Cheſter. *P.*

3. FOREIGN.

M. le Preſident de Virly, Dijon. *P.*
John Bacounin, Eſq; of Ruſſia. *L.*

Office-Bearers of the Society.

General Office-Bearers.

GENERAL OFFICE-BEARERS, elected at the firſt and ſecond General Meetings, holden June 23. and Auguſt 4. 1783.

Preſident.

His Grace the Duke of BUCCLEUGH.

Vice-Preſidents.

Right Hon. *Henry Dundas.* | *Tho. Miller*, Eſq; Ld. Juſtice-Clerk.

Secretary.

Mr *John Robiſon.*

Treaſurer.

Mr *Alexander Keith.*

Counſellors.

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

Office-Bearers of the Claſſes.

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

PHYSICAL CLASS.

Preſidents.

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

Secretaries.

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

LITE-

* March 1. 1784, Dr *Alexander Monro* was elected a Preſident of the Phyſical Claſs in the room of Sir *George Clerk* deceaſed.

LITERARY CLASS.

Presidents.

Ilay Campbell, Esq; Ld. Advocate.	Lord *Elliock*.
Dr *William Robertson*.	Dr *Hugh Blair*.

Secretaries.

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

THE same OFFICE-BEARERS were continued by re-election till Nov. 27. 1786, when, in consequence 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 last Monday of November.

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

General Office-Bearers.

President.

His Grace the Duke of BUCCLEUGH.

Vice-Presidents.

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

Secretary.	Treasurer.
Mr *John Robison*.	Mr *Alexander Keith*.

Counsellors.

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

PHYSICAL

Office-Bearers of the Claſſes.

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 diſcovery of the circulation of the blood in animals was ſoon followed by conjectures concerning the exiſtence of a like circulation in the ſap of vegetables. Theſe conjectures gave riſe to the firſt improvements in vegetable phyſiology, which may be dated from the appearance of a ſet of queries concerning the motion of the juices of plants, publiſhed in the Philoſophical Tranſactions, *anno* 1668. Theſe queries immediately engaged Dr BEALE and Dr TONGE, and afterwards Dr GREW, Mr WILLOUGHBY, Mr RAY, and Dr LISTER, to enter upon the ſubject; who, in a great variety of obſervations, ſtruck out the firſt conſiderable diſcoveries in the vegetable œconomy.

THEIR obſervations, however, fell ſhort either of proving or diſproving a circulation of the ſap: Nor have the diſcoveries of a variety of Philoſophers, ſince that time, been able to demonſtrate either ſide of the queſtion; which ſtill remains a controverted and undetermined point in the hiſtory of vegetation.

To trace the progreſs of the ſap, in the way of experiment, ſeems to be the only method by which we can expect to arrive at

at a ſatisfactory ſolution of this intricate queſtion. For this purpoſe, thoſe trees which are ſaid to bleed are the moſt convenient; or thoſe which, at a certain ſeaſon of the year, have ſuch an exuberance of ſap, that it flows freely from them upon a ſlight inciſion. PLINY * mentions twice the bleeding of the mulberry; but he ſpeaks of it as an extraordinary phænomenon, and ſeems to have been unacquainted with the bleeding of the vine. The trees of this ſort are indeed more frequent in the cold than in the warmer climates. Some trees of our own country do not bleed, ſuch as the *oak*, *aſh*, *elm*, *aſpen*, *hazel*, and *hawthorn*. Of thoſe that bleed, the birch and the plane are the moſt remarkable; and upon theſe the experiments here related were performed.

IN the laſt age, the following important query was propoſed on this ſubject by Dr LISTER †:

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

FIFTY years afterwards, this queſtion, ſtill unreſolved, was again reſumed by Dr HALES ‡, who, in arguing againſt the circulation of the ſap, expreſſes himſelf thus:

"IF, ſays he, early in the ſpring, the oak, and ſeveral other "trees, were to be examined near the top and bottom, when the "ſap firſt begins to move, ſo as to make the bark eaſily run or "peel off, I believe it would be found, that the lower bark "would be firſt moiſtened; whereas the bark of the top-branches "ought firſt to be moiſtened, if the ſap deſcends by the bark."

OF late years, M. BONNET, when reaſoning in favour of a circulation, and againſt this ſuppoſition of Dr HALES, delivers the following remarks:

"Is it eaſy, ſays he, exactly to fix the time when the ſap "begins to riſe in trees? That fluid riſes at firſt in very ſmall "quantity;

* Nat. Hiſt. lib. xvi. cap. 38.—Lib. xxiii. cap. 7.

† Philoſ. Tranſ. *anno* 1671, p. 2122.

‡ Vegetable Staticks, vol. i. p. 141.

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

But after the doctrine of the circulation of the ſap has been agitated for above a century paſt; after ſo many obſervations, and ſuch lengthened philoſophical diſcuſſions upon the ſubject; is it not ſurpriſing that this enquiry, firſt ſtarted by Dr Lister, and ſince ſuggeſted by Dr Hales, ſhould have been ſo much overlooked, and ſhould ſtill remain undetermined by experiment, when it is evidently the previous and leading enquiry on the ſubject?

M. Bonnet, indeed, in the above paſſage, ſeems to think, that the deciſion of this queſtion by experiment muſt be extremely difficult, if not impracticable. But that this is far from being the caſe, will appear from the ſequel of the preſent 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 ſucceſſion: How far the aſcent and diffuſion of the ſap depends on the temperature of the air: To trace the route which it obſerves, and to obtain ſatisfaction concerning what is called its *recidivation*, and in ſeveral other particulars relative to its movement.

From this experiment alſo, ſome light was expected concerning a noted problem in vegetation, Why the terminating buds of trees are the firſt which are diſcloſed in the ſpring.

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

On the 1ſt of February, there was a hole bored in the trunk of this tree, cloſe by the ground, and one of its branches cut at the extremity, in order to diſcover when and where the running of the ſap would firſt appear. This was repeated every ſecond

* Bonnet ſur l'Uſage des Feuilles, p. 284.

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

MARCH 5.

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.

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 1. 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 1. 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 ſhewing a little more moiſture between the wood and bark.

OBSERVATION 1. The ſap then on this day, which was the warmeſt ſince the 1ſt of February, with bright ſun-ſhine, had riſen a foot, or a little more, in the trunk of the tree, ſo as to bleed at an inciſion.

OBS. 2. At this inciſion, a foot from the ground, the ſap flowed only from the wood. The bark, which was of a conſiderable thickneſs, was quite dry, and not a drop was formed till the wood was penetrated. The moiſture between the wood and bark was indeed conſiderable, but not ſufficient to bleed.

EXP. 2. This day inciſions were made upon another birch, which was found to bleed copiouſly, both in its trunk and branches. The ſap, therefore, in this tree was farther advanced, by ſeveral days, than in that which was the chief object of our experiments. The latter roſe in one trunk, and ſtood in a thin ſoil and expoſed ſituation. The former was a younger tree, had a great number of luxuriant ſuckers, conſequently more vigorous roots, and was placed in a deep rich ſoil, in a low warm part of the wood. To theſe differences may be attributed the more forward aſcent of the ſap in this tree above the other.

EXP. 3. A little paſt ſix o'clock in the evening, when the ſun was ſet, the two inciſions which bled at mid-day were dried up; nor did the ſap iſſue at a new inciſion made a foot from the ground. But an inciſion made at that height in the other tree, through which the ſap was wholly diffuſed, ſtill bled.

MARCH 12.

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

THE two loweſt inciſions bled as on the former day; and the third inciſion, two feet from the ground, began to bleed for the firſt time; but the fourth inciſion, and thoſe above it, were ſtill 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.

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 inciſions bled this day. The fifth, which had bled on the two preceding days, was only moiſt.

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

OBS. 9. It was now obſerved, and always found to be the caſe afterwards, that each inciſion bled ſparingly at firſt, and more plentifully as the ſap aſcended higher. The moſt copious flow of the ſap was always from the loweſt inciſions. When the birch tree, therefore, is to be pierced, in order to procure a large quantity of its ſap, it will be found proper to make the inciſions as near the ground as poſſible.

MARCH 18.

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

THE five lower inciſions bled, as on the former days ; but the ſixth ſtill continued dry.

OBS. 10. The ſap, by the temperature of the air, is capable of remaining long ſtationary. During the four laſt days, it ſtood nearly at the height of four feet, without aſcending farther. In another experiment, the ſap continued ſtationary 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 ſun, 65.

THE ſixth inciſion did this day bleed for the firſt time; the ſeventh was moiſt, and the reſt dry. But though the inciſions in the trunk above the ſixth, and ſome that were made in the branches, did not bleed ; yet they did all along gradually and viſibly increaſe in moiſture.

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 the

the caſe, the eccentricity is to be aſcribed to a different and more general cauſe, which is pointed out in the above experiment.

For as there is a more copious flow of the ſap on the ſouth than on the north ſide of trees, owing to the one being more in the ſun, and the other in the ſhade, this muſt naturally affect the ſhape of their trunks; the ſap on the ſouth ſide being more plentiful, there the growth of the wood muſt, of courſe, be more conſiderable. And this again ſuggeſts the reaſon, why the wood on the north ſide of a large tree is often found harder and more durable than that on the ſouth ſide; becauſe it is of a ſlower growth, and conſequently of a more compacted ſubſtance.

March 21.

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

Thermometer, at noon, in the ſun, 60.

The ſeventh inciſion bled to-day for the firſt time; the eighth was a little moiſt, but all above it were ſtill dry.

Obs. 11. So far up as the tree bled, which was now ſix feet, the bark ſeparated eaſily from the wood, and a great deal of moiſture appeared between them. Above this, the ſpace between the wood and bark grew gradually drier, and the bark was, with more difficulty, ſeparable from the wood. Upon many trials, it was found, that, in the birch, the bark ſeparates from the wood upon the ſap's aſcent, and not before; nor any higher than where the ſap will ſtream upon inciſion; and that wherever the tree will bleed, there the bark not only parts eaſily from the wood, but the *epidermis* ſeparates 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 eaſy to be detached from one another.

Cor. 6.

Cor. 6. As the aſcent of the ſap thus renders all the ſtrata of a tree eaſily ſeparable; and as this is the caſe in the lower parts of the tree, ſo far as the ſap has aſcended, while theſe parts remain firmly attached to one another in the upper parts of the tree, to which the ſap has not aſcended; it is therefore evident, though contrary to what is generally ſuppoſed, that this phænomenon is occaſioned by the ſap in its aſcent, and not by any return of the ſap downwards from the extremities of the tree.

Cor. 7. As the ligneous circles, during the aſcent of the ſap, do thus ſubſiſt in a looſe and unconnected ſtate, the felling of timber, during that period, ought by all means to be avoided. This period of the ſap's aſcent varies conſiderably 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 1ſt of March to the 26th of April; in the oak, from the 20th of March to the 1ſt of June; and it would be of uſe, were the period of the aſcent of the ſap aſcertained in like manner in the other foreſt trees. The oaks, which are cut for their bark in April and May, during the aſcent of the ſap, afford a ſoft and periſhable timber, compared to thoſe which are cut in the depth of winter. And the ſame is the caſe with all the plane-trees cut in the months of January and February, compared to thoſe which are cut in the month of November. To obtain timber in its greateſt perfection, I believe it cannot be cut too ſoon after the fall of the leaf, as it is then in its moſt ſapleſs ſtate, and the ligneous circles more firmly compacted than at any other ſeaſon.

March 22.

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

The ſeven lower inciſions bled as on the former day; the eighth was wet, but all the upper ones remained dry.

Obs. 12. On the day an inciſion began to bleed, the one immediately above it appeared always moiſter than formerly. This moiſture appeared firſt, and in greateſt quantity, between the wood and bark, and always ſhewed itſelf firſt on the loweſt ſide of the inciſion.

Obs. 13. At whatever height an inciſion bled, all the inciſions below it conſtantly did ſo at the ſame time.

March 23.

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

Thermometer, at noon, in the ſun, 68.

The eighth inciſion, which was ſeven feet high, bled for the firſt time; the ninth was moiſt, but all above it dry.

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

March 24.

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

This day the ninth inciſion began to bleed; the tenth was moiſt, but thoſe above it dry as formerly.

Exp. 5. The ſap having now mounted to the juncture of ſeveral branches, the branches B and C were cut at the extremity, but without bleeding. The branch D was alſo cut at the extremity, and, in like manner, refuſed to bleed. But when this branch was bent down into the perpendicular direction D E, and kept ſo bent by the cord G H, the inciſion at the extremity did then begin to bleed, and in five minutes continued to drop. Yet the branch below it C, that remained in its lateral poſition, had its inciſion at the extremity ſtill dry.

Cor. 8.

* *Vide* Plate I. Fig. 1.

Cor. 8. The motion of the ſap then is accelerated by the perpendicular poſition of the branches; a leading fact, not only in the motion of the ſap, but in the ſtructure of the veſſels which convey it. And from which at preſent we may thus far conclude, that the motion of the ſap of trees is not the ſame with that of fluids in capillary tubes, as has been generally thought, but deſcends with a greater force than it aſcends; and conſequently its motion muſt depend upon ſome different principle.

Cor. 9. From this experiment we may likewiſe infer, that the ſap makes its way ſooner, and in greater quantity, to the extremity of pendent than of erect branches. Hence the reaſon appears, why the gems upon pendent branches always burſt ſooner than upon thoſe which are in an upright poſition. And it is probably alſo for the ſame reaſon, that moſt fruits are of a briſker growth, and of a larger ſize, upon thoſe branches which hang down, than upon ſuch as are erect.

Obs. 15. In the branches, A, B, C, D, to which the ſap had now aſcended, we remarked a conſiderable alteration in the buds, though very little change had been obſerved in them for ſix weeks before. They now began to ſwell, and their ſcales to ſhoot from under one another; but the buds upon the ſuperior branches, to which the ſap had not yet aſcended, were not ſo ſwelled, but compact as formerly.

March 25.

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

Continued ſun-ſhine all day. Thermometer, in the ſun, at noon, 63.

The ninth inciſion continued to bleed, but all the ſuperior inciſions were dry.

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

Obs. 17.

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

To obſerve the effects of an inverted poſition of the branches upon the motion of the ſap, the two following experiments were alſo made:

Exp. 6. On the 1ſt 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 theſe two inverted branches ſwelled larger, broke ſooner, and threw out larger leaves, than any other buds upon the tree.

Exp. 7. At the ſame time, and in the ſame manner, two other branches of a birch were inverted, in every reſpect ſimilar to each other. All the extremities of the one were cut; but thoſe of the other were left entire. That branch whoſe extremities were cut, continued to drop at every twig during the whole bleeding ſeaſon; yet the buds upon this branch ſwelled larger and broke ſooner than thoſe upon the other branch, which had been ſuffered to remain entire.

Cor. 10. From theſe experiments, I ſhall only draw this obvious, though not unimportant concluſion, That wherever the aſcending ſap moves moſt freely, and in the largeſt quantity, there, the buds ſwell to the largeſt ſize, and diſcloſe themſelves ſooneſt.

Obs. 18. At five this afternoon, the ninth inciſion, eight feet high, on the north ſide of the tree, was dried up; yet an inciſion, at the ſame height, on the ſouth ſide, continued to bleed till ſunſet, and was bleeding when the inciſion, only ſix feet high, on the north ſide, was become quite dry.

Cor. 11. This obſervation ſuggeſts a fact, relative to the cauſe of the ſap's motion, which deſerves to be noted: That the motion and bleeding of the ſap does not proceed from a force

communicated to it from the root, but from the action of heat. The ſouth ſide of the trunk was this day far more conſiderably heated than the north ſide; and therefore, in the evening, we found it bleed on the ſouth ſide, at the height of eight feet, when it refuſed to bleed, at the height of ſix feet, on the north ſide.

MARCH 26.

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

THE ſeventh inciſion 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 inciſion bled on the trunk of the tree, all the inciſions below it bled likewiſe.

OBS. 20. In the courſe of this experiment, we have found the uppermoſt inciſion ſometimes dry, though it had bled the day before; but here we find the two uppermoſt inciſions dry, which had bled the two former days. The cauſe is evident from the thermometer, which this day ſtood lower than on any of the preceding days of obſervation.

AT this ſeaſon, ſo like is the ſap in a tree, to the fluid in a thermometer, and ſo dependent in its motion on the heat and cold of the atmoſphere, that, by looking at the thermometer before I went abroad, I came now to gueſs nearly the height at which I ſhould find the tree bleeding.

OBS. 21. The inverted branch D E bled this day plentifully at E, though the two inciſions below it refuſed to bleed; as did alſo the branches below it, which were in their natural poſition.

COR. 12. If at any time we would wiſh to obtain a large quantity of the ſap of the birch, or of any other bleeding tree, it would appear, therefore, to be a uſeful practice, to bend the branches into a perpendicular poſition, 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 ſap, they will bleed with a certain degree of heat, but will refuſe to bleed with a ſmaller degree: That the more a tree is repleniſhed with ſap, the leſs degree of heat is neceſſary to make it bleed, and *vice verſa*. On the 13th of March, the third inciſion refuſed to bleed with the heat of 44.; but on this day, the ſeventh inciſion bled with the heat of 39.

March 27.

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

The eighth inciſion 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 inciſion 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 ſwelled to a larger ſize, and were evidently more forward than any others upon the tree, though this was only the fifth day ſince the branch was placed in that poſture.

Exp. 8. On the 23d inſtant, I had cut ſeven inciſions, a foot diſtant from each other, upon the branch B. Theſe inciſions were cut deep, near to the pith of the branch, perpendicular to the horizon, and were made with a view to ſolve the two following queries:

1. Whether the ſap makes a ſwifter progreſs in young than in old wood? And,
2. Whether, at this time, there was any deſcending ſap to be diſcovered in the tree?

The experiment upon this branch afforded full ſatisfaction concerning both theſe queſtions.

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,

ceſſively, upon the lower ſide of all the other inciſions, marked i, and flowed plentifully, while the upper ſide of all the ſeven inciſions, marked k, remained dry.

Cor. 15. The reſult of theſe trials then amounts to this: That there was at preſent no deſcending ſap from the branches: That the whole ſap of the tree was in an aſcending ſtate: That it had now reached about nine feet high in the trunk; beyond which height it was ſtill dry, and refuſed to bleed.

Being aſſured of this, I now applied myſelf to examine an experiment of M. du Hamel, upon which he founds his doctrine of a deſcending ſap in the bleeding ſeaſon.

Exp. 9. This experiment was made, by ſawing two inches deep into the tree, at L, one foot from the ground. Another inciſion, of the ſame depth, was made three inches below, both being horizontal; and the wood and bark between the two were completely extracted. The ſap was then perceived to flow as plentifully from the ſurface of the upper inciſion at m, as from that of the under inciſion at n.

Cor. 16. From this experiment, M. du Hamel* ſuppoſes, that, in the bleeding ſeaſon, there is not only an aſcending but a deſcending ſap. Finding the ſap to iſſue from both inciſions, 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 alſo repeated, are certainly true; but this concluſion which he draws from them is unqueſtionably erroneous.

It is evident, from the whole train of our experiment, that, from the earlieſt ſpring to the preſent day, the 28th of March, all the ſap which flowed in the birch was in an aſcending ſtate, and that there was no deſcending ſap whatever from the extremities of the tree towards the root. But when once any part of a tree comes to be replete with this aſcending

* Phyſique des Arbres, tom. i. p. 66.

ing ſap, we find it will run out in any direction, either upwards or downwards, wherever an inciſion is made.

MARCH 29.

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

THE eighth inciſion bled ; but the ninth was ſtill dry. The inverted branch bled ſtill freely at E. The ſeven inciſions on the branch B did not bleed.

OBS. 24. Dr TONGE *, in the laſt century, firſt noticed what he termed the *recidivation* of the ſap, that is, its ſubſidence or deſcent in a tree during the cold of the night. This opinion was alſo adopted by Dr HALES †, who ſays, " That the ſap " in all vegetables does probably recede, in ſome meaſure, " from the tops of branches, as the ſun leaves them." It is an opinion that has ſince been generally admitted, and the phænomenon itſelf termed the *ocillatory motion* of the ſap.

SUCH a motion of the ſap, however, appeared very queſtionable, on ſeveral occaſions, in the courſe of our preſent experiment. Often, when the ſap was riſen to a conſiderable height in the tree, the inciſions which had formerly bled would be found dry in a cold morning ; but a warm gleam of the ſun would, of a ſudden, ſet them a-bleeding, not ſucceſſively, but all at once. This ſeems to prove, that the ſap does not deſcend when the inciſions ceaſe to bleed by an increaſe of cold, but is only bound up.

To verify or invalidate this concluſion, the following experiments were made :

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

* Philoſ. Tranſ. *anno* 1668. p. 855.

† HALES Staticks, vol. i. p. 145.

tree thus cut, being kept in the ſame upright poſition 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 ſap ceaſed to deſcend whenever the cold of the evening began to take place.

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

Cor. 17. From theſe experiments, we are, therefore, ſtill led to conclude, that the ſap does not deſcend by cold: That when a tree ceaſes to bleed by an increaſe of cold, this effect is not produced by a ſubſiding or deſcent of the ſap; but that, by the cold, it ſeems only to be arreſted and held in a ſtate of ſtagnation.

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

Cor. 18. In the laſt experiment, we have the force of the ſap's motion, and the influence of the cold upon that force, weighed, the one againſt the other. The freezing cold was not able to prevent the motion of the ſap upwards, but was powerful enough to obſtruct its motion downwards. Here, as it was found in many other caſes, the force of the ſap aſcending

aſcending at the under ſection of the branch, was greatly ſuperior to its force in deſcending at the upper ſection.

MARCH 30.

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

THE eighth inciſion bled; but the ninth continued dry. The inverted branch ſtill bled freely at E. The under ſections of the ſeven inciſions on the branch B bled; but their upper ſections were as yet dry.

OBS. 25. The ninth inciſion ſtill refuſed to bleed, though the heat of this day appeared ſufficient to elevate the ſap to that height; but between the eighth and ninth inciſions, there were two large young branches, which ſeem to have led off the ſap faſter 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 ſooner than an inciſion in the trunk, placed even below the inſertion of the branch. This evidently ariſes from a quicker and more eaſy flow of the ſap in young than in old wood; by which means, the branch comes to be ſooner replete with ſap than the adjoining part of the ſtem.

MARCH 31.

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

THE ſeventh inciſion upon the trunk bled; but thoſe above it were dry. The ſection of the inverted branch at E continued to bleed. All the ſeven inciſions upon the branch B were dry.

OBS. 27. When I found the thermometer ſo much higher this day than it had been at any time during the ſeaſon, I went out, expecting to find the tree bleeding at a greater height than it had hitherto done: But in this I was diſappointed; for all the inciſions above the ſeventh, 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

* 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 ſap has aſcended, the whole body of the wood is replete with it: That, upon inciſion, it iſſues from the wood downwards, and in every other direction; and that this happens before any ſap 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 obſervation was made on theſe days.

APRIL 7.

Thermometer, at noon, 49.; at midnight, 42.

THE eleventh inciſion bled; and the inverted branch bled at E.

APRIL 8.

Thermometer, at noon, 48.; at midnight, 40.

THE eleventh inciſion continued to bleed.

APRIL 9.

Thermometer, at noon, 50.; at midnight, 44.

THE twelfth inciſion bled this day.

APRIL 10.

Thermometer, at noon, 53.; at midnight, 49.

THE thirteenth inciſion began this day to bleed for the firſt time; but all the inciſions above it were ſtill dry. The inverted branch alſo bled at E.

OBS. 30. This day I attended carefully to the iſſuing of the ſap, both from the upper and under inciſions of the branch B, and found, that it flowed in each inciſion, both from the ligneous circles, and from between them. It evidently appeared, how-

ever, to flow from the veins ſeparating the circles, before it iſſued from the circles themſelves; which ſerves to ſhew, that the ſap 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 itſelf.

OBS. 31. It was alſo this day remarked, that, in all the inciſions upon the branch B, the ſap appeared ſooner, and flowed more copiouſly from the outer than from the inner circles of the wood. To be further aſſured of this, a number of branches, both of the birch and plane, were cut over, when the ſame appearance conſtantly took place, and which confirms the obſervation formerly made, "That the ſap is more "expeditiouſly and plentifully conveyed by young than by "old wood."

DURING the 11th, 12th and 13th of April, the thermometer, at noon, ſtood at 45. 44. and 43. reſpectively; and, at midnight, at 36. 35. and 39. Theſe degrees of cold arreſted the ſap. It iſſued ſparingly at the thirteenth inciſion, and at all the under inciſions, but went no higher.

APRIL 14.

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

THE fourteenth inciſion bled this day for the firſt time; but all the inciſions above it were ſtill dry. The inverted branch alſo bled.

OBS. 32. It was again carefully obſerved, by new inciſions on the branch B, whether, according to M. DU HAMEL, there was an aſcending ſap by the ligneous circles, and a deſcending ſap by their veins; but it was found, as formerly, that the ſap proceeded from both in the ſame direction. It iſſued, indeed, in leſs quantity, from the upper than from the under ſections. When a thin ſlice of wood was taken off a cicatriſed or dried ſection, the ſap iſſued from the veins before it made

made its appearance from the circles; and when the place cicatriſed was only in part cut away, the veins would appear moiſtened with the ſap, while the circles themſelves remained perfectly dry. Theſe appearances, I imagine, made M. DU HAMEL ſuppoſe, that there was a diſtinct deſcending ſap by theſe veins. Such appearances do, indeed, at firſt ſight, very naturally lead to this ſuppoſition; but, on farther inſpection, muſt be referred to the cauſe already eſtabliſhed, the more eaſy and copious flow of the ſap between the circles than in the circles themſelves.

APRIL 15.

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

THE fourteenth inciſion bled as yeſterday. The fifteenth was very moiſt, but did not bleed.

APRIL 16.

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

THE fifteenth and ſixteenth inciſions bled this day for the firſt time.

OBS. 33. In the courſe of theſe experiments, this was the firſt inſtance in which the ſap moved two feet in twenty-four hours. But the thermometer, in the ſhade, ſtood higher than it had hitherto been, and there was bright ſunſhine during the whole day.

APRIL 17.

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

APRIL 18.

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

DURING both theſe days the ſixteenth inciſion bled; but the ſeventeenth, though wet, did not bleed. This ſeemed to be owing to ſome vigorous young branches which led off the ſap, and thereby prevented its riſe, for a time, in the ſtem.

APRIL

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.

APRIL

APRIL 30.

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.

MAY 1.

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.

MAY 2.

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 trunk

trunk continued to bleed during the ſeaſon, but it gave over bleeding at the ſame time with the other trees. The wood became dry, the ſap flowed between wood and bark, which were then eaſily ſeparable from one another, and the bark itſelf became moiſt, though it had neither buds nor leaves upon it.

Exp. 14. All the buds were ſtripped off one ſide of another birch tree and all the buds on the other ſide, were left entire. Both ſides of the tree, however, ceaſed to bleed at the ſame time. The wood turned dry, the ſap flowed between the wood and bark, and the bark became moiſt on that ſide of the tree which was deprived of its buds, in the ſame manner, and at the ſame time, in which theſe alterations took place on the ſide of the tree which retained its buds, and whoſe leaves were now conſiderably expanded.

Cor. 21. The drying up of the ſap, therefore, in the wood of trees, about the time of their vernation, proceeds not from the evaporation occaſioned by their leaves, but from a general communication and diffuſion of the ſap from the wood into the bark, at that ſeaſon. To this cauſe, likewiſe, and not to any influence of the leaves, is to be aſcribed the running of the ſap between the wood and bark, during the ſeaſon 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 ſap flowed between the wood and the bark, ſo as to wet the finger, and bled ſenſibly. The bark did not, in any degree, bleed; but was every where more moiſt and ſucculent than when the ſap flowed in the wood. The bark peeled eaſily from the wood, the alburnum from both, and its fibres were more eaſily ſeparated from one another than at any period while the ſap 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.

§ 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 unfold 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 deſcending, 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 perceived 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 diſcerned 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 ſeparated: 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 ariſen from ſome miſtake. The flow of the ſap, between the wood and bark, was daily and evidently perceived; likewiſe, that it was there always in an aſcending ſtate; and that it even moved more freely, and with greater rapidity, in this channel, than in any part of the ſubſtance of the wood.

§ 4.

THE cauſe of the aſcent of the ſap in trees, is a curious and important point in the hiſtory of vegetation, but ſtill involved in obſcurity. Many opinions have been formed on the ſubject, but theſe only at random, or, at beſt, only from a general view of vegetation. The cauſe ſtill remains ſecret; nor is it likely that it will ever be brought to light, but by means of minute and accurate experiments.

THE aſcent of the ſap has been aſcribed, by ſome, to fermentation *, and, by others, to a certain force communicated to it from the root; but without any evidence to ſhew, that ſuch cauſes even exiſt.

THE aſcent of the ſap by filtration was an opinion rather more plauſible; but it is oppoſed by ſome of the principal phænomena. Did the ſap aſcend like water in a ſponge, or in capillary tubes, why ſhould its motions be affected, nay even almoſt entirely regulated by heat and cold? Or why, as has been found in theſe experiments, ſhould its motion be accelerated by placing a branch in an inverted poſition?

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

* HENCKEL. Flora Saturnizans, cap. 4.

THE aſcent of the ſap was aſcribed by LUDWIG *, to the expanſion of the air with which it is impregnated; and, with more reaſon, by others, to the expanſion of the air contained in the *tracheæ*, or air-veſſels of the plant. As theſe veſſels exiſt only in the wood, and as it is by the wood chiefly that the aſcending ſap is conveyed, this, no doubt, forms a preſumption, that they contribute, in ſome degree, to the elevation of the ſap. But, as we have found, that the ſap moves with more force upwards than in any other direction; and that, in certain circumſtances, it is made to flow and aſcend by cold as well as by heat, the expanſion of air cannot, therefore, be admitted, in any ſhape whatever, as the cauſe of its aſcent.

THE above experiments leave us ſtill in the dark, as to the preciſe cauſe of the aſcent of the ſap. They ſhew, indeed, upon many occaſions, that heat is the prime agent in producing this effect; and that, probably, by the expanſion of the ſap itſelf, rather than of any air, either contained in it, or in the *tracheæ*. The inciſions upon the birch ran freely in the day-time, eſpecially during ſunſhine, but dried up regularly, as the cold of the evening advanced. With a few exceptions, we find the aſcent of the ſap conſtantly promoted by heat, but retarded and even arreſted by cold: Yet the preciſe manner in which heat and cold produce theſe effects does not appear. It is likely that there are other cauſes which co-operate. Theſe probably are lodged in the ſtructure of the plant, and to diſcover them, would require a more minute examination of that ſtructure, than has as yet been beſtowed upon it.

§ 5.

FROM the preceding experiments, we may now attempt a ſolution of that curious queſtion in vegetation, why the terminating buds of branches are the firſt which diſcloſe themſelves in the ſpring? This phænomenon has been often imagined, and particularly

* LUDWIG Inſtitutiones Regni vegetabilis, Lipſ. 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

* BONNET, p. 285.

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

In our experiments, no ſap could, at any time, be diſcerned either to aſcend or deſcend by the pith. It is a ſubſtance quite unqualified for this purpoſe. It contains no lymphatics; and, ſo far as I know, none of the peculiar ſap-veſſels of any tree are ever ſituated in the pith *; a ſingularity which is not to be found in any of the other parts of a plant.

The ſubſtance of the pith very much reſembles that of the cellular texture of plants, but is, notwithſtanding, of a very different nature †. The cellular texture freely imbibes and tranſmits water; but the ſubſtance of the pith obſtinately repels it. I have often ſeen coloured liquors riſe in the bark and wood of trees, eſpecially in the wood of the elder, but not a particle was admitted by the pith, though a ſubſtance, to appearance, much better adapted for imbibing a fluid. All theſe circumſtances lead to ſuſpect, that the pith has little or no ſhare in ſupporting the wood, the bark, or the general vegetation of the tree, and that its principal uſe is to aid the formation of the fruit.

Accordingly, in the numerous ſections of trunks and branches made in the foregoing experiments, the buds were conſtantly obſerved to be connected with, and, in a manner, rooted, in the pith, by means of the *diametral inſertions* ‡. It may alſo be every where obſerved, that no bud exiſts upon any tree, without a connection with the pith; and that buds are always in greater abundance where the pith is moſt copious.

It is ſuppoſed by Linnæus §, that the pith draws the nouriſhment from the bark; but the argument he uſes in ſupport of this poſition does, by no means, prove it. On the contrary, it rather appears from our experiments, that the pith muſt draw its nouriſhment from the wood; becauſe, during the whole ſpring

* M. du Hamel imagines, that there are in the pith both *vaiſſeaux propres*, and *lymphatiques*.

† M. du Hamel thinks, that the pith and the *tiſſu cellulaire* are the ſame ſubſtance.

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

§ Amœn. Acad. vol. 6. p. 325.

ſpring ſeaſon, the wood was replete with ſap, while the bark was dry. Beſides, when the trunk of a tree, for a certain ſpace, is decorticated quite round, the pith, in the decorticated part, lives, and all the parts of the tree above it, ſo long as the wood continues green, and conveys ſap, which it will do for years. The wood appears to be the great ſource of nouriſhment to all the parts of the tree. It is probable, that, from this alone, the pith is nouriſhed, and that its communication with the bark is not to draw nouriſhment from it, but to afford ſome 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 falſehood of the doctrine of a circulation chiefly depended, has been, in the courſe of theſe experiments, completely verified.

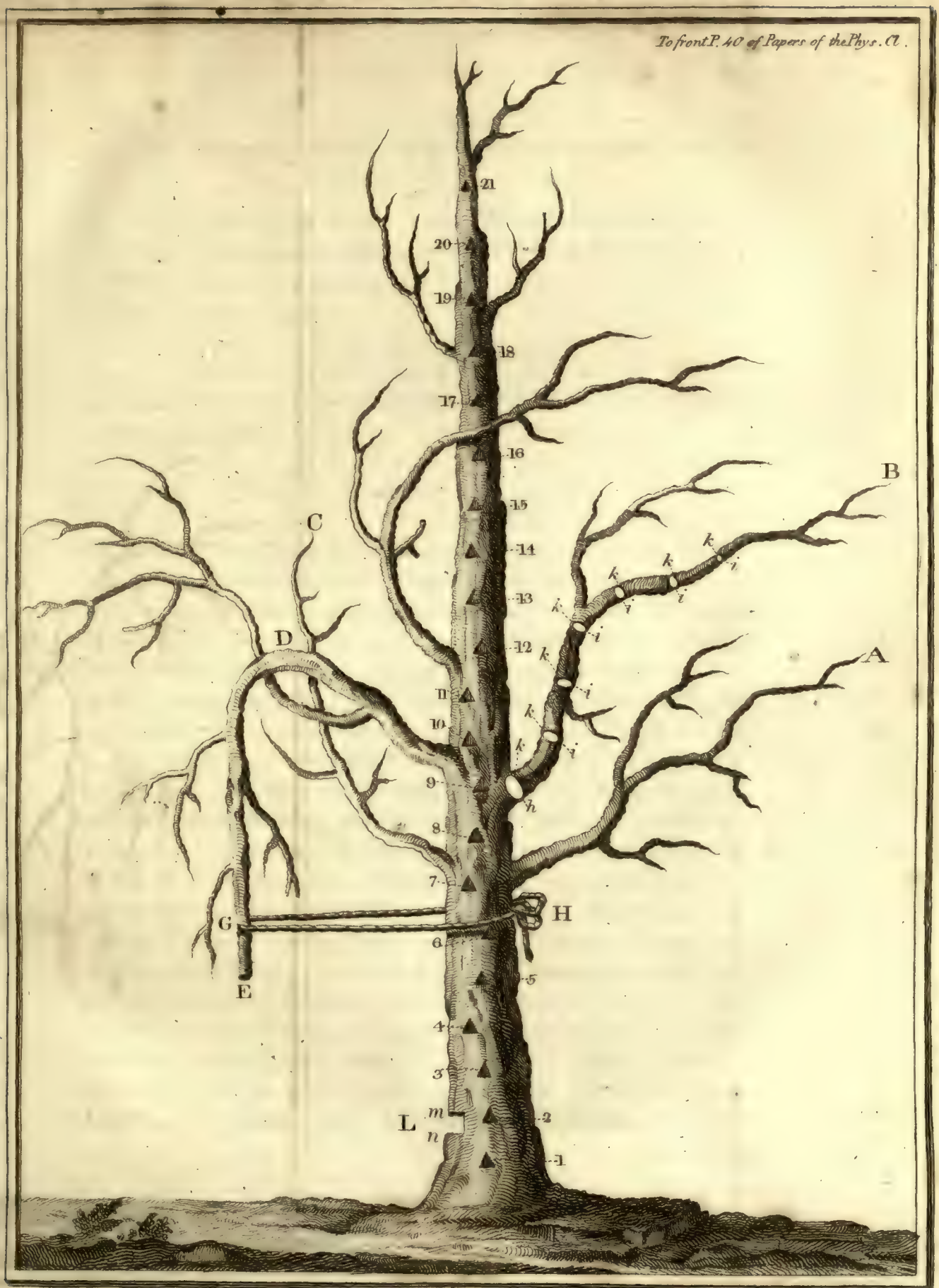
WE have found, that, in the early ſpring, the ſap firſt begins to move at the bottom of a tree, and proceeds gradually upwards through all its parts: That the lower bark is firſt moiſtened, by a ſap aſcending from the root, and not by a ſap deſcending from the branches, which was generally ſuppoſed. And further, that, from the firſt movement of the ſap in the ſpring, till the time of vernation, no deſcending ſap whatever can be diſcerned in the tree.

THESE, indeed, are important points againſt the doctrine of a circulation, but I do not think that they completely diſprove it. They only prove, that there is no circulating ſap in a tree during a certain ſeaſon 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 neceſſary, that the route of the ſap ſhould alſo be traced, by accurate experiments, from the time the leaves firſt appear, till the defoliation of the tree in autumn. What the reſult of ſuch an enquiry might be, I cannot determine:

mine: And ſhall only obſerve, that, from a few trials made with this view, I have been led to ſuſpect, that, while a tree is in leaf, its ſap obſerves a very different courſe, and moves by laws very different from thoſe, by which it is regulated in the bleeding ſeaſon.



II.



D. Lizars Sculpt



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 atmoſpherical appearance which is not explained by the known laws of heat and cold. It is the breath of animals becoming viſible, in being expired into an atmoſphere which is cold or moiſt; and the transformation of tranſparent ſteam into the ſtate of miſt, when mixed with air which is of a colder temperature. Natural philoſophers have certainly conſidered theſe appearances as being explained in the general law by which heat and cold are communicated among contiguous bodies, otherwiſe they would have endeavoured to point out this particular law, which ſeems to depart from a more general rule, or does not follow the natural courſe of things obſerved on other occaſions. The ſubject of this paper is to inveſtigate a certain rule which, in the caſe now mentioned, may be diſcovered as directing the action and effects of heat and cold; and to form a theory of rain upon that inveſtigated rule, concerning the evaporation and condenſation of water.

THE air, inſpired by an animal, may be conſidered as a menſtruum diſſolving water upon the warm and humid ſurface of the lungs, and as thus becoming ſaturated with humidity in this degree of heat. When this ſolution is again cooled, then,

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.

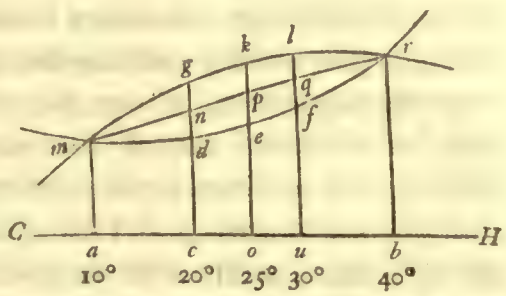
There

THERE are juſt three different ratios, in which this operation of heat on water may be conceived as proceeding.

1. THE ſolution may vary at the ſame rate with the heat, ſo that equal increments of heat ſhall be accompanied by equal increments of diſſolved vapour.

2. IT may vary at a greater rate, ſo that while the heat increaſes by equal differences, the quantity of diſſolved vapour ſhall increaſe by differences which are continually augmenting.

3. IT may vary at a leſs rate than the heat, ſo that while the heat increaſes by equal differences, the quantity of diſſolved vapour ſhall increaſe by differences which are continually diminiſhing.



THESE three rates of evaporation, or ſolution of water in air, may be repreſented geometrically, thus: Let the ſtraight line *C H* repreſent the ſcale of the thermometer. Let the perpendicular ordinates, *a m*, *b r*, be taken in the proportion of the quantity of water, which can be held in ſolution, by a given quantity of air, of the temperatures *a* and *b*. Draw the ſtraight line *m r*. Draw alſo 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 progreſs of heat, and alſo of a ſolution, varying at the ſame rate with the heat. In like manner, the ordinates to the curve *m d e f r*, will mark the progreſs of ſolution, varying at a greater rate than the heat; and the ordinates to the curve *m g k l r*, will mark the progreſs of ſolution, varying at a leſs rate than the heat: For theſe ordinates are taken in the proportion of the quantity of water diſſolved in

air, of the different temperatures, indicated by the points of the line *C H*, from which they are drawn.

LET us now conſider theſe three rates of aqueous ſolution, with a view to know the effect of mixing together ſaturated portions of the atmoſphere of different temperatures. For this purpoſe, let it be obſerved, that the ordinates to the line *m r*, drawn from the point of *C H*, which denotes the temperature of the mixture, will always repreſent the quantity of water contained (whether diſſolved 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 preſumed, that, upon mixture, the heat, and alſo the water, are uniformly diſſolved; and, therefore, both the heat and water, contained in an unit of the mixture, vary in the ſame proportion, and may be expreſſed by the ſame meaſure.

IN the ſuppoſition of equable ſolution, let us mix equal portions of ſaturated air, of the temperatures 10. and 40. the mixture will produce a temperature 25. which will be repreſented by the ordinate *o p*. This ordinate alſo repreſents the quantity of water contained in an unit of the mixture. But it alſo repreſents (in the preſent ſuppoſition) the quantity of water, held in ſolution by an unit of air of the temperature 25.

INSTEAD of equal portions, let two parts of a ſaturated ſolution, of the temperature 40. be mixed with one part of a ſaturated ſolution, of the temperature 10. the temperature produced will be 30. and will be expreſſed by *u q*; which will alſo expreſs both the water contained in an unit of the mixture, and the quantity of water held in ſolution 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* expreſſes the heat, mixture, and ſolution of the unit.

EVERY mixture, therefore, that can be made of this ſolution will be found equally ſaturated, as are its conſtituent parts, and will

will have neither exceſs nor deficiency of the diſſolved ſubſtance. This, however, is not the caſe in the other two rates of ſolution; for, as in thoſe two caſes the ordinates of heat and ſolution are not the ſame, the medium of heat will not expreſs a ſolution ſaturated with humidity, or a mixture in which there is not ſuperfluity of the diſſolved ſubſtance. Let us now conſider theſe more particularly.

In the curve *m d e f r*, which repreſents the increaſing rate of ſolution, let equal portions of the ſolution in 40. and in 10. be mixed, then the medium of heat in 25. will have for the ordinate of mixture, that is to ſay, the quantity of water contained in this mixture *o p*, whilſt *o e* is the ordinate of ſolution, that is to ſay, the quantity of water that may be diſſolved in this degree of heat, conſequently, *e p* is the quantity of water that cannot be retained in ſolution, in this medium temperature produced by the mixture.

If two parts of the ſolution in 40. be mixed with one of that in 10. the medium temperature will be 30.; and, if two parts of the laſt be mixed with one of the other, the medium temperature produced will be 20. In thoſe two caſes, *f q* and *d n* are the quantities which will be ſeparated from the ſolution.

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 ſeparated on theſe occaſions aſcertained, if the actual curve of evaporation were known, or that rate in which the ſolution of water in air proceeded.

The progreſs of ſolution, inſtead of being in an increaſing rate, may be in one that decreaſes, in relation to the progreſs of heat. In that caſe, the mixture of two portions of the ſolution in different degrees of heat, inſtead of producing a ſeparation of ſuperfluous moiſture in the medium temperature, by reaſon of the ſuperſaturation, as in the former caſe, will be followed by an increaſed power for the evaporation of water, by having an underſaturation in the mixed maſs.

THIS propoſition will be illuſtrated in the curve *m g k l r*, which repreſents the decreaſing rate of ſolution. Let equal portions in 40. and 10. be mixed, and let the ordinate be raiſed in the medium degree of heat 25. *o k* will then be the whole power of ſolution, or the quantity of water that air is capable of diſſolving in this degree of heat; but *o p* is the quantity of water that is actually in this mixture; conſequently, the air is here underſaturated with humidity by the quantity *p k*.

IF two parts of 40. ſhall be mixed with one in 10. or two of 10. with one in 40. the quantities of underſaturation will be changed, and *q l* and *n g* will expreſs thoſe quantities, in relation to the mixtures in the medium temperatures.

THUS, in every mixture of ſolution in this decreaſing rate of ſolution, there will be found an underſaturation of the air, with regard to the diſſolved moiſture, inſtead of a ſuperſaturation, which is found in all the mixtures of the ſolution in the increaſing rate.

LET us recapitulate:

IF the ſolution of water in air increaſes with heat in an equal rate, no mixture can be made of portions, in different degrees of heat, that will produce either ſuper or underſaturation; but the mixture, like the conſtituent portions, will be always ſaturated without ſuperfluity.

IF the ſolution of water in air increaſes with heat in a decreaſing rate, the mixture of two ſaturated portions, in different degrees of heat, will produce no condenſation of humidity, but, on the contrary, will be capable of diſſolving more aqueous ſubſtance.

IF, on the other hand, the ſolution of water in air increaſes with heat in an increaſing rate, the mixture of two ſaturated portions, in different degrees of heat, will produce a condenſation of humidity, as being ſuperſaturated in the medium temperature of heat.

THIS

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

may

may influence water condenſed in the atmoſphere, and operate variouſly, in either retaining it longer in a ſuſpended ſtate, or bringing it ſooner to the ground, the condenſation of the water is properly the cauſe of rain. We may now endeavour to confirm this theory of rain, in having again recourſe to natural appearances.

THE moſt convincing experiment, in confirmation of the theory, would be, to have rain or ſnow produced by a mixture of portions of the atmoſphere, properly conditioned for the condenſation of the contained vapour. But ſuch an experiment as this we alſo have. M. DE MAUPERTUIS, in his *Diſcours ſur la méſure de la terre*, ſays, That, at Tornea, upon the opening of a door, the external air immediately converts the warm vapour of the chamber into ſnow, which then appears in what he calls "de gros tourbillons blancs." A ſimilar appearance happened at St Peterſburgh, *anno* 1773. I have it from Profeſſor ROBISON, who ſaw it. It was in a crowded aſſembly, the company ſuffering from the cloſeneſs of the room, a gentleman broke a window for relief. The cold air ruſhing in, formed a viſible circumgiration of a ſnowy ſubſtance.

THE law of nature, on which this theory of rain is founded, may be now conſidered in relation to its final cauſe; or how far it may appear to be conceived in wiſdom for the purpoſe of this world, as affording a proper climate for plants and animals.

HAD the law, reſpecting aqueous evaporation in the atmoſphere, been conceived in any other manner than that which has been now found eſtabliſhed in nature, the ſummer's heat, which is the cauſe of vegetation, could never have been attended, as at preſent, with refreſhing ſhowers of rain. By the circulation of the fluid atmoſphere, the heat of torrid regions is carried away, and the cold of frigid regions is brought to temperate the exceſſive heat that is excited upon the ſurface of the earth in the ſummer ſolſtice; but, if no condenſation of humidity in the atmoſphere could be produced by the mixture of its

its parts, however ſaturated with aqueous vapour, and in different degrees of heat, the natural cold of the polar regions, and the contingent cold of ſnows, accumulated, during winter, upon the higher countries, however tranſported to warmer regions, would be altogether ineffectual for the purpoſe of forming clouds and condenſing rain.

THE preſent ſyſtem of the atmoſphere is ſo calculated as that every mixture of different portions of that fluid, unequal in their degrees of heat, and ſaturated with humidity, muſt procure a condenſation of water. This ſyſtem, therefore, of the atmoſphere, 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 ſyſtem, we ſhall ſee, that the cold regions of the polar circles are not uſeleſs and inactive in the operations of this world. In like manner, the frozen regions of the Alpine ſituations of the Continent, ſerve a purpoſe, in the conſtitution of this earth, by preſerving, in the accumulated ſnows, a ſtore of the winter cold for the ſummer ſeaſon; and thus preparing cold portions of the atmoſphere to be mixed with the warmer portions, ſaturated with humidity, and ready to produce rain *.

WHILE the atmoſphere is thus tempered, by tranſporting the heat and cold of diſtant regions, the regions of the earth moſt diſtant from the ſea, may be ſupplied with ſhowers of rain at every ſeaſon of the year, or at any ſeaſon, according to the arrival of thoſe ſtreams of the atmoſphere which are in the proper conditions for producing, by their mixture, a medium degree of heat, and a ſuperſaturation or condenſation of aqueous vapour. This wiſe ſyſtem of things, or this uſeful purpoſe in the œconomy of the world, could not have been accompliſhed without that particular law of nature reſpecting aqueous condenſation; for, if the mixing together of the atmoſpheric ſtreams produced no condenſation, the ſummer hemiſphere of

G the

* THE explanation of this propoſition depends upon Dr BLACK's theory of latent heat.

the globe would be parched with drought, and the winter hemiſphere deluged with rain.

To ſee this, let us conſider the ſummer hemiſphere of the globe, warmed by the influence of the aſcending ſun. From the laws of hydroſtatics, it will appear, that there ſhould be formed, on this occaſion, two oppoſite currents in the atmoſphere above this half of the globe, the one moving along the ſurface of the earth, from the polar region towards the equator, the other flowing above, in a contrary direction. This circulation, therefore, being ſuppoſed, let us ſee what follows, according to the actual conſtitution of things. On the one hand, the evaporation of the winter's moiſture from the ſurface of the continent, warmed by the ſummer ſun, muſt tend to ſaturate with humidity the polar atmoſphere, as it acquires an evaporating power from its increaſing heat; on the other hand, the progreſs of the upper current, from the tropic towards the pole, in having its degree of heat diminiſhed by the general cooling cauſe, will naturally bring the maſs to a point of ſaturation with the aqueous vapour which it had received. In this ſtate of things, the two oppoſite currents in the atmoſphere, while ſeparate, might paſs on without condenſing humidity ſufficient to produce rain; but the moment that ſufficient portions of thoſe ſaturated ſtreams ſhall mix, not only cloud, but ſhowers will be produced; becauſe the ſudden formation of a mean degree of heat, in the mixture of two portions in different temperatures, muſt condenſe a quantity of vapour ſufficient to form rain.

RAIN having fallen in a place, in conſequence of the mixture in the atmoſphere above, this will naturally be followed by clearneſs in the ſky and ſunſhine, which is ſo neceſſary for warming the ſurface of the earth, and for giving health and vigour to growing plants.

BUT, without the particular law now inveſtigated, reſpecting evaporation and condenſation of vapour, neither rain nor dew could

could be produced upon the ſummer hemiſphere of the globe, nor perhaps ever in tropical latitudes; evaporation would every where take place, more or leſs; the general tendency would be to ſaturate the atmoſphere with water, or fill it with vapour in its greateſt heat; and the mixture of the different parts of the atmoſphere would only conduce to temper the ſaturation, without producing any condenſation of vapour in the mean degrees of heat. But when, in conſequence of the declining ſun, the influence of the general cooling cauſe ſhould prevail, the atmoſphere would gradually become clouded, and be darkened. This cloudineſs would increaſe to a general diſtillation of the condenſed vapour; and this diſtillation would be uniformly continued, until the returning ſummer ſhould change the ſtate of condenſation to that of evaporation.

SUCH a ſyſtem as this, of ſix months rain and ſix months drought, conſtantly ſucceeding, would not have preſented us with all that variety of beautiful objects which we now behold; nor would it, like the preſent conſtitution of this world, appear calculated with all that wiſdom of deſign which we may perceive to be in the poſſibility of things; for ſuch an uniform exceſs of cloud and condenſation, on the one hand, and of ſunſhine and evaporation, on the other, would not appear to fulfil the intention of providing ſuſtenance and ſatisfaction, as far as poſſible, for every living thing; whereas, in the actual ſyſtem, now under contemplation, while both the extremes of drought and of wetneſs are ſo wiſely avoided, temperate drought and moiſture, rain and ſunſhine, ſo beneficial to the œconomy of this world, are every where beſtowed with the moſt provident attention, but not without a variety of different degrees; which moſt evidently marks out perfection in the deſign, where ſuch a multitude of different beings, dependent on the various temperament of thoſe oppoſite elements, are to be provided with the neceſſary 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 reſpecting the condenſation of aqueous vapour contained in the air, it is now propoſed to make ſome application of this theory to natural events, in conſidering the meteorological obſervations of the globe, and endeavouring, either to explain appearances that are not otherwiſe underſtood, or, from thoſe appearances that are evident in themſelves, to draw concluſions in confirmation of the theory.

UPON this occaſion, where there is an indefinite variety in a ſeries of particular obſervations, it is neceſſary to inveſtigate ſome order in thoſe events, and to form a generality among phænomena, which will then be phyſical truths, and may be compared with the theory.

1ſt, IT may be required to ſhow ſome reaſon why, on all the ſurface of the earth in general, there are always ſeaſons of rain, whether regular or irregular. Here the ſubject of enquiry will properly reſpect the generality of rain.

2dly, IT will be proper to conſider ſuch regular periodical rains, as may be found with the circumſtances attending their production, which then would ſerve to try the theory, or to illuſtrate it. Here the regularity of rain will be the object in view, and not its generality.

3dly, IT will be neceſſary to examine the apparent exceptions from the doctrine founded on the theory, or thoſe appearances of irregularity in nature that do not flow from the theory, although they may be in perfect conſiſtence with it, and might be explained, had we the peculiar circumſtances which are the occaſion

occaſion of the event. Here, again, the ſubject to be diſcuſſed will be the apparent exception from the generality of rain.

4thly, THE proportional quantities of rain falling in the different ſituations of the earth may be made an object of our attention, in order to illuſtrate the theory, as well as to explain appearances. Here a comparative eſtimate will be made of climates in relation to rain.

5thly, and *laſtly*, HAVING thus conſidered the particular appearances of the globe in general, ſo far as our imperfect knowledge 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 regiſter, or to every obſervation of change in our weather, that is, ſuch as ſhall be attended with circumſtances proper for judging 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 vertical 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 illuminated 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 cooling cauſe, this fluid body could only arrive at a certain degree of heat; and this would be regularly decreaſing from the centre of illumination to the oppoſite point of the globe, moſt diſtant from the light and heat. Between thoſe two regions of extreme heat and cold, there would, in every place, be found

two

two ſtreams of air, flowing in oppoſite directions. If thoſe ſtreams of air, therefore, ſhall be ſuppoſed as both ſufficiently ſaturated with humidity, then, as they are of different temperatures, there would be formed a continual condenſation of aqueous vapour, in ſome middle region of the atmoſphere, by the commixtion of part of thoſe two oppoſite ſtreams.

HENCE there is reaſon to believe, that, in this ſuppoſed caſe, there would be formed, upon the ſurface of the globe, three different regions, the torrid region, the temperate, and the frigid. Theſe three regions would continue ſtationary; and the operations of each would be continual. In the torrid region, nothing but evaporation and heat would take place; no cloud could be formed, becauſe, in changing the tranſparency of the atmoſphere to opacity, it would be heated immediately by the operation of light; and thus the condenſed water would be again evaporated. But this power of the ſun 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 hemiſphere of darkneſs, there would be found a region of extreme cold and perfect dryneſs.

LET us now ſuppoſe the earth as turning on its axis, in the equinoctial ſituation. The torrid region would thus be changed into a zone, in which there would be night and day; conſequently here would be much temperance, compared with the torrid region now conſidered; and here perhaps there would be formed periodical condenſation and evaporation of humidity, correſponding to the ſeaſons of night and day. As temperance would thus be introduced into the torrid extremity, ſo would the effect of this change be felt over all the globe, every part of which would be now illuminated, conſequently heated in ſome degree. Thus we would have a line of great heat and evaporation, graduating each way into a point of great cold and congelation. Between theſe two extremes of heat and cold, there would

would be found, in each hemiſphere, a region of much temperance, in relation to heat, but of much humidity in the atmoſphere, perhaps of continual rain and condenſation.

THE ſuppoſition now formed muſt appear extremely unfit for making this globe a habitable world, in every part; but, having thus ſeen the effect of night and day, in temperating the extremities of heat and cold in every place, we are now prepared to contemplate the effects of ſuppoſing this globe to revolve around the ſun, with a certain inclination of its axis. By this beautiful contrivance, that comparatively uninhabitable globe is now divided into two hemiſpheres, each of which is thus provided with a ſummer and a winter ſeaſon. But our preſent view is limited to the evaporation and condenſation of humidity; and, in this contrivance of the ſeaſons, there muſt appear an ample proviſion for thoſe alternate operations in every part; for, as the place of the vertical ſun is moved alternately from the one tropic to the other, heat and cold, the original cauſes of evaporation and condenſation muſt be carried over all the globe, producing either annual ſeaſons of rain, or diurnal ſeaſons of condenſation and evaporation, or both thoſe ſeaſons, more or leſs, that is, in ſome degree.

THE original cauſe of motion in the atmoſphere is the influence of the ſun heating the ſurface of the earth, expoſed to that luminary. We have now ſuppoſed that ſurface to be of one uniform ſhape, and ſimilar ſubſtance; from whence it has followed, that the annual progreſs of the ſun, perhaps alſo the diurnal progreſs, would produce a regular condenſation of rain in certain regions, and the evaporation of humidity in others; and this would have a regular progreſs in certain determined ſeaſons, which would not vary. But nothing can be more diſtant from this ſuppoſition than is the natural conſtitution of the earth; for the globe is compoſed of ſea and land, in no regular ſhape or mixture, while the ſurface of the land is alſo irregular, with reſpect to its elevations and depreſſions, and various,

ous, with regard to the humidity and dryneſs of that ſurface which is expoſed to heat as the cauſe of evaporation. Hence a ſource of the moſt variable motions in the fluid atmoſphere, always affected with the heat of each particular part of the ſurface with which it comes in contact; hence a tendency to ſaturate every part of the atmoſphere with aqueous vapour, more or leſs, ſo far as other natural operations will admit; and hence a ſource of the moſt irregular commixture of the ſeveral parts of this elaſtic fluid, whether ſaturated or not with aqueous vapour.

ACCORDING to the theory, nothing is required for the production of rain beſides the mixture of portions of the atmoſphere, ſufficiently ſaturated with humidity, and in different degrees of heat. But we have ſeen the cauſes of ſaturating every portion of the atmoſphere with humidity, and of mixing the parts that are in different degrees of heat. Conſequently, over all the ſurface of the globe, there ſhould happen occaſionally rain and evaporation, more or leſs; and alſo, in every place, thoſe viciſſitudes ſhould be obſerved to take place, with ſome tendency to regularity, which, however, may be ſo diſturbed as to be hardly diſtinguiſhable upon many occaſions. Variable winds, and variable rains, ſhould be found in proportion as each place is ſituated in an irregular mixture of land and water; whereas regular winds ſhould be found in proportion to the uniformity of the ſurface; and regular rains, in proportion to the regular changes of thoſe winds, by which the mixture of the atmoſphere neceſſary to rain may be produced. But, as it will be acknowledged, that this is the caſe in almoſt all this earth, where rain appears according to the conditions here ſpecified, 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 ſnow, which happen irregularly in moſt places, having been explained from the natural conſtitution of this globe, from the proper diſpoſition of its ſolid and its fluid parts, and from the periodical influence of heat and cold, occaſioned by the motion and poſition of this globe, in relation to the ſun, we ſhall find it eaſy to underſtand the more regular periodical appearances, with regard to rain, which happen in a few places of the earth.

IN looking for a regular periodical cauſe for the mixture of portions of the atmoſphere, in different degrees of heat, and ſufficiently ſaturated with humidity, nothing appears ſo promiſing as the trade-winds in the Indian ſea, blowing one half of the year in one direction, and, during the other half, in a contrary direction; for, as theſe ſtreams of atmoſphere are limited, they muſt ſomewhere produce a mixture of different portions of that fluid maſs; and, in finding rain to be the conſequence of theſe regulated events, or as correſponding to theſe probable cauſes, we ſhall have reaſon to conclude, that thoſe mixed portions of the atmoſphere have been ſufficiently ſaturated with humidity, and in different temperatures, in relation to heat. But this is actually the caſe; we find, in this place, regular appearances, with regard to rain, which correſpond to the regular cauſes now aſſigned, for the commixtion of the atmoſphere. This correſpondency, therefore, while it explains thoſe natural appearances, confirms the theory.

THE iſlands which are placed under the line, in the middle of the Indian ocean, ſeem to form for themſelves conditions of periodical condenſation, that correſpond to the diurnal influence of the ſun, and to the nocturnal motions in the atmoſphere. It is not here pretended to explain, *a priori*, how, in ſuch places, either always, or at certain ſeaſons, there ſhould be daily periods of rain. It is enough to find that ſuch is the fact, and that

it can be explained by no other theory but this, in which we find a diurnal cauſe of mixing together the different parts of the atmoſphere, by means of heating the mountains, and ſurface of the earth, by the great illumination of the ſun, thus rarefying ſome parts of the atmoſphere, and producing commotions in the fluid maſs of air which ſurrounds the iſland.

THESE periodical commotions in the atmoſphere of iſlands in tropical ſituations muſt not be conſidered as a thing doubtful in its nature, or a matter merely conjectural. The fact is well aſcertained in the ſea and land breezes that are felt regularly blowing every day in thoſe oppoſite directions. This is the fact; and that rain ſhould accompany theſe commotions follows from the theory proviſionally; that is, in caſe of the proper conditions for the condenſation of vapour being found in the atmoſphere thus mixed. Now, theſe conditions are not always found where we find the breezes. But, in the iſlands now under conſideration, ſituated under the line, and in a ſea that muſt be hotter than any other upon the globe; a ſea, either confined conſtantly between the tropics, or continually ſupplied from the tropical region of the Pacific ocean, it is not unreaſonable to ſuppoſe that ſufficient ſaturation with aqueous vapour may be found in the atmoſphere; nor that, in the diurnal commotions of this fluid, there may be portions of it mixed in different degrees of heat.

IT is, in like manner, that the periodical rains which happen regularly upon the different coaſts of the peninſula of India muſt be explained. The regular monſoons in thoſe ſeas occaſion the tranſportation of air, ſaturated with aqueous vapour, which has flowed along the ſurface of the ſea, here to be elevated and mixed with thoſe portions which, having loſt their heat to a ſufficient degree, are in a condition to produce, by their commixture, a condenſation of water upon the land. Nothing can better illuſtrate this explanation than the great annual and periodical rains which happen upon this continent, and which are exhibited

hibited upon ſo large a ſcale, that it is almoſt impoſſible to have them explained in any other manner. Let us examine thoſe circumſtances which cannot be miſtaken, and which may be ſufficient for deciding in this queſtion.

FROM the eaſt to the weſt of this great tropical continent of Aſia and Africa, the rivers inform us, that it rains in the ſeaſon of the ſummer ſolſtice; and that, on the contrary, fair weather is here produced by the removal of the heating cauſe. We cannot ſuppoſe, that heat is an immediate cauſe for the condenſation of aqueous vapour; nor can we ſuppoſe that this effect ſhould not be produced by cold; for this would be no leſs than to ſuppoſe in nature an inconſiſtency, which never has appeared. While, therefore, we allow the laws of nature to be ſteady, the effect of the ſummer ſun, in this continental ſituation, muſt be, to elevate the heated air, and to have its place ſupplied by that which has come, fraught with aqueous vapour, from the neighbouring ſeas: But being arrived here, upon this heated continent, this humid air muſt be elevated into the higher regions of the atmoſphere, and either be tranſported from thence towards the polar regions, there to be gradually condenſed, as the cooling cauſe takes place, or it muſt here fall in rain, by finding a cauſe for its condenſation. Upon the firſt ſuppoſition, no rain ſhould be found here during the ſummer ſeaſon; or the rivers, by which we are to judge of this event, ſhould be at the loweſt after ſummer. But, as the oppoſite of this is true, the rivers being then in their ſwelled ſtate, it neceſſarily follows, that the humid atmoſphere, tranſported from the ſea, muſt have its water condenſed upon this heated continent in the ſummer ſolſtice; and there is not, at preſent, any other principle known, by which this operation might take place, or any other theory by which thoſe natural appearances of periodical rain might be explained.

THE ſummer ſun, which proves a cauſe of rain in certain regions, where ſeas, affording great evaporation from their heat,

are in the neighbourhood, proves, on the contrary, a cauſe of drought in other regions, where the ſource of water, or evaporation, is more ſcanty, or at a diſtance. A winter continent, heated by the elevation of the ſummer ſun, ſhould be more diſpoſed to have drought than rain, during the period of its heat, unleſs ſome tranſient ſtreams of atmoſphere, proper for the purpoſe, ſhould reach this place, and happen to meet: There would thus be occaſioned ſhowers of rain, of great importance to the vegetation of the place, but not to be conſidered as a general ſeaſon of rain.

BUT the caſe is altered, upon the declining of the ſummer ſun. The atmoſphere, upon this continent, then becoming either ſaturated to its degree of heat, or cooled to its degree of ſaturation, is diſpoſed to produce rain, with every mixture which is in a different temperature. Hence a ſource of autumnal rains and winter ſnows, which may fall with all the regularity of the tropical rains; and of this we alſo have information, from the regular covering of thoſe northern continental regions, with a permanent ſnow; an event that happens with great conſtancy, and may be conſidered as a regular periodical rain.

HAVING thus found rain as being properly cauſed, upon two oppoſite principles, a vertical or highly elevated ſun, and the removal of that cauſe of heat, no place ſhould be found, upon the ſurface of this earth, where rain may not happen, more or leſs, from the one or other of thoſe cauſes. But there are places where it is ſaid never to rain: And now the queſtion is, how far theſe appearances may be conſiſtent 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 theſe two principles, *firſt*, That mixed portions of the atmoſphere are, by means of a certain law of nature, qualified for

for the production of rain; and, *2dly*, That there is, in the conſtitution of this terraqueous globe, cauſes for mixing the different parts of the atmoſphere, particularly, during ſummer, or by the influence of the ſun. Had the rule, eſtabliſhed by nature, for the evaporation of water and condenſation of vapour, followed any other ratio than that which has been inveſtigated in the theory, no mixture of the atmoſphere could have produced either miſt or rain, and the regions of condenſation muſt have been limited to the regions of cold, where, in all probability, there muſt have been continual rain, with no other variation, perhaps, than a little change in the limits of the condenſing regions, each of theſe two regions increaſing and diminiſhing alternately, with the ſeaſons of winter and ſummer.

In the actual ſyſtem of the globe, the caſe is different, and there is ample proviſion made, in general, for rain; but, in the theory which has been given with regard to a certain part of that ſyſtem, there is required, for the production of rain, certain circumſtances and conditions which do not flow immediately from the heating and cooling cauſes exerted every where upon the globe. If thoſe conditions, therefore, are not obſerved in certain places, no rain ſhould there appear, notwithſtanding the nature and ſituation of ſuch places ſhould be ſimilar to thoſe of other places where abundant rain is found. But, if it be reaſonable to conclude, that, in ſome particular ſituations, there ſhould not be found the proper conditions for mixing together portions of the atmoſphere, ſufficiently ſaturated with humidity, and in different degrees of heat, or that theſe ſhould occur but ſeldom, then, in finding upon the whole earth preciſely ſuch a ſpot or two, in which ſeldom or very rarely it is found to rain, we might be allowed to ſuppoſe a failure in the conditions proper for rain in thoſe places; and to conclude this from the effect, where it is not poſſible to ſee farther into the cauſe.

The

THE lower Egypt, and a narrow ſpot upon the coaſt of Peru, are the only examples that we have of this ſingular occurrence. It would have been impoſſible, *a priori*, to have concluded, that, of all the places upon the earth, theſe two ſhould have been thoſe in which rain ſhould not happen; the knowledge of man, in tracing future effects from known cauſes, will ever be, perhaps, too imperfect for ſuch an undertaking, where it is neceſſary, not only to value every condition neceſſary in the data, but alſo every quantity and degree in thoſe different conditions; but, though we may not form that judgment *a priori*, yet, finding that theſe are the only places in which rain does not fall, we may be allowed to conclude, that ſuch is the natural ſtate of the winds about thoſe places, as to prevent the proper conditions for producing rain.

This concluſion is alſo, in ſome meaſure, confirmed from ULLOA's obſervations with regard to the wind, which appears to blow ſo ſteadily upon the coaſt of Peru, that either continual rain might be here expected, or no rain at all, upon this coaſt. In this laſt caſe, we would have reaſon to conclude, that the vapours from the ſea were carried over the coaſt to be condenſed, by mixing with other ſtreams of cold atmoſphere in the mountainous regions of the Andes, where it rains ſo abundantly for moſt part of the year.

IF, on the one hand, we ſuppoſe the wind blowing continually from the ſea, without mixing with a ſtream of air proper to condenſe humidity, it muſt paſs over this heated coaſt, without letting fall a drop of rain. If, on the other hand, we ſhall ſuppoſe the trade-wind, which has come over the Atlantic, to be continued over the ridge of the Andes, weſtward, after having depoſited much rain in this hilly region, there would be alſo no reaſon to ſuppoſe, that this current of atmoſphere, paſſing over the heated coaſt, ſhould there find conditions proper for condenſing its humidity.

BUT

But the queſtion is not, if, in any ſituation upon the ſurface 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 conſtitution 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 conſidered, 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 conſiſtent 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 mountain and of valley, ſhould be found without rain, inſtead of tranſgreſſing the neceſſary concluſion of a generality with regard 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 always ſufficient to produce the full effect; for a ſcanty condenſation of aqueous vapour will not deſcend in rain, but remain 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 ſummer ſun is, to form a certain haze, that diminiſhes very much the

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.

The

THE meeting together of different ſtreams of air is not ſufficient for the production of rain; it is alſo required, that thoſe ſtreams of air be in degrees of heat ſufficiently different to produce a proper condenſation; but as every place, except the poles themſelves, may be conſidered as ſituated between two different regions, the one hotter and the other colder than itſelf, any place in which circumſtances are found favourable for the commixtion of different winds, may be conſidered as having alſo this condition favourable for the condenſation of rain; and thus theſe two conditions, the mixture of winds, and the proper temperatures of thoſe winds, may be comprehended under this firſt principle.

THE ſecond principle to be now conſidered, is the quantity of humidity contained in the ſtreams of air which are mixed for the production of rain. Here is a diſtinct principle, which is perfectly different from the firſt; and, according to the theory, the quantity of rain in any place, *cæteris paribus*, will neceſſarily depend upon this principle. There being thus two different principles for determining the quantity of rain, we muſt always have an eye to each of thoſe principles, in comparing natural appearances with the theory. With this view, it will be proper to conſider ſeparately theſe two principles as the cauſe of rain; and it will be eaſy to underſtand the compounded effect of both, after aſcertaining what ſhare of operation may belong to each.

WERE the ſurface of this globe uniform, or a perfect ſpherical form, whether of ſea or land, it does not appear how there ſhould be produced any wind, or ſtreams of air, but what were regular, in being determined by the influence of the ſun and motion of the earth, by which the different parts of that ſurface would come variouſly, but regularly, to be affected by the influence of this luminary. But the ſurface of this globe is compoſed of ſea and land; and this diverſification is various and irregular. Here is, therefore, a ſource of variable winds,

or different ſtreams of air, which may mix for the production of rain. The ſurface of the earth is alſo diverſified with plains and mountains, woods and barren deſarts; and here is fixed another ſource of variation; firſt, for the various heating of that ſurface; ſecondly, for the production and mixture of different ſtreams of air; and, laſtly, for the influencing or determining the quantities of rain in each place.

MOUNTAINS, in general, may be conſidered as conducing much to the mixing of different ſtreams of air; for, by the heating of the ſides of thoſe mountains, more directly expoſed to the rays of the ſun, there are neceſſarily formed partial ſtreams, or occaſional currents, in that fluid maſs of atmoſphere; and theſe currents muſt tend to mix its different parts. Mountains, alſo, in oppoſing the more general ſtreams or currents of the atmoſphere, muſt deflect thoſe currents in their courſe, and form a ſource for the meeting together of currents coming from the different ſides of thoſe ridges, and from the oppoſite quarters of the ſame ſide. Therefore, mountains and their neighbourhood may be conſidered as being, *cæteris paribus*, more favourable to the production of rain than plains and low countries little above the level of the ſea. But, as this concluſion is found, in general, to be verified from experience, the theory here receives freſh confirmation from natural appearances.

THUS, it will appear, that the effects commonly aſcribed to mountains, *viz.* breaking the clouds by their mechanical operation, and attracting them by their electric quality, and ſuch like operations, are erroneous, or unneceſſary for explaining the general appearance of mountainous ſituations having more rain and thunder than the plains. Neither is the cold, natural to the tops of mountains, to be conſidered as productive of rain, in cooling and condenſing the atmoſphere; for the cold upon the top of a mountain is the effect of the atmoſphere; this

this place being no colder, in general, than any other in the neighbouring atmoſphere at the ſame height.

ACCORDING to this principle, there ſhould be more rain upon the land than upon the ſea, which, being a plane, and homogeneous in its nature, has neither the ſame power to produce ſtreams of air, nor to mix together thoſe which it may produce. We find this alſo conſiſtent with experience. There is leſs rain, in general, upon the ſea than upon the land, ſo far as we may judge from all that we know. In the conſtant trade-winds, there is very little rain; but, in the variable winds adjoining to the trade-winds, rain falls in abundance, which is ſtrictly agreeable to the theory. So certain alſo is this general principle, that the moſt experienced ſeamen and beſt obſervators have made the remark, that, in thoſe great oceans, the appearance of a cloud at a diſtance was an indication of an iſland, which they ſeldom failed to find from that indication.

THE ſecond principle in the cauſe of rain is the different degrees of humidity that may happen to be in the ſtreams of air which are mixed. Here we ſhall alſo find a great ſource of variation as to the quantity of rain to be produced in equal circumſtances, *i. e.* with a perfect ſimilarity in the other requiſite conditions. It is not, however, ſo eaſy to exemplify the reality of this principle from actual obſervation, as it is with regard to the other, which had been ſo evident as to have been received into a general opinion. We ſhall, therefore, be obliged to look out for ſome appearances, by which the theory may be confirmed, in proving the two following general propoſitions:

1ſt, THAT the place where the greateſt quantity of rain ſhould fall, *cæteris paribus*, is in the land contiguous to a great ſea in a tropical ſituation.

2dly, THAT the place where the leaſt quantity of rain ſhould fall upon the earth, *cæteris paribus*, is the moſt inland part of the continent of Europe and Aſia, in a cool or temperate latitude.

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.

We

We may next compare the two extents of land which ſupply with water thoſe two compared evaporating ſurfaces. If, in thoſe two caſes, the ſurfaces of land, collecting rain, be equally proportioned to the ſurfaces from which that water is to be evaporated; and, if we ſhall ſuppoſe, that the quantity of rain which falls upon thoſe two ſurfaces of land, is equal in proportion to their ſpaces; in that caſe, we ſhould conclude, that all the water received into thoſe lakes might be evaporated, as it is in the Caſpian ſea. If, on the contrary, an immenſe quantity of water iſſues annually from thoſe lakes, while there is reaſon to conclude, from the compariſon of the Caſpian, that all the received water ſhould be evaporated, we ſhall then have reaſon to conclude, that there falls much more rain upon this inland place of North America, than upon a ſimilar ſituation in the great continent of Europe and Aſia. The fact is, that the Caſpian receives its water from a ſurface of land, larger, in proportion, than that from whence the lakes of America are ſupplied; conſequently, there ſhould no water iſſue from the lakes, but all evaporate, according to this rule.

In this calculation, the evaporation has been ſuppoſed to be equal, from equal ſpaces, on the ſurface of the Caſpian and the lakes. But it may be alleged, that the evaporation from the lakes may be leſs than that from the Caſpian; conſequently, there might appear to be a redundancy of water, in this caſe, from the lakes, although the proportion of rain might be no greater. This argument, upon another occaſion, might be concluſive; but, in this caſe, where a greater power of evaporating water muſt attend the leſſer quantity of condenſed vapour, as flowing neceſſarily from the ſame cauſe, *viz.* the great diſtance from the ſea, to allege a greater evaporating power upon the ſurface of the Caſpian than on that of the lakes, is evidently to give up the argument; unleſs the greater evaporation ſhall be ſuppoſed to ariſe from a different cauſe; and here the only cauſe of this

this kind that occurs is a greater degree of heat; which may be now conſidered.

THERE is no doubt that there would appear to be leſs heat in the climate of North America than in that of Europe, comparing equal latitudes; but, unleſs this greater cold ariſes from ſome other cauſe than that which produces the greater quantity of condenſed vapour, this argument from the temperatures, in relation to heat and cold, would be no more concluſive than that from the dryneſs of the climate. Now, it muſt be evident, that, upon a continent where there is a greater quantity of condenſed vapour, there muſt be more clouds to intercept the heat of the ſun, or its influence in heating the ſurface of the earth; and alſo, there muſt be more of that heat loſt, in relation to our ſenſation, by being employed in evaporating the greater humidity from the ſurface of that earth. The proper concluſion is, that the greater cold, in the climate of North America, compared with the climate of the Caſpian, ariſes from the ſame cauſe which produces the greater quantity of rain; at leaſt, that this is the caſe in a great meaſure, and that we have no rule for valuing the effect of any other cauſe.

HAVING thus found, that a greater quantity of rain falls upon a given ſurface in the ſmaller continent of the new world, than upon a ſimilar one in the greater continent of the old, the theory is ſo far confirmed; as, according to this theory, there ſhould be found more favourable circumſtances, or conditions, for the condenſation of aqueous vapour in the atmoſphere, and the production of rain in the ſmaller than in the greater continent.

5. *The Theory applied to Meteorological Obſervations.*

HAVING compared the general appearances of the globe, in relation to rain, with the theory, and having found that perfect correſpondency betwixt them, which is neceſſarily required in phyſical truths, we may now conſider the general appearances of

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: *1ſt*, The motion of the wind, or the quarter from whence it comes. *2dly*, 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 are

are to be conſidered in relation to the perceived effects, rain or drought, which are ſuppoſed to happen in conſequence of one or more of thoſe three cauſes; that thus we may endeavour to diſcover which of theſe is to be eſteemed the proper cauſe, and which to be conſidered as only a concomitant appearance.

NOTHING appears to us ſo diſtinct as the motion and direction of the wind, yet nothing is ſo fallacious as the reaſoning from this appearance, conſidered as a cauſe in the changes to be produced in the atmoſphere, and as explaining thoſe effects of change which we perceive. In making our obſervations on the wind, we are limited to a ſpot, which may be conſidered as a point in the line of the wind's direction; and, from our obſervations in this ſpot, we are apt to conclude with regard to operations which include a great extent. When, for example, the wind blows from the weſt, in our obſervation, we ſay, it has come along the Atlantic; when, from the eaſt, that it has come from the continent of Europe; yet, unleſs we ſuppoſe the wind, in moving, to preſerve a ſtraight line, or direct courſe, it muſt be evident, that, in thoſe two caſes, the wind, inſtead of coming, as we imagine, from the eaſt or weſt, may truly have come from the north or ſouth. Now, to any one who conſiders attentively the nature of motions in the fluid atmoſphere, it muſt appear, that a ſtraight line is that, of all others, which there is the leaſt reaſon to conclude ſhould take place in the variable winds of the globe; but theſe are the winds only with which we are now concerned.

IT will likewiſe be evident how great a difference there is between a weſt or eaſt wind and a ſouth wind, on the one hand, or a north wind, on the other. Now, what a confuſion, in our reaſoning, muſt ſometimes follow this preſumption of our principles? For, if we may confound a ſouth wind, in our obſervations, with a wind coming to us directly from the weſt, we muſt alſo be ſubject to miſtake a north wind upon a like occaſion, *i. e.* in taking it for a weſt wind. Thus, therefore, in reaſoning

reaſoning from our obſervations, a ſouth wind and a north wind, things as different in their qualities as oppoſite in their directions, will ſometimes be confounded.

THE practical obſervation to be now made from this is, that we ſhould always allow the appearance, with regard to the direction of the wind, or place from whence it came, to be corrected by thoſe concerning the temperature of this fluid, in relation to heat and cold, ſo far as there is reaſon to conclude that this indication of the thermometer is a thing of greater certainty than that of the wind's direction.

THERMOMETRICAL obſervations, with regard to the temperature of the atmoſphere, are, from their nature, variable. The ſurface of this earth is heated by the influence of the ſun; and the atmoſphere, in contact with this ſurface, is heated by communication of temperature: Or, in like manner, it is cooled, upon another occaſion, when it happens to be warmer than the ſurface of the earth. But, whatever may be the temperature of the atmoſphere, there is, in general, a certain allowance to be made for the diurnal influence of the ſun; and this is found out, by experience, both with regard to its quantity upon the ſcale 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 conſidered, and the cauſes of that change. It muſt be evident, that nothing can contribute ſo much to change the temperature of the atmoſphere, as change in the direction of the wind, ſuppoſing, that, in our obſervation, it gives no falſe indication. It is impoſſible, that the ſouthern atmoſphere ſhould be tranſported over this iſland, without giving heat above the mean temperature of the ſeaſon at which the obſervation is made; or that the wind ſhould come directly from the north, without producing the oppoſite effect. Therefore, we are obliged to eſtabliſh this

principle, that whatever degree of heat or cold is felt exceeding the mean temperature, or that which is proper to the ſeaſon of the obſervation, muſt be attributed to the motion of the atmoſphere from the ſouth or north, although the direction of the wind, upon the little ſpot of our obſervation, may have given another indication.

THE atmoſphere moving from the eaſtern or weſtern regions is not neceſſarily either warmer or colder than the place of our obſervation; but it may be occaſionally either the one or the other; and, from the known nature and circumſtances of ſuch places, there are alſo rules to be formed for judging of theſe occurrences. It would, however, be foreign to our preſent view to enquire into theſe rules; and it is only neceſſary to obſerve, upon the whole, that there is no ſteady cauſe for either heat or cold, in general, being tranſported to us, in the caſe of the atmoſphere being moved directly from the eaſt or weſt.

HENCE will appear the truth of that general rule which was propoſed for judging of the region from whence the atmoſpheric ſtream has moved to us, *viz.* that we ſhould aſcribe more to the heat and cold of that fluid, compared with our mean temperature for the ſeaſon, than to the direction in which the ſtream paſſes over our head. The obſervations which relate to the barometer may now be conſidered.

THE barometer is as juſt a meaſure of the weight or compreſſion of our atmoſphere, as is the thermometer of its degree of heat or cold. But natural philoſophers, obſerving the connection of changes in the barometer, with the diſpoſition of the atmoſphere to rain, have judged, that one of thoſe things ſtood in relation of a cauſe to the other; and, finding, that often the mercury in the barometer fell from its ſtationary place before the change from fair to rainy weather, they have concluded, that rarity in the atmoſphere was an immediate cauſe of rain. If ſuch a concluſion as this could be admitted upon ſound principles, the theory now given, with regard to the phænomenon of rain,

rain, would be uſeleſs or uncertain; but, that ſuppoſition with regard to the effect of rarity in the atmoſphere, ſo far from being ſupported by the truth of obſervation, or from phyſical principles, is deſtitute of every confirmation.

WHATEVER ſhall be ſuppoſed the cauſe of rain, one thing is evident, that the neceſſary conſequence of the falling of rain from the atmoſphere is to make that atmoſphere more light, proportionally to the quantity of water which, after being ſeparated from the air, is ſupported by the earth on which it falls. But there do not fall ſuch quantities of rain in theſe regions, as to explain the quantity of loſt preſſure, indicated by the barometer upon theſe occaſions; therefore we are obliged to reject the conſideration of the appearance of the barometer, either as the cauſe or the effect of rain; although, inaſmuch as they are connected with the cauſes of rain, the indications of the barometer are found, from experience, to be of ſome uſe in the prognoſtication of that event.

THOSE great changes in the atmoſphere, which occaſion the remarkable riſings and fallings of the barometer, are not partial, as happening to a narrow ſpot around the place of obſervation, but are of great extent. This appears from the compariſon of different regiſters; for, at the diſtance of 400 miles, and perhaps much more, two barometers proceed nearly in the ſame manner, riſing and falling, in general, almoſt in the ſame ratio; but, within that diſtance, rainy weather often happens in one place, while it is fair weather in another; conſequently, in ſuppoſing either the levity of the atmoſphere, or its gravity, to occaſion rain, we ſhould be led into abſurdity, by concluding the ſame cauſe as producing contrary effects, or a cauſe exiſting without its proper effect.

INSTEAD of ſuppoſing the changed compreſſion of the atmoſphere to be an immediate cauſe of rain, let us ſuppoſe this change to be the conſequence of ſome great emotion produced in that fluid body; then, as different parts of the atmoſphere

come naturally to be mixed on thoſe occaſions of inteſtine motion, 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, appear 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 barometer, 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 evaporation 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 atmoſphere, 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 indicates 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 ſuppoſition; yet it is only true conditionally; that is, providing no other cauſe interferes, or that the ſtationary place of the mercury 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 extent as might render doubtful, in general, the poſitive indication of the barometer, in relation to fair weather.

Having thus obtained a poſitive indication of what may be called the fair-weather ſeaſons, and the rainy ſeaſons, requiring commotions

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 thoſe cauſes, which, in the temperate zone, excite to ſo great changes in the preſſure of the impending atmoſphere. This moving cauſe in the equinoctial region is more equable than it is any where elſe, except perhaps at the poles; and it is always exerted nearly in the ſame direction, in forming a motion from eaſt to weſt. When it is otherwiſe, that is, when ſome caſual change interrupts the equable progreſſion of the atmoſphere, the moſt violent effects may appear, in particular places, for a ſhort ſpace of time, without much change in the general quantity of the atmoſphere in this region, by which the ſtation of the mercury in the barometer is determined; conſequently, the barometer, which is much affected by the motions of the atmoſphere in the temperate regions, ſhould be but little affected with thoſe motions in the middle region.

To conclude, the barometer is an inſtrument neceſſarily connected with motions in the atmoſphere; but it is not equally affected with every motion in that fluid body. The barometer is chiefly affected by thoſe motions by which there are produced accumulations and abſtractions of this fluid, in places or regions of ſufficient extent to affect the preſſure of the atmoſphere upon the ſurface of the earth. But as every commotion in the atmoſphere may, under proper conditions, be a cauſe for rain, and as the want of commotion in the atmoſphere is naturally a cauſe of fair weather, this inſtrument may be made of great importance for the purpoſe of meteorological obſervations, although not in the certain and more ſimple manner in which it has been, with the increaſe of ſcience, ſo ſucceſsfully applied to the meaſuring of heights.

HAVING thus eſtabliſhed this principle, that the barometer is but little affected with the fall of rain, we may now employ ſome general obſervations of this inſtrument, to diſcover or illuſtrate certain operations in the atmoſphere, which are more immediately connected with the cauſe of rain in the region now conſidered.

IT

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

feſted in this, that, by people who reaſon from the immediate obſervation alone, wind is attributed to the ſhower as an effect, when it may more truly be conſidered as ſtanding in the relation of a cauſe.

2. When, in calm weather, rain begins, it is reaſonable to expect that this ſhould be followed by wind; and, in like manner, if in windy weather it begins to rain, it may be reaſonable to expect that the wind ſhould calm, after a certain period, with the rain. Theſe undoubtedly are the general appearances; and theſe appearances are explained upon this principle, that wind is the cauſe of rain, and that, in the oppoſition of winds, a calm may be produced.

3. During a calm and clear ſky, ſhowers never happen; but, with ſqualls of wind, ſudden ſhowers appear. In calm weather, before it rains, the heaven is all overclouded, and the rain becomes general, equable, and not in ſpots: But, when attended with wind, the rain is unſteady; one while, the ſpot around us is involved in the thickeſt cloud and heavy rain; another while, it is under the cleareſt ſky; and theſe alternate operations in the atmoſphere of thickening and clearing continue during the ſqually weather.

4. These facts are from my own obſervation; and they neceſſarily imply the mixture of hot and cold ſtreams of air for the production of rain. But ſometimes this operation is a thing viſible in itſelf; for when, by means of the motion of the clouds, the atmoſphere is perceived to be moved in oppoſite directions, here, it is evident, nothing is required beſides the proper conditions, in thoſe mixing ſtreams, for the condenſation of rain. Now, I have had it from experienced ſeamen, men of great knowledge and obſervation, that, in our channel, they had often occaſion to remark this oppoſition in the winds, or the clouds going againſt the wind, as being a ſure mark of heavy rain to follow.

5. The

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

or commotion in the atmoſphere that will be followed by this effect; for though mixture of the atmoſphere be a neceſſary condition in the cauſe of rain, it is not the only condition; and, therefore, the ſame appearances, in relation to the winds, and to the different temperatures of the atmoſphere, may be obſerved, 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 atmoſphere be ſufficiently ſaturated with vapour or humidity; which is a thing that cannot perhaps be made the ſubject of our obſervation.

6. RAIN happens in the hotteſt weather, and in every degree of temperature, down to the freezing point; it requires, therefore, much attention to obſerve the changes of temperature in the atmoſphere that uſually 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 ſo manifeſt, in the fluidity and congelation of water, that a perſon can hardly avoid making obſervations which will tend to confirm the theory.

WHEN, after ſettled froſt, it begins to ſnow, the cold is always found to relent, and the thermometer to riſe to the freezing point, or nearly, however low it may have been before. But after the ſnow has fallen, and the ſky becomes clear, the cold increaſes, until it again reſumes its former intenſity, or even proceeds to a greater degree. This is an appearance which is eaſily explained in the theory; and it is an appearance which every perſon, who can make an obſervation, has it frequently in his power to verify.

7. THE climate which we inhabit has, for character, temperance in extreme; our winters and our ſummers differ but little from each other in their mean temperatures. There is, in this iſland, but little ſteady 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 meaſure, be produced in conſequence of the variable nature of our winds. So far as this is the caſe, that the mixture of different ſtreams of the atmoſphere temperates the heat and cold of our air, this operation ſhould be attended with proportionate condenſation of aqueous vapour. Here the theory is brought to the teſt of obſervation. But, before deciding the point in queſtion, let us underſtand what it is which, in obſervation, ſhould be deciſive with reſpect 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 preſent queſtion; 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 ſubject for our obſervation, in order to form an eſtimate with regard to the point in queſtion; but it is not itſelf that point in queſtion. The point is the condenſation of aqueous vapour in the atmoſphere; and though no rain can fall without the condenſation of aqueous vapour, there may be much condenſation of that vapour, without rain, as a teſtimony of that event. Thus we are led to direct our obſervation to other phænomena beſides rain; appearances which may be equally concluſive, in relation to the point to be decided, with rain itſelf. Now, theſe appearances, in which the condenſation of aqueous vapour is equally demonſtrated with that of rain, are no other than cloudineſs in our atmoſphere.

The queſtion reſpecting the theory being now brought to this iſſue, with regard to obſervation, it may be demanded, what is the proportion of ſerene ſky and cloudineſs in the atmoſphere that properly belongs to this climate? Here is a queſtion propoſed, that requires not extreme exactneſs in its anſwer. I believe every body, from their recollection, will allow, that, for one day or hour of clear ſunſhine, there are two or three of

cloudineſs in the atmoſphere; and this is ſufficient for determining the queſtion, whether or not the condenſation of aqueous vapour be prevalent in the climate of this iſland?

8. CLOUDINESS in the ſky being a demonſtration of aqueous condenſation in the atmoſphere, in like manner as is the caſe with rain, this appearance may now be examined with regard to the temperature of the air, in relation to heat and cold, that commonly attends on this occaſion. Let us begin with ſummer; and ſuppoſe the weather to be warm; that is, preciſely in the natural temperature of the ſeaſon. There is no queſtion with regard to the effect of a clear ſky, or continued ſunſhine: Heat is certainly the effect of ſunſhine; and this heat is accumulated in the earth, *cæteris paribus*, in proportion to the intenſity of the light and the duration of the illumination. The queſtion now to be examined is this, what ſhould be the effect of condenſation of aqueous vapour in the atmoſphere at this ſeaſon, and in this ſummer temperature; that is to ſay, whether ſhould heat or cold be the conſequence of this operation?

NOTHING is ſo eaſy as the anſwer to this queſtion. We ſuppoſe the atmoſphere in the mean temperature of the ſummer-ſeaſon, and that a condenſation of aqueous vapour is produced by the admixture of a current of atmoſphere in a different temperature. Now, as this effect may be produced by the admixture of air, either hotter or colder than our atmoſphere, which is ſuppoſed to be quite ſerene, the effect muſt be a change of the temperature of our atmoſphere, either to a greater or a leſs degree of heat than its mean temperature for the ſeaſon, according as the ſupervening atmoſphere, producing cloudineſs in our ſky, ſhall be either hotter or colder, in its temperature, than that in which we had been involved immediately before.

FROM this concluſion, we will now draw a practical obſervation, which may be of ſome utility in trying the theory and explaining appearances. If the heat of the atmoſphere be,

at

at any time, above its mean temperature for the ſeaſon, and a change ſhall happen from a ſerene ſky to cloudineſs, we have reaſon to expect, that the extreme heat will be temperated, and the atmoſphere conſequently cooled. But, if the temperature of our atmoſphere be below its mean heat for the ſeaſon, then, from the change of clearneſs for a cloudy ſky, we have reaſon to look for a change from cold to hot.

FROM this alſo we have a proper explanation of a general appearance, with regard to the ſerenity of the ſky, in every climate, and in the oppoſite ſeaſons of ſummer and winter; for this ſerene ſky, or clear atmoſphere, is perfectly conſiſtent 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 thoſe two extremes, that is to ſay, of hot and cold atmoſphere, which produces, at the ſame time, cloudineſs to the ſight, and temperance in relation to the ſenſe of heat and cold. Thus will be explained a common obſervation, with regard to the weather of this country, that the air is always cold, below its mean temperature for the ſeaſon, when the ſky is clear. The country people allege that it is then froſt, even in the midſt of ſummer. They probably find hoar-froſt early in the morning, eſpecially in the higher parts of the country; and ſurely the making of ice in Bengal juſtifies that obſervation.

9. THE formation of hail is evidently upon the ſame principle as that of ſnow. 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 ſnow; but theſe peculiar circumſtances are to us, perhaps, unknown; and as there is nothing in the appearance of hail that is, in any reſpect, inconſiſtent with the theory, the confounding of ſnow and hail brings no error into our ſcience, nor affects the doctrine with the leaſt uncertainty. Hail is evidently formed by the collection of ſmaller molecules, which ultimately are of the

nature

nature of ſnow; and it is probably by means of electrical attraction, that this collection is performed.

10. THERE is one appearance more, that often attends rain, and, therefore, ſhould be conſidered; this is thunder, which ſo frequently accompanies violent and ſudden rain. But, as we are ignorant of any principle upon which electricity ſhould be the cauſe of condenſing aqueous vapour in the atmoſphere, this is not the place for examining what may be the effects of electricity, with regard to aqueous vapour condenſed from its elaſtic ſtate, farther than that it is moſt reaſonable, and alſo conſiſtent with appearances, to ſuppoſe a more ſudden attraction of the condenſed particles of water, than what happens upon other occaſions, where even a degree of electrical repulſion may preſerve them from immediate contact, and protract the fall of rain, by ſuſpending the condenſed vapour in form of miſt.

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 $69^\circ\frac{1}{4}$ 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 $69^\circ\frac{1}{4}$, 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.

* General ROY makes the fixed temperature 32°, and the expanſion for 1°, = .00245, at a medium. Sir G. SHUCKBURGH makes the fixed temperature 31° $\frac{1}{4}$, and the expanſion, as here aſſigned, *viz.* .00243. *Phil. Tranſ.* 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. Tranſ. 1777.

troduced. The atmoſphere, therefore, is warmed by the earth, from the ſurface of which a quantity of heat is continually flowing off, and aſcending through the different ſtrata of the air into the regions of vacuity, or of æther. But this aſcent, on the whole, is uniform; becauſe there is a certain temperature which, though varied by periodical viciſſitudes, remains under every parallel the ſame, as to its mean quantity. Every ſtratum, therefore, of the atmoſphere, whatever be its height, gives out, at a medium, the ſame quantity of heat that it receives; in other words, its mean temperature is conſtant, and neither increaſes nor decreaſes, on the whole.

3. LET there be three ſtrata, then, of the atmoſphere of the ſame thickneſs $\dot{x}$, and contiguous to one another; ſo that, if x be the diſtance of the firſt from the ſurface of the earth, that of the ſecond may be $x+\dot{x}$, and of the third $x+2\dot{x}$. Let b, b', b'', be the heats of the ſtrata, and Δ, Δ', Δ'', their denſities reſpectively: Then, ſince the quantity of heat, communicated in an inſtant from one ſtratum of a fluid to a contiguous ſtratum, muſt be, as the difference of their temperatures, multiplied into the denſity of the colder, and divided by the denſity of the warmer, the heat communicated, in an inſtant, from the firſt ſtratum to the ſecond, $= (b-b')\frac{\Delta'}{\Delta}$; and that communicated by the ſecond to the third, $= (b'-b'')\frac{\Delta''}{\Delta'}$. But, ſince the difference of Δ and Δ'' is indefinitely ſmall, as alſo that of Δ' and Δ'', we have $\frac{\Delta}{\Delta}=1$, and $\frac{\Delta''}{\Delta'}=1$; ſo that the heat gained by the middle ſtratum is $= b-b'$, and that loſt by it $= b'-b''$. Now, theſe two quantities muſt be equal, in order that the temperature of the ſtratum may remain uniform, that is, $b-b'=b'-b''$; or, in other words, the heat of the firſt ſtratum exceeds the heat of the ſecond, as much as the heat of the ſecond exceeds the heat of the third. Therefore, the heat of the ſucceſſive ſtrata muſt decreaſe, by equal differences, as we aſcend through equal

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 b the heat at any given height a, above the ſurface, the heat, at any other height, as x, will be $H-\frac{(H-b)x}{a}$. 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 $=H-\frac{x}{50}$.

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 in one circumſtance; for the formula makes the expanſion increaſe with the heat continually, though not uniformly; whereas the experiments give the greateſt expanſion between the temperatures of 60° and 70°. But this ſeems to be ſo anomalous a fact, that it looks more like ſome 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 temperature.

7. BUT this is not the only irregularity to which the expanſion of air by heat, and its contraction by cold, appear to be ſubject. We learn from the manometrical experiments of the ſame excellent obſerver, that a given variation of temperature is accompanied with more or leſs variation of bulk, according as the air is compreſſed by a greater or a leſs force. Air, for inſtance, compreſſed by the weight of an entire atmoſphere, was expanded by the 180 degrees from freezing to boiling, no leſs than 484 of thoſe parts, whereof, at the temperature 32°, it occupied 1000. But the ſame air, when compreſſed only by $\frac{1}{3}$ of an atmoſphere, was, by the ſame difference of heat, expanded no more than 141 parts; and that though the heat of boiling water was applied to it for an hour together. It is not eaſy either to aſſign the cauſe, or to determine the law of this inequality. General ROY has, indeed, conſtructed a table of the correction to be made on account of it; which proceeds on the ſuppoſition, that the expanſion, for one degree of heat, decreaſes in the ſame proportion that the column of mercury in the barometer exceeds a given length. This given length is nearly $= 4.5$ inches; ſo that if b be the length of the column of mercury in the barometer, and .00252 the expanſion for one degree of heat, when the barometer is at 30 inches, and the temperature of the air 32°, then $\frac{b-4.5}{25.5} \times .00252$, will be the expanſion of air of the ſame temperature, for the ſame change of heat, when

when the mercury in the barometer ſtands at the height b. But this formula cannot be juſt, otherwiſe air, compreſſed 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 caſes, to ſuppoſe, that the expanſion for a certain degree of heat is as a certain power of the compreſſing force. If this power be called μ, m being the expanſion for 1 degree of heat, when the mercury in the barometer is of the height b, the expanſion for any other height of the mercury, as β, will be $\frac{\beta^\mu}{b^\mu}m$; and combining this with the former formula for expanſion (§ 5.), we have the ſpace which air occupies, as far as it depends on temperature, $= (1-\frac{m\beta^\mu}{b^\mu})^{32-h}$. From a compariſon of General Roy's experiments *, μ appears to be between $\frac{1}{2}$ and $\frac{1}{3}$; and it muſt be confeſſed, that it is very difficult to aſſign its value within nearer limits. The form of the correction, however, if not its abſolute quantity, may be found from what is here determined. The laſt of theſe muſt be aſcertained by future experiments.

9. These inequalities belong to the temperature of the air; there is another that depends wholly on the compreſſion. In deducing the rule for the meaſurement of heights by the barometer, it has hitherto been ſuppoſed, agreeably to the experiments of Mr Boyle and M. Mariotte, that the denſity of the air, while its temperature remains the ſame, is exactly as the force that compreſſes it. But the experiments referred to were not accurate enough to eſtabliſh this law with abſolute preciſion; and they left room to ſuſpect a deviation from it, either when the compreſſing force is very great or very ſmall. Accordingly, from experiments deſcribed in the 9th vol. of the Mem. of Berlin, it appears that the elaſticity of air of the temperature

* Tab. 2. and 3. p. 701. 703. Tranſ. 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. It 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 alſo

alſo reckoned too great. The effect of both theſe errors is of the ſame kind, tending to make the height leſs than it is in reality; yet it is only the firſt of them, and that too the leaſt conſiderable, which has hitherto been taken into account.

12. It were to be wiſhed, that, to the cauſes here enumerated, and that are to be introduced into the computation, we could add the operation of moiſture, in altering the weight and elaſticity of the air. But the law of that operation has not yet been diſcovered; and it will be ſufficient to point out, in the concluſion of this paper, a method by which it may be determined from obſervations of the barometer itſelf.

Before proceeding to the inveſtigation of the effect which all theſe inequalities together muſt produce, it is proper to remark, that the two inequalities in the expanſion of air, taken notice of (§ 5. and 7.), after having been diſcovered by General Roy, were applied by him to correct the height of mountains, meaſured by the barometer; but that it is, by no means, certain, that he has given to thoſe corrections the preciſe form which they ought to have. This, indeed, cannot be known, unleſs the effect of each inequality, on a ſingle ſtratum, be firſt introduced into the differential equation between the denſity of the air and the height above the ſurface, and the amount of its effect on a whole column of air be deduced from thence by integration.

13. Let y, then, be the denſity of the air, at any height x above the ſurface of the earth, the heat at the ſurface being $= H$, expreſſed in degrees of Fahrenheit's thermometer. If alſo λ be ſuch a number, that λx gives the degrees by which the thermometer ſtands lower at the height x than at the ſurface (§ 4.), the temperature at the height x will be $= H - \lambda x$; and, if the expanſion of a given quantity of air, which occupies the ſpace 1, and is of the temperature 32°, for 1° of heat, be called m, then, abſtracting at preſent from that inequality of expanſion

expanſion which depends on preſſure, we have the ſpace occupied by that ſame 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 ſpace $=(1-m)^{\tau+\lambda x}$.

Now, if the given quantity of air, of which the bulk has been ſuppoſed $=1$, and the temperature $=32°$, be compreſſed by a column of air of the ſame denſity and temperature with itſelf, but of the height p, and if its denſity, in this caſe, be alſo called 1 ; then, in the caſe of its having any other temperature, as $H-\lambda x$, and being compreſſed by any other force, as $-\int y\dot{x}$, or the weight of the ſuperincumbent air at the height x, we have $1 : y :: p : \frac{-\int y\dot{x}}{(1-m)^{\tau+\lambda x}}$, and likewiſe

$$y = \frac{-\int y\dot{x}}{p(1-m)^{\tau+\lambda x}}.$$

No account is here taken of the diminution of gravity, any more than of the departure of the law of the elaſticity of air from direct proportionality to the denſity (§ 8.), becauſe it is convenient to conſider the problem at firſt under the more ſimple view, where only the two firſt inequalities are introduced.

13. SINCE $y = \frac{-\int y\dot{x}}{p(1-m)^{\tau+\lambda x}}$ we have

$$py(1-m)^{\tau+\lambda x} = -\int y\dot{x}, \text{ and}$$

$$\dot{py}(1-m)^{\tau+\lambda x} + p\lambda y(\log. 1-m)(1-m)^{\tau+\lambda x}\dot{x} = -y\dot{x},$$

$$\text{Or, } \frac{\dot{py}}{y} + p\lambda \log.(1-m)\dot{x} = -\frac{\dot{x}}{(1-m)^{\tau+\lambda x}}.$$

Hence

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 denſity of the air at the ſurface of the earth, D will be the value of y, when $x=0$, and ſo

$$p\,(log.D+log.C)=\frac{1}{\lambda g(1-m)^{\tau}}. \text{ Therefore}$$

$$p\,log.C=\frac{1}{\lambda g(1-m)^{\tau}}-p\,log.D; \text{ and ſo by ſubſtituting for}$$

$$p\,log.C,\ p(log.y-log.D)+\frac{1}{\lambda g(1-m)^{\tau}}=-p\lambda gx+\frac{1}{\lambda g(1-m)^{\tau+\lambda x}};$$

or changing the ſigns,

$$p(log.D-log.y)-\frac{1}{\lambda g(1-m)^{\tau}}=p\lambda gx-\frac{1}{\lambda g(1-m)^{\tau+\lambda x}}.$$

This equation exhibits, in general, the relation between the denſity of any ſtratum of air, and the height of that ſtratum above the ſurface of the earth, on the ſuppoſitions that the heat of the atmoſphere decreaſes uniformly as we aſcend, and that the contraction produced in air by cold, obſerves the law deſcribed in § 5. It might be conſidered as an equation to a curve, of which the abſciſſæ repreſented the height of the different ſtrata of the atmoſphere, and the ordinates, the denſities of thoſe ſtrata: This curve would evidently be different from the logarithmic, but would be found to have certain relations to it not unintereſting, and not difficult to trace, if we had leiſure for ſuch a digreſſion.

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 $\lambda = \frac{H-b}{z}$. Therefore, by ſubſtituting theſe values of y, x, λ, and $\tau + \lambda z$, in the preceding equation, we have,

$$p(log.\,D - log.\,\Delta) - \frac{z}{g(H-b)(1-m)^{\frac{z}{\tau}}} =$$

$$pg(H-b) - \frac{z}{g(H-b)(1-m)^{\frac{z}{r-b}}}.$$

Hence, by tranſpoſition, &c.

$$gp(H-b)(log.\,D - log.\,\Delta - (H-b)\,g) = z\left((1-m)^{\frac{H-r}{z}} - (1-m)^{\frac{b-r}{z}}\right);$$

$$\text{and } x = \frac{gp\,(H-b)(log.\,D - log.\,\Delta - (H-b)g)}{(1-m)^{\frac{H-r}{z}} - (1-m)^{\frac{b-r}{z}}}.$$

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

$D =$

$D = \frac{b}{(1-m)^{r-H}}$; and, for a like reaſon, $\Delta = \frac{\beta}{(1-m)^{r-b}}$. Therefore, $log.D = log.b-(r-H)g$, and $-log.\Delta = -log.\beta+(r-b)g$. Hence $log.D-log.\Delta = log.b-log.\beta+(H-b)g$, and ſubſtituting for $log.D-log.\Delta$ in the formula of the laſt ſection,

$$z = \frac{gp(H-b)(log.b-log.\beta)}{(1-m)^{H-r}-(1-m)^{b-r}}.$$

16. THIS is the exact value of z, or of the whole height to be meaſured, on the ſuppoſition that the heat of the atmoſphere decreaſes uniformly as the height increaſes; and that the contraction for a given difference of heat decreaſes according to the law deſcribed in § 5. But, in order that it may be more convenient for computation, and may be more eaſily compared with the formula now in uſe, the quantity $\frac{1}{(1-m)^{H-r}-(1-m)^{b-r}}$ muſt be reduced into a ſeries. Now $\frac{1}{(1-m)^{H-r}-(1-m)^{b-r}} = \frac{(1-m)^{r}}{(1-m)^{H}-(1-m)^{b}}$. But from the nature of logarithms, (g being, as before, the logarithm of $1-m$)

$$(1-m)^{H} = 1+Hg+\frac{H^2g^2}{2}+\frac{H^3g^3}{6}+ \&c.$$ And

$$-(1-m)^{b} = -1-bg-\frac{b^2g^2}{2}-\frac{b^3g^3}{6}- \&c.$$ Therefore

$$\frac{(1-m)^{r}}{(1-m)^{H}-(1-m)^{b}} = \frac{1+rg+\frac{r^2}{2}g^2+\frac{r^3}{6}g^3+ \&c.}{(H-b)g+\frac{H^2-b^2}{2}g^2+\frac{H^3-b^3}{6}g^3+ \&c.};$$

$$\text{and } \frac{g(H-b)(1-m)^{r}}{(1-m)^{H}-(1-m)^{b}} = \frac{1+rg+\frac{r^2}{2}g^2+\frac{r^3}{6}g^3+\&c.}{1+\frac{H+b}{2}g+\frac{H^2+Hb+b^2}{6}g^2+\&c.}.$$

$$\text{Hence } z = p(log.\,b-log.\,\beta)\left(\frac{1+rg+\frac{r^2}{2}g^2+\frac{r^3}{6}g^3+\&c.}{1+\frac{H+b}{2}g+\frac{H^2+Hb+b^2}{6}g^2+\&c.}\right).$$

17. These series will not converge fast, unless rg, Hg, and bg, be all of them quantities much less than unity. Now, as m, or the expansion of air of the temperature r, for 1° of heat, is, in fact, very small, being nearly $= .00245$, and as g, or the logarithm of $1-m$, must, of consequence, be nearly $= -m = -.00245$, it is plain, that, in all moderate temperatures, these series will converge with great rapidity; though, in extreme cases, where z is supposed vastly great, and where b may be negative, and also great, the series in the denominator may converge so slowly that recourse must be had to the formula in § 15. from which no quantities are rejected.

When m, and, of consequence, g, are very small, and when H and b do not differ much from r, the preceding formula, agreeably to a remark in § 6. will comprehend the case of uniform expansion, and will give the same expression for the height, that would be derived from considering only the equable decrease of heat as we ascend in the atmosphere. Now, as in the case supposed, we may reject all the powers of g but the first, and may also suppose $g = -m$, we have

$$z = p(log.\,b-log.\,\beta)\left(\frac{1-rm}{1-\frac{H+b}{2}m}\right), \text{ or}$$

$$z = p\left(1+\left(\frac{H+b}{2}-r\right)m\right)(log.\,b-log.\,\beta).$$

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 $z = p(1+m\left(\frac{nH+b}{n+1}-r\right))\ log.\ \frac{b}{\beta}$. 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 $z = p(1+m\left(\frac{H+b}{2}-r\right))\ log.\ \frac{b}{\beta}$, 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

* 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. Tranſ. 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;

$$\frac{1+rg+\frac{r^2}{2}g^2+\&c.}{1+\frac{H+b}{2}g+\frac{H^2+Hb+b^2}{6}g^2+\&c.} =$$

$$1+\left(r-\frac{H+b}{2}\right)g+\left(\frac{r^2-r(H+b)}{2}+\frac{H^2+4Hb+b^2}{12}\right)g^2;$$

$$\text{and } g = log.(1-m) = -m+\frac{m^2}{2}-\&c.$$

$$\text{so that } g^2 = \qquad m^2-\&c.$$

$$\text{Therefore, by substitution, } \frac{1+rg+\frac{r^2}{2}g^2}{1+\frac{H+b}{2}g+\frac{H^2+Hb+b^2}{6}g^2} =$$

$$1+\left(\frac{H+b}{2}-r\right)m+\left(\frac{r}{2}-\frac{H+b}{4}+\frac{r^2-r(H+b)}{2}+\frac{H^2+4Hb+b^2}{12}\right)m^2.$$

THIS is the coefficient of $p\,log.\frac{b}{\beta}$, which gives z, corrected both for the temperature of the air and the first inequality of expansion, (§ 5). The term $\left(\frac{H+b}{2}-r\right)m$, is M. DE LUC's correction, as has been already observed, the third term, *viz.* $\left(\frac{r}{2}-\frac{H+b}{4}+\frac{r^2-r(H+b)}{2}+\frac{H^2+4Hb+b^2}{12}\right)m^2$, 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 conſiderable. The coefficient of it vaniſhes when both H and h are equal to r, but increaſes as theſe two quantities recede from r on either ſide. In no inſtance where the barometer is to be applied to actual meaſurement, 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 $84^\circ\frac{1}{2}$, and h, or the height of the thermometer at the top of the mountain, $43^\circ\frac{1}{2}$; the coefficient of m^2 comes out, in this caſe $+426$, 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 ſtation, there are two values of h, or the temperature at the upper ſtation, that make the coefficient, $\frac{r}{2} - \frac{H+h}{4} + \frac{r(r-H-h)}{2} + \frac{H^2+4Hh+h^2}{12}$, and, of conſequence, the correction depending on it equal to nothing. This is evident from the nature of the coefficient; but, as the law by which this laſt increaſes and decreaſes is, by no means, ſimple, it were convenient to have it reduced into a table, for the different values that might be aſſigned to H and h, from which it would be immediately obvious in what caſes it was to be taken into account, and when it might ſafely be omitted.

BUT though this correction may ſometimes be of conſequence enough to be included in the meaſurement of heights, it is certain that it may be ſafely neglected in the computation of the other corrections. For the error thereby committed in the eſtimation of a new correction, will be nearly the ſame part of the former correction, that the new one is of the whole height. If, for inſtance, the new correction be $\frac{1}{100}$ of the whole

whole height, the error committed in eſtimating it will be but $\frac{1}{100}$ of the former correction; and, if that did not exceed $\frac{1}{400}$, the error in queſtion will not exceed $\frac{1}{40000}$ of the whole height.

21. In computing the effect of the ſecond inequality of expanſion, deſcribed § 8. we may, therefore, abſtract from the laſt inequality, and may even ſuppoſe, with M. De Luc, that the temperature, which is a mean between thoſe of the extremities of a column of air, is uniformly diffuſed through that column. Let the exceſs of that mean, above the temperature r, or $\frac{H+h}{2} - r = f$; and let β, the height of the mercury in the uppermoſt barometer, be conſidered as variable. Then taking the formula of § 8. and ſuppoſing m to be the expanſion for 1° of heat, when the mercury in the barometer is of a given height, which we ſhall here call γ *, (to avoid the confuſion that would ariſe 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 $py\left(1+\frac{fm\beta^{\mu}}{\gamma^{\mu}}\right) = -\int y\dot{x}$, ſo that, taking the fluxions,

$$p\dot{y}$$

* According to the experiments of General Roy, above quoted, the expanſion of air, for 1° of heat, at the temperature 32°, is .00245 nearly, that air being compreſſed at the ſame time by the weight of a column of mercury 29.5 inches high. As we have ſuppoſed m, in the preceding computations, to be .00245, we muſt ſuppoſe $\gamma = 29.5$. The formula ſuppoſed here to give the ſpace occupied by the air, ſo far as heat is concerned, *viz.* $1+\frac{fm}{\gamma^{\mu}}\beta^{\mu}$, is changed from the exponential expreſſion of § 8. in conſequence of what has been juſt obſerved about the effect of neglecting one inequality in the computation of another.

$p\dot{y}+\frac{pfm\beta^{\mu}\dot{y}}{\gamma^{\mu}}+\frac{pfm\mu y\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}=-y\dot{x}$, 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 remarked, that $y=\frac{\beta}{p(1+\frac{fm}{\gamma^{\mu}}\beta^{\mu})}$, and that therefore

$\frac{\dot{y}}{y}=\frac{\dot{\beta}}{\beta}-\frac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}+fm\beta^{\mu}}$. Hence, by ſubſtitution, $\dot{x}=$

$$p\left(-\frac{\dot{\beta}}{\beta}+\frac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}+fm\beta^{\mu}}-\frac{(1+\mu)fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}+\frac{\mu f^{2}m^{2}\beta^{2\mu-1}\dot{\beta}}{\gamma^{\mu}\left(\gamma^{\mu}+fm\beta^{\mu}\right)}\right).$$

But $\frac{\mu f^{2}m^{2}\beta^{2\mu-1}\dot{\beta}}{\gamma^{\mu}\left(\gamma^{\mu}+fm\beta^{\mu}\right)}=\frac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}-\frac{\mu fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}+fm\beta^{\mu}}$;

therefore $\dot{x}=p(-\frac{\dot{\beta}}{\beta}-\frac{fm\beta^{\mu-1}\dot{\beta}}{\gamma^{\mu}}\Big)$, the other terms deſtroying one another. By integration, then, $x=p\,(-log.\beta-\frac{fm\beta^{\mu}}{\mu\gamma^{\mu}}+C)$.

If C be taken ſuch that x may vaniſh when $\beta=b$, the height of the mercury in the lower barometer, we will have

$$x=p\left(log.\frac{b}{\beta}+\frac{fm(b^{\mu}-\beta^{\mu})}{\mu\gamma^{\mu}}\right).$$

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, $\frac{b^{\mu} - \beta^{\mu}}{\gamma^{\mu}} = \mu\, log.\frac{b}{\beta} + \frac{\mu^2}{2}\, log.\frac{b\beta}{\gamma^2} \times log.\frac{b}{\beta}$, rejecting all the terms which involve powers, of $log.\frac{b}{\gamma}$, of $log.\frac{\beta}{\gamma}$, 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 the difference of the tabular logarithms, to give the true height of the one barometer above the other. In other caſes, the proportional part, to be added or ſubtracted, will be greater as β becomes leſs, 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 leſs.

24. THERE remain to be conſidered the two corrections that depend, one, on the relation between the denſity of the air and the force compreſſing it; the other, on the diminution of gravity as we aſcend from the ſurface of the earth. It was obſerved (§ 9.), that, if D denote the denſity of the air, and F the compreſſing force, $D = F^{1+n}$. But the force, compreſſing a ſtratum of the atmoſphere at the height x above the ſurface of the earth, and of the denſity y, which, on the ſuppoſition of uniform gravity, is denoted by $-\int y\dot{x}$, on that of gravity decreaſing as the ν power of the diſtance from the centre of the earth, is denoted by $-\int \frac{s^{\nu}}{(s+x)^{\nu}} y\dot{x}$; where s is the ſemidiameter of the earth. This is evident, becauſe the weight of each ſtratum of air is proportional to its denſity, multiplied into the accelerating force which draws the particles of it toward the earth. Now, let q be the length of ſuch a column of mercury, that air, compreſſed by it, would be of the ſame denſity with the mercury itſelf, which denſity, in all the preceding inveſtigations, is underſtood to be conſtant, and to be $= 1$ *;

then,

* THE mercury in the barometers is ſuppoſed 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 aſtronomer royal. *Phil. Tranſ. vol.* 64. *part* 1. *p.* 164.

then, $1 : y :: q^{1+n} : \frac{\left(-\int \frac{s^{\nu}}{(s+x)^{\nu}} y\dot{x}\right)^{1+n}}{(1-m)^{\tau+\lambda x}}$, and

$$y = \frac{\left(-\int \frac{s^{\nu}}{(s+x)^{\nu}} y\dot{x}\right)^{1+n}}{q^{1+n}(1-m)^{\tau+\lambda x}}, \quad \text{or } y^{\frac{1}{1+n}} = \frac{-\int \frac{s^{\nu}}{(s+x)^{\nu}} y\dot{x}}{q(1-m)^{\frac{\tau+\lambda x}{1+n}}}.$$

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,

$$q\left(\frac{1}{1+n} y^{\frac{1}{1+n}-1} \dot{y}(1-m)^{\frac{\tau+\lambda x}{1+n}} + \frac{\lambda g}{1+n} y^{\frac{1}{1+n}} (1-m)^{\frac{\tau+\lambda x}{1+n}} \dot{x}\right) = -\frac{s^{\nu} y\dot{x}}{(s+x)^{\nu}}.$$

Dividing therefore by y,

$$q\left(\frac{1}{1+n} y^{\frac{1}{1+n}-2} \dot{y}(1-m)^{\frac{\tau+\lambda x}{1+n}} + \frac{\lambda g}{1+n} y^{\frac{1}{1+n}-1} (1-m)^{\frac{\tau+\lambda x}{1+n}} \dot{x}\right) =$$

$-\frac{s^{\nu}\dot{x}}{(s+x)^{\nu}}$; and making $y^{\frac{1}{1+n}-1} = v$, and, conſequently,

$$\frac{-n}{1+n} y^{\frac{1}{1+n}-2} \dot{y} = \dot{v}, \text{ we have}$$

$$\dot{v}(1-m)^{\frac{\tau+\lambda x}{1+n}} - \frac{n\lambda g}{1+n} v(1-m)^{\frac{\tau+\lambda x}{1+n}} \dot{x} = \frac{ns^{\nu}\dot{x}}{q(s+x)^{\nu}}.$$

This

This equation will become integrable if it be multiplied by $(1-m)^{-\lambda x}$, for it is then

$$\dot{v}\,(1-m)^{\frac{\tau-n\lambda x}{1+n}} - \frac{n\lambda g}{1+n}\,v\,(1-m)^{\frac{\tau-n\lambda x}{1+n}}\,\dot{x} = \frac{ns'\dot{x}}{q(s+x)^{n}\,(1-m)^{\lambda x}};$$

$$\text{and so } v\,(1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{ns^{n}}{q}\int\frac{\dot{x}}{(s+x)^{n}\,(1-m)^{\lambda x}}.$$

$$\text{But } v = y^{\frac{1}{1+n}-1} = y^{-\frac{n}{1+n}}, \text{ therefore,}$$

$$y^{-\frac{n}{1+n}}\,(1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{ns^{n}}{q}\int\frac{\dot{x}}{(s+x)^{n}\,(1-m)^{\lambda x}}.$$

25. It is neceſſary to introduce β into this formula, by ſubſtituting for y, its value, $= \frac{\left(\frac{s^{n}}{(s+x)^{n}}\beta\right)^{1+n}}{q\,(1-m)^{\tau+\lambda x}}$; and, therefore, as

$$y^{\frac{n}{1+n}} = \frac{s^{n}\,\beta^{n}}{q\,(s+x)^{n}\,(1-m)^{\frac{n(\tau+\lambda x)}{1+n}}}, \text{ we have}$$

$$\frac{q\,(s+x)^{n}\,(1-m)^{\frac{n(\tau+\lambda x)}{1+n}}}{s^{n}\,\beta^{n}} \times (1-m)^{\frac{\tau-n\lambda x}{1+n}} + C = \frac{ns^{n}}{q}\int\frac{\dot{x}}{(s+x)^{n}\,(1-m)^{\lambda x}},$$

or

$$\text{or, } \frac{q\,(s+x)^{n}\,(1-m)^{\tau}}{s^{\nu n}\,\beta^{n}} + C = \frac{ns^{\nu}}{q}\int \frac{\dot{x}}{(s+x)^{\nu}\,(1-m)^{\lambda x}}.$$

26. In the caſes which actually take place in nature, ν is either equal to $+2$, or to -1. It is equal to $+2$, when the barometer is raiſed above the ſurface of the earth, and to -1, when it is depreſſed below it. When $\nu = +2$, the laſt equation becomes

$$\frac{q\,(s+x)^{n}\,(1-m)^{\tau}}{s^{2n}\,\beta^{n}} + C = \frac{ns^{2}}{q}\int \frac{\dot{x}}{(s+x)^{2}\,(1-m)^{\lambda x}}.$$

When x is ſuppoſed very ſmall in compariſon of s, the fluent $\int \frac{\dot{x}}{(s+x)^{2}\,(1-m)^{\lambda x}}$ may be expreſſed by a ſeries, converging with ſuch rapidity, that the two firſt terms will be ſufficient for the preſent purpoſe. Now, as $\frac{1}{(s+x)^{2}} = \frac{1}{s^{2}\left(1+\frac{x}{s}\right)^{2}} =$

$\frac{1}{s^{2}}\left(1-\frac{2x}{s}\right)$ nearly, $\frac{ns^{2}}{q}\int \frac{\dot{x}}{(s+x)^{2}\,(1-m)^{\lambda x}}$ becomes

$$= \frac{n}{q}\int \overline{(1-m)^{-\lambda x}\,\dot{x}\left(1-\frac{2x}{s}\right)} = \frac{n}{q\,(1-m)^{\lambda x}}\left(-\frac{1}{\lambda g}+\frac{2x}{\lambda g s}+\frac{2}{\lambda^{2} g^{2} s}\right).$$

$$\text{Therefore, } \frac{q\,(s+x)^{n}\,(1-m)^{\tau}}{s^{2n}\,\beta^{n}} + C =$$

$\frac{n}{q\,(1-m)^{\lambda x}}\left(-\frac{1}{\lambda g}+\frac{2x}{\lambda g s}+\frac{2}{\lambda^{2} g^{2} s}\right)$. To define C, x muſt be put

$= 0$,

$= 0$, and $\beta = b$, ſo that

$$\frac{q^{n}(1-m)^{\tau}}{b^{n}} + C = \frac{n}{q}\left(-\frac{1}{\lambda g} + \frac{2}{\lambda^2 g^2 s}\right), \text{ and } C =$$

$$-\frac{q^{n}(1-m)^{\tau}}{b^{n}} + \frac{n}{q}\left(-\frac{1}{\lambda g} + \frac{2}{\lambda^2 g^2 s}\right).$$ If this value be ſubſtituted for C, and if all the terms be divided by $(1-m)^{\tau}$, we ſhall have

$$\frac{q^{n}(s+x)^{2n}}{s^{2n}\beta^{n}} - \frac{q^{n}}{b^{n}} = \frac{n}{q\lambda g}\left(\frac{1}{(1-m)^{\tau}} - \frac{1}{(1-m)^{\tau+\lambda x}} + \frac{2x}{s(1-m)^{\tau+\lambda x}} - \right.$$

$$\left. \frac{2}{\lambda g s(1-m)^{\tau}} + \frac{2}{\lambda g s(1-m)^{\tau+\lambda x}}\right).$$

THE approximation which has been uſed here for finding the fluent $\int \frac{\dot{x}}{(s+x)^{2}(1-m)^{\lambda x}}$, 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,

$$\tau + \lambda x = r - b, \ \lambda = \frac{H-b}{z}, \text{ and } \tau = r - H, \text{ as in } \S\ 14.;$$

and ſo by ſubſtitution, $\frac{q^{n}(s+z)^{2n}}{s^{2n}\beta^{n}} - \frac{q^{n}}{b^{n}} =$

$$\frac{nz}{qg(H-b)(1-m)^{\frac{H-b}{z}}}$$

$$\frac{nz}{qg(H-b)(1-m)^{r-H}}\left(1-\frac{1}{(1-m)^{H-b}}-\frac{2z}{gs(H-b)}+\right.$$

$$\left.\frac{2z}{s(1-m)^{H-b}}+\frac{2z}{gs(H-b)(1-m)^{H-b}}\right)=\frac{nz}{qg(H-b)}\left((1-m)^{H-r}-\right.$$

$$(1-m)^{b-r}-\frac{2z}{gs(H-b)}(1-m)^{H-r}+\frac{2z}{s}(1-m)^{b-r}+$$

$$\left.\frac{2z}{gs(H-b)}(1-m)^{b-r}\right).$$

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

introduced, and the formula will become ſimilar to that which was formerly inveſtigated. For $\frac{1}{\beta^{\frac{1}{n}}}$, 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 ſmall, as in the preſent caſe, this ſeries converges with extreme rapidity; and the terms involving n^3, &c. may ſafely be rejected. Therefore,

$$\frac{1}{\beta^{\frac{1}{n}}} - \frac{1}{b^{\frac{1}{n}}} = 1 - n\log.\beta + \frac{n^2}{2}(\log.\beta)^2 - 1 + n\log.b - \frac{n^2}{2}(\log.b)^2 =$$

$$n(\log.b - \log.\beta) - \frac{n^2}{2}\left((\log.b)^2 - (\log.\beta)^2\right).$$

Hence, $z = \dfrac{q^{1+n}\, g\,(H-b)\left(\log.b - \log.\beta - \frac{n}{2}(\log.b)^2 + \frac{n}{2}(\log.\beta)^2\right)}{(1-m)^{\frac{H-r}{}} - (1-m)^{\frac{b-r}{}}}$

29. When n vaniſhes altogether, the value of z, aſſigned by this formula, coincides, as it ought to do, with that which was inveſtigated, on the ſuppoſition of the denſity being preciſely as the compreſſion; for by applying the reduction of art. 17. we have,

$$z = q\left(1 + m\left(\frac{H+b}{2} - r\right)\right)\log.\frac{b}{\beta}.$$

But when n, though very ſmall, does not vaniſh altogether, by the ſame reduction,

$$z = q^{1+n}\left(1 + m\left(\frac{H+b}{2} - r\right)\right)\log.\frac{b}{\beta}\left(1 - \frac{n}{2}\log.b\beta\right).$$

If, therefore, we ſuppoſe q^{1+n} to be equal to p, or to 4343 fathoms,

fathoms, which muſt be nearly true; and, if we call A the height, or the value of z, computed from the formula $z = p\left(1+m\left(\frac{H+b}{2}-r\right)\right) log.\frac{b}{\beta}$, 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.*

$$z = \frac{\frac{1}{n}q^{1+n}g(H-b)\left(\frac{1}{\beta^n}-\frac{1}{b^n}\right)}{(1-m)^{H-r}-(1-m)^{b-r}},$$ or that to which it may be reduced, $z = q\left(1+m\left(\frac{H+b}{2}-r\right)\right)\left(\frac{q^n}{n\beta^n}-\frac{q^n}{nb^n}\right)$, it is evident, that $\frac{q^n}{n\beta^n}-\frac{q^n}{nb^n}$ 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^{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 $b = \frac{5}{12}$,

and $\beta = \frac{5}{18}$, so that $b\beta = \frac{5\times5}{12\times6\times3}$, half the hyperbolic logarithm of which, or that of $\frac{5}{6\sqrt{6}}$, is $= -1.0782$, and this multiplied into $-n$, supposing $n = .0015$, 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 cases, it will exceed this proportion as $b\beta$ diminishes, but (because $b\beta$ will rarely be greater than $\frac{25}{144}$), its minimum will be about $\frac{1}{770}$. In the measurement of great heights, therefore, this equation may deserve to be considered.

31. We come now to find the correction which must be made on the ordinary rule, on account of the diminution of gravity as we ascend from the surface of the earth. By § 27. we have,

$$\frac{q^{1+n}\left(1+\frac{z}{s}\right)^{n}}{\beta} - \frac{q^{1+n}}{b^{n}} =$$

$$\frac{nz}{g(H-b)}\left((1-m)^{H-r} - (1-m)^{b-r} - \frac{2z}{gs(H-b)}(1-m)^{H-r} + \frac{2z}{s}(1-m)^{b-r} + \frac{2z}{gs(H-b)}(1-m)^{b-r}\right)$$; and since we know already, that $z = \frac{\frac{1}{n}q^{1+n}g(H-b)\left(\frac{1}{\beta^{n}} - \frac{1}{b^{n}}\right)}{(1-m)^{H-r} - (1-m)^{b-r}}$ nearly, if we substitute this value of z, or rather that which was before derived from

from it, *viz.* $z = q\left(1+m\left(\frac{H+b}{2}-r\right)\right)\left(\frac{q^n}{n\beta^n}-\frac{q^n}{nb^n}\right)$, in all the terms of this equation, into which s enters as a diviſor, we ſhall have a new and more accurate value of z, and, by a like proceſs, might from thence obtain one ſtill more accurate, if it were neceſſary.

Now, if this be done, and if the correction depending on n be ſuppoſed ſufficiently determined by the computations of the two preceding articles, ſo that it may now be neglected altogether; and if m alſo be ſo ſmall, that all the powers of it, higher than the firſt, may be neglected, we obtain,

$$z = p\left(1+m\left(\frac{H+b}{2}-r\right)\right)\log.\frac{b}{\beta}+\frac{2p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\log.\frac{b}{\beta}$$

$$+\frac{p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\left(\log.\frac{b}{\beta}\right)^2.$$

32. The firſt term of the preceding equation is the height corrected by M. de Luc's method; the ſecond term, *viz.* $\frac{2p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\log.\frac{b}{\beta}$, is the correction for the diminution of the weight of the quickſilver in the uppermoſt barometer; and the third term, or $\frac{p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\left(\log.\frac{b}{\beta}\right)^2$, is the correction for the gradual diminution of the weight of the air in the different ſtrata between the lower and the upper ſtaſtion. The laſt of theſe two corrections, which, in all ordinary caſes, is alſo the leaſt, is the only one of them to which, it would ſeem, that any attention has hitherto been paid. The other, or the effect of the diminution of the gravity of the quickſilver, was included in this inveſtigation, when, at § 25. we ſubſtituted for

y,

ν its value, $\frac{\left(\frac{s'}{(s+x)'}\beta\right)^{1+n}}{q^{1+n}(1+m)^{\tau+\lambda x}}$. It is found by making as s to $p\left(1+m\left(\frac{H+b}{2}-r\right)\right)$, 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 $\nu = -1$, ſo that the compreſſing force, at any depth x below the ſurface, is $= \left(\int \frac{s-x}{s} y\dot{x}\right)^{1+n}$; 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, $y = \frac{+\left(\int \frac{s-x}{x} y\dot{x}\right)^{1+n}}{p^{\tau+\lambda x}(1-m)}$, we have,

by proceeding as above,

$$z = p\left(1+m\left(\frac{H+b}{2}-r\right)\right)\log.\frac{\beta}{b} - \frac{p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)\log.\frac{\beta}{b}$$

$$+\frac{p^2}{2s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)^2\left(\log.\frac{\beta}{b}\right)^2.$$

In

In this formula, the ſecond term, *viz.* $-\frac{p^2}{s}\left(1+m\left(\frac{H+b}{2}-r\right)\right)log.\frac{\beta}{b}$ is juſt half the correſponding term in the preceding formula, (§ 31.) with a contrary ſign, ſo that the correction for the diminution of the gravity of the quickſilver 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 ſame ſign in both caſes, but in this is only half of what it was in the former. That theſe laſt corrections ſhould be each half of the correſponding one in the preceding caſe, might have been concluded from this, that, by any ſmall aſcent above the ſurface of the earth, the force of gravity is twice as much diminiſhed as by an equal deſcent below it. The reaſon of the change of the ſigns in the ſecond term is alſo ſufficiently obvious.

34. THOUGH theſe corrections ſuppoſe that z is ſmall in reſpect of s, yet they would afford a ſufficient approximation to the truth, were we to reaſon concerning much greater depths under the ſurface of the earth than any to which man can penetrate. For example, on a ſuppoſition that the atmoſphere was continued downwards within the earth, its denſity being always as its compreſſion, and its temperature every where the ſame, (and, for the greater caſe of computation equal to r), let it be required to find, at what depth its denſity would become equal to that of mercury. To reſolve this problem, it muſt be remembered, that the denſity of mercury, throughout all this computation, has been ſuppoſed $= 1$, and p equal to the height of a column of mercury, which, gravitating every where with the ſame force as at the ſurface, would, by its preſſure, give to air the denſity 1. If a barometer, therefore, were carried down to the depth at which air was as denſe as mercury, the mercury in it would riſe to the height p, or to 4343 fathoms nearly, ſuppoſing, at the ſame time, that its own gravity were not diminiſhed. Now, on this ſuppoſition, (by § 33.) any

any depreſſion below the ſurface, as, $z = p\,log.\frac{\beta}{b} + \frac{p^2}{2s}\left(log.\frac{\beta}{b}\right)^2$, the temperature being ſuppoſed $= r$, and the term $-\frac{p^2}{s}\,log.\frac{\beta}{b}$ 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 $\frac{5}{12}$ of a fathom, and $\beta = 4343$, we find $p\,log.\frac{\beta}{b} =$ 10000 × *tabular log.* 10423 = 40180 fathoms = 45.6 miles nearly. The ſecond term, $\frac{p^2}{2s}\left(log.\frac{\beta}{b}\right)^2$, (or the ſquare of the former 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, paradoxical, 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, $y = \frac{\left(-\int \frac{s'}{(s+x)'}\,y\dot{x}\right)^{1+n}}{q^{\frac{1+n}{r+\lambda x}}\,(1-m)}$; 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 $(1-m)^{r+\lambda x}$ 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, $= v$, $ay^{\frac{1}{1+n}} = -\int s'v^{-\nu}y\dot{v}$; wherefore, taking the fluxions, dividing by y, and integrating,

$$-\frac{a}{n}y^{-\frac{n}{1+n}} + C = (\nu-1)s'v^{1-\nu}.$$

To define C, ſuppoſe that $y = D$ when $x = 0$, or when $v = s$;

then, $C = \frac{a}{n}D^{-\frac{n}{1+n}} + (\nu-1)s$; and ſo,

$$\frac{a}{n}\left(D^{-\frac{n}{1+n}} - y^{-\frac{n}{1+n}}\right) = (\nu-1)(s'v^{1-\nu} - s);$$

and making $\nu = 2$, $\frac{a}{n}\left(D^{-\frac{n}{1+n}} - y^{-\frac{n}{1+n}}\right) = s\left(\frac{s}{v} - 1\right)$.

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

$$\frac{a}{n}\left(D^{\frac{n}{1-n}} - y^{\frac{n}{1-n}}\right) = s\left(1 - \frac{s}{v}\right).$$

And if we now ſuppoſe the atmoſphere to terminate, or y to become $= 0$, then $\frac{aD}{n}^{\frac{n}{1-n}} = s\left(1 - \frac{s}{v}\right)$, and the entire height of the atmoſphere, or $v = \frac{s^2}{s - \frac{a}{n}D^{\frac{n}{1-n}}}$.

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 $\frac{a}{n}D^{\frac{n}{1-n}}$, it is obvious that v is infinite; but if s be greater than $\frac{a}{n}D^{\frac{n}{1-n}}$, v muſt be finite and affirmative. If s be leſs than $\frac{a}{n}D^{\frac{n}{1-n}}$, 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 $v = \frac{s^2}{s - \frac{a}{n}}$.

As $a = 4343$ fathoms, (on the ſuppoſition that the temperature of the atmoſphere is 32^c,) and as $s = 349184$0, 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 4342.94.8 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, $\frac{\beta^{\mu}}{\gamma^{\mu}} \times m =$ 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 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.) =

$$+m^2\left(\frac{r}{2}-\frac{H+h}{4}+\frac{r(r-H-h)}{2}+\frac{H^2+4Hh+h^2}{12}\right)p\,log.\frac{b}{\beta}.$$

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.) $= +\frac{\mu m}{2}\left(\frac{H+h}{2}-r\right)p\,log.\frac{b}{\beta}\times log.\frac{b\beta}{\gamma^2}$; 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.) $= -\frac{n}{2}p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}\times log.\,b\beta$. 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 quickſilver in the upper barometer, there is an equation to be applied $=$

$$+\frac{2p^2}{s}\left(1+m\left(\frac{H+h}{2}-r\right)\right)^2 log.\frac{b}{\beta}.$$

6*to.* ON account of the diminiſhed gravity of the air in aſcending from the ſurface of the earth, there is a ſixth correction $= +\frac{p^2}{s}\left(1+m\left(\frac{H+h}{2}-r\right)\right)^2\left(log.\frac{b}{\beta}\right)^2$.

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 obſervations. But this would lead into diſquiſitions far exceeding the bounds of the preſent inquiry, the object of which is, to aſcertain the form, rather than the abſolute quantity of theſe corrections.

41. It is evident, that, in the preceding inveſtigation, as well as in all the other methods of meaſuring heights by the barometer, it is ſuppoſed, either that the one of the barometers is vertical to the other, or that a perfect æquilibrium prevails through that part of the atmoſphere intercepted between them. The determination of the conſtant quantity in the foregoing integrations, by ſuppoſing that $b = \beta$ when $x = 0$, or that the mercury in the two barometers ſtands at the ſame height in them, when they are at the ſame diſtance from the ſurface of the earth, obviouſly involves in it either the one or the other of theſe conditions. But the laſt of them, the æquilibrium of the atmoſphere, never takes place; and, therefore, it is neceſſary, in order that barometrical meaſurements be perfectly accurate, that the one barometer be immediately above the other, or, at leaſt, that the horizontal diſtance between them be very ſmall. If this be not the caſe, the unequal diſtribution of the heat through the different parts of the ſame ſtratum of air will render it impoſſible to deduce the difference of the heights of the barometers from a compariſon of the columns of mercury contained in them.

For inſtance, let there be three barometers; the *firſt* at the ſurface of the earth, the *ſecond* raiſed up into the air perpendicularly above the *firſt*, and the *third* removed into a colder climate, but raiſed up alſo into the air, ſo as to have in it a column of mercury of the ſame length with that in the *ſecond*. Theſe two laſt, when compared together by M. de Luc's, or by the preceding rules, will appear to be at the ſame height above the ſurface, or above the firſt barometer. But, if each of them be compared with the *firſt*, the *ſecond* will appear more

more elevated above it than the *third*, becauſe of the greater cold ſuppoſed to prevail in the region where this laſt barometer is placed. Here, therefore, are two different determinations of the height of the third ſtation above the firſt, neither of which has any claim to be preferred to the other. It is evident, therefore, that, in barometrical meaſurements, there is always a degree of uncertainty introduced by the horizontal diſtance between the two ſtations, and that, beſide thoſe accidental errors, which are of the leſs conſequence, that, in a number of obſervations, they may nearly compenſate for one another.

IT muſt be confeſſed, too, that we have not at preſent the means of removing this uncertainty, nor even of aſcertaining its limits with tolerable exactneſs. Theſe depend on a problem which is no longer to be reſolved by the principles of ſtaticks, but requires the *motions* of an elaſtic fluid, under various degrees of compreſſion and rarefaction, to be determined. The ſolution, therefore, is extremely difficult; and no reſult, ſufficiently ſimple to be of uſe in theſe computations, is ever likely to be obtained from it.

IT would, however, be of conſequence to determine, by obſervation, the mean height of the barometer at the level of the ſea in the different regions of the earth. That mean height is not every where the ſame. Under the line, it appears, from the obſervations 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 ſame temperature. The mean temperature of the air, as well as its mean weight in different climates, will alſo require to be determined before the art of levelling extenſive tracts by the barometer can be brought to perfection.

42. THERE is another cauſe of error which, had the effects of it been ſufficiently known, ought, no doubt, to have entered into this inveſtigation. Moiſture, when chemically united to air, or diſſolved in it, ſo as to compoſe a part of the ſame homogeneous

mogeneous and inviſible fluid, appears to have a powerful effect to encreaſe the elaſticity of the air, and its expanſion for every additional degree of heat which it receives. In experiments with the manometer*, it has been obſerved, that, till the moiſture was diſſolved in the air, it had no ſenſible effect on its elaſticity; but that, as ſoon as it began to diſſolve, the expanſion, for one degree of heat, was encreaſed, and continued to be ſo, for every ſucceſſive 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 atmoſphere, approaches near to the ſurface of the earth, and where the air may naturally be ſuppoſed to be very dry, the uſual rule for the meaſurement of heights was found to err greatly in exceſs, and it appeared, that the denſity of the air was greater than could have been inferred from its compreſſion and its temperature.

43. THOUGH the judicious and accurate experiments of General ROY have aſcertained this effect of humidity, and have even gone far to determine the law of its operation, yet, for want of a meaſure of the quantity of it, contained, at any given time, in the air, it is impoſſible to make any application of this knowledge to the object under our conſideration. While I was reflecting on this difficulty, it occurred, that the barometer itſelf might become a meaſure of the humidity of the air, and that the error committed in the meaſuring of a known height, if all other circumſtances were taken in, would determine the quantity of that humidity. For, if we ſuppoſe, that the formula $z = p\left(1 + m\left(\frac{H+b}{2} - r\right)\right) log.\frac{b}{\beta}$ gives the true height between the ſtations at which two barometers have been obſerved, when the moiſture diſſolved in the air is of its medium quantity, (which we may call unity), then, if that moiſture

* See General ROY's experiments, ſection 2. Phil. Tranſ. vol. 67. part 2.

moiſture be either increaſed or diminiſhed, the expreſſion $p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}$ 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 $p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}$ 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 $p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}$ is greater than the true height. To determine π, ſince $z=(1+\pi)\,p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}$, $1+\pi=\frac{z}{p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}}$.

Or if the error, that is $z-p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}=e$,

then $\pi=\frac{+e}{p\left(1+m\left(\frac{H+h}{2}-r\right)\right)log.\frac{b}{\beta}}$, or $\pi=\frac{+e}{z-e}$.

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

the unavoidable errors of obſervation, (which may amount to five feet), may be conſiderable in reſpect of the whole; nor ſo great as to introduce error from other cauſes. It ought not, therefore, to be leſs than 100, nor much greater than 500 feet.

45. In this manner, we ſhall have a meaſure, not indeed of the abſolute quantity of humidity diſſolved in the air at a given time, but of the differences of the humidity diſſolved in it at different times. Our hygrometer, therefore, will afford a ſcale for the meaſuring of moiſture, not unlike that which the thermometer affords for the meaſuring of heat; and both deduced from the changes produced on the bulk, or the ſpecific gravity of certain bodies. The beginning, or zero, of this ſcale may alſo be fixed by a certain and invariable rule, if we aſſume m, in the preceding formula, (or the expanſion of air for one degree of heat), of a given magnitude, as, for inſtance, .00245, and conceive the ſcale to begin when $\pi = 0$, or when the formula, thus adjuſted, gives the true height.

The hygrometer with which we will be thus furniſhed, ſeems well adapted to the purpoſes of aſtronomy. For it meaſures the humidity chemically united with the air, and not merely the diſpoſition of the air to depoſit that humidity, which, though much connected with the changes of the weather, has little to do with the aſtronomical 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 thoſe differences of humidity may produce; but they are probably connected with theſe laſt, by ſome fixed and invariable law, which future experiments may be able to aſcertain. Nor can this application of the barometer fail of leading to ſome uſeful concluſion; for if, on trial, it ſhall be found, that the operation of humidity in changing the ſpecific gravity of the air, is over-ruled or concealed by the action of more powerful cauſes, the diſcovery, even of this fact, will give a value to the obſervations.

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 its ſign in the equation. It is evident how vaſt an acceſſion was thus gained to the elegance and univerſality of algebraical ſolutions.

ALBERT GIRARD appears to have been the firſt who obſerved this uſe of negative roots. In his work, publiſhed in the year 1629, entitled, *Invention nouvelle en Algebre*, he mentions it with great diſtinctneſs, and as a matter unknown before *.

MONTUCLA, who acknowledges that he never ſaw the work of GIRARD, inſiſts very ſtrenuouſly that DES CARTES was the perſon, to whom we owe our knowledge of the nature and uſe of negative roots; that it was he, who firſt introduced them into geometry and algebra †. But without derogating from the very extraordinary merit of that philoſopher, we muſt beg leave, in this matter, to differ ſomewhat from MONTUCLA. For, according to his own account, the work of GIRARD was publiſhed in 1629, whereas the *Geometry* of DES CARTES was not publiſhed till ſeven or eight years afterwards, in 1637 ‡.

WE may, perhaps, go farther, and add, that although DES CARTES indeed obſerved, that the ſhifting of a line or point from one ſide of a given line or point to the other, made no change in the equation, except in the ſigns + and —, yet he did not ſee, in its full extent, all the advantage to be derived from the uſe of negative quantities. This will appear not altogether improbable from the following circumſtances: In the third book

* I HAVE not been able to procure the book; but the following paſſage, quoted by Dr HORSELEY, ſeems to warrant what has been aſſerted: "Juſques icy nous n'avons encore "expliqué à quoy ſervent *les ſolutions par moins*, quand il y en a. La ſolution par "moins s'explique en geometrie en retrogradant, et le moins recule là où le + avance." And, after giving an inſtance, he adds; "Et ainſi faudrâ-t-il entendre de toutes ſolu-"tions par moins; qui eſt une choſe de conſequence en geometrie incognue aupara-"vant." HORSELEY'S NEWTON, *vol.* 1. *p.* 171. *note* (*u*).

† MONTUCLA Hiſt. de Math. vol. 2. p. 85.

‡ MONTUCLA Hiſt. de Math. vol. 2. p. 82. & 84.

book of his *Geometry*, where he treats expreſsly of the nature of equations, he takes no notice of thoſe which have all their roots negative; and, in the ſecond book, where he mentions his new method of conſidering curves, he ſays nothing of negative abſciſſæ and ordinates, although the analyſis of curves is, of all the parts of mathematics, that which moſt obviouſly ſuggeſts and requires the uſe of the negative roots.

In fact, the uſe of negative quantities appears not to have been, either at this time, or for ſome time afterwards, familiar to mathematicians. This is evident from the *Elementa Curvarum* of John de Witt, a work, at that time, of ſome merit, but which will be conſidered, rather as affording a curious piece of information in the life of that great man, than as adding to a fame, which is ſo far ſuperior to all literary eminence. In this work, which is publiſhed by Schooten at the end of his edition of Des Cartes's *Geometry*, no notice is taken of negative abſciſſæ and ordinates: So that the author is obliged to conſider ſeparately two or more equations, which every mathematician at preſent, from the view of negative quantities, which is now become familiar, would conſider as one ſingle equation, denoting for one and the ſame line referred to the ſame axis, the relation between the abſciſſæ and ordinates, through all the different caſes of their ſituation with reſpect to each other, that is, through all the angles of the coordinates. Thus, in his ſecond book, where he conſiders the lines of the firſt and ſecond order, beyond which he does not go, he demonſtrates, in the four firſt theorems, that the four following equations belong to ſtraight lines: 1. $y = \frac{bx}{a}$; 2. $y = \frac{bx}{a} + c$; 3. $y = \frac{bx}{a} - c$; 4. $y = -\frac{bx}{a} + c$. But he does not ſhow, either in this or any other part of the work, that each of theſe equations, by changing the ſigns of y or x, gives the relation between the abſciſs and ordinate, when the one or the

the other is taken in an oppoſite ſituation; and that the ſecond and fourth equation ought to be conſidered as one, and as belonging to the ſame ſtraight line referred to the ſame axis.

EVEN long after this time, we find, that Dr WALLIS, although, in his *Algebra*, he conſiders at ſome length the meaning and uſe of negative quantities, yet, in his *Arithmetic of Infinites*, falls into a ſtrange miſtake, which leads us to ſuſpect, that his notions on this ſubject were not perfectly clear. For, obſerving that his general expreſſion for hyperbolic areas would, in certain caſes, be a fraction with a negative denominator, he did not perceive, that this expreſſed the area on the other ſide of the ordinate, inſtead of the area ſought; but he contents himſelf with ſaying, that the denominator of the fraction being leſs than nothing, denoted the area to be more than infinite.

THAT even ſome time afterwards, the uſe of negative quantities had not become familiar, appears from the aſtoniſhment which Dr HALLEY expreſſes at his own diſcovery of a formula, which, by the mere change of the ſigns, gave the focus both of converging and diverging rays, whether reflected or refracted by convex or concave ſpecula or lenſes. And Mr MOLYNEUX ſpeaks of the univerſality of HALLEY's formula as ſomewhat that reſembled magic.

THUS it appears to have been long, before mathematicians ventured to employ negative quantities ſo freely, as we now perceive them to be employed. The reaſon of which probably was, that no ſatisfactory account had been given of the grounds upon which the concluſions drawn from them are founded. But the conſiſtency of theſe concluſions, with all the moſt indiſputable truths of the mathematical ſciences, and the great beauty and advantage, derived from the very general ſolutions which are thus obtained, gradually eſtabliſhed their uſe.

STILL, however, a complaint remains, which appears to be too well founded, that the Method of negative quantities, as has been the caſe with ſome other rules of the art, is ſupported,

ed, rather by induction and analogy, than by mathematical demonſtration. But ſomething more than this is to be expected from mathematicians; and their knowledge of algebra will ſtill be conſidered as imperfect, if there be any of its operations which they cannot, in every letter and ſign of it, explain as a ſeries of juſt reaſoning, capable of being expreſſed in common language. Now, it does not appear that our inſtructors in mathematics have enabled us to do this in the caſes to which we allude, that is, where negative quantities are found, without any intimation of the quantities from which they are ſubtracted. In conſidering the abſtract operations of addition, ſubtraction, multiplication, *&c.* we may indeed take negative quantities by themſelves: For here the meaning is obvious; we are examining, in what manner ſuch operations will affect thoſe quantities, which are ſubtracted from other quantities. But when we come to apply theſe operations to the buſineſs of algebra, the reſolution of equations, it is not ſo eaſy to perceive, nor does it appear to have been ſufficiently explained, in what light we are to conſider negative quantities, or how mathematicians are to be juſtified in the uſe which they make of them. The very vague and unſatisfactory, and often myſterious accounts of the matter, which are given even by writers of the greateſt eminence, ſerve only to ſhew, that although they are ſatisfied of the certainty of the method, yet they perceive that ſomething ſtill remains which ought to be explained, and of which no good explanation has been given.

Mr Baron MASERES, indeed, has publiſhed a large work, which he entitles, "A Diſſertation, on the uſe of the negative "ſign in algebra; containing a demonſtration of the rules uſu-"ally given concerning it, and ſhewing how quadratic and "cubic equations may be explained, without the conſideration "of negative roots." But this diſſertation 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 diſcarded from it * ;" yet ſtill he has carried us to the length only of cubic equations. The truth is, that the whole buſineſs of algebra might be carried on without the conſideration of the negative roots. The difference between ſuch a ſyſtem and the preſent, is preciſely this ; that wherever a problem required us to conſider any of the quantities, as exiſting in oppoſite ſituations ; wherever, for inſtance, a line or a point was to be conſidered, as ſituated firſt on the right hand, and then on the left ; it would be neceſſary, to find and to reſolve a ſeparate equation for each of theſe caſes. Thus, in the analyſis of any particular curve, it would be neceſſary to have a ſeparate equation for each of the four angles of the co-ordinates ; except, indeed, the axes were ſo choſen, as to make us certain that there were ſome of theſe angles, in which no part of the curve was to be found. Since, therefore, the uſe of negative quantities frees us from this inconvenience, which, in many caſes, particularly in the analyſis of curves, would be exceedingly perplexing ; and ſince it evidently affords ſo great elegance and univerſality to algebraical ſolutions ; to find our author gravely declaring that he can ſee no advantage in it, is perfectly aſtoniſhing : As it is to be lamented, that he did not exert his induſtry and ingenuity, rather to confirm than to deſtroy ; rather to demonſtrate, how far we might rely on the method of negative quantities, than to overturn at once ſo great a part of the labours of the modern algebraiſts.

WHAT follows is an attempt to explain this ſubject, without conſidering the negative ſign in any other light, than as the ſign of ſubtraction ; and without propoſing any alteration in the received ſyſtem of algebra.

* Diſſert. on the Neg. Sign, p. 34.

I. *Of*

I. *Of the Negative Roots of Equations.*

1. *Of Determinate Equations.*

In the ſolution of problems by means of equations, the analyſt fixes upon one or more quantities, by the determination of which all that is required may be known or performed. We ſhall at preſent ſuppoſe that there is only one quantity to be determined. The problem ſhews the conditions which are required of this quantity; and theſe conditions, as far as they can be ſo expreſſed, 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 ſign + denotes, at pleaſure, either the addition or ſubtraction of the terms to which it is prefixed.

In many caſes, nothing elſe is required, but to determine the *magnitude* of the quantity ſought. There the poſitive roots alone can determine the magnitude; ſo that if the equation has no poſitive roots, or none which come within the limits of the problem, then the problem is impoſſible.

But let the problem require us to determine, not only the different magnitudes of the line AB (x), but alſo, with reſpect to each of theſe magnitudes, whether it lies on the right or left of the given point A. Here we ſuppoſe the problem to be ſuch, that whether we reduce it to an equation, upon the ſuppoſition that AB lies to the right, or upon the ſuppoſition that it lies to the left, there is no circumſtance, except only the oppoſite ſituation of AB, to make any difference in theſe equations.



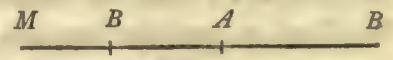
In this caſe, we make either ſuppoſition at pleaſure; as, for inſtance, that it lies to the right; and, on this ſuppoſition,

we expreſs 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 poſitive roots are to be employed.

Now, on the other ſide of A, take MA, which we ſhall denote by X; and let it be of any magnitude, not leſs than any of the negative roots of L. It is evident that L may be reduced to the form



$$M \ldots \left\{ \begin{array}{l} A \\ + BX + Bx \\ + CX^2 + 2CXx + Cx^2 \\ \qquad + \&c. \end{array} \right\} = 0.$$

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 expreſſion of the conditions required of x, upon the ſuppoſition that it lies to the right of A.

But if we make the contrary ſuppoſition, that AB lies to the left of A; then ſince 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 expreſſed in the equation

$$N' \ldots A + B(X-x) + C(X-x)^2 + \&c. = 0.$$

Now, this equation may be reduced to the form

$$M' \ldots \left\{ \begin{array}{l} A \\ + BX - Bx \\ + CX^2 - 2CXx + Cx^2 \\ \qquad + \&c. \end{array} \right\} = 0.$$

By

By comparing this equation with M and L, it will be evident that it may be reduced to the form

$$L' \ldots a - bx + cx^2 - \&c. = 0.$$

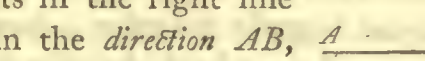
This equation L', therefore, expreſſes the conditions required of AB, when it lies to the left of A; and, conſequently, the poſitive roots of L' determine the different magnitudes of AB in that ſituation.

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, 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.



In like manner, let it be required to determine, not only the *value* of a certain ſum 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

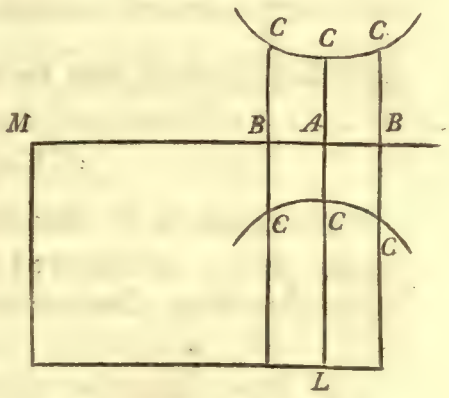
the number which, ſubtracted from its ſquare, leaves a remainder equal to *a*.

WHAT has been ſaid is eaſily applicable to thoſe problems, where more than one quantity is to be determined.

2. *Of Indeterminate Equations.*

IN problems which are ſolved by indeterminate equations, there is often nothing elſe required, but to determine the different *magnitudes* of one or more of the variable quantities, correſponding to any given magnitudes of the remaining variable quantities. There the poſitive roots alone can determine theſe correſponding magnitudes; ſo that if there be no poſitive roots, or none which come within the limits of the problem, then the problem is impoſſible.

BUT let the problem require us to determine, not only the different correſponding magnitudes of the lines *AB* (*x*) and *BC* (*y*); but alſo, with reſpect to each of the values of *x*, whether it lies to the *right* or *left* of the given point *A*; and with reſpect to each of the correſponding values of *y*, whether it is to be taken *above* or *below* the line *AB*. Here we ſuppoſe that, whether *AB* lies to the right or left, and whether the correſponding line *BC* is to be taken upwards or downwards, there is nothing, except only theſe oppoſite ſituations of *AB* and *BC*, to make any difference in the equations, to which the problem would be reduced upon each of theſe ſuppoſitions. Then, we make any of theſe ſuppoſitions at pleaſure; as for inſtance, that *AB* lies to the right, and that *BC* lies above *AB*; and on this ſuppoſition, we expreſs the conditions



ditions required of theſe 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 correſponding magnitudes of AB and BC in theſe directions, the poſitive roots are to be employed.

Now, on the other ſide of A, in the line AB, take MA, which we ſhall denote by X, not leſs than any of the negative values of x; and in the line AC, below AB, take AL, which we ſhall denote by Y, not leſs than any of the negative values of y. It is evident, that the equation L may be reduced to the form

$$M \ldots \left\{\begin{array}{l} A \\ +BX \quad +Bx \\ +CY \quad +\ldots+Cy \\ +DX^2+2DXx+\ldots+Dx^2 \\ +EXY+EYx \quad +EXy+\ldots+Exy \\ +FY^2+\ldots+2FYy+\ldots+\ldots+Fy^2 \\ \qquad\qquad +\&c. \end{array}\right\} = 0.$$

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 expreſſion of the conditions which are required of the variable quantities, upon the ſuppoſition that x lies to the right of A, and that y lies above AB.

But if we make the ſuppoſition that x lies ſtill to the right of A, but that y lies below AB; then, ſince 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 ſuppoſition, will be expreſſed 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.

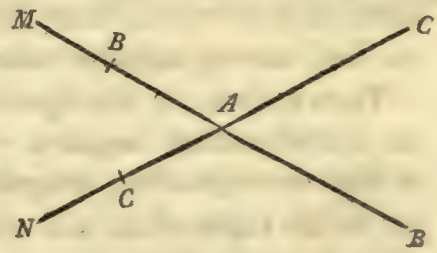
The obſervations which have been made under the head of determinate equations, are equally applicable to thoſe which are indeterminate. And the foregoing demonſtration may be eaſily extended to any number of indeterminate quantities.

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 conſider ſome of the *given* quantities, as capable, conſiſtently with the conditions of the problem, of exiſting in one or other of two oppoſite ſituations, which may be repreſented by addition and ſubtraction.

SUPPOSE, for inſtance, 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 ſuppoſition that they are each taken to the right. This equation, when ordered according to the powers of a and b, will be repreſented 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 leſs reſpectively than a, b.

THEN the equation L may be reduced to the form,

$$M \ldots \left\{ \begin{array}{llllll} P & & & & & \\ +\mathfrak{Q}A & +\mathfrak{Q}a & & & & \\ +RB & +\ldots & +Rb & & & \\ +SA^2 & +2SAa & +\ldots & +Sa^2 & & \\ +\mathfrak{T}AB & +\mathfrak{T}Ba & +\mathfrak{T}Ab & +\ldots & +\mathfrak{T}ab & \\ +VB^2 & +\ldots & +2VBb & +\ldots & +\ldots & +Vb^2 \\ & & & +\&c. & & \end{array} \right\} = 0.$$

And

And this again is reducible to the form,

$$N \ldots P+Q(A+a)+R(B+b)+S(A+a)^2+T(A+a)(B+b)+V(B+b)^2+\&c. = 0.$$

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 that 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.

V. EXPERIMENTS *and* OBSERVATIONS *upon a* REMARKABLE 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, muſt expoſe a vaſt quantity of ſurface to the action of the external air.

THIS view of the matter appeared to me ſtill more probable, from having formerly been witneſs to a very quick evaporation of icy films from the ſurface of poliſhed metal at very low temperatures; and from other experiments, demonſtrating the actual evaporation of ice, of which I had read an account in the French Memoirs.

HAVING always been a great admirer of Dr BLACK's Philoſophy, in regard to heat and cold, and conſidering the preſent phænomenon as an immediate conſequence of his law of evaporation, I reſolved to attend to it further, in all its circumſtances, from a deſire of extending a little the boundaries of that induction which, in his hands, has been ſo fertile in general principles of ſo much importance.

IN the two papers above quoted may be ſeen by what ſteps, as opportunities offered, I followed out this deſign, and how very early I was perplexed by facts which ſeemed ſtrongly to evince, that no evaporation whatever was going on when the exceſs of cold, at the ſurface of the ſnow, was perceivable. On the contrary, the further the experiments were puſhed, the ſtronger were the preſumptions, that the air, ſo far from abſorbing from the ſnow, or waſting it by evaporation, was all the while depoſiting hoar-froſt profuſely upon its ſurface, as well as upon all other bodies with which it had a free communication.

THE following extract from the paper of the year 1780, will ſet this in a ſtrong light, and will ſhow, how far my firſt impreſſions were obliged to yield to the authority of facts.

" ON Sunday night, January 23. 1780, ſeveral things were " laid out at the Obſervatory, ſuch as ſheets of brown paper, " pieces of boards, plates of metal, glaſſes of ſeveral kinds, " *&c.* which all began to attract hoar-froſt, ſeemingly as ſoon " as they had time to cool down to the temperature of the air.

" The ſheets of paper, being thin and eaſily cooled, acquired " it ſooneſt, and, when beheld by candle-light, were beauti- " fully ſpangled over by innumerable reflexions from the mi- " nute cryſtals of hoar-froſt which had parted from the air.

" EVIDENT ſymptoms of the ſame diſpoſition of the air to " depoſit hoar-froſt occurred on all the former nights of ob- " ſerving, and the tubes of the thermometers were ſo much " cruſted with it, that it required ſome attention to keep that " part which correſponded to the ſcale quite free." At the end of ſaid paper is the following ſcholium:

" THESE experiments, indeed, rather favour the opinion of " the exceſs of cold at preſent treated of, depending upon a " principle the very reverſe of evaporation. But till opportu- " nities offer, in this, or in a colder climate, of making more " experiments, it will be too early to ſay any thing very de- " cided concerning the nature and extent of a cooling proceſs " which has ſo recently come under obſervation. All that can at " preſent be affirmed is, that, in certain circumſtances, ſuch a " proceſs takes place; and that it depends probably upon ſome " principles different from evaporation. At the ſame time, ſome " of the experiments ſhow, that a free communication betwixt " the ſnow and external air, perhaps whilſt in motion, is ne- " ceſſary; but in what manner this promotes the refrigeration " does not as yet appear."

THE experiments gone through this firſt ſeaſon, rendering it ſo difficult to account for the phænomenon by an evaporation from the ſnow, the next ſtep was, to comprehend, if poſſible, by what other means ſuch a cooling proceſs could be maintained, conſiſtently with thoſe general principles which were already known to have a real exiſtence; and to this point, I confeſs, I frequently turned my thoughts, from a ſuſpicion of there being ſomething ſingular and undiſcovered at bottom.

ACCORDINGLY, before the return of the ſucceeding winter, ſeveral views occurred, concerning which it was propoſed to make

make an appeal to experiment as ſoon as the froſt ſhould afford an opportunity.

First of all, it did not ſeem impoſſible, that the air, in ſuch low temperatures, might impart ſome ſaline ingredient to the ſnow, along with the hoar-froſt it ſo freely depoſited; and, by that means, produce a conſtant liquefaction at the ſurface, which, though very inconſiderable, might be ſufficient to prevent the ſnow from acquiring the warmth of the higher air. I was led to this random ſuſpicion, by having obſerved that ſnow, after lying for ſome time on the ground, acquired a certain degree of firmneſs at the ſurface, as if the parts there had caked together by the gradual intervention of ſome fluid medium; and this, too, in caſes where ſuch an effect ſeemed not to depend upon the influence of the ſun in the day-time.

It was imagined alſo, that, in ſevere froſt, the ſnow ſpread abroad upon the face of a country might poſſeſs a power of depurating the atmoſphere from any phlogiſtic taint; and thus, according to ſome late diſcoveries of my very ingenious friend Dr Crawford, there would be a conſtant production of cold, by the air in contact with the ſnow, abſorbing ſenſible heat, as it was gradually ſo purified.

That property of ice, mentioned by Mairan, of expanding in volume whilſt expoſed to the action of a ſharp and increaſing froſt, joined to the preſumption from analogy, that bodies, when ſo expanding, muſt become colder by an increaſed capacity for heat, ſeemed alſo, in ſome meaſure, applicable to the preſent difficulty.

One other conjecture was, that the hoar-froſt, in the act of ſeparating from the air, and forming upon the ſnow, might aſſume ſome particular arrangement, favourable to a ſudden increaſe of its capacity for retaining heat, and thereby give riſe to a continual abſorption of it; and, of courſe, to a cooling proceſs.

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 expoſed to the free air in the Obſervatory-park, four feet from the ground, and at a conſiderable diſtance to windward of the houſe. To an arm which projected from a ſlender frame of wood, the thermometer was ſo applied, as to preſent itſelf ſloping, not far from a horizontal poſition, for the greater convenience of quickly reading off the degrees. Near by the frame, another thermometer was laid down upon the ſurface of the ſnow, which covered the ground to a conſiderable depth. At this time, the heavens were very clear all around, and the motion of the air from the eaſt, ſo ſoft as only to bend a little the flame of the candle, when ſteadily held out.

AT eleven o'clock, the thermometer in air pointed to $+5$, and the one upon the ſnow 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 ſettled froſty night.

I NOW returned to the Obſervatory to attend to ſome aſtronomical buſineſs. After lighting up the tranſit-room, I ſet the meridian teleſcope to the altitude of a ſtar, which preceded the planet in right aſcenſion, and which was very ſoon to paſs the mid wire at a certain ſecond 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 inſtrument was rightly directed, I looked for the ſtar again, but could perceive nothing. Stepping now forward, and turning my back towards the candles, the better to behold the heavens through the tranſverſe ſlit in the roof, I immediately diſcovered, that the ſtar-light there was wholly gone. This was quite unexpected, as about five or ſix minutes before, the heavens, when

when ſeen through the ſame opening, promiſed a very good obſervation.

Upon going abroad, I found the face of things entirely changed, the heavens being now overcaſt, not however by clouds, but by a thick uniform haze or fogginеſs above, which obſcured even the ſtars of the firſt magnitude. Being now out of doors, I thought of viſiting the thermometers; and, upon approaching them with ſome caution, I found, not without ſurpriſe, that the exceſs of cold, at the ſurface of the ſnow, had almoſt quite vaniſhed. The thermometer in air pointed to +6, two degrees higher than before, and the one upon the ſnow to +4: This was at fifty minutes paſt eleven. Till half paſt twelve the fogginеſs above continued rather to increaſe, when both thermometers pointed exactly to the ſame degree +7; which, at ſo low a temperature, and from the ſuddenneſs of the change, I could not help regarding as very remarkable, eſpecially as nothing ſimilar to this had occurred in my former obſervations.

By half an hour after one in the morning, the ſtars began again to ſhine out; when now I was amuſed to find the exceſs of cold at the ſurface of the ſnow returning. The air, by this time, was +8, and the ſnow +4. As the morning advanced, the atmoſphere turned more and more ſerene, and the thermometers came to differ no leſs than eight degrees. The obſervations made at this time are ſet down in the following regiſter:

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	Overcaſt, -	+ 6	+4
12	3′0	More overcaſt, -	+ 7	+7
		Morning.		
1	3′0	Turning a good deal clearer,	+ 8	+4
1	4′5	Still more ſo, -	+ 8	+2
2	2′0	Clear every where, except an ill defined cloud in N. E.	+ 9	+4
3		Ditto, except a ſmall ill defined cloud near zenith, -	+11	+3
3	4′5	Very clear, except ſome better defined clouds near horizon, from N. to N. E. -	+12	+4

December 29. 1783.

From ſun-ſetting till paſt ten o'clock this night, the heavens were ſometimes clear and ſometimes overcaſt, which induced me to go to the Obſervatory in hopes of ſeeing the planet, and of tracing farther the effects of ſuch a fluctuation of the atmoſphere upon the thermometers. On my way, I was overtaken by a low fog or miſt, and the thermometers being immediately expoſed, as before pointed, as follows:

December 29. 1783, at night.			Air.	Snow upon the ground.
11	2′0	- - -	+11	+ 3
11	3′0	Miſt increaſing, 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

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-

periments made in the year 1780, except in one inſtance, which ſhall be particularly taken notice of in the ſequel. Agreeably to this, it was found alſo, that the ſnow-ſcale was all the while gaining weight, as marked in the foregoing regiſter. From the regiſter alſo, it is manifeſt, that this depoſition of hoar-froſt took place whilſt the air was ſerene, and whilſt there was an exceſs of cold at the ſurface of the ſnow.

FROM twenty minutes after eleven till half an hour paſt one in the morning, there were very plain indications of all theſe ſubſtances ſurrendering to the air, though indeed ſlowly, the hoar-froſt which had been before imparted to them; whilſt the ſnow-ſcale, as is marked in the regiſter, was loſing weight. From the regiſter it alſo appears, that all this happened when the heavens were overcaſt, and when the ſnow upon the ground was of a higher temperature than the air.

DURING moſt part of the winter, the atmoſphere was extremely liable to change from a ſerene to a foggy or clouded ſtate, and *vice verſa*. Theſe alternations affecting the cooling proceſs at the ſurface of the ſnow, in ſo particular a manner, I was frequently led to repeat the obſervations and ſtatical experiments which have juſt now been deſcribed, without meeting with any difference in the circumſtances worthy of being mentioned. The phænomena of the nights of December 28. and 30. occurred frequently afterwards in the ſame order, but particularly in the night of January 25. when the heavens were overcaſt three times, and turned twice clear in the ſpace of ſix hours.

REMARKS.

FROM the foregoing regiſters, obſervations, and experiments, as alſo from thoſe of the years 1780 and 1781, it ſeems evident, that the ſnow continued colder than the air four feet above it, only ſo long as it was attracting hoar-froſt at its ſurface; and that whenever this attraction ceaſed, and even when it was followed

lowed by a ſlow 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 ſurface

face of the ſnow, conſidered as a phænomenon, either wholly or in a great meaſure depending upon a conſtant attraction of hoar-froſt, always vaniſhed when the heavens were overcaſt, or when any fog or hazineſs interrupted the clearneſs of the lower air.

THERE is, however, one circumſtance to be found in the regiſter of December 28. which ſeems repugnant to the explanations that have now been attempted. From midnight till near four o'clock that morning, the air continued to riſe in its temperature, and at ſuch a rate as ſeems incompatible with the conſtant giving out of hoar-froſt, and with the correſponding exceſs of cold, which took place at the ſurface of the ſnow, unleſs we ſuppoſe, that the warmer air, which ſucceſſively arrived at the place of obſervation, was, at the ſame time, more and more charged with vapours, for which, it muſt be confeſſed, we have very little or no evidence.

A DIFFICULTY of this kind coming in the way of our general reaſonings upon ſuch phænomena, rather leads to a ſuſpicion of there being ſome other principles concerned, which as yet may have altogether eſcaped obſervation. I have been the more inclined to harbour ſuch a ſuſpicion, ſince reading lately in the Berlin Memoirs for 1780, a Diſſertation by M. ACHARD upon the diſpoſition of the air to ſhed night-dew, in which there are ſome curious remarks. It is much to our purpoſe here to take notice, that this author mentions particularly the ſudden overcaſting of a ſerene ſky, as having frequently come under his obſervation; and that it was always accompanied with moſt ſenſible and deſultory changes in the electricity of the lower air. The ſcope of M. ACHARD's Memoir, is, to ſhow how much electricity is concerned in the phænomena of the atmoſphere, and how neceſſary it is, in all our meteorological reſearches, to have reſpect to the operations and effects of ſuch a principle. According to this author, the different diſpoſitions of the air, as to giving out and taking in moiſture,

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.

SECT. 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.

The

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 ſand to + 8. I continued to obſerve till half an hour after one in the morning; and the following regiſter ſhows how the thermometers pointed according to their ſeveral ſituations:

Jan. 24. 1784, at night.	Air.	Snow-ſcale.	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 ſo frequently I had occaſion to remark, that the balls and ſtems of the two which lay upon the ſnow and ſand were cruſted with hoar-froſt much ſooner than the other which was to windward in the air. The one upon the ſand contracted hoar-froſt the ſooneſt, and, what at the time I thought ſtrange, more early than the fourth thermometer which I had laid down upon the ſnow at the ground. In regard to the thermometer in air, I ſhould rather think it attracted no hoar-froſt whatever, properly ſpeaking, and that what was diſcernible upon it proceeded from accidental minute floating particles which clung to the glaſs, and afterwards entangled more of the ſame kind: For the ball of this thermometer was not, like the one belonging to the ſand, cruſted over with an uniform dead ſilver whiteneſs, but was beſet with a number of ſmall tufts or prickles of the hoar-froſt, whilſt the intervals of glaſs between them were entirely clear.

With a view to a repetition of the ſtatical experiment, I had carefully aſcertained the weight of the ſnow-ſcale and ſand-

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 thermometer 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 packthread 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 circular 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 ſide, as uſual.

THE reſult was, that all, except the ſnow, kept nearly of the ſame temperature, full ſix degrees below that of the air, at the ſame height, and immediately to windward, which then was + 12. The ſand ſeemed rather the coldeſt, and the ſnow obviouſly neareſt to the heat of the air.

IN the mean time, the ſeparation of hoar-froſt from the air was very manifeſt. It was moſt diſcernible to the ſight upon the ſand and charcoal duſt, though the manner of attaching itſelf to theſe ſubſtances was very different. On the ſand, it ſhowed itſelf by making the ſurface all over ſparkle with an infinity of minute bright points, whilſt, on the charcoal duſt, it ſettled without ſuch contiguity, and formed into many broken filaments, of a dull hue, which here and there lay cluſtered as if aiming at ſome ſtellated arrangement.

THE preſent experiment was made about midnight, when the heavens were very clear, and the wind at eaſt and one point ſouth, and ſo briſk as to trail horizontally the flame of the candle till it ſometimes went out. Now and then this gentle current came ſuddenly ſtraight downwards for a few ſeconds, 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 ſtate of the atmoſphere, nor any alternation in the cooling proceſs. Laſt night, however, the caſe was very different, as has been already mentioned. The experiments then made were chiefly with the ſnow-ſcale and ſand-board. When the heavens were overcaſt, both ſoon acquired the temperature of the air, which then was very ſtill. It was found, too, by ſtatical experiments, that the ſand acquired an addition to its weight, when it happened to be for ſome length of time colder than the air; but when the cooling proceſs was interrupted, and the ſand continued for ſome time of the ſame tem-

perature as the air, the ſcale gradually became lighter, though in a ſmall degree.

REMARKS.

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 refrigeration, by the action of the ſurface over which it travels, is, upon its arrival at the leeward ſide, and during the fit, diſpoſed to part with a greater quantity of hoar-froſt in a given time, than what otherwiſe it would do, even though equally cold. According to this idea, were the ſurface ſo much extended as to bring the fit of refrigeration to a maximum, and ſo put an end to it, before the arrival of the air at the leeward ſide, a body at this leeward ſide would acquire hoar-froſt more ſlowly than another lying ſomewhat more to windward, to which the air can reach whilſt in the fit of cooling. Thus, therefore, in regard to the greater part of the air, which ſweeps the endleſs continuous ſurface of the ſnow upon the ground, we may conceive the fit of refrigeration as conſummated; on which account, it will be leſs diſpoſed than that which croſſes the ſand upon the ſcale to give out its hoar-froſt: And, in this way, the fact under conſideration may be accounted for.

From a deſire of making ſome more formal experiments upon the air whilſt in this progreſs of cooling, by the action of ſurfaces expoſed 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 ſand, I intended to have expoſed on ſome favourable night for the froſty air to glide along it; and by thermometers placed at certain intervals, as well as plates of metal, *&c.* which I could bring to the teſt of a balance, to have determined the greateſt degree of cold, and the rate of cooling, and of giving out hoar-froſt, from the windward to the leeward end: But before I could conveniently enter upon this experiment, I was ſtopped by the thaw. Perhaps a platform of deals laid cloſe to one another, and covered with ſand, would be a much better apparatus; as the more a ſurface, deſigned for ſuch a purpoſe, is extended in breadth, the warmer air would the leſs readily flow in ſidewiſe, ſo as to mar the effect produced by the ſlow current:

rent advancing to leeward. It would not be wonderful, though ſomewhere upon an elevated and detached platform of this kind, we ſhould find an *artificial cold* greater than what prevails at the ſame time on the ſnow at the ground; as the warmer ſnow, which lies immediately beneath, at leaſt for the moſt part, muſt more or leſs counteract the cooling proceſs kept up there.

But to return from this digreſſion, I now come to relate the moſt ſtriking experiment I had an opportunity of making this winter, during the time I was occupied in ſuch cold vigils.

In ſome of the ſereneſt and ſtilleſt nights, having frequently amuſed myſelf by attending to the capricious arrangement of the hoar-froſt as it ſettled upon different bodies, I was led to remark, that quickſilver was a long while of attracting any, and even at laſt ſparingly, and chiefly at thoſe places of its ſurface which were ſullied by a duſty film. This naturally ſuggeſted a compariſon of quickſilver and the ſand, as to their powers of contributing to the cooling proceſs at their ſurface.

For the apparatus, I borrowed from a cabinet-maker two mahogany tea-trays, of an oval form, twenty-two inches by ſeventeen, and near an inch deep, inſide meaſure.

January 29. 1784.

About nine o'clock at night, I placed them out in the park upon a ſlight plane-tree table, about a foot aſunder, and with their longer axes pointing to windward. After levelling one of the trays, its bottom was completely flooded over with quickſilver, to the amount of twenty-four pounds weight, which Meſſrs Hill and Monteath, ſurgeons and druggiſts here, moſt obligingly lent me for that purpoſe. The bottom of the other tray was covered to the depth of a quarter of an inch with the fine flinty ſand. Upon each of the ſurfaces of the ſand and of the quickſilver, I laid down a thermometer, with the ball near to the leeward end as uſual, and expoſed 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 obſerve them now and then for two hours more. During all this time, I found, that the thermometer placed upon the quickſilver continually pointed higher than the other upon the ſand, as ſet down in the following regiſter:

Jan. 29. 1784. at night.	Air.	Tray with quickſilver.	Tray with ſand.	Exceſs of cold on the quickſilver.	Ditto on the ſand.
10 o'clock,	+ 4	+ 3	— 1	1	5
10 30′ -	+ 3	+ 2	— 1	1	4
11 -	+ 3	+ 2	— 1½	1	4½
11 30′ -	+ 3	+ 1½	— 1½	1½	4½
12 -	+ 4	+ 2	0	2	4

To make ſure of every thing in this experiment, eſpecially as the extremes of temperature were but inconſiderable, I ſometimes changed the thermometers, and ſhifted the ſand-tray from the right to the left ſide of the other, without at all altering the report. Whilſt this experiment was going forward, I diſcerned plainly all the common ſymptoms of the hoar-froſt joining the ſand, and ſettling upon the inſide and outſide wood of both trays. Though at length, ſome made its appearance upon the face of the quickſilver, yet I am apt to think, that the cold generated all around by the hoar-froſt which attached itſelf to the wood, was the chief cauſe of the quickſilver keeping 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 quickſilver to the very brim, and to have defended the outſide wood from the air by ſome rare ſubſtance. Had things been ſo managed, and the other tray completely filled alſo with ſand, and defended in the ſame manner, I am perſuaded the reſult would have been more remarkable; and that the quickſilver, thus expoſed with an

an unſullied face, would have kept as warm as the air to windward, how much ſoever the ſand might have been colder.

But taking the reſult of this experiment as we found it, we may ſafely regard it as an inſtance of what may be called the ſame volume of air in one part, laying down its vapour in the form of hoar-froſt, and in another, paſſing away without ſuch a decompoſition taking place. In the former caſe, we accordingly found the correſponding cold produced, but very ſmall indications of any ſuch thing in the latter.

As quickſilver thus reſiſts the hoar-froſt, ſo may ſome other ſubſtances; and, on the contrary, there may be ſome much more fitted than others to promote this ſort of decompoſition of the air in low temperatures. But this ſuggeſts a variety of experiments which I have had no opportunity of purſuing. Certain late appearances have made me think of trying a broad ſurface, made up of a combination of wool-cards, having obſerved ſomething like a preference of ſharp points in the ſettling of hoar-froſt.

Though it would require many more experiments than our opportunities have allowed of, to underſtand fully ſeveral points belonging to this Enquiry; ſuch as, the fits of refrigeration of the air, and the correſponding aptitude to part with its hoar-froſt, yet the foregoing experiments, regiſters, and obſervations, when attentively conſidered and compared with one another, and with thoſe narrated in the two papers publiſhed in the London Philoſophical Tranſactions, ſeem to conſpire in ſupport of the following

GENERAL CONCLUSIONS:

That when bodies attract hoar-froſt from a clear air, there is a cold produced at their ſurfaces; and that this cold does not originate from any peculiar qualities of bodies upon which the hoar-froſt ſettles, any farther than as ſome bodies are capable of attracting from the air more or leſs of it in a given time:

That

That the diſpoſition of the air of thus parting with hoar-froſt, and the cold which accompanies that ſeparation, has a conſtant dependence upon the general ſerenity of the atmoſphere, and is always interrupted upon the ſky being overcaſt with clouds or foggineſs, eſpecially near to the place of obſervation.

THE analyſis which has now been detailed, though imperfect in many reſpects, ſeems, however, to demand our aſſent to theſe general propoſitions, how anomalous ſoever they may appear.

THE nature or eſſence of the thing we call HEAT is ſo far removed beyond the immediate reach of our ſenſes, 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 eſtabliſhed. If, upon mature reflection, the preſent 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 neceſſity of enlarging our ſtock of principles, and inviting us forward to ſo deſirable a work.

IN the *firſt* propoſition above laid down, it is aſſerted, that the cold produced is in proportion to the quantity of hoar-froſt ſeparated from the air in a given time. This, however, muſt be underſtood with ſome limitation, and may not perhaps hold true, if we compare together the degrees of cold and quantities of hoar-froſt ſeparated in different ſtates of the air.

THE import of the propoſition only is, " That, at any given " time, the more hoar-froſt the air imparts to bodies over " which it paſſes in a clear ſtate, the greater is the cold then " produced." For it is very conceivable, that, according to the different ſtates of the air, in different ſeaſons, or in different nights of the ſame ſeaſon, ariſing from its being more or leſs charged with vapour, or perhaps with electricity, or ſome other

latent principles, the quantity of hoar-froſt 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-froſt 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 proceſs had no immediate dependence upon the ſeparation of hoar-froſt. But, from the facts which have been aſcertained this winter, it ſeems neceſſary to correct this opinion in the extent above explained. It ought alſo to be conſidered, that the compariſon above quoted between the years 1780 and 1781, had reſpect to the temperature of the ſnow upon the ground only; and it is evident, that this may, *cæteris paribus*, differ more or leſs from that of the air, according as the ſnow has fallen more or leſs recently, or is more or leſs deep, upon warm or upon frozen ground.

It may alſo be proper here to take notice of what may be called a ſpurious kind of hoar-froſt, which is attended with no cold whatever at ſettling upon bodies. I mean that which trees and buildings are ſo apt to be decorated with during a miſt in froſty weather; in which caſe it is obvious, that the hoar-froſt was previouſly formed in the air, and floated in it, and was not formed in the act of being depoſited upon the body.

SECT. III.

Though the night-obſervations of this and the former winters afforded ſo many examples of cold thus depending upon the ſeparation of hoar-froſt from the air, I come now to mention one, and the only one inſtance wherein, during the night, this condition of things was totally reverſed, and when the ſame phænomenon, of an exceſs of cold at the ſurface of the ſnow, took its riſe from a moſt manifeſt evaporation.

JANUARY 28. 1784.

ABOUT nine o'clock this night, the exceſs of cold was four, five, and ſometimes ſix degrees. The circumſtances of the weather, indeed, were now very particular. With the air ſo warm as + 27, the ſky was quite clear, whilſt a ſtrong wind blew directly from the north. At the ſame time, too, the heavens were illumined with a moſt vivid diſplay of the Aurora Borealis, which ſhooted from the north, round by the eaſt, and up beyond the zenith towards the ſouth, where the wandering irradiations all converged, ſo as to form an imperfect crown.

DURING this play of the elements, there were no longer to be found the ſmalleſt traces of that hoar-froſt about which I had ſo often been employed in calmer and in colder times. Early in the afternoon, I had laid out a parcel of things, which might ſhow me the ſtate of the air when night ſhould come. But neither upon them, nor upon the wooden ſpars of the wicket which opens from the foſſe round the Obſervatory to the park, nor upon its ſide-ſtones, nor the hedge, nor the thorn-tree near by, was there to be ſeen the ſmalleſt particle. Every thing around was entirely ſtripped of hoar-froſt by this dry and devouring gale.

THE ſand-board and ſnow-ſcale, ſet out as formerly, gave now a very different report. The thermometer on the ſand never cooled a fraction of a degree below the temperature of the air, whilſt the ſweeping wind cooled down the ſnow ſeveral degrees. Evaporation in all this was ſo evidently concerned, that it would have been abſurd to have tried if the ſand had loſt weight in that way. But, at any rate, ſuch an attempt would have been difficult, as the ſand was ſo liable to be diſperſed by the wind, that I was obliged to lay it very thick upon the ſcale, and to ſhelter it a little under the lee of the hedge. Being, however, deſirous to know, at what rate the ſnow waſted by evaporation in this ſituation, I got the white iron ſcale, with

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 detecting 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 temperature, 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 proceſs? 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 refrigeration 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 environed 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

obſerved ſuch a thermometer in air point ſenſibly below another beſide it, whoſe ball was perfectly clear. In ſhort, the whole features of the one proceſs, compared to thoſe of the other, are ſo diſſimilar, as to ſhew evidently they depend upon principles of a very different nature.

In the proſecution of ſo dark a ſubject, we have proceeded hitherto entirely in the way of analyſis, and have been careful to prevent any ſuppoſition or conjecture from mixing with, or affecting our concluſions. But having now arrived at what appears to be a general and leading fact, and of ſo anomalous a kind, the ſituation obliges us, more or leſs, to take up with ſurmiſes, as guides to farther experiments; in the view of finally reconciling the preſent phænomena with what we already know concerning the nature and properties of heat.

When ſuch a cold is produced, as that which has been conſidered at ſo much length, the queſtion is, What becomes of the ſenſible heat which thus conſtantly diſappears?

From the experiments mentioned in the paper of 1781, we are diſpoſed to think, that this heat does not enter into the compoſition of the hoar-froſt which is given out by the air.

If, however, it ſhould be found, that the air itſelf, at the moment the decompoſition takes place, has its capacity for retaining heat much increaſed, ſuch a circumſtance would immediately ſolve the difficulty. For, by this means, the air, when parting with any given portion of hoar-froſt, might abſorb, not only the whole heat, which, according to Dr Black's law, ſerved to keep the hoar-froſt diſſolved, but alſo, it might abſorb a portion of the ſenſible heat belonging to the body or ſurface upon which the hoar-froſt ſettles; and thus occaſion a diminution of ſenſible temperature, or the cold in queſtion.

But regarding the air, in theſe extreme colds, and whilſt the hoar-froſt is diſſolved in it, as a chemical mixt, it may be demanded, What reaſon is there for ſuppoſing that the capacity of the air for heat ſhould increaſe 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 conſidered, 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 leiſurely and intimate communion betwixt the air and the ſnow, which is neceſſary to the extrication of hoar-froſt; and that accordingly the thermometer approached conſiderably nearer to the temperature of the air.

" THAT the extrication of hoar-froſt requires an action con-
" tinued for ſome length of time, upon a given portion of
" air,"

is a propoſition of ſome moment, becauſe, taken along with the other general fact, it enables us ſo eaſily to explain certain collateral phænomena which ſo much characteriſe this kind of cooling proceſs; ſome examples of which have now been produced. On that account, it might be worth while to eſtabliſh the propoſition farther, by more direct experiments. For this purpoſe, a ſimple apparatus might be conſtructed for making the air, in night-obſervations, to paſs with different rates of velocity over the cooling ſurfaces, in order to diſcover how much the extrication of hoar-froſt, and the cold produced at the leeward ſide, depends upon an undiſturbed and leiſurely communication between the air and the ſubſtances expoſed. As to the iſſue, I am already almoſt entirely convinced, that, were the natural ſlow paſſage of the air over the ſurfaces changed ſuddenly, by machinery, into a rapid current, the thermometers at the leeward ſide would very ſoon riſe, if not to the ſame, at leaſt nearly to the ſame temperature as the air to windward.

IT might alſo be proper to try how far, and for what length of time, a conſiderable quantity of cold air, when ſhut up on all ſides from the external atmoſphere, would, by a leiſurely and ſucceſſive application of all its parts to a ſurface of ſand, *&c.* keep up a cooling proceſs; 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 ſo far in a diſcuſſion which has ſwelled to a much greater extent than originally was intended, and where ſo perpetual a recurrence of the ſame phraſeology, how neceſſary ſo-

ever

ever to the illuſtration of ſo new a ſubject, muſt doubtleſs have been felt as tedious. We ſhall, therefore, conclude with obſerving, that experiments of this kind fall moſt properly under the province of thoſe philoſophers who live in climates where the winter is of longer continuance, and attended with more rigour, and a more permanent ſerenity of the atmoſphere. Here, in this latitude, the opportunities are ſo rare, and, when they do occur, ſo tranſient, that our progreſs in ſuch an experimental enquiry muſt advance only by ſlow ſteps. To thoſe, therefore, more favoured by ſituation, would we humbly recommend a farther proſecution of a ſubject, which, beſides its entire novelty, ſeems, upon ſeveral other accounts, to have a claim to ſome attention.

VI. *An* ACCOUNT *of the Method of making a* WINE, *called by the* TARTARS *KOUMISS; with Obſervations on its Uſe in Medicine. By* JOHN GRIEVE, M. D. F. R. S. EDIN. *and late Phyſician to the Ruſſian Army.*

[*Read by Dr* BLACK, *July* 12. 1784.]

IN an age like the preſent, when few things in nature ſeem to have eluded the reſearches of philoſophy, when the communications of learning are as well eſtabliſhed as thoſe of commerce, it may appear ſomewhat ſurpriſing, that one of the moſt important productions of milk ſhould ſtill remain, in a great meaſure, unknown to the moſt enlightened parts of Europe.

THE production I mean is the vinous liquor which is procured by fermentation from mares milk. And it was ſcarcely to be expected, that, after it had eſcaped the obſervation of men the moſt ſkilled in chemiſtry, it ſhould be taught us by a horde of Tartars, whoſe rank in ſociety is not above that of Barbarians.

EVEN in Ruſſia itſelf, it was with difficulty I could learn the particulars of the preparation; and though it has been uſed, for ſome ages, by ſeveral tribes of people who belong to that empire, yet, in the year 1781, when I firſt began to think of employing it in medicine, it was as little known in what may be called *Ruſſia proper*, as it is now in Great Britain. If the academicians of St Peterſburgh gave ſome accounts of it, theſe accounts have never excited the attention of the phyſicians of Ruſſia.

THIS neglect is moſt probably to be aſcribed, partly to the obſcure relations of travellers, and partly to the pride of ſyſtem, 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.

* De Region. Oriental. lib. 1. cap. 57.

† Beſchreibung des Ruſſichen Reichs, p. 319.

‡ Gmelin's Reiſſe durch Siberien, t. 1. p. 273.

THE lateſt writer that I find mentioning *Koumiſs*, is the celebrated profeſſor of natural hiſtory in St Peterſburgh, Dr PALLAS *. His account is as circumſtantial as could well be expected from a traveller, whoſe object was natural hiſtory in general; yet the principles on which the fermentation depends, as well as the mode of conducting the proceſs, are not ſufficiently explained in his work.

THESE accounts, however imperfect, might have led philoſophers, long before this time, to a diſcovery of the true method of fermenting milk, had not the writings of NEWMAN ‡, an eminent German chemiſt, contributed to deceive them. He was himſelf impoſed upon by one LUCAS, a Dominican monk, who aſcribed its fermentation to the flour of millet and the grains of barley, which, he ſaid, the Tartars added to it, and to the wine-caſk in which the operation was performed. NEWMAN, it would ſeem, was unwilling to admit of the fermentability of milk, becauſe it was contrary to the ideas he had entertained of an animal liquor; and, therefore, adopting the oppoſite opinion, he ſeems glad to have an authority, however weak, to ſupport it.

VOLTELEN ‡, too, a chemiſt of Holland, affords a ſtriking example, how eaſily men are miſled, even in matters of ſcience, by their own prejudices. He had no doubt of the exiſtence of a fermentable principle in milk, inaſmuch as it contained a certain quantity of a ſaccharine ſubſtance. He knew alſo, that the whey contained the ſugar in ſolution; it was on it, therefore, that he inſtituted his experiments; he added even more ſugar 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 ſucceſs undeceive him. He never once imagined, that the butyraceous and caſeous parts of the milk were no leſs neceſſary to its fermentation than the ſaccharine and ſerous.

Even

* Phyſicaliſh. Reiſe durch einig. provintz. des Ruſſiſch. Reichs, t. 1. p. 316.

† NEWMAN, Chem. experimental. t. 1. part 2. p. 18.

‡ Obſervat. de lacte humano cum aſinino 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 diſſolved, a conſiderable quantity of ex- "tractive ſubſtance, of the nature of the ſaccharine juices, and "it is accordingly ſuſceptible of the ſpirituous fermentation. "The Tartars certainly make from it a ſpirituous 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 ſucceſs. 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 Ruſſian nobleman, in whoſe caſe I was conſulted, and who was the firſt who made uſe of it by my advice. He went into that country on purpoſe to drink it; and, as he reſided for ſome time there, he could not be miſtaken with reſpect to the proceſs.

TAKE of freſh mares milk, of one day, any quantity; add to it a ſixth part of water, and pour the mixture into a wooden veſſel; uſe then, as a ferment, an eighth part of the ſoureſt cows milk that can be got; but, at any future preparation, a ſmall portion of old *Koumiſs* will better anſwer the purpoſe of ſouring; cover the veſſel with a thick cloth, and ſet it in a place of moderate warmth; leave it at reſt twenty-four hours, at the end of which time, the milk will have become ſour, and a thick ſubſtance will be gathered on the top; then, with a ſtick, made at the lower end in the manner of a churnſtaff, beat it, till the thick ſubſtance above mentioned be blended intimately with the ſubjacent fluid: In this ſituation, leave it again at reſt for twenty-four hours more; after which, pour it into a higher and narrower veſſel, reſembling a churn, where the agitation muſt be repeated, as before, till the liquor appear to be perfectly homogeneous; and, in this ſtate, it is called *Koumiſs*; of

* MACQUER Dictionary of Chemiſt. p. 432.

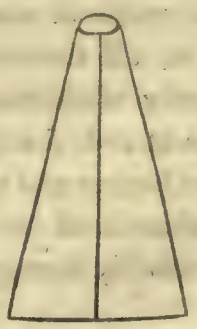
of which the taſte ought to be a pleaſant mixture of ſweet and ſour. Agitation muſt be employed every time before it be uſed.

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 allowing 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 manuſcript now in my poſſeſſion, I will add ſome particulars, taken from other communications with which I was favoured by Tartars 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 narrow 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



* 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 cloſely ſecured. It had a dirty appearance, and a very diſagreeable 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 uſed by the Kalmucks for the preparation and carriage of their *Koumiſs*, I learned, that the proceſs may be much ſhortened by heating the milk before the ſouring be added to it, and as ſoon as the parts begin to ſeparate, and a thick ſubſtance to riſe to the top, by agitating it every hour, or oftener. In this way, he made ſome in my preſence in the ſpace of twelve hours. I learned alſo, that it was common, among ſome Tartars, to prepare it in one day during ſummer, 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 neceſſary. And though it is commonly uſed within a few days after the preparation, yet, when well ſecured in cloſe veſſels, and kept in a cold place, that it may be preſerved for three months, or even more, without any injury to its qualities.

He ſaid farther, that the acid fermentation might be produced by ſour milk, as above, by a ſour paſte of rye-flour, by the rennet of a lamb's ſtomach, or, what is more common, by a portion of old *Koumiſs*; and that, in ſome places, they ſaved much time, by adding the new milk to a quantity of that already fermented, on being mixed with which, it very ſoon undergoes the vinous change. It was according to the firſt proceſs, however, that all the *Koumiſs* which I have employed in medicine was prepared.

From all theſe accounts, it appears, that three things are eſſential to the vinous fermentation of milk. Theſe are *heat*, *ſouring*, and *agitation*. Heat is neceſſary to every ſpecies of fermentation, and ſouring is perhaps not leſs ſo, though not in ſo ſenſible a degree as in the preſent caſe; but the chief art of fermenting milk conſiſts in *agitation*. This laſt circumſtance has wholly eſcaped the attention of chemiſts, notwithſtanding it appears to be conſonant to the operations of nature in other ſpecies of fermentation. In fermenting vegetable juices and infuſions, nature has no need of the aſſiſtance of art; the inteſtine

teſtine motion which accompanies the fermentation is ſufficient to produce the degree of agitation which ſeems neceſſary to keep the parts of the fluid in mutual contact, or to fit them for mutual action. Milk, on the contrary, is no ſooner ſoured than a ſeparation of its parts takes place; the cream riſes to the top, while the cheeſe either falls to the bottom, or is ſuſpended in the whey. When theſe parts are brought, however, into cloſe contact with one another, by agitation, and this repeated at proper intervals, a vinous liquor is produced; of the medical virtues of which I ſhall now treat.

FROM the time I had heard of *Koumiſs*, I had conceived an opinion of its importance in the cure of certain diſeaſes. I judged, that a preparation of milk, which could not be curdled by the juices of the ſtomach, while, at the ſame time, it poſſeſſed all its nutritive qualities, with the ſuperaddition of a fermented ſpirit, might be of eſſential ſervice in all thoſe diſorders where the body is defective either in nouriſhment or ſtrength.

THE caſe of the above mentioned nobleman, who communicated to me the firſt proceſs, gave me an opportunity of trying, how far my conjectures were well founded. He was in that ſtate which ſeemed to me ſtrongly to indicate the uſe of ſuch a medicine as *Koumiſs*. I accordingly adviſed him to it.

AT twenty-ſix years of age, he laboured under a complication of chronic complaints. A confirmed *lues venerea*, injudiciouſly treated, with three ſucceſſive ſalivations by mercury, added to bad management of himſelf under theſe, had given riſe to his diſeaſe. His body was much emaciated; his face was of a livid yellow colour; his eyes were ſunk, and round his eye-lids there was a dark ſhade; he felt a ſevere pain in his breaſt, and that was accompanied with a conſiderable cough and mucous expectoration; his appetite and digeſtion were greatly impaired; he had frequent tremblings and faintings; he began to feel the ſymptoms of hectic fever. In a word, his whole appearance was conſumptive, and he was ſo weak that he

he required aſſiſtance to get into the carriage in which he was to be conveyed into Tartary.

After drinking *Koumiſs* ſix weeks only, he returned perfectly free from all the above ſymptoms, and was become ſo plump and freſh-coloured, that, at firſt ſight, it was with difficulty his friends could recogniſe him. As he did not come immediately to *Niſchne-Novogorod*, where I then was, he wrote me a letter, the ſubſtance of which, as far as it related to this ſubject, I ſhall give here.

After telling me the ſudden and remarkable change the *Koumiſs* had produced, during the firſt few days; that he ceaſed to be diſturbed in his ſleep; that his nervous and dyſpeptic ſymptoms left him; that he felt as if his veſſels had been diſtended with a freſh cooling liquor; that he became cheerful; that it ſerved him both for food and drink; that though he uſed it to the quantity of a gallon and a half, and ſometimes even more, in the twenty-four hours, yet he always drank it with pleaſure, and without intoxication; that his body, during its uſe, was regularly open; but that his urine was ſo much increaſed, that he was uſually excited to make water every hour: He proceeded to expreſs himſelf in the following ſtrong terms, which ſerves to ſhow how much he had profited by it.

"I am diſpoſed to conſider *Koumiſs*, (ſays he) with all defe-
"rence to you, as an univerſal medicine, which will cure every
"diſeaſe, if you do not chuſe to except fever; for I am per-
"ſuaded, that the moſt ſkilful phyſician, with all the drugs of
"the ſhop, could not have reſtored me to the health I now en-
"joy."

The next caſe in which it was employed, though not ſo deſperate as the former, gave ſufficient proofs of its nutritive and ſtrengthening qualities. A lady, who had been witneſs to its uncommon efficacy in the nobleman's caſe above mentioned, was encouraged to try it in her own. It was not convenient for

her to go herſelf to Tartary, and therefore ſhe had it ſent to her, well ſecured in caſks, during the autumn.

She had been long ſubject to a train of nervous diſorders. By theſe, ſhe was much extenuated, and reduced to a ſtate of extreme weakneſs and irritability. She uſed it for about a month, at the end of which time, the functions of her nervous ſyſtem were reſtored, and, with health and vigour, ſhe acquired a plumpneſs and freſh complexion.

The following year, I reſolved to try it at *Niſchne-Novogorod* under my own eye. As mares milk could not be obtained in ſufficient quantity in town, it was made at the ſeat of a nobleman, not far diſtant, from which it was occaſionally tranſported. The ſeaſon was far advanced, however, before a caſe was preſented, in which its efficacy might be tried. At laſt, about the middle of Auguſt 1782, I was conſulted by the General Governor's nephew. He had all the ſymptoms of incipient phthiſis; pain of breaſt, dry cough, occaſional hæmoptyſis, and great emaciation; he was not, however, become hectic. His two elder brothers had died of true pulmonary conſumptions. He had taken much medicine, in a different part of the country, and had obſerved a very ſtrict antiphlogiſtic regimen; but though milk had conſtituted the greateſt part of his diet, yet there were no ſigns of recovery. He drank *Koumiſs* for about two months only, and that in rather an unfavourable ſeaſon; but the conſequence was, that all the above ſymptoms diſappeared, and his fleſh and ſtrength returned; nor was there any reaſon to apprehend a relapſe, at the time I left that country.

About the ſame time, I adviſed its uſe to another young nobleman, who had laboured under an abſceſs in the left ſide, about the region of the twelfth rib. As he had then reſided in a remote part of the country, no attention had been paid to it; on the contrary, by improper applications, the ſides of the ulcer were become hard. He had loſt his fleſh and ſtrength; he had occaſional 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

* 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 ſubſtance 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 frequently 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 vigour 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 advantage in the cure of nervous diſorders in general, from the manner in which it operated in the *ſecond* caſe? And in the incipient, 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 body is threatened with hectic fever?

Whether all theſe queſtions can be anſwered in the affirmative, muſt be determined by future experience; and, if they ſhould, perhaps the ſcarcity of mares milk in this country would greatly circumſcribe its utility.

Hence enquiries will naturally be made, whether other ſpecies 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 reſpecting that which is the moſt common, the milk of cows.

Dr PALLAS*, in the work above quoted, ſays, that cows milk is alſo ſuſceptible 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 *Koumiſs* when it can be got, as it is more agreeable, and contains a greater quantity of ſpirit; that *Koumiſs* on diſtillation yields of a weak ſpirit one third, but that *Airen* yields only two ninth parts of its whole quantity; which ſpirit they call *Arika*.

THIS account is confirmed by OSERETSKOWSKY, a Ruſſian †, who accompanied LEPECHIN, and other academicians, in their travels through Siberia and Tartary. He publiſhed lately a Diſſertation on the ardent ſpirit to be obtained from cows milk.

FROM his experiments, it appears, that cows milk may be fermented with, or even without, ſouring, provided ſufficient time and agitation be employed; that no ſpirit could be produced from any one of its conſtituent parts taken ſeparately, nor from any two of them, unleſs inaſmuch as they were mixed with ſome part of the third; that the milk, with all its parts in their natural proportion, was the moſt productive of it; that the cloſer it was kept, or, which is the ſame thing, the more difficultly the fixed air is allowed to eſcape during the fermentation, (care being taken, however, that we do not endanger the burſting of the veſſel), the more ſpirit is obtained. He alſo informs us, that it had a ſourer ſmell before than after agitation; that the quantity of ſpirit was increaſed, by allowing the fermented liquor to repoſe for ſome time before diſtillation; that from ſix pints of milk, fermented in a cloſe veſſel, and thus ſet to repoſe, he obtained three ounces of ardent ſpirit, of which one was conſumed

* Phyſicaliſch. Reiſe durch verſchied. provintz. des Ruſſiſch. Reichs, t. 1. p. 316. et 317.

† Specim. inaug. de Spir. Ardent. ex lact. Bub. Argentorat. 1778.

conſumed in burning; but that from the ſame quantity of the ſame milk, fermented in an open veſſel, he could ſcarcely obtain one ounce.

THESE particulars of the fermentation of mares and cows milk are an intereſting addition to the facts concerning fermentation in general; a ſubject ſo very obſcure and imperfectly underſtood, that I ſhall not hazard any remarks on it. My principal intention was, to point out to phyſicians what appears to me a powerful means which may be employed by them on many occaſions in the cure of diſeaſes.

VII.

VII. *An* IMPROVEMENT *of the Method of correcting the* OBSERVED DISTANCE *of the* MOON *from the* SUN *or a* FIXED STAR. *By the Rev. Mr* THOMAS ELLIOT, *Miniſter of the Goſpel at Cavers.*

[*Communicated by Mr* ROBISON, *General Secretary, Aug.* 2. 1784.]

PROBLEM.

HAVING the apparent diſtance 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 diſtance.

SOLUTION.

THE difference between the apparent and true altitudes, and the angles which the Moon and Star make with the zenith and each other, muſt be known before the ſeveral corrections of diſtance are computed.

THE difference between the apparent and true altitude of a Star is the refraction in altitude, given p. 2. of *Tables requiſite to be uſed with the nautical ephemeris*. If the diſtance was taken from the Sun in place of a Star, his refraction may be corrected by ſubtracting from it his parallax in altitude, given at the end of the *requiſite tables*, and the difference uſed inſtead of the refraction of a Star; and, if great accuracy is required, the mean refractions may be corrected by the barometer and thermometer, according to Dr BRADLEY's rule, p. 130. *requiſite 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, muſt be reduced to the time of obſervation, according to the inſtructions in the *requiſite*

ſite tables. Then to the arithmetical complement of the logarithmic coſine of the moon's altitude, add the proportional logarithm of the reduced horizontal parallax, the ſum will be the proportional logarithm of the parallax in altitude; from the parallax in altitude ſubtract 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 obſervation, the moon and ſtar are in the ſame vertical, which may ſometimes happen in low latitudes, no angles are to be found. They will be in the ſame vertical, and on the ſame ſide of the zenith, if the apparent diſtance and leſſer altitude together are equal to the greater altitude. In which caſe, the ſum of the corrected parallax and ſtar's refraction, added to the apparent diſtance when the moon's altitude is greateſt, or ſubtracted from it when the moon's altitude is leaſt, will give the true diſtance. They will alſo be on the ſame vertical, but on oppoſite ſides of the zenith, if the apparent diſtance, added to the ſum of the altitudes, is equal to 180°. In this caſe, the difference of the corrected parallax and ſtar's refraction, *ſubtracted* from the apparent, will give the true diſtance; except when the moon is ſo near the zenith, that the corrected parallax becomes leſs than the ſtar's refraction, in which caſe the difference muſt be *added* to the apparent diſtance.

If the apparent altitudes are equal, the angles at the moon and ſtar will alſo 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 diſtance, the ſum, rejecting radius, will be the logarithmic coſine of each of the angles at the moon and ſtar, and each of them will be acute, or leſs than 90°.

When the altitudes are unequal, the angles may be found by the following method:

To

To the logarithmic cotangent of half the ſum of the apparent altitudes add the logarithmic tangent of half their difference, and from the ſum ſubtract the logarithmic tangent of half the apparent diſtance, the remainder will be the logarithmic tangent of a 1ſt arc.

The ſum of arc 1ſt and half the apparent diſtance, will be a 2d arc.

The difference of arc 1ſt and half the apparent diſtance, will be a 3d arc.

To the log. tangent of arc 3d add the log. tangent of the greater altitude, the ſum, rejecting radius, will be the log. coſine, either of the angle itſelf at the higher object, between the other object and the zenith, or of its ſupplement to 180°, as arc 1ſt is leſs or greater than the half diſtance. As the application of the *firſt* and *third* corrections depends on the quality of the angles, it muſt be obſerved, that, if arc 1ſt is leſs than the half diſtance, the angle *itſelf* will be found, and will be acute; but if arc 1ſt is greater than the half diſtance, the angle found will be the *ſupplement* of the angle at the higher object to 180°, and the angle itſelf will be obtuſe, or greater than 90°. Nevertheleſs, if the greater altitude is that of the Moon, the coſine thus found is to be uſed in computing the *firſt* correction of diſtance.

To the log. tangent of arc 2d add the log. tangent of the leſſer altitude, the ſum, rejecting radius, will be the log. coſine 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 ſeveral corrections of diſtance will be found as follows:

1. To the arithmetical complement of the log. coſine of the angle at the Moon, add the proportional logarithm of the corrected parallax, the ſum will be the proportional logarithm of the *firſt* correction, which is to be added to the apparent di-

ſtance if the angle at the Moon is obtuſe, and ſubtracted if acute.

2. ADD together the proportional logarithms of the ſum and difference of the corrected parallax and *firſt* correction of diſtance, and take their ſum, which, for diſtinction, call the rectangle logarithm. To the rectangle logarithm, add the conſtant logarithm 1.5819, and the log. tangent of the diſtance *once* corrected, the ſum of theſe three logarithms, rejecting ten from the index, will be the proportional logarithm of the *ſecond* correction of diſtance, which is always to be added, except the diſtance is more than 90°, in which caſe it is to be ſubtracted.

To half the rectangle logarithm add the log. ſine of the diſtance *twice* corrected, the ſum, rejecting ten from the index, will be the proportional logarithm of a correction, to be ſubtracted from the angle at the Star, or to be added to its ſupplement.

3. To the arithmetical complement of the log. coſine of the corrected angle at the Star, add the proportional logarithm of the Star's refraction, the ſum will be the proportional logarithm of the *third* correction, which (contrary to the *firſt*) is to be ſubtracted from the diſtance, if the angle at the Star is obtuſe, and added if acute.

THESE three corrections, applied as above directed, will give the true diſtance of the Moon from the Sun or a fixed Star.

THERE is, indeed, a *ſecond* correction for the Star's refraction, ſimilar to the *ſecond* correction for parallax; but in moſt caſes it will not amount to 1″; and even when the Star's altitude is only 5°, and the diſtance only 20°, it will not exceed 2″½: It may, therefore, generally be omitted. But, if it is deſired, this correction may be found in the ſame manner as the *ſecond*.

4. ADD together the proportional logarithms of the ſum and difference of the Star's refraction and *third* correction of diſtance, the conſtant logarithm 1.5819, and the log. tangent of the diſtance *thrice* corrected, the ſum of theſe 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 ſum and the difference between the half ſum and the zenith diſtance of the Moon. Half the ſum of theſe four logarithms will be the log. coſine 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 ſeveral corrections of diſtance are to be computed and applied according to the rules already given.

INVESTIGATION.

IN the ſpherical triangle *MZS*, let *Z* repreſent the zenith, *M* the apparent place of the Moon, *S* the apparent place of the Star, and *MS* the apparent diſtance of the Star from the Moon's centre. Let *Zp* be a perpendicular arc let fall from *Z* upon *MS*, produced if neceſſary, and let *m* be the middle of the baſe, ſo that *Mm* or *Sm* be equal to half the diſtance of the objects. If the zenith diſtances *MZ* and *SZ* are equal, the triangle will be iſoſceles, and the angles *ZMS* and *ZSM* will alſo be equal, and *Zp* will fall upon *MS* in *m*; but if *MZ* and *SZ* are unequal, *Zp* will fall upon *MS* at ſome diſtance from *m*, either within or without the triangle, and the angles *ZMS* and *ZSM* will alſo be unequal. Then (by caſe 11. *obliq. ſpher. triang.*) *pm* will be the *firſt* arc, equal to the diſtance between the perpendicular and the middle of the baſe; half the baſe added to *pm* will be the *ſecond* arc, equal to the diſtance of the perpendicular from the lower object; and the difference between half the baſe and *pm* will be arc *third*, equal to the diſtance of the perpendicular from the higher object. It is evident that, when *pm* is leſs than half the baſe, the perpendicular muſt fall within the triangle, and the angles, both at *M* and *S* muſt be acute; on the contrary, when *pm* is greater than half the baſe, the perpendicular muſt fall without the triangle, and the angle at that object which is next the perpendicular will be obtuſe; and

ZSp

ZSp (fig. 1.) will be the ſupplement of *ZSM*, and *ZMP* (fig. 2.) will be the ſupplement of *ZMS* to 180°.

Zp being perpendicular to *MS*, the two triangles *ZpM* and *ZpS* will both be right-angled at *p*. The hypothenuſes *MZ* and *SZ* are the zenith diſtances of the objects, or the complements of their apparent altitudes, and the legs *MP* or *SP* are the *ſecond* or *third* arches. Then (by caſe 6. *right ang. ſpher. triang.*) the cotangent of the hypothenuſe, or, which is the ſame, the tangent of the altitude, multiplied by the tangent of the leg, and divided by radius, gives the coſine of the angle between the hypothenuſe and that leg; by which the angles *ZMS* and *ZSM* will be found.

THE other method of finding the angles is prop. 17. *ſpher. triangles*, prefixed to SHERWIN's Tables, reviſed by CLARK; and is the ſame with that given in the *requiſite tables* for finding the horary angle.

THE ſine of the horizontal parallax being to the ſine of the parallax in altitude, as radius to the ſine of the zenith diſtance, (KEIL's *Aſtron. lect.* 21.) the ſine of the horizontal parallax, multiplied by the ſine of the zenith diſtance, or, which is equal to it, by the coſine of the altitude, and divided by radius, will give the ſine of the parallax in altitude.

LET *Lq* repreſent the parallax in altitude, and *Mq* the refraction in altitude, then *Mq* ſubtracted 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 diſtance. Let *La* be a perpendicular arc from *L*, falling upon *MS*, produced if neceſſary, and let *Rc* be a perpendicular arc from *R*, falling upon *LS*, produced if neceſſary with the diſtance *LS* draw *Lb*, and with the diſtance *LR* draw *Rd*; then *LR* and *Ld* being radii from the ſame centre, or rather arches from *L*, as a pole, to the ſame parallel, will be equal to one another; and, for

for the ſame reaſon, *SL* and *Sb* will be equal to one another: Then the ſeveral corrections and corrected diſtances will be as follows:

1*ſt* correction *Ma*, diſtance once corrected *Sa*.

2*d* correction *ab*, diſtance twice corrected *Sb*, equal to *SL*.

3*d* correction *Sc*, diſtance thrice corrected *Lc*.

4*th* correction *cd*, diſtance four times corrected *Ld*, equal to *LR* the true diſtance. Radius 1.

THE *firſt* correction *Ma* is equal *ML* multiplied by the coſine 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 *ſecond* correction, will be the difference between *SL* and *Sa*; and is found by the following proportion: The rectangle under the tangents of half the ſum, and half the difference of *LM*, the hypothenuſe, and *aM*, one of the legs, is equal to the ſquare tangent of half *La*, the other leg; and the rectangle, under the tangents of half the ſum and half the difference of *SL* and *Sa*, is alſo equal to the ſquare tangent of half *La*, (HEATH's *Aſtron. p.* 330.) Hence the ſquare tangent of half *La*, divided by the tangent of half the ſum 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 ſquare tangent of half *La*, divided by the tangent of half the ſum of *SL* and *Sa*, will be equal to the tangent of *ab*. The proper diviſor, therefore, for finding this *ſecond* correction juſtly, is the tangent of *Sa* increaſed by half *ab*. But, as this will not make the correction $\frac{1}{4}''$ leſs than when *Sa* is made the diviſor, ſuppoſing the diſtance not under 20°, it was thought needleſs to mention it in the precepts.

IN ſuch a ſmall triangle, where the corrected parallax is the hypothenuſe, which can never exceed $56'\frac{1}{2}$, the difference between the arcs themſelves and their ſines or tangents is ſo very inconſiderable, that they may be taken indifferently for one another

ther, without any ſenſible error; and, by this means, the calculator may avail himſelf of that convenient and uſeful table of the proportional logarithms, and ſave a great deal of trouble in making proportions for ſeconds. When the arcs themſelves are taken inſtead of the tangents of the arcs, it will ſhorten the operation, and the reſult will be the ſame, if half the rectangle under the ſum and difference of *LM* and *aM* is ſubſtituted for twice the rectangle under half the ſum and half the difference of *LM* and *aM*; each of them is equal to half the ſquare of *La*, or twice the ſquare of half *La*, and half the ſquare of *La*, divided by the tangent of half the ſum of *SL*, and *Sa* is equal to *ab*.

WHAT is called the rectangle logarithm is the proportional logarithm of the ſquare of *La*; its half is the proportional logarithm of *La*, and *La*, divided by the ſine of *LS*, is equal to the angle *LSa*, which being ſubtracted from *ZSM*, leaves *ZSL*, equal to the oppoſite angle *dSR*, fig. 2.; or, when the angle at the Star is obtuſe, as in fig. 1. the angle *pSi*, equal to the oppoſite angle *LSa*, being added to the ſupplement of the angle at the Star, makes the angle *ZSi* equal to the oppoſite 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 coſine 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*, ſo that *cd* is found by the ſame proportion 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

ruſhed from the eaſt and weſt, in oppoſite currents, towards a line acroſs the bay, and about the edge of the deep, roſe 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 diſtance of between 90 and 100 yards from its natural boundary. When the oppoſite currents met, they made a claſhing noiſe, and foamed; and the ſtronger impulſe being from the eaſt, the wave, after riſing to its greateſt height, rolled weſtward, but ſlowly, diminiſhing as it went, for the ſpace of five minutes, when it wholly diſappeared. As the wave ſubſided, the water flowed back with ſome 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 ſpace of two hours, the ebbings ſucceeding each other at the diſtance of about ſeven minutes, and gradually leſſening till the water ſettled into its ordinary level.

AT the ſame time that the undulation was obſerved in the bay on the ſouth ſide of the village, the river on the north was ſeen to run back; the weeds at its bottom, which before pointed with the ſtream, received a contrary direction; and its channel was left dry above twelve feet from either edge. Under the bridge, (which is ſixty or ſeventy 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 obſerved, 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) ſtood the whole of that and the preceding day about 29½ inches.

ON the next, and the four ſucceeding days, an ebbing and flowing was obſerved nearly about the ſame time, and for the ſame length of time, but not at all in the ſame degree as on the firſt day. A ſimilar agitation was remarked at intervals, ſome

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 for 1774.

Month.	Rain.	Barom.	Therm.	Wind, E^ly	Wind, 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.	Wind, E^ly	Wind, 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	Wind, E^ly	Wind, 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.	Wind, E^ly	Wind, 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	29.100	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	29.100	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	Wly
				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	Wly
				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			125	240
Mean.		29.107	45.045		

ABSTRACT for all the preceding Years.

Year.	Rain,	Barom.	Therm.	Wind, E ly	Wly
				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,	31.648	29.106		133.3	231.9
Ditto, 9 Years			44.7930		

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.

	1773.			1774.			1775.			1776.			1777.		
Month.	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		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	5.475	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	2.600	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	0.225	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	0.375	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	0.625	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	3.125	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	5.225	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	5.500	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	4.425	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	4.225	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 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

a

a ſubject which, in another view, has appeared as the work of chance, or as abſolute diſorder and confuſion.

To acquire a general or comprehenſive view of this mechaniſm of the globe, by which it is adapted to the purpoſe of being a habitable world, it is neceſſary to diſtinguiſh three different bodies which compoſe the whole. Theſe are, a ſolid body of earth, an aqueous body of ſea, and an elaſtic fluid of air.

It is the proper ſhape and diſpoſition of theſe three bodies that form this globe into a habitable world; and it is the manner in which theſe conſtituent bodies are adjuſted to each other, and the laws of action by which they are maintained in their proper qualities and reſpective departments, that form the Theory of the machine which we are now to examine.

Let us begin with ſome general ſketch of the particulars now mentioned.

1*ſt*, There is a central body in the globe. This body ſupports thoſe parts which come to be more immediately expoſed to our view, or which may be examined by our ſenſe and obſervation. This firſt part is commonly ſuppoſed to be ſolid and inert; but ſuch a concluſion is only mere conjecture; and we ſhall afterwards find occaſion, perhaps, to form another judgment in relation to this ſubject, after we have examined ſtrictly, upon ſcientific principles, what appears upon the ſurface, and have formed concluſions concerning that which muſt have been tranſacted in ſome more central part.

2*dly*, We find a fluid body of water. This, by gravitation, is reduced to a ſpherical form, and by the centrifugal force of the earth's rotation, is become oblate. The purpoſe of this fluid body is eſſential in the conſtitution of the world; for, beſides affording the means of life and motion to a multifarious race of animals, it is the ſource 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*, We have an irregular body of land, raiſed above the level of the ocean. This, no doubt, is the ſmalleſt portion of the globe; but it is the part to us by far moſt intereſting. It is upon the ſurface of this part that plants are made to grow; conſequently, it is by virtue of this land that animal life, as well as vegetation, is ſuſtained in this world.

Laſtly, We have a ſurrounding body of atmoſphere, which completes the globe. This vital fluid is no leſs neceſſary in the conſtitution of the world than are the other parts; for there is hardly an operation upon the ſurface of the earth, that is not conducted or promoted by its means. It is a neceſſary condition for the ſuſtenance of fire; it is the breath of life to animals; it is at leaſt an inſtrument in vegetation; and while it contributes to give fertility and health to things that grow, it is employed in preventing noxious effects from ſuch as go into corruption. In ſhort, it is the proper means of circulation for the matter of this world, by raiſing up the water of the ocean, and pouring it forth upon the ſurface of the earth.

Such is the mechaniſm of the globe; let us now mention ſome of thoſe powers by which motion is produced, and activity procured to the mere machine.

First, There is the progreſſive force, or moving power, by which this planetary body, if ſolely actuated, would depart continually from the path which it now purſues, and thus be for ever removed from its end, whether as a planetary body, or as a globe ſuſtaining plants and animals, which may be termed a living world.

But this moving body is alſo actuated by gravitation, which inclines it directly to the central body of the ſun. Thus it is made to revolve about that luminary, and to preſerve its path.

It is alſo upon the ſame principles, that each particular part upon the ſurface of this globe, is alternately expoſed to the influence of light and darkneſs, 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 exiſtence is well known, but of which the proper uſe in the conſtitution of the world is ſtill obſcure.

We have thus ſurveyed the machine in general, with thoſe moving powers, by which its operations, diverſified almoſt *ad infinitum*, are performed. Let us now confine our view, more particularly, to that part of the machine on which we dwell, that ſo we may conſider the natural conſequences of thoſe operations which, being within our view, we are better qualified to examine.

This ſubject is important to the human race, to the poſſeſſor of this world, to the intelligent being Man, who foreſees events to come, and who, in contemplating his future intereſt, is led to enquire concerning cauſes, in order that he may judge of events which otherwiſe he could not know.

If, in purſuing this object, we employ our ſkill in reſearch, not in forming vain conjectures; and if *data* are to be found, on which Science may form juſt concluſions, we ſhould not long remain in ignorance with reſpect to the natural hiſtory of this earth, a ſubject on which hitherto opinion only, and not evidence, has decided: For in no ſubject is there naturally leſs defect of evidence, although philoſophers, led by prejudice, or miſguided by falſe theory, have neglected to employ that light by which they ſhould have ſeen the ſyſtem of this world.

But to proceed in purſuing a little farther our general or preparatory ideas. A ſolid body of land could not have anſwered the purpoſe of a habitable world; for a ſoil is neceſſary to the growth of plants; and a ſoil is nothing but the materials collected from the deſtruction of the ſolid land. Therefore, the ſurface of this land, inhabited by man, and covered with plants and animals, is made by nature to decay, in diſſolving from that hard and compact ſtate in which it is found below the ſoil; and this ſoil is neceſſarily waſhed away, by the continual circulation of the water, running from the ſummits of the mountains towards the general receptacle of that fluid.

The

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, by

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 ſucceſs; and an end from which we may perceive wiſdom, in contemplating the means employed.

BUT is this world to be conſidered thus merely as a machine, to laſt no longer than its parts retain their preſent poſition, their proper forms and qualities? Or may it not be alſo conſidered as an organized body? Such as has a conſtitution in which the neceſſary decay of the machine is naturally repaired, in the exertion of thoſe productive powers by which it had been formed.

THIS is the view in which we are now to examine the globe; to ſee if there be, in the conſtitution of this world, a reproductive operation, by which a ruined conſtitution may be again repaired, and a duration or ſtability thus procured to the machine, conſidered as a world ſuſtaining plants and animals.

IF no ſuch reproductive power, or reforming operation, after due enquiry, is to be found in the conſtitution of this world, we ſhould have reaſon to conclude, that the ſyſtem of this earth has either been intentionally made imperfect, or has not been the work of infinite power and wiſdom.

HERE is an important queſtion, therefore, with regard to the conſtitution of this globe; a queſtion which, perhaps, it is in the power of man's ſagacity to reſolve; and a queſtion which, if ſatisfactorily reſolved, might add ſome luſtre to ſcience and the human intellect.

ANIMATED with this great, this intereſting view, let us ſtrictly examine our principles, in order to avoid fallacy in our reaſoning; and let us endeavour to ſupport our attention, in developing a ſubject that is vaſt in its extent, as well as intricate in the relation of parts to be ſtated.

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 nature

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;

and for the aſcertaining this portion of time, we muſt again have recourſe to the regular operations of this world. We ſhall thus arrive at facts which indicate a period to which no other ſpecies of chronology is able to remount.

In what follows, therefore, we are to examine the conſtruction of the preſent earth, in order to underſtand the natural operations of time paſt; to acquire principles, by which we may conclude with regard to the future courſe of things, or judge of thoſe operations, by which a world, ſo wiſely ordered, goes into decay; and to learn, by what means ſuch a decayed world may be renovated, or the waſte of habitable land upon the globe repaired.

This, therefore, is the object which we are to have in view during this phyſical inveſtigation; this is the end to which are to be directed all the ſteps in our coſmological purſuit.

The ſolid parts of the globe are, in general, compoſed of ſand, of gravel, of argillaceous and calcareous ſtrata, or of the various compoſitions of theſe with ſome other ſubſtances, which it is not neceſſary now to mention. Sand is ſeparated and ſized by ſtreams and currents; gravel is formed by the mutual attrition of ſtones agitated in water; and marly, or argillaceous ſtrata, have been collected, by ſubſiding in water with which thoſe earthy ſubſtances had been floated. Thus, ſo far as the earth is formed of theſe materials, that ſolid 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 immenſe quantities of calcareous bodies which had belonged to animals, and the intimate connection of theſe maſſes of animal production with the other ſtrata of the land. For it is to be proved, that all theſe calcareous bodies, from the collection of which the ſtrata were formed, have belonged to the ſea, and were produced in it.

We find the marks of marine animals in the moſt ſolid parts of the earth, conſequently, thoſe ſolid parts have been formed after

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, 2*dly*, 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:

1*ſt*, 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

Andes *, there ſhall be found one cockle-ſhell, or piece of coral, it muſt be concluded, that this bed of ſtone had been originally formed at the bottom of the ſea, as much as another bed which is evidently compoſed almoſt altogether of cockle-ſhells and coral. If one bed of limeſtone is thus found to have been of a marine origin, every concomitant bed of the ſame kind muſt be alſo concluded to have been formed in the ſame manner.

We thus ſhall find the greateſt part of the calcareous maſſes upon this globe to have originated from marine calcareous bodies; for whether we examine marbles, limeſtones, or ſuch ſolid maſſes as are perfectly changed from the ſtate of earth, and are become compact and hard, or whether we examine the ſoft, earthy, chalky or marly ſtrata, of which ſo much of this earth is compoſed, we ſtill find evident proofs, that thoſe beds had their origin from materials depoſited at the bottom of the ſea; and that they have the calcareous ſubſtance which they contain, from the ſame ſource as the marbles or the limeſtones.

2*dly*, In thoſe calcareous ſtrata, which are evidently of marine origin, there are many parts that are of a ſparry ſtructure, that is to ſay, the original texture of thoſe beds, in ſuch places, has been diſſolved, and a new ſtructure has been aſſumed, which is peculiar to a certain ſtate of the calcareous earth. This change is produced by cryſtallization, in conſequence of a previous ſtate of fluidity, which has ſo diſpoſed the concreting parts, as to allow them to aſſume a regular ſhape and ſtructure proper to that ſubſtance. A body, whoſe external form has been

* "Cette ſommité élevée de 984 toiſes au deſſus de notre lac, et par conſequent de "1172 au deſſus de la mer, eſt remarquable en ce que l'on y voit des fragmens d'huîtres "pétrifiés.—Cette montagne eſt dominée par un rocher eſcarpé, qui s'il neſt pas in-"acceſſible, eſt du moins d'un bien difficile accès; il paroît preſqu'entierement composé "de coquillages pétrifiés, renfermés dans un roc calcaire, ou marbre groſſier noirâtre. "Les fragmens qui s'en detachent, et que l'on rençontre en montant à la Croix de fer, "ſont remplis de *turbinites* de différentes eſpeces." M. de Saussure, *Voyage dans les Alpes*, p. 394.

been modified by this proceſs, is called a *cryſtal;* one whoſe internal arrangement of parts is determined by it, is ſaid to be of a *ſparry ſtructure;* and this is known from its fracture.

3dly, THERE are, in all the regions of the earth, huge maſſes of calcareous matter, in that cryſtalline form or ſparry ſtate, in which perhaps no veſtige can be found of any organized body, nor any indication that ſuch calcareous matter had belonged to animals; but as, in other maſſes, this ſparry ſtructure, or cryſtalline ſtate, is evidently aſſumed by the marine calcareous ſubſtances, in operations which are natural to the globe, and which are neceſſary to the conſolidation of the ſtrata, it does not appear, that the ſparry maſſes, in which no figured body is formed, have been originally different from other maſſes, which, being only cryſtallized in part, and in part ſtill retaining their original form, leave ample evidence of their marine origin.

WE are led, in this manner, to conclude, that all the ſtrata of the earth, not only thoſe conſiſting of ſuch calcareous maſſes, but others ſuperincumbent upon theſe, have had their origin at the bottom of the ſea, by the collection of ſand and gravel, of ſhells, of coralline and cruſtaceous bodies, and of earths and clays, variouſly mixed, or ſeparated and accumulated. Here is a general concluſion, well authenticated in the appearances of nature, and highly important in the natural hiſtory of the earth.

THE general amount of our reaſoning is this, that nine tenths, perhaps, or ninety-nine hundredths of this earth, ſo far as we ſee, have been formed by natural operations of the globe, in collecting looſe materials, and depoſiting them at the bottom of the ſea; conſolidating thoſe collections in various degrees, and either elevating thoſe conſolidated maſſes above the level on which they were formed, or lowering the level of that ſea.

THERE is a part of the ſolid earth which we may at preſent neglect, not, as being perſuaded that this part may not alſo be found

found to come under the general rule of formation with the reſt, but as conſidering this part to be of no conſequence in forming a general rule, which ſhall comprehend almoſt the whole, without doing it abſolutely. This excluded part conſiſts of certain mountains and maſſes of granite. Theſe are thought to be ſtill older in their formation, and are very rarely, at leaſt, found ſuperincumbent on ſtrata which muſt be acknowledged as the productions of the ſea.

HAVING thus found the greater part, if not the whole, of the ſolid land to have been originally compoſed at the bottom of the ſea, we may now, in order to form a proper idea of theſe operations, ſuppoſe the whole of this ſea-born land to be again diſperſed along the bottom of the ocean, the ſurface of which would riſe proportionally over the globe. We would thus have a ſpheroid of water, with granite rocks and iſlands ſcattered here and there. But this would not be the world which we inhabit; therefore, the queſtion now is, how ſuch continents, as we actually have upon the globe, could be erected above the level of the ſea.

IT muſt be evident, that no motion of the ſea, cauſed by this earth revolving in the ſolar ſyſtem, could bring about that end; for let us ſuppoſe the axis of the earth to be changed from the preſent poles, and placed in the equinoctial line, the conſequence of this might, indeed, be the formation of a continent of land about each new pole, from whence the ſea would run towards the new equator; but all the reſt of the globe would remain an ocean. Some new points might be diſcovered, and others, which before appeared above the ſurface of the ſea, would be ſunk by the riſing of the water; but, on the whole, land could only be gained ſubſtantially at the poles. Such a ſuppoſition as this, if applied to the preſent ſtate of things, would be deſtitute of every ſupport, as being incapable of explaining what appears.

BUT

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 ſolar ſyſtem, great continents of land could have been erected from the place of their formation, the bottom of the ſea, and placed in a higher elevation, compared with the ſurface of that water, yet ſuch a continent as this could not have continued ſtationary for many thouſand years; nor could a continent of this kind have preſented to us, every where within its body, maſſes of conſolidated marble, and other mineral ſubſtances, in a ſtate as different as poſſible from that in which they were, when originally collected together in the ſea.

CONSEQUENTLY, beſides an operation, by which the earth at the bottom of the ſea ſhould 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 conſolidating power, by which the looſe materials that had ſubſided from water, ſhould be formed into maſſes of the moſt perfect ſolidity, having neither water nor vacuity between their various conſtituent parts, nor in the pores of thoſe conſtituent parts themſelves.

HERE is an operation of the globe, whether chemical or mechanical, which is neceſſarily connected with the formation of our preſent continents: Therefore, had we a proper underſtanding of this ſecret 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 ſurface of that water wherein they had their birth.

IF this conſolidating operation be performed at the bottom of the ocean, or under great depths of the earth, of which our continents are compoſed, we cannot be witneſſes to this mineral proceſs, or acquire the knowledge of natural cauſes, by immediately obſerving the changes which they produce; but though we have not this immediate obſervation of thoſe changes of bodies, we have, in ſcience, the means of reaſoning from diſtant

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.

PART

* 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.

PART 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-

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-

tion in thoſe maſſes may be formed. In this caſe, therefore, where the means are not naturally in the ſuppoſition, a philoſopher, who is to explain the phænomenon by the natural operation of water in this ſituation, muſt not have recourſe to another agent, ſtill more powerful, to aſſiſt his ſuppoſition, which cannot be admitted.

Thus, it will appear, that, to conſolidate ſtrata formed at the bottom of the ſea, in the manner now conſidered, operations are required unnatural to this place; conſequently, not to be ſuppoſed in order to ſupport a hypotheſis.

But now, inſtead of enquiring how far water may be ſuppoſed inſtrumental in the conſolidation of ſtrata which were originally of a looſe texture, we are to conſider how far there may be appearances in thoſe conſolidated bodies, by which it might be concluded, whether or not the preſent ſtate of their conſolidation has been actually brought about by means of that agent.

If water had been the menſtruum by which the conſolidating matter was introduced into the interſtices of ſtrata, maſſes of thoſe bodies could only be found conſolidated with ſuch ſubſtances as water is capable of diſſolving; and theſe ſubſtances would be found only in ſuch a ſtate as the ſimple ſeparation of the diſſolving water might produce.

In this caſe, the conſolidation of ſtrata 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 ourſelves unlimited powers in bodies, on purpoſe to explain thoſe appearances, by which we ſhould be made to know the powers of nature. Let us, therefore, attend, with every poſſible circumſpection, to the appearances of thoſe bodies, by means of which we are to inveſtigate the principles of mineralogy, and know the laws of nature.

The queſtion now before us concerns the conſolidating ſubſtances of ſtrata. Are theſe ſuch as will correſpond to the diſ-

ſolving

ſolving power of water, and to the ſtate in which thoſe ſubſtances might be left by the ſeparation of their menſtruum? No; far, far from this ſuppoſition is the concluſion that neceſſarily follows from natural appearances.

We have ſtrata conſolidated by calcareous ſpar, a thing perfectly diſtinguiſhable from the ſtalactical concretion of calcareous earth, in conſequence of aqueous ſolution. We have ſtrata made ſolid by the formation of fluor, a ſubſtance not ſoluble, ſo far as we know, by water. We have ſtrata conſolidated with ſulphureous and bituminous ſubſtances, which do not correſpond to the ſolution of water. We have ſtrata conſolidated with ſiliceous matter, in a ſtate totally different from that under which it has been obſerved, on certain occaſions, to be depoſited by water. We have ſtrata conſolidated by feldſpar, a ſubſtance inſoluble in water. We have ſtrata conſolidated by almoſt all the various metallic ſubſtances, with their almoſt endleſs mixtures and ſulphureous compoſitions; that is to ſay, we find, perhaps, every different ſubſtance introduced into the interſtices of ſtrata which had been formed by ſubſidence at the bottom of the ſea.

If it is by means of water that thoſe interſtices have been filled with thoſe materials, water muſt be, like fire, an univerſal ſolvent, or cauſe of fluidity, and we muſt change entirely our opinion of water in relation to its chemical character. But there is no neceſſity thus to violate our chemical principles, in order to explain certain natural appearances; more eſpecially if thoſe appearances may be explained in another manner, conſiſtently with the known laws of nature.

If, again, it is by means of heat and fuſion that the looſe and porous ſtructure of ſtrata ſhall be ſuppoſed to have been conſolidated, then every difficulty which had occurred in reaſoning upon the power or agency of water is at once removed. The looſe and diſcontinuous body of a ſtratum may be cloſed by means of ſoftneſs and compreſſion; the porous ſtructure of the

the materials may be conſolidated, in a ſimilar manner, by the fuſion of their ſubſtance; and foreign matter may be introduced into the open ſtructure of ſtrata, in form of ſteam or exhalation, as well as in the fluid ſtate of fuſion; conſequently, heat is an agent competent for the conſolidation of ſtrata, which water alone is not. If, therefore, ſuch an agent could be found acting in the natural place of ſtrata, we muſt pronounce it proper to bring about that end.

THE examination of nature gives countenance to this ſuppoſition, ſo far as ſtrata are found conſolidated by every ſpecies of ſubſtance, and almoſt every poſſible mixture of thoſe different ſubſtances; conſequently, however difficult it may appear to have this application of heat, for the purpoſe of conſolidating ſtrata formed at the bottom of the ocean, we cannot, from natural appearances, ſuppoſe any other cauſe, as having actually produced the effects which are now examined.

THIS queſtion, with regard to the means of conſolidating the ſtrata of the globe, is, to natural hiſtory, of the greateſt importance; and it is eſſential in the theory now propoſed to be given of the mineral ſyſtem. It would, therefore, require to be diſcuſſed with ſome degree of preciſion, in examining the particulars; but of theſe, there is ſo great a field, and the ſubject is ſo complicated in its nature, that volumes might be written upon particular branches only, without exhauſting what might be ſaid upon the ſubject; becauſe the evidence, though ſtrong in many particulars, is chiefly to be enforced by a multitude of facts, conſpiring, in a diverſity of ways, to point out one truth, and by the impoſſibility of reconciling all theſe facts, except by means of one ſuppoſition.

BUT, as it is neceſſary to give ſome proof of that which is to be a principle in our reaſoning afterwards, I ſhall now endeavour to generalize the ſubject as much as poſſible, in order to anſwer that end, and, at the ſame time, to point out the particular method of enquiry.

THERE

THERE are to be found, among the various ſtrata of the globe, bodies formed of two different kinds of ſubſtances, *ſiliceous* bodies, and thoſe which may be termed *ſulphureous*. With one or other, or both of thoſe two ſubſtances, every different conſolidated ſtratum of the globe will be found ſo intimately mixed, or cloſely connected, that it muſt be concluded, by whatever cauſe thoſe bodies of ſiliceous and ſulphureous matter had been changed from a fluid to a concreted ſtate, the ſtrata muſt have been ſimilarly affected by the ſame cauſe.

THESE two ſpecies of bodies, therefore, the ſiliceous and the ſulphureous, may now be examined, in relation to the cauſes of their concretion, with a view to determine, what has been the general concreting or conſolidating power, which has operated univerſally in the globe; and particularly to ſhew, it has not been by means of any fluid ſolution, that ſtrata in general have been conſolidated, or that thoſe particular ſubſtances have been cryſtallized and concreted.

SILICEOUS matter, phyſically ſpeaking, is not ſoluble in water; that is to ſay, in no manner of way have we been enabled to learn, that water has the power of diſſolving this matter.

MANY other ſubſtances, which are ſo little ſoluble in water, that their ſolubility could not be otherwiſe detected of themſelves, are made to appear ſoluble by means of ſiliceous matter; ſuch is feld-ſpar, one of the component parts of rock-granite.

FELD-SPAR is a compound of ſiliceous, argillaceous, and calcareous earth, intimately united together. This compound ſiliceous body being, for ages, expoſed to the weather, the calcareous part of it is diſſolved, and the ſiliceous part is left in form of a ſoft white earth. But whether this diſſolution is performed by pure water, or by means alſo of an acid, may perhaps be queſtioned. This, however, is certain, that we muſt conſider ſiliceous ſubſtances as inſoluble in water.

THE

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 cryſtallize 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 being 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 diſſolved, 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, demonſtrates,

ſtrates, *firſt*, That they have been introduced among thoſe ſtrata in a fluid ſtate, by injection from ſome other place. 2*dly*, That they have been diſperſed in a variety of ways among thoſe ſtrata, then deeply immerſed at the bottom of the ſea; and, *laſtly*, That they have been there congealed from the ſtate of fuſion, and have remained in that ſituation, while thoſe ſtrata have been removed from the bottom of the ocean to the ſurface of the preſent land.

To deſcribe thoſe particular appearances would draw this paper beyond the bounds of an eſſay. We muſt, therefore, refer thoſe who would enquire more minutely into the ſubject, to examine the chalk-countries of France and England, in which the flint is found variouſly formed; the ſand-hills interſperſed among thoſe chalk-countries, which have been alſo injected by melted flint; and the pudding-ſtone of England, which I have not ſeen in its natural ſituation. More particularly, I would recommend an examination of the inſulated maſſes of ſtone, found in the ſand-hills by the city of Bruſſels; a ſtone which is formed by an injection of flint among ſand, ſimilar to that which, in a body of gravel, had formed the pudding-ſtone of England *.

All theſe examples would require to be examined upon the ſpot, as a great part of the proof for the fuſion of the flinty ſubſtance, ariſes, in my opinion, from the form in which thoſe bodies are found, and the ſtate of the ſurrounding parts. But there are ſpecimens brought from many different places, which contain, in themſelves, the moſt evident marks of this injection of the flinty ſubſtance in a fluid ſtate. Theſe are pieces of foſſil wood, penetrated with a ſiliceous ſubſtance, which are brought from England, Germany, and Lochneagh in Ireland.

It appears from theſe ſpecimens, that there has ſometimes been a prior penetration of the body of wood, either with

* Accurate deſcriptions of thoſe appearances, with drawings, would be, to natural hiſtory, a valuable acquiſition.

irony matter, or calcareous ſubſtance. Sometimes, again, which is the caſe with that of Lochneagh, there does not ſeem to have been any penetration of thoſe two ſubſtances. The injected flint appears to have penetrated the body of this wood, immerſed at the bottom of the ſea, under an immenſe compreſſion of water. This appears from the wood being penetrated partially, ſome parts not being penetrated at all.

Now, in the limits between thoſe two parts, we have the moſt convincing proofs, that it had been flint in a ſimple fluid ſtate which had penetrated the wood, and not in a ſtate of ſolution.

Firſt, BECAUSE, however little of the wood is left unpenetrated, the diviſion is always diſtinct between the injected part and that which is not penetrated by the fluid flint. In this caſe, 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 muſt have been the caſe if ſiliceous matter had been depoſited from a ſolution. *2dly*, The termination of the flinty impregnation has aſſumed ſuch a form, preciſely, as would naturally happen from a fluid flint penetrating that body.

IN other ſpecimens of this mineralizing operation, foſſil wood, penetrated, more or leſs, with ferruginous and calcareous ſubſtances, has been afterwards penetrated with a flinty ſubſtance. In this caſe, with whatever different ſubſtances the woody body ſhall be ſuppoſed to have been penetrated in a ſtate of ſolution by water, the regular ſtructure of the plant would ſtill have remained, with its vacuities variouſly filled with the petrifying ſubſtances, ſeparated from the aqueous menſtruum, and depoſited in the vaſcular ſtructure of the wood.

THERE cannot be a doubt with regard to the truth of this propoſition; for as it is, we frequently find parts of the conſolidated wood, with the vaſcular ſtructure remaining perfectly in

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;

but, by aqueous ſolution, this particular combination is again reſolved, and forms an acido-metallic, that is, a vitriolic ſubſtance, after the phlogiſton (which refuſes aqueous ſolution) has been ſeparated from the compoſition, by means of the joint operation of vital air.

THE variety of theſe ſulphureo-metallic ſubſtances, in point of compoſition, is almoſt indefinite; but, unleſs they were all ſoluble in water, this could not have happened by the action of that ſolvent. If we ſhall allow any one of thoſe bodies to have been formed by the fluidity of heat, they muſt all have been formed in the ſame manner; for there is ſuch a chain of connection among thoſe bodies in the mineral regions, that they muſt all have been compoſed, either, on the one hand, by aqueous ſolution, or, on the other, by means of heat and fuſion.

HERE, for example, are cryſtallized together in one maſs, *firſt*, *Pyrites*, containing ſulphur, iron, copper; *2dly*, *Blend*, a compoſition of iron, ſulphur, and calamine; *3dly*, *Galena*, conſiſting of lead and ſulphur; *4thly*, *Marmor metallicum*, being the terra ponderoſa, ſaturated with the vitriolic acid; a ſubſtance inſoluble in water; *5thly*, *Fluor*, a ſaturation of calcareous earth, with a peculiar acid, called the acid of ſpar, alſo inſoluble in water; *6thly*, *Calcareous ſpar*, of different kinds, being calcareous earth ſaturated with fixed air, and ſomething beſides, which forms a variety in this ſubſtance; *laſtly*, *Siliceous ſubſtance*, or *Quartz cryſtals*. All theſe bodies, each poſſeſſing its proper ſhape, are mixed in ſuch a manner as it would be endleſs to deſcribe, but which may be expreſſed in general by ſaying, that they are mutually contained in, and contain each other.

UNLESS, therefore, every one of theſe different ſubſtances may be diſſolved in water, and cryſtallized from it, it is in vain to look for the explanation of theſe appearances in the operations of nature, by the means of aqueous ſolution.

ON

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,

ſulphur, is found generally in its native ſtate. Iron, again, which is ſo eaſily mineralized and ſcorified, is ſeldom found in its malleable ſtate. The other metals are all found more or leſs mineralized, though ſome of them but rarely in the native ſtate.

BESIDES being found with circumſtances thus correſponding to the natural facility, or to the impediments attending the metallization of thoſe different calces, the native metals are alſo found in ſuch a ſhape, and with ſuch marks, as can only agree with the fuſion of thoſe bodies; that is to ſay, thoſe appearances are perfectly irreconcileable with any manner of ſolution and precipitation.

FOR the truth of this aſſertion, among a thouſand other examples, I appeal to that famous maſs of native iron, diſcovered, by Mr PALLAS, in Siberia. This maſs being ſo well known to all the mineraliſts of Europe, any comment upon its ſhape and ſtructure will be unneceſſary *.

WE

* SINCE this Diſſertation was written, M. DE LA PEYROUSE has diſcovered a native manganeſe. The circumſtances of this mineral are ſo well adapted for illuſtrating the preſent doctrine, and ſo well related by M. DE LA PEYROUSE, that I ſhould be wanting to the intereſt of mineral knowledge, were I not to give here that part of his Memoir.

" LORSQUE je fis inſérer dans le journal de phyſique de l'année 1780, au mois de Janvier, une Diſſertation contenant la claſſification des mines de manganèſe, je ne connoiſſois point, à cette epoque, la mine de manganèſe native. Elle a la couleur de ſon régule: elle ſalit les doigts de la même teinte. Son tiſſu paroit auſſi lamelleux, et les lames ſemblent affecter une ſorte de divergence. Elle a ainſi que lui, l'éclat métallique; comme lui elle ſe laiſſe applatir ſous le marteau, et s'exfolie ſi l'on redouble les coups; mais une circonſtance qui eſt trop frappante pour que je l'omette, c'eſt la figure de la manganèſe native, ſi prodigieuſement conforme à celle du régule, qu'on s'y laiſſeroit tromper, ſi la mine n'étoit encore dans ſa gangue: figure très-eſſentielle à obſerver ici, parce qu'elle eſt due à la nature même de la manganèſe. En effet, pour réduire toutes les mines en général, il faut employer divers flux appropriés. Pour la reduction de la manganèſe, bien loin d'uſer de ce moyen, il faut, au contraire, éloigner tout flux, produire la fuſion, par la ſeule violence et la promptetude du feu. Et telle eſt la propenſion naturelle et prodigieuſe de la manganèſe à la vitrification, qu'on n'a pu parvenir encore à réduire ſon régule en un ſeul culot; on trouve dans le creuſet pluſieurs petits boutons, qui forment autant de culots

We come now to the *ſecond* ſpecies of inflammable bodies called oily or bituminous. Theſe ſubſtances are alſo found variouſly mixed with mineral bodies, as well as forming ſtrata of themſelves; they are, therefore, a proper ſubject for a particular examination.

In the proceſs of vegetation, there are produced oily and reſinous ſubſtances; and from the collection of theſe ſubſtances at the bottom of the ocean, there are formed ſtrata, which have afterwards undergone various degrees of heat, and have been variouſly changed, in conſequence of the effects of that heat, according as the diſtillation of the more volatile parts of thoſe bodies has been ſuffered to proceed.

In order to underſtand this, it muſt be conſidered, that, while immerſed in water, and under inſuperable compreſſion, the vegetable, oily, and reſinous ſubſtances, would appear to be unalterable by heat; and it is only in proportion as certain chemical ſeparations take place, that theſe inflammable bodies are changed in their ſubſtance by the application of heat. Now, the moſt general change of this kind is in conſequence of evaporation, or the diſtillation of their more volatile parts, by which oily ſubſtances become bituminous, and bituminous ſubſtances become coaly.

There is here a gradation which may be beſt underſtood by comparing the extremes.

On

lots ſéparés. Dans la mine de manganèſe native, elle n'eſt point en une ſeule maſſe; elle eſt diſpoſée également en pluſieurs culots ſéparés, 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 reſſemblance ſi exacte, ſemble devoir vous faire penſer que la mine native à été produite par le feu, tout comme ſon régule. La preſence de la chaux argentée de la manganèſe, me permettroit de croire que la nature n'a fait que réduire cette chaux. Du reſte, cette mine native eſt très-pure, et ne contient aucune partie attirable à l'aimant. Cette mine, unique juſqu'à ce moment, vient, tout comme les autres manganèſe que j'ai décrites, des mines de fer de *Sem*, dans la vallée de *Viederſos*, en Comté de Foix." *Journal de Phyſique, Janvier* 1786.

On the one hand, we know by experiment, that oily and bituminous ſubſtances can be melted and partly changed into vapour by heat, and that they become harder and denſer, in proportion as the more volatile parts have evaporated from them. On the other hand, coaly ſubſtances are deſtitute of fuſibility and volatility, in proportion as they have been expoſed to greater degrees of heat, and to other circumſtances favourable to the diſſipation of their more volatile and fluid parts.

If, therefore, in mineral bodies, we find the two extreme ſtates of this combuſtible ſubſtance, and alſo the intermediate ſtates, we muſt either conclude, that this particular operation of heat has been thus actually employed in nature, or we muſt explain thoſe appearances by ſome other means, in as ſatisfactory a manner, and ſo as ſhall be conſiſtent with other appearances.

In this caſe, it will avail nothing to have recourſe to the falſe analogy of water diſſolving and cryſtallizing ſalts, which has been ſo much employed for the explanation of other mineral appearances. The operation here in queſtion is of a different nature, and neceſſarily 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 ſolid, we have but to find bituminous ſubſtance in the moſt complete ſtate of coal, intimately connected with ſome other ſubſtance, which is more generally found conſolidating the ſtrata, and aſſiſting in the concretion of mineral ſubſtances. But I have in my poſſeſſion the moſt undoubted proof of this kind. It is a mineral vein, or cavity, in which are blended together coal of the moſt fixed kind, quartz and marmor metallicum. Nor is this all; for the ſpecimen now referred to is contained in a rock of this kind, which every naturaliſt now-a-days will allow to have congealed from a fluid ſtate of fuſion. I have alſo ſimilar ſpecimens from the ſame place, in which the coal

coal is not of that fixed and infuſible kind, which burns without flame or ſmoak, but is bituminous or inflammable coal.

WE have hitherto been reſting the argument upon a ſingle point, for the ſake of ſimplicity or clearneſs, not for want of thoſe circumſtances which ſhall be found to corroborate the theory. The ſtrata of foſſil coal are found in almoſt every intermediate ſtate, as well as in thoſe of bitumen and charcoal. Of the one kind is that foſſil coal which melts or becomes fluid upon receiving heat; of the other, is that ſpecies of coal, found both in Wales and Scotland, which is perfectly infuſible in the fire, and burns like coaks, without flame or ſmoak. The one ſpecies abounds in oily matter, the other has been diſtilled by heat, until it has become a *caput mortuum*, or perfect coal.

THE more volatile parts of theſe bituminous bodies are found in their ſeparate ſtate on ſome occaſions. There is a ſtratum of limeſtone in Fifeſhire near Raith, which, though but ſlightly tinged with a black colour, contains bituminous matter, like pitch, in many cavities, which are lined with calcareous ſpar cryſtallized. I have a ſpecimen of ſuch a cavity, in which the bitumen is in ſphericles, or rounded drops, immerſed in the calcareous ſpar.

NOW, it is to be obſerved, that, if the cavity in the ſolid limeſtone or marble, which is lined with calcareous cryſtals containing pyrites, had been thus encruſted by means of the filtration of water, this water muſt have diſſolved calcareous ſpar, pyrites and bitumen. But theſe natural appearances would not even be explained by this diſſolution and ſuppoſed filtration of thoſe ſubſtances. There is alſo required, *firſt*, a cauſe for the ſeparation of thoſe different ſubſtances from the aqueous menſtruum in which they had been diſſolved: 2*dly*, An explanation of the way in which a diſſolved bitumen ſhould be formed into round hard bodies of the moſt ſolid ſtructure; and, *laſtly*, Some probable means for this complicated operation being per-

formed, below the bottom of the ocean, in the cloſe cavity of a marble ſtratum.

THUS, the additional proof, from the facts relating to the bituminous ſubſtances, conſpiring with that from the phænomena of other bodies, affords the ſtrongeſt corroboration of this opinion, that the various concretions found in the internal parts of ſtrata have not been occaſioned by means of aqueous ſolution, but by the power of heat and operation of ſimple fuſion, preparing thoſe different ſubſtances to concrete and cryſtallize in cooling.

THE arguments which have been now employed for proving that ſtrata have been conſolidated by the power of heat, or by the means of fuſion, have been drawn chiefly from the inſoluble nature of thoſe conſolidating ſubſtances in relation to water, which is the only general menſtruum that can be allowed for the mineral regions. But there are found in the mineral kingdom, many ſolid maſſes of ſal gem, which is a ſoluble ſubſtance. It may be now enquired, How far theſe maſſes, which are not unfrequent in the earth, tend either to confirm the preſent theory, or, on the contrary, to give countenance to that which ſuppoſes water the chief inſtrument in conſolidating ſtrata.

THE formation of ſalt at the bottom of the ſea, without the aſſiſtance of ſubterranean fire, is not a thing unſuppoſable, as at firſt ſight it might appear. Let us but ſuppoſe a rock placed acroſs the gut of Gibraltar, (a caſe nowiſe unnatural), and the bottom of the Mediterranean would be certainly filled with ſalt, becauſe the evaporation from the ſurface of that ſea exceeds the meaſure of its ſupply.

BUT ſtrata of ſalt, formed in this manner at the bottom of the ſea, are as far from being conſolidated by means of aqueous ſolution, as a bed of ſand in the ſame ſituation; and we cannot explain the conſolidation of ſuch a ſtratum of ſalt by means of water, without ſuppoſing ſubterranean heat employed, to

to evaporate the brine which would ſucceſſively occupy the interſtices of the ſaline cryſtals. But this, it may be obſerved, is equally departing from the natural operation of water, as the means for conſolidating the ſediment of the ocean, as if we were to ſuppoſe the ſame thing done by heat and fuſion. For the queſtion is not, If ſubterranean heat be of ſufficient intenſity for the purpoſe of conſolidating ſtrata by the fuſion of their ſubſtances; the queſtion is, Whether it be by means of this agent, ſubterranean heat, or by water alone, without the operation of a melting heat, that thoſe materials have been variouſly conſolidated.

THE example now under conſideration, conſolidated mineral ſalt, will ſerve to throw ſome light upon the ſubject; for as it is to be ſhewn, that this body of ſalt had been conſolidated by perfect fuſion, and not by means of aqueous ſolution, the conſolidation of ſtrata of indiſſoluble ſubſtances, by the operation of a melting heat, will meet with all that confirmation which the conſiſtency of natural appearances can give.

THE ſalt rock in Cheſhire lies in ſtrata of red marl. It is horizontal in its direction. I do not know its thickneſs, but it is dug thirty or forty feet deep. The body of this rock is perfectly ſolid, and the ſalt, in many places, pure, colourleſs and tranſparent, breaking with a ſparry cubical ſtructure. But the greateſt part is tinged by the admixture of the marl, and that in various degrees, from the ſlighteſt tinge of red, to the moſt perfect opacity. Thus, the rock appears as if it had been a maſs of fluid ſalt, in which had been floating a quantity of marly ſubſtance, not uniformly mixed, but every where ſeparating and ſubſiding from the pure ſaline ſubſtance.

THERE is alſo to be obſerved a certain regularity in this ſeparation of the tinging from the colourleſs ſubſtance, which, at a proper diſtance, gives to the perpendicular ſection of the rock a diſtinguiſhable figure in its ſtructure. When looking at this appearance near the bottom of the rock, it, at firſt, preſented

ſented me with the figure of regular ſtratification; but, upon examining the whole maſs of rock, I found, that it was only towards the bottom that this ſtratified appearance took place; and that, at the top of the rock, the moſt beautiful and regular figure was to be obſerved; but a figure the moſt oppoſite to that of ſtratification. It was all compoſed of concentric circles; and theſe appeared to be the ſection of a maſs, compoſed altogether of concentric ſpheres, like thoſe beautiful ſyſtems of configuration which agates ſo frequently preſent us with in miniature. In about eight or ten feet from the top, the circles growing large, were blended together, and gradually loſt their regular appearance, until, at a greater depth, they again appeared in reſemblance of a ſtratification.

THIS regular arrangement of the floating marly ſubſtance in the body of ſalt, which is that of the ſtructure of a coated pebble, or that of concentric ſpheres, is altogether inexplicable upon any other ſuppoſition, than the perfect fluidity or fuſion of the ſalt, and the attractions and repulſions of the contained ſubſtances. It is in vain to look, in the operations of ſolution and evaporation, for that which nothing but perfect fluidity or fuſion can explain.

THIS example of a mineral ſalt congealed from a melted ſtate, may be confirmed from another which I have from Dr BLACK, who ſuggeſted it to me. It is an alkaline ſalt, found in a mineral ſtate, and deſcribed in the Philoſophical Tranſactions, *anno* 1771. But to underſtand this ſpecimen, ſomething muſt be premiſed with regard to the nature of foſſil alkali.

THE foſſil alkali cryſtallizes from a diſſolved ſtate, in combining itſelf with a large portion of the water, in the manner of alum; and, in this caſe, the water is eſſential to the conſtitution of that tranſparent cryſtalline body; for, upon the evaporation of the water, the tranſparent ſalt loſes its ſolidity, and becomes a white powder. If, inſtead of being gently dried, the

the cryſtalline ſalt is ſuddenly expoſed to a ſufficient degree of heat, that is, ſomewhat more than boiling water, it enters into the ſtate of aqueous fuſion, and it boils, in emitting the water by means of which it had been cryſtallized in the cold, and rendered fluid in that heated ſtate. It is not poſſible to cryſtallize this alkaline ſalt from a diſſolved ſtate, without the combination of that quantity of water, nor to ſeparate that water without deſtroying its cryſtalline ſtate.

But in this mineral ſpecimen, we have a ſolid cryſtalline ſalt, with a ſtructure which, upon fracture, appears to be ſparry and radiated, ſomething reſembling that of zeolite. It contains no water in its cryſtallization, but melts in a ſufficient heat, without any aqueous fuſion. Therefore, this ſalt muſt have been in a fluid ſtate of fuſion, immediately before its congelation and cryſtallization.

It would be endleſs to give examples of particular facts, ſo many are the different natural appearances that occur, attended with a variety of different circumſtances.

There is one, however, which is peculiarly diſtinct, admits of ſufficiently accurate deſcription, and contains circumſtances from which concluſions may be drawn with clearneſs. This is the iron-ſtone, which is commonly found among the argillaceous ſtrata, attendant upon foſſil coal, both in Scotland and in England.

This ſtone is generally found among the bituminous ſchiſtus, or black argillaceous ſtrata, either in ſeparate maſſes of various ſhapes and ſizes, or forming of itſelf ſtrata which are more or leſs continuous in their direction among the ſchiſtus or argillaceous beds.

This mineral contains in general from 40 to 50 *per cent.* of iron, and it loſes near one third of its weight in calcination. Before calcination it is of a gray colour, is not penetrable by water, and takes a poliſh. In this ſtate, therefore, it is perfectly ſolid; but being calcined, it becomes red, porous, and tender.

The

THE fact to be proved with regard to theſe iron-ſtones is this, That they have acquired their ſolid ſtate from fuſion, and not in concreting from any aqueous ſolution.

To abridge this diſquiſition, no argument is to be taken from contingent circumſtances, (which, however, are often found here as well as in the caſe of marbles); ſuch only are to be employed as are general to the ſubject, and ariſe neceſſarily from the nature of the operation.

IT will be proper to deſcribe a ſpecies of theſe ſtones, which is remarkably regular in its form. It is that found at Aberlady in Eaſt Lothian.

THE form of theſe iron-ſtones is that of an oblate or much compreſſed ſphere, and the ſize from two or three inches diameter to more than a foot. In the circular or horizontal ſection, they preſent the moſt elegant ſeptarium *; and, from the examination of this particular ſtructure, the following concluſions may be drawn.

Firſt, THAT the ſepta have been formed by the uniform contraction of the internal parts of the ſtone, the volume of the central parts diminiſhing more than that of the circumference; by this means, the ſeparations of the ſtone diminiſh, in a progreſſion from the centre towards the circumference.

2*d*, THAT there are only two ways in which the ſepta muſt have received the ſpar with which they are filled, more or leſs, either, *firſt*, By inſinuation into the cavity of the ſepta after theſe were formed; or, 2*dly*, By ſeparation from the ſubſtance of the ſtone, at the ſame time that the ſepta were forming.

WERE the firſt ſuppoſition true, appearances would be obſervable, ſhewing that the ſparry ſubſtance had been admitted, either through the porous ſtructure of the ſtone, or through proper apertures communicating from without. Now, if either one or other of theſe had been the caſe, and that the ſtone had been conſolidated from no other cauſe than concretion from a diſſolved

* Plate I.

diſſolved ſtate, that particular ſtructure of the ſtone, by means of which the ſpar had been admitted, muſt appear at preſent upon an accurate examination.

THIS, however, is not the caſe, and we may reſt the argument here. The ſepta reach not the circumference; the ſurface of the ſtone is ſolid and uniform in every part; and there is not any appearance of the ſpar in the argillaceous bed around the ſtone.

IT, therefore, neceſſarily follows, that the contraction of the iron-ſtone, in order to form ſepta, and the filling of theſe cavities with ſpar, had proceeded *pari paſſu*; and that this operation muſt have been brought about by means of fuſion, or by congelation from a ſtate of ſimple fluidity and expanſion.

IT is only further to be obſerved, that all the arguments which have been already employed, concerning mineral concretions from a ſimply fluid ſtate, or that of fuſion, here take place. I have ſeptaria of this kind, in which, beſides pyrites, iron-ore, calcareous ſpar, and another that is ferruginous and compound, there is contained ſiliceous cryſtals; a caſe which is not ſo common. I have them alſo attended with circumſtances of concretion and cryſtallization, which, beſides being extremely rare, are equally curious and intereſting.

THERE is one fact more which is well worth our attention, being one of thoſe which are ſo general in the mineral regions. It is the cryſtallizations which are found in cloſe cavities of the moſt ſolid bodies.

NOTHING is more common than this appearance. Cavities are every where found cloſely lined with cryſtallizations, of every different ſubſtance which may be ſuppoſed in thoſe places. Theſe concretions are well known to naturaliſts, and form part of the beautiful ſpecimens which are preſerved in the cabinets of collectors, and which the German mineraliſts have termed *Druſen*. I ſhall only particularize one ſpecies, which may be deſcribed upon principle, and therefore may be a pro-

per

per ſubject on which to reaſon, for aſcertaining the order of production in certain bodies. This body, which we are now to examine, is of the agate ſpecies.

We have now been conſidering the means employed by nature in conſolidating ſtrata which were originally of an open ſtructure; but in perfectly ſolid ſtrata, we find bodies of agate, which have evidently been formed in that place where they now are found. This fact, however, is not ſtill 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 itſelf, we are to ſhew, from what appears within its cavity, that the cryſtallizations which are found in this place had ariſen from a ſimply fluid ſtate, and not from that of any manner of ſolution.

The agates now in queſtion are thoſe of the coated kind, ſo frequent in this country, called pebbles. Many of theſe are filled with a ſiliceous cryſtallization, which evidently proceeds from the circumference towards the centre. Many of them, again, are hollow. Thoſe cavities are variouſly lined with cryſtallized ſubſtances; and theſe are the object of the preſent examination.

But before deſcribing what is found within, it is neceſſary to attend to this particular circumſtance, that the cavity is perfectly incloſed with many ſolid coats, impervious to air or water, but particularly with the external cortical part, which is extremely hard, takes the higheſt poliſh, and is of the moſt perfect ſolidity, admitting the paſſage of nothing but light and heat.

Within theſe cavities, we find, *firſt*, The coat of cryſtals with which this cavity is always lined; and this is general to all ſubſtances concreting, in ſimilar circumſtances, from a ſtate of fuſion; for when thus at liberty they naturally cryſtallize. *2dly*, We have frequently a ſubſequent cryſtallization, ſet upon the firſt, and more or leſs immerſed in it. *3dly*, There is alſo

ſometimes

ſometimes a third cryſtallization, ſuperincumbent on the ſecond, in like manner as the ſecond was on the firſt. I ſhall mention ſome particulars.

I HAVE one ſpecimen, in which the primary cryſtals are ſiliceous, the ſecondary thin foliaceous cryſtals of deep red but tranſparent iron-ore, forming elegant figures, that have the form of roſes. The tertiary cryſtallization is a froſting of ſmall ſiliceous cryſtals upon the edges of the foliaceous cryſtals.

IN other ſpecimens, there is firſt a lining of colourleſs ſiliceous cryſtals, then another lining of amethyſtine cryſtals, and ſometimes within that, fuliginous cryſtals. Upon theſe fuliginous and amethyſtine cryſtals are many ſphericles or hemiſpheres of red compact iron-ore, like hæmatites.

IN others, again, the primary cryſtals are ſiliceous, and the ſecondary calcareous. Of this kind, I have one which has, upon the calcareous cryſtals, beautiful tranſparent ſiliceous cryſtals, and iron-ſphericles upon theſe.

Laſtly, 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, firſt, with colourleſs ſiliceous cryſtals; ſecondly, with fuliginous cryſtals; and, laſtly, with white or colourleſs calcareous ſpar. But between the ſpar and cryſtals there are many ſphericles, ſeemingly of iron, half ſunk into each of theſe two different ſubſtances.

FROM theſe facts, I may now be allowed to draw the following concluſions:

Firſt, THAT concretion had proceeded from the ſurface of the agate body inwards. This neceſſarily follows from the nature of thoſe figured bodies, the figures of the external coats always determining the ſhape of thoſe within, and never, contrarily, thoſe within affecting thoſe without.

2*dly*, THAT when the agate was formed, the cavity then contained every thing which now is found within it, and nothing more.

3dly, THAT the contained ſubſtances muſt have been in a fluid ſtate, in order to their cryſtallizing.

Laſtly, THAT as this fluid ſtate had not been the effect of ſolution in a menſtruum, it muſt have been fluidity from heat and fuſion.

THERE are in jaſpers and agates many other appearances, from whence this laſt concluſion may be formed with great certainty and preciſion; but it is hoped, that what has been now given may ſuffice for eſtabliſhing that propoſition without any doubt.

IT muſt not be here objected, That there are frequently found ſiliceous cryſtals and amethyſts containing water; and that it is impoſſible to confine water even in melted glaſs. It is true, that here, at the ſurface of the earth, melted glaſs cannot, in ordinary circumſtances, be made to receive and incloſe condenſed water; but let us only ſuppoſe a ſufficient degree of compreſſion in the body of melted glaſs, and we can eaſily imagine it to receive and confine water, as well as any other ſubſtance. But if, even in our operations, water, by means of compreſſion, 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 ſurface of the earth; and we are not to limit nature with our imbecility, or eſtimate the powers of nature by the meaſure of our own.

TO conclude this long chemico-mineral diſquiſition, I have ſpecimens in which the mixture of calcareous, ſiliceous and metallic ſubſtances, in almoſt every ſpecies of concretion which is to be found in mineral bodies, may be obſerved, and in which there is exhibited, in miniature, almoſt every ſpecies of mineral tranſaction, which, in nature, is found upon a ſcale of grandeur and magnificence. They are nodules contained in the whinſtone, porphyry, or baſaltes of the Calton-hill, by Edinburgh; a body which is to be afterwards examined, when

it

it will be found to have flowed, and to have been in fuſion, by the operation of ſubterraneous heat.

THIS evidence, though moſt concluſive with regard to the application of ſubterraneous heat, as the means employed in bringing into fuſion all the different ſubſtances with which ſtrata may be found conſolidated, is not directly a proof that ſtrata had been conſolidated by the fuſion of their proper ſubſtance. It was neceſſary to ſee the general nature of the evidence, for the univerſal application of ſubterraneous heat, in the fuſion 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 ſoftening or fuſion 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 ſubſtances, and whoſe origin is perfectly underſtood, conſequently, whoſe ſubſequent changes may be reaſoned upon with certainty and clearneſs. Theſe are the ſiliceous and calcareous ſtrata; and theſe are the two prevailing ſubſtances 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 ſubſtances. If, therefore, it can be ſhewn, that both of thoſe two general ſtrata have been conſolidated by the ſimple fuſion of their ſubſtance, no *deſideratum* or doubt will remain, with regard to the nature of that operation which has been tranſacted 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 fuſion; and, 2*dly*, 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

cannot, while in that hard ſtate, be made to correſpond ſo preciſely 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 abundance 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 limeſtones, 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 pudding-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 bodies, into one maſs. *Laſtly*, This compound body is conſolidated in ſuch a manner as to give the moſt diſtinct evidence, that

that this had been executed by the operation of heat or ſimple fuſion.

THE proof I give is this, That beſides the general conformation of thoſe hard bodies, ſo as to be perfectly adapted to each other's ſhape, there is, in ſome places, a mutual indentation of the different pieces of gravel into each other; an indentation which reſembles perfectly that junction of the different bones of the *cranium*, called ſutures, and which muſt have neceſſarily required a mixture of thoſe bodies while in a ſoft or fluid ſtate.

THIS appearance of indentation is, by no means, ſingular or limited to one particular ſpecimen. I have ſeveral ſpecimens of different marbles, in which fine examples of this ſpecies of mixture may be perceived. But in this particular caſe of the Spaniſh pudding-ſtone, where the mutual indentation is made between two pieces of hard ſtone, worn round by attrition, the ſoftening or fuſion of theſe two bodies is not ſimply rendered probable, but demonſtrated.

HAVING thus proved, that thoſe ſtrata had been conſolidated by ſimple fuſion, as propoſed, we now proceed to ſhew, that this mineral operation had been not only general, as being found in all the regions of the globe, but univerſal, in conſolidating our earth in all the various degrees, from looſe and incoherent ſhells and ſand, to the moſt ſolid bodies of the ſiliceous and calcareous ſubſtances.

TO exemplify this in the various collections and mixtures of ſands, gravels, ſhells and corals, were endleſs and ſuperfluous. I ſhall only take, for an example, one ſimple homogeneous body, in order to exhibit it in the various degrees of conſolidation, from the ſtate of ſimple incoherent earth to that of the moſt ſolid marble. It muſt be evident that this is chalk; naturally a ſoft calcareous earth, but which may be alſo found conſolidated in every different degree.

THROUGH the middle of the iſle of Wight, there runs a ridge of hills of indurated chalk. This ridge runs from the iſle

iſle of Wight directly weſt into Dorſetſhire, and goes by Corfcaſtle 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 oppoſite 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 Scotland, 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 degree, 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 bodies, 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 generally ſtratified, and which, being a body perfectly ſolid, and forming

forming ſome part in the ſtructure of this earth, deſerves to be conſidered.

THE nature of granite, as a part of the ſtructure of the earth, is too intricate a ſubject to be here conſidered, where we only ſeek to prove the fuſion of a ſubſtance from the evident marks which are to be obſerved in a body. We ſhall, therefore, only now conſider one particular ſpecies of granite; and if this ſhall appear to have been in a fluid ſtate of fuſion, we may be allowed to extend this property to all the kind.

THE ſpecies now to be examined comes from the north country, about four or five miles weſt from Portſoy, on the road to Huntly. I have not been upon the ſpot, but am informed that this rock is immediately connected or continuous with the common granite of the country. This indeed appears in the ſpecimens which I have got; for, in ſome of theſe, there is to be perceived a gradation from the regular to the irregular ſort.

THIS rock may indeed be conſidered, in ſome reſpects, as a porphyry; for it has an evident ground, which is feld-ſpar, in its ſparry ſtate; and it is, in one view, diſtinctly maculated with quartz, which is tranſparent, but ſomewhat dark-coloured *.

CONSIDERED as a porphyry, this ſpecimen is no leſs ſingular than as a granite. For, inſtead of a ſiliceous ground, maculated with the rhombic feld-ſpar, which is the common ſtate of porphyry, the ground is uniformly cryſtallized, or a homogeneous regular feld-ſpar, maculated with the tranſparent ſiliceous ſubſtance. But as, beſides the feld-ſpar and quartz, which are the conſtituent parts of the ſtone, there is alſo mica, in ſome places, it may, with propriety, be termed a granite.

THE ſingularity of this ſpecimen conſiſts, not in the nature or proportions of its conſtituent parts, but in the uniformity of the ſparry ground, and the regular ſhape of the quartz mixture. This ſiliceous ſubſtance, viewed in one direction, or longitudinally, may be conſidered as columnar, priſmatical, or

* Plate II. fig. 1. 2. 3.

or continued in lines running nearly parallel. Theſe columnar bodies of quartz are beautifully impreſſed with a figure on the ſides, where they are in contact with the ſpar. This figure is that of furrows or channels, which are perfectly parallel, and run acroſs the longitudinal direction of the quartz. This is repreſented in fig. 4. This ſtriated figure is only ſeen when, by fracture, the quartz is ſeparated from the contiguous ſpar.

But what I would here more particularly repreſent is, the tranſverſe ſection of thoſe longitudinal ſiliceous bodies. Theſe are ſeen in fig. 1. 2. and 3. They have not only ſeparately the forms of certain typographic characters, but collectively give the regular lineal appearance of types ſet in writing.

It is evident from the inſpection of this foſſil, that the ſparry and ſiliceous ſubſtances had been mixed together in a fluid ſtate; and that the cryſtallization of the ſparry ſubſtance, which is rhombic, had determined the regular ſtructure of the quartz, at leaſt in ſome directions.

Thus, the ſiliceous ſubſtance is to be conſidered as included in the ſpar, and as figured according to the laws of cryſtallization proper to the ſparry ground; but the ſpar is alſo to be found included in the quartz. It is not, indeed, always perfectly included or incloſed on all ſides; but this is ſometimes the caſe, or it appears ſo in the ſection. Fig. 5. 6. 7. 8. 9. and 10. are thoſe caſes magnified, and repreſent the different figured quartz incloſing the feld-ſpar. In one of them, the feld-ſpar, which is contained within the quartz, contains alſo a ſmall triangle of quartz, which it incloſes. Now, it is not poſſible to conceive any other way in which thoſe two ſubſtances, quartz and feld-ſpar, could be thus concreted, except by congelation from a fluid ſtate, in which they had been mixed.

There is one thing more to be obſerved with regard to this curious ſpecies of granite. It is the different order or arrangement of the cryſtallization or internal ſtructure of the feld-ſpar ground, in two contiguous parts of the ſame maſs. This is to be

be perceived in the poliſhed ſurface of the ſtone, by means of the reflection of light.

THERE is a certain direction in which, viewing the ſtone, when the light falls with a proper obliquity, we ſee a luminous reflection from the internal parts of the ſtone. This ariſes from the reflecting ſurfaces of the ſparry ſtructure or minute cracks, all turned in one direction, conſequently, giving that luminous appearance only in one point of view.

NOW, all the parts of the ſtone in which the figured quartz is directed in the ſame manner, or regularly placed in relation to each other, preſent that ſhining appearance to the eye at one time, or in the ſame point of direction. But there are parts of the maſs, which, though immediately contiguous and properly continuous, have a different diſpoſition of the figured quartz; and theſe two diſtinguiſhed maſſes, in the ſame ſurface of the poliſhed ſtone, give to the eye their ſhining appearance in very different directions. Fig. 3. ſhows two of thoſe figured and ſhining maſſes, in the ſame plane or poliſhed ſurface.

IT muſt be evident, that, as the cryſtallization of the ſparry ſtructure is the figuring cauſe of the quartz bodies, there muſt be obſerved a certain correſpondency between thoſe two things, the alinement (if I may be allowed the expreſſion) of the quartz, and the ſhining of the ſparry ground. It muſt alſo appear, that, at the time of congelation of the fluid ſpar, thoſe two contiguous portions had been differently diſpoſed in the cryſtallization of their ſubſtance. This is an obſervation which I have had frequent opportunities of making, with reſpect to maſſes of calcareous ſpar.

UPON the whole, therefore, whether we ſhall conſider granite as a ſtratum or as an irregular maſs, whether as a collection of ſeveral materials, or as the ſeparation of ſubſtances which had been mixed, there is ſufficient evidence of this body having been conſolidated by means of fuſion, and in no other manner.

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 muſt have formed rents or ſeparations of their ſubſtance, by the unequal degrees of contraction which the contiguous ſtrata may have ſuffered. Here is a moſt deciſive mark by which the preſent queſtion muſt be determined.

THERE is not in nature any appearance more diſtinct than this of the perpendicular fiſſures and ſeparations in ſtrata. Theſe are generally known to workmen by the terms of veins or backs and cutters; and there is no conſolidated ſtratum that wants theſe appearances. Here is, therefore, a clear deciſion of the queſtion, Whether it has been by means of heat, or by means of aqueous ſolution, that collections of looſe bodies at the bottom of the ſea have been conſolidated into the hardeſt rocks and moſt perfect marbles.

ERROR never can be conſiſtent, nor can truth fail of having ſupport from the accurate examination of every circumſtance. It is not enough to have found appearances deciſive of the queſtion, with regard to the two ſuppoſitions which have been now conſidered, we may farther ſeek confirmation of that ſuppoſition which has been found alone conſiſtent with appearances.

IF it be by means of heat and fuſion that ſtrata have been conſolidated, then, in proportion to the degree of conſolidation they have undergone from their original ſtate, they ſhould, *cæteris paribus*, abound more with ſeparations in their maſs. But this concluſion is found conſiſtent with appearances. A ſtratum of porous ſand-ſtone does not abound ſo much with veins and cutters as a ſimilar ſtratum of marble, or even a ſimilar ſtratum of ſand-ſtone that is more conſolidated. In proportion, therefore, as ſtrata have been conſolidated, they are in general interſected with veins and cutters; and in proportion as ſtrata are deep in their perpendicular ſection, the veins are wide, and placed at greater diſtances. In like manner, when ſtrata are thin, the veins are many, but proportionally narrow.

IT is thus, upon chemical principles, to be demonſtrated, That all the ſolid ſtrata of the globe have been condenſed by

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 ſurrounding 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

conſolidated

conſolidated maſſes, although not always ſo well illuſtrated in a cabinet ſpecimen.

THUS we have diſcovered a truth that is confirmed by every appearance, ſo far as the nature of the ſubject now examined admits. We now return to the general operation, of forming continents of thoſe materials which had been depoſited at the bottom of the ſea.

PART III.

Inveſtigation of the Natural Operations employed in the Production of Land above the Surface of the Sea.

WE ſeek to know that operation by means of which maſſes of looſe materials, collected at the bottom of the ſea, were raiſed above its ſurface, and transformed into ſolid land.

WE have found, that there is not in this globe (as a planet revolving in the ſolar ſyſtem) any power or motion adapted to the purpoſe now in view; nor, were there ſuch a power, could a maſs of ſimply collected materials have continued any conſiderable time to reſiſt the waves and currents natural to the ſea, but muſt have been quickly carried away, and again depoſited at the bottom of the ocean. But we have found, that there had been operations, natural to the bowels of this earth, by which thoſe looſe and unconnected materials have been cemented together, and conſolidated into maſſes of great ſtrength and hardneſs; thoſe bodies are thus enabled to reſiſt the force of waves and currents, and to preſerve themſelves, for a ſufficient time, in their proper ſhape and place, as land above the general ſurface of the ocean.

WE

We now deſire to know, how far thoſe internal operations of the globe, by which ſolidity and ſtability are procured to the beds of looſe materials, may have been alſo employed in raiſing up a continent of land, to remain above the ſurface of the ſea.

There is nothing ſo proper for the erection of land above the level of the ocean, as an expanſive power of ſufficient force, applied directly under materials in the bottom of the ſea, under a maſs that is proper for the formation of land when thus erected. The queſtion is not, how ſuch a power may be procured; ſuch a power has probably been employed. If, therefore, ſuch a power ſhould be conſiſtent with that which we found had actually been employed in preparing the erected maſs; or, if ſuch a power is to be reaſonably concluded as accompanying thoſe operations which we have found natural to the globe, and ſituated in the very place where this expanſive power appears to be required, we ſhould 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 ſea into the place of land, as it is perfect for the preparation of thoſe materials to ſerve the purpoſe of their elevation.

In oppoſition to this concluſion, it will not be allowed to allege, that we are ignorant how ſuch a power might be exerted under the bottom of the ocean; for the preſent queſtion is not, what had been the cauſe 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 conſolidating ſtrata, had been employed alſo for another purpoſe, that is, for raiſing thoſe ſtrata into the place of land.

We may, perhaps, account for the elevation of land, by the ſame cauſe with that of the conſolidation of ſtrata, already inveſtigated, without explaining the means employed by nature in procuring the power of heat, or ſhewing from what general ſource of action this particular power had been derived; but, by finding in ſubterranean heat a cauſe for any other change, beſides

ſides the conſolidation of porous or incoherent bodies, we ſhall generalize a fact, or extend our knowledge in the explanation of natural appearances.

THE power of heat for the expanſion of bodies, is, ſo far as we know, unlimited; but by the expanſion of bodies placed under the ſtrata at the bottom of the ſea, the elevation of thoſe ſtrata may be affected; and the queſtion now to be reſolved regards the actual exertion of this power of expanſion, How far it is to be concluded as having been employed in the production of this earth above the level of the ſea.

BEFORE attempting to reſolve that queſtion, it may be proper to obſerve, there has been exerted an extreme degree of heat below the ſtrata formed at the bottom of the ſea; and this is preciſely the action of a power required for the elevation of thoſe 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, conſiſtent with the preſent ſtate of things, or what actually appears, we ſhall have a right to conclude, that ſuch had been the order of procedure in natural things, and that the ſtrata formed at the bottom of the ſea had been elevated, as well as conſolidated, by means of ſubterraneous heat.

THE conſolidation of ſtrata by means of fuſion or the power of heat, has been concluded from the examination of nature, and from finding, that the preſent ſtate of things is inconſiſtent with any other ſuppoſition. Now, again, we are conſidering the only power that may be conceived as capable of elevating ſtrata from the bottom of the ſea, and placing ſuch a maſs above the ſurface of the water. It is a truth unqueſtionable, that what had been originally at the bottom of the ſea, is at preſent the higheſt of our land. In explaining this appearance, therefore, no other alternative is left, but either to ſuppoſe ſtrata elevated by the power of heat above the level of the preſent ſea, or the ſurface of the ocean reduced many miles below the height

height at which it had ſubſiſted during the collection and induration of the land which we inhabit.

Now, if, on the one hand, we are to ſuppoſe no general power of ſubterraneous fire or heat, we leave to our theory no means for the retreat of the ſea, or the lowering of its ſurface; if, on the other hand, we are to allow the general power of ſubterraneous heat, we cannot have much difficulty in ſuppoſing, either the ſurface of the ſea to have ſubſided, or the bottom of the ocean, in certain parts, to have been raiſed by a ſubterranean power above the level of its ſurface, according as appearances ſhall be found to require the one or other of thoſe concluſions. Here, therefore, we are again remitted to the hiſtory of nature, in order to find matter of fact by which this queſtion may be properly decided.

If the preſent land had been diſcovered by the ſubſiding of the waters, there has not been a former land, from whence materials had been procured for the conſtruction of the preſent, when at the bottom of the ſea; for there is no veſtige remaining of that land, the whole land of the preſent earth having been formed evidently at the bottom of the ſea. Neither could the natural productions of the ſea have been accumulated, in the ſhape in which we now find them, on the ſurface of this earth; for how ſhould the Alps and Andes have been formed within the ſea from the natural productions of the water? Conſequently, this is a ſuppoſition inconſiſtent with every natural appearance.

The ſuppoſition, therefore, of the ſubſidence of the former ocean, for the purpoſe of diſcovering the preſent land, is beſet with more difficulty than the ſimple erection of the bottom of the former ocean; for, *firſt*, There is a place to provide for the retirement of the waters of the ocean; and, 2*dly*, There is required a work of equal magnitude; this is, the ſwallowing up of that former continent, which had procured the materials of the preſent land.

On

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;

and the power that has been neceſſarily 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 caſe, natural appearances are not anomalous. They are, indeed, infinitely various, as they ought to be, according to the rule; but all thoſe varieties in appearances conſpire to prove one general truth, *viz.* That all which we ſee had been originally compoſed according to certain principles, eſtabliſhed in the conſtitution of the terraqueous globe; and that thoſe regular compoſitions had been afterwards greatly changed by the operations of another power, which had introduced apparent confuſion among things firſt formed in order and by rule.

It is concerning the operation of this ſecond power that we are now enquiring; and here the apparent irregularity and diſorder of the mineral regions are as inſtructive, with regard to what had been tranſacted in a former period of time, as the order and regularity of thoſe ſame regions are concluſive, in relation to the place in which a former ſtate of things had produced that which, in its changed ſtate, we now perceive.

We are now to conclude, that the land on which we dwell had been elevated from a lower ſituation by the ſame agent which had been employed in conſolidating the ſtrata, in giving them ſtability, and preparing them for the purpoſe of the living world. This agent is matter actuated by extreme heat, and expanded with amazing force.

If this has been the caſe, it will be reaſonable to expect, that ſome of the expanded matter might be found condenſed in the bodies which have been heated by that igneous vapour; and that matter, foreign to the ſtrata, may have been thus introduced into the fractures and ſeparations of thoſe indurated maſſes.

We have but to open our eyes to be convinced of this truth. Look into the ſources of our mineral treaſures; aſk the miner, from

from whence has come the metal into his vein? Not from the earth or air above, not from the ſtrata which the vein traverſes; theſe do not contain one atom of the minerals now conſidered: There is but one place from whence theſe minerals may have come; this is, the bowels of the earth, the place of power and expanſion, the place from whence muſt have proceeded that intenſe heat by which looſe materials have been conſolidated into rocks, as well as that enormous force by which the regular ſtrata have been broken and diſplaced.

Our attention is here peculiarly called upon, where we have the opportunity of examining thoſe mineral bodies, which have immediately proceeded from the unknown region, that place of power and energy which we want to explore; for, if ſuch is the ſyſtem of the earth, that materials are firſt depoſited at the bottom of the ocean, there to be prepared in a certain manner, in order to acquire ſolidity, and then to be elevated into the proper place of land, theſe mineral veins, which contain matter abſolutely foreign to the ſurface of the earth, afford the moſt authentic information with regard to the operations which we want to underſtand. It is theſe veins which we are to conſider as, in ſome meaſure, the continuation of that mineral region, which lies neceſſarily out of all poſſible reach of our examination. It is, therefore, peculiarly intereſting to know the ſtate in which things are to be found in this place, which may be conſidered as intermediate between the ſolid land, upon the one hand, and the unknown regions of the earth, upon the other.

We are now to examine thoſe mineral veins; and theſe may be conſidered, firſt, in relation to their form, independent of their ſubſtance or particular contents; and, ſecondly, in relation to the contained bodies, independent of their form.

In examining conſolidated ſtrata, we remarked veins and cutters as a proof of the means by which thoſe bodies had been conſolidated. In that caſe, the formation of theſe veins is

a regulated proceſs, determined by the degree of fuſion, and the circumſtances of condenſation or refrigeration. In reſpect of theſe, the mineral veins now to be examined are anomalous. They are; but we know not why or how. We ſee the effect; but, in that effect, we do not ſee the cauſe. We can ſay, negatively, that the cauſe of mineral veins is not that by which the veins and fiſſures of conſolidated ſtrata have been formed; conſequently, that it is not the meaſured contraction and regulated condenſation of the conſolidated land which has formed thoſe general mineral veins; however, veins, ſimilar in many reſpects, have been formed by the co-operation of this cauſe.

HAVING thus taken a view of the evident diſtinction between the veins or contractions that are particular to the conſolidated body in which they are found, and thoſe more general veins which are not limited to that cauſe, we may now conſider what is general in the ſubject, or what is univerſal in theſe effects of which we wiſh to inveſtigate the cauſe.

THE event of higheſt generalization or univerſality, in the form of thoſe mineral veins, is fracture and diſlocation. It is not, like that of the veins of ſtrata, ſimple ſeparation and meaſured contraction; it is violent fracture and unlimited diſlocation. In the one caſe, the forming cauſe is in the body which is ſeparated; for, after the body had been actuated by heat, it is by the reaction of the proper matter of the body, that the chaſm which conſtitutes the vein is formed. In the other caſe, again, the cauſe is extrinſic in relation to the body in which the chaſm is formed. There has been the moſt violent fracture and divulſion; but the cauſe is ſtill to ſeek; and it appears not in the vein; for it is not every fracture and diſlocation of the ſolid body of our earth, in which minerals, or the proper ſubſtances of mineral veins, are found.

WE are now examining matter of fact, real effects, from whence we would inveſtigate the nature of certain events which do not now appear. Of theſe, two kinds occur; one which has acted

acted in relation to the hardneſs and ſolidity, or the natural conſtitution of the body; the other, to its ſhape or local ſituation. The firſt has been already conſidered; the laſt is now the ſubject of enquiry.

But, in examining thoſe natural appearances, we find two different kinds of veins; the one neceſſarily connected with the conſolidating cauſe; the other with that cauſe of which we now particularly enquire. For, in thoſe great mineral veins, violent fracture and diſlocation is the principle; but there is no other principle upon which ſtrata, or maſſes formed at the bottom of the ſea, can be placed at a height above its ſurface. Hence, in thoſe two different operations, of forming mineral veins, and erecting ſtrata from a lower to a higher place, the principle is the ſame; for neither can be done without violent fracture and diſlocation.

We now only want to know, how far it is by the ſame power, as well as upon the ſame principle, that thoſe two operations have been made. An expanſive force, acting from below, is the power moſt proper for erecting maſſes; but whether it is a power of the ſame nature with that which has been employed in forming mineral veins, will beſt appear in knowing the nature of their contents. Theſe, therefore, may be now conſidered.

Every ſpecies of fracture, and every degree of diſlocation and contortion, may be perceived in the form of mineral veins; and there is no other general principle to be obſerved in examining their form. But, in examining their contents, ſome other principle may appear, ſo far as, to the diſlocating power or force, there may be ſuperadded matter, by which ſomething in relation to the nature of the power may be known. If, for example, a tree or a rock ſhall be found ſimply ſplit aſunder, although there be no doubt with regard to ſome 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, ſhould 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 caſe with mineral veins. We find them containing matter, which indicates a cauſe; and every information in this caſe is intereſting to the theory.

THE ſubſtances contained in mineral veins are preciſely the ſame with thoſe which, in the former part of this paper, we have conſidered as being made inſtrumental in the conſolidation of ſtrata; and they are found in every ſpecies of mixture and concretion.

BUT, beſides this evidence for the exertion of extreme heat, in that proceſs by which thoſe veins were filled, there is another important obſervation to be gathered from the inſpection of this ſubject. There appears to have been a great mechanical power employed in the filling of theſe veins, as well as that neceſſarily required in making the firſt fracture and divulſion.

THIS appears from the order of the contents, or filling of theſe veins, which is a thing often obſerved to be various and ſucceſſive. But what it is chiefly now in view to illuſtrate, is that immenſe force which is manifeſted in the fracture and diſperſion of the ſolid contents which had formerly filled thoſe veins. Here we find fragments of rock and ſpar floating in the body of a vein filled with metallic ſubſtances; there, again, we ſee the various fragments of metallic maſſes floating in the ſparry and ſiliceous contents.

ONE thing is demonſtrable from the inſpection of the veins and their contents; this is, the ſucceſſive irruptions of thoſe fluid ſubſtances breaking the ſolid bodies which they meet, and floating thoſe fragments of the broken bodies in the vein. It is very common to ſee three ſucceſſive ſeries of thoſe operations; and all this may be perceived in a ſmall fragment of ſtone, which a man of ſcience may examine in his cloſet, often better

better than deſcending to the mine, where all the examples are found on an enlarged ſcale.

Let us now conſider what power would be required to force up, from the moſt unfathomable depth of the ocean, to the Andes or the Alps, a column of fluid metal and of ſtone. This power cannot be much leſs than that required to elevate the higheſt land upon the globe. Whether, therefore, we ſhall conſider the general veins as having been filled by mineral ſteams, or by fluid minerals, an elevating power of immenſe force is ſtill required, in order to form as well as fill thoſe veins. But ſuch a power acting under the conſolidated maſſes at the bottom of the ſea, is the only natural means for making thoſe maſſes land.

If ſuch have been the operations that are neceſſary for the production of this land; and if theſe operations are natural to the globe of this earth, as being the effect of wiſdom in its contrivance, we ſhall have reaſon to look for the actual manifeſtation of this truth in the phænomena of nature, or thoſe appearances which more immediately diſcover the actual cauſe in the perceived effect.

To ſee the evidence of marble, a body that is ſolid, having been formed of looſe materials collected at the bottom of the ſea, is not always eaſy, although it may be made abundantly plain; and to be convinced that this calcareous ſtone, which calcines ſo eaſily in our fires, ſhould have been brought into fuſion by ſubterraneous heat, without ſuffering calcination, muſt require a chain of reaſoning which every one is not able to attain. But when fire burſts forth from the bottom of the ſea, and when the land is heaved up and down, ſo as to demoliſh cities in an inſtant, and ſplit aſunder rocks and ſolid mountains, there is nobody but muſt ſee in this a power, which may be ſufficient to accompliſh every view of nature in erecting land, as it is ſituated in the place moſt advantageous for that purpoſe.

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 neceſſary always to ſee this immediate connection, in order to acknowledge the operation of a power which, at preſent, is extinguiſhed in the effect, we ſhould loſe the benefit of ſcience, or general principles, from whence particulars may be deduced, and we ſhould be able to reaſon no better than the brute. Man is made for ſcience; he reaſons from effects to cauſes, and from cauſes to effects; but he does not always reaſon without error. In reaſoning, therefore, from appearances which are particular, care muſt be taken how we generalize; we ſhould be cautious not to attribute to nature, laws which may perhaps be only of our own invention.

THE immediate queſtion now before us is not, if the ſubterraneous fire, or elevating power, which we perceive ſometimes as operating with ſuch energy, be the conſolidating cauſe of ſtrata formed at the bottom of the ſea; nor, if that power be the means of making land appear above the general ſurface of the water; for, though this be the end we want to arrive at ultimately, the queſtion at preſent in agitation reſpects the laws of nature, or the generality of particular appearances.

HAS the globe within it ſuch an active power as fits it for the renovation of that part of its conſtitution which may be ſubject to decay? Are thoſe powerful operations of fire, or ſubterraneous heat, which ſo often have filled us with terror and aſtoniſhment, to be conſidered as having always been? Are they to be concluded as proper to every part upon the globe, and as continual in the ſyſtem of this earth? If theſe points in queſtion ſhall be decided in the affirmative, we can be at no loſs in aſcertaining the power which has conſolidated ſtrata, nor in explaining the preſent ſituation of thoſe bodies, which had their origin at the bottom of the ſea. This, therefore, ſhould be the object of our purſuit; and, in order to have demonſtration in a caſe of phyſical enquiry, we muſt again have recourſe to the book of nature.

THE general tendency of heat is to produce fluidity and ſoftneſs; as that of cold is, on the contrary, to harden ſoft and fluid bodies. But this ſoftening power of heat is not uniform in its nature; it is made to act with very different effect, according to the nature of the ſubſtance to which it is applied. We are but limited in the art of increaſing the heat or the cold of bodies; we find, however, extreme difference in their ſubſtances with reſpect to fuſibility.

A FUSIBLE ſubſtance, or mineral compoſition in a fluid ſtate, is emitted from thoſe places of the earth at which ſubterraneous fire and expanſive force are manifeſted in thoſe eruptive operations. In examining theſe emitted bodies, men of ſcience find a character for ſuch productions, in generalizing the ſubſtance, and underſtanding the natural conſtitution of thoſe bodies. It is in this manner, that ſuch a perſon, finding a piece of lava in any place of the earth, ſays with certainty, Here is a ſtone which had congealed from a melted ſtate.

HAVING thus found a diſtinguiſhing character for thoſe fuſed ſubſtances called, in general, lavas, and having the moſt viſible marks for that which had been actually a volcano, naturaliſts, in examining different countries, have diſcovered the moſt undoubted proofs of many ancient volcanos, which had not been before ſuſpected. 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, ſo far as there is no place upon the earth that may not have an eruption of this kind; although it is by no means neceſſary for every place to have had thoſe eruptions.

VOLCANOS are natural to the globe, as general operations; but we are not to conſider nature as having a burning mountain for an end in her intention, or as a principal purpoſe in the general ſyſtem of this world. The end of nature in placing an internal fire or power of heat, and a force of irreſiſtible expanſion, in the body of this earth, is to conſolidate the ſediment collected

collected at the bottom of the ſea, and to form thereof a maſs of permanent land above the level of the ocean, for the purpoſe of maintaining plants and animals. The power appointed for this purpoſe is, as on all other occaſions, where the operation is important, and where there is any danger of a ſhortcoming, wiſely provided in abundance; and there are contrived means for diſpoſing of the redundancy. Theſe, in the preſent caſe, are our volcanos.

A VOLCANO is not made on purpoſe to frighten ſuperſtitious people into fits of piety and devotion, nor to overwhelm devoted cities with deſtruction; a volcano ſhould be conſidered as a ſpiracle to the ſubterranean furnace, in order to prevent the unneceſſary elevation of land, and fatal effects of earthquakes; and we may reſt aſſured, that they, in general, wiſely anſwer the end of their intention, without being in themſelves an end, for which nature had exerted ſuch amazing power and excellent contrivance.

LET us take a view of the moſt elevated places of the earth; if the preſent theory is juſt, it is there that we ſhould find volcanos. But is not this the caſe? There are volcanos in the Andes; and round the Alps we find many volcanos, which are in France upon the one ſide, and in Germany upon the other, as well as upon the Italian ſide, where Veſuvius ſtill continues to exhibit violent eruptions.

IT is not meant to allege, that it is only upon the ſummit of a continent volcanos ſhould appear. Subterraneous fire has ſometimes made its appearance in burſting from the bottom of the ſea. But, even in this laſt caſe, land was raiſed from the bottom of the ſea, before the eruption made its exit into the atmoſphere. It muſt alſo be evident, that, in this caſe of the new iſland near Santorini, had the expanſive power been retained, inſtead of being diſcharged, much more land might have been raiſed above the level of the ocean.

Now, the eruption of that elaſtic force through the bottom of the ſea, may be conſidered 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 conſider 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 forming

forming dry land above its ſurface, it will be allowed, that we have diſcovered the ſecret operations of nature concocting future land, as well as thoſe by which the preſent habitable earth had been produced from the bottom of the abyſs. Here, therefore, we ſhall at preſent reſt the argument, with endeavouring to ſhew that ſuch is actually the caſe.

It appears from CRONSTEDT's Mineralogy, that the rock-ſtone, called trap by the Swedes, the amygdaloides and the ſchwarts-ſtein of the Germans, are the ſame with the whin-ſtone of this country. This is alſo fully confirmed by ſpecimens from Sweden, ſent me by my friend Dr GAHN. Whatever, therefore, ſhall be aſcertained with regard to our whin-ſtone, may be ſo far generalized or extended to the countries of Norway, Sweden, and Germany.

The whinſtone of Scotland is alſo the ſame with the toad-ſtone of Derbyſhire, which is of the amygdaloides ſpecies; it is alſo the ſame with the ragſtone of the ſouth of Staffordſhire, which is a ſimple whinſtone, or perfect trap. England, therefore, muſt be included in this great ſpace of land, the mineral operations of which we explore; and alſo Ireland, of which the Giants Cauſeway, and many others, are ſufficient proof.

In the ſouth of Scotland, there is a ridge of hills, which extends from the weſt ſide of the iſland in Galloway to the eaſt ſide in Berwickſhire, compoſed of granite, of ſchiſtus, and of ſiliceous ſtrata. The Grampians on the north, again, form another range of mountains of the ſame kind; and between theſe two great fields of broken, tumbled and diſtorted ſtrata, there lies a field of leſſer hardneſs and conſolidation, in general; but a field in which there is a great manifeſtation of ſubterraneous fire, and of exerted force.

The ſtrata in this ſpace conſiſt, in general, of ſandſtone, coal, limeſtone or marble, ironſtone, and marl or argillaceous ſtrata, with ſtrata of analogous bodies, and the various compoſitions of theſe. But what is to the preſent purpoſe is this, that,

that, through all this ſpace, there are interſperſed immenſe quantities of whinſtone; a body which is to be diſtinguiſhed as very different from lava; and now the diſpoſition of this whinſtone is to be conſidered.

SOMETIMES it is found in an irregular maſs or mountain, as Mr CRONSTEDT has properly obſerved; but he has alſo ſaid, that this is not the caſe in general. His words are: "It is "oftener found in form of veins in mountains of another "kind, running commonly in a ſerpentine manner, contrary "or acroſs to the direction of the rock itſelf."

THE origin of this form, in which the trap or whinſtone appears, is moſt evident to inſpection, when we conſider that this ſolid body had been in a fluid ſtate, and introduced, in that ſtate, among ſtrata which preſerved their proper form. The ſtrata appear to have been broken, and the two correſpondent parts of thoſe ſtrata are ſeparated to admit the flowing maſs of whinſtone.

A FINE example of this kind may be ſeen upon the ſouth ſide of the Earn, on the road to Crief. It is twenty-four yards wide, ſtands perpendicular, and appears many feet above the ſurface of the ground. It runs from that eaſtward, and would ſeem to be the ſame with that which croſſes the river Tay, in forming Campſy-lin above Stanley, as a leſſer one of the ſame kind does below it. I have ſeen it at Lednoc upon the Ammon, where it forms a caſcade in that river, about five or ſix miles weſt of Campſy-lin. It appears to run from the Tay eaſt through Strathmore, ſo that it may be conſidered as having been traced for twenty or thirty miles, and weſtwards to Drummond caſtle, perhaps much farther.

TWO ſmall veins of the ſame kind, only two or three feet wide, may be ſeen in the bed of the Water of Leith, traverſing the horizontal ſtrata, the one is above St BERNARD's well, the other immediately below it. But, more particularly, in the ſhire of Ayr, to the north of Irvine, there are to be ſeen upon the

the coaſt, between that and Scarmorly, in the ſpace of about twenty miles, more than twenty or thirty ſuch dykes (as they are called) of whinſtone. Some of them are of a great thickneſs; and, in ſome places, there is perceived a ſhort one, running at right angles, and communicating with other two that run parallel.

THERE is in this country, and in Derbyſhire *, another regular appearance of this ſtone, which CRONSTEDT has not mentioned. In this caſe, the ſtrata are not broken in order to have the whinſtone introduced, they are ſeparated, and the whinſtone is interjected in form of ſtrata, having various degrees of regularity, and being of different thickneſs. On the ſouth ſide of Edinburgh, I have ſeen, in little more than the ſpace of a mile from eaſt to weſt, nine or ten maſſes of whinſtone interjected among the ſtrata. Theſe maſſes of whinſtone 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 ſeen at all times in the hill of Saliſbury Craggs.

HAVING thus deſcribed theſe maſſes, which have flowed by means of heat among the ſtrata of the globe, ſtrata which had been formed by ſubſidence at the bottom of the ſea, it will now be proper to examine the difference that ſubſiſts between theſe ſubterraneous lavas, as they may be termed, and the analogous bodies, which are proper lavas, in having iſſued out of a volcano †.

THERE

* See Mr WHITEHURST's Theory of the Earth.

† The Chevalier de Dolomieu, in his accurate examination of Ætna and the Lipari iſlands, has very well obſerved the diſtinction of theſe two different ſpecies of lavas; but without ſeeming to know the principle upon which this eſſential difference depends. No bias of ſyſtem, therefore, can here be ſuppoſed as perverting the Chevalier's view, in taking thoſe obſervations; and theſe are intereſting to the preſent theory, as correſponding perfectly with the facts from whence it has been formed. It will be proper to give the account of theſe in his own words.

LA

THERE can be no doubt that theſe two different ſpecies of bodies have had the ſame origin, and that they are compoſed of the ſame materials nearly; but from the different circumſtances of their production, there is formed a character to theſe bodies, by which they may be perfectly diſtinguiſhed. The difference of thoſe circumſtances conſiſts in this; the one has been emitted to the atmoſphere in its fluid ſtate, the other only came to be expoſed to the light in a long courſe of time, after it had congealed under the compreſſion of an immenſe load of earth, and after certain operations, proper to the mineral regions, had been exerciſed upon the indurated maſs. This is the cauſe of the difference between thoſe erupted lavas, and our whinſtone, toadſtone, and the Swediſh trap, which may be termed ſubterraneous lava. The viſible effects of thoſe different operations may now be mentioned.

IN the erupted lavas, thoſe ſubſtances which are ſubject to calcine and vitrify in our fires, ſuffer ſimilar changes, when delivered from a compreſſion which had rendered them fixed, though

LA zeolite eſt tres-commune dans certains laves de l'Ethna; il ſeroit peut-être poſſible d'y en rencontrer des morceaux auſſi gros que ceux que fournit l'iſle de Ferroé. Quoique cette ſubſtance ſemble ici appartenir aux laves, je ne dirai cependant point que toutes les zeolites ſoient volcaniques, ou unies à des matieres volcaniques; celles que l'on trouve en Allemagne ſont, dit-on, dans des circonſtances differentes; mais je doit annoncer que je n'ai trouvé cette ſubſtance en Sicile, que dans les ſeules laves qui evidemment ont coulé dans la mer, et qui ont été recouvertes par ſes eaux. La zeolite des laves n'eſt point une dejection volcanique, ni une production du feu, ni même un matiere que les laves aient enveloppée lorſqu'elles etoient fluides; elle eſt le reſultat d'une operation et d'une combinaiſon poſterieure, auxquelles les eaux de la mer ont concouru. Les laves qui n'ont pas été ſubmergées, n'en contiennent jamais. J'ai trouvé ces obſervations ſi conſtantes, que par-tout où je rencontrois de la zeolite, j'étois sûr de trouver d'autres preuves de ſubmerſion, et partout où je voyois des laves recouvertes des dépôts de l'eau, j'étois sûr de trouver de la zeolite, et un de ces faits m'a toujours indiqué l'autre. Je me ſuis ſervi avec ſucces de cette obſervation 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 diſtinction of ſubterraneous lava, in which zeolite and calcareous ſpar may be found, and that which has flowed from a volcano, in which neither of theſe are ever obſerved.

though in an extremely heated ſtate. Thus, a lava in which there is much calcareous ſpar, when it comes to be expoſed to the atmoſphere, or delivered from the compreſſing force of its confinement, effervesces by the exploſion of its fixed air; the calcareous earth, at the ſame time, vitrifies with the other ſubſtances: Hence ſuch violent ebullition in volcanos, and hence the emiſſion of ſo much pumice-ſtone and aſhes, which are of the ſame nature.

In the body of our whinſtone, on the contrary, there is no mark of calcination or vitrification. We frequently find in it much calcareous ſpar, or the *terra calcarea aerata*, which had been in a melted ſtate by heat, and had been cryſtallized by congelation into a ſparry form. Such is the *lapis amygdaloides*, and many of our whinſtone rocks, which contain pebbles cryſtallized and variouſly figured, both calcareous, ſiliceous, and of a mixture in which both theſe ſubſtances form diſtinct parts. The ſpecimens of this kind, which I have from the whinſtone or porphyry rock of the Calton-hill, exhibit every ſpecies of mineral operation, in forming jaſper, figured agate, and marble; and they demonſtrate, that this had been performed by heat or fuſion.

I do not mean to ſay, that this demonſtration is direct; it is conditional, and proceeds upon the ſuppoſition, that the baſaltic or porphyry rock, in which thoſe ſpecimens are found, is a body which had been in a melted ſtate. Now, this is a ſuppoſition for which I have abundance of evidence, were it required; but naturaliſts are now ſufficiently diſpoſed to admit that propoſition; they even draw concluſions from this fact, which, I think, they are not ſufficiently warranted in doing; that is, from this appearance, they infer the former exiſtence of volcanos in thoſe places. For my part, though I have made the moſt ſtrict examination, I never ſaw any veſtige of ſuch an event. That there are, in other countries, evident marks of volcanos which have been long extinguiſhed, is unqueſtionably

true; but naturaliſts, imagining that there are no other marks of ſubterraneous fire and fuſion, except in the production of a lava, attribute to a volcano, as a cauſe, theſe effects, which only indicate the exertion of that power which might have been the cauſe of a volcano.

If the theory now given be juſt, a rock of marble is no leſs a mark of ſubterraneous fire and fuſion, than that of the baſaltes; and the flowing of baſaltic ſtreams among ſtrata broken and diſplaced, affords the moſt ſatisfactory evidence of thoſe operations by which the body of our land had been elevated above the ſurface of the ſea; but it gives no proof that the eruptive force of mineral vapours had been diſcharged in a burning mountain. Now, this diſcharge is eſſential in the proper idea of a volcano.

Besides this internal mark of an unerupted lava in the ſubſtance of the ſtone or body of the flowing maſs, there are others which belong to it in common with all other mineral ſtrata, conſolidated by ſubterraneous fire, and changed from the place of their original formation; this is, the being broken and diſlocated, and having veins of foreign matter formed in their ſeparations and contractions.

If theſe are mineral operations, proper to the lower regions of the earth, and exerted upon bodies under immenſe compreſſion, ſuch things will be ſometimes found in the unerupted lavas, as well as in the contiguous bodies with which they are aſſociated. If, on the contrary, theſe are operations proper to the ſurface of the earth, where the diſſolving power of water and air take place, and where certain ſtalactical and ferruginous concretions are produced by theſe means; then, in erupted lavas, we ſhould find mineral concretions, which concretions ſhould be denied to bodies which had been conſolidated at the bottom of the ſea; that is to ſay, where, without the operation of ſubterraneous fire, no changes of that kind could have taken place, as has already been obſerved. But in the unerupted ſpecies

cies of lava, that is to ſay, in our whinſtone, every ſpecies of mineral appearance is occaſionally to be found. Let thoſe who have the opportunity to examine, ſay, what are to be found in proper lavas, that is, thoſe of the erupted kind. Sir WILLIAM HAMILTON informed me, when I ſhewed him thoſe mineral veins and ſpars in our whinſtone, that he had never obſerved the like in lavas.

WE have now formed ſome concluſions with regard to the nature and production of thoſe 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 ſpecimens which are brought to us from diſtant parts, we have reaſon to believe, that all the reſt of the earth is of the ſame nature with that which has been now conſidered. The great maſſes of the earth are the ſame every where; and all the different ſpecies of earths, of rocks or ſtone, which have as yet appeared, are to be found in the little ſpace of this our iſland.

IT is true, that there are peculiar productions in the mineral kingdom which are rare, as being found only in few places; but theſe things are merely accidental in relation to the land, for they belong in property to thoſe parts of the mineral region which we never ſee. Such are, the diamond of the eaſt, the platina of the weſt, and the tin of Cornwall, Germany, and Sumatra. Gold and ſilver, though found in many countries, do not appear to be immediately neceſſary in the production of a habitable country. Iron, again, is univerſal in the operations of the globe, and is found often in that profuſion which equals its utility. Between theſe two extremes, we find all other minerals, that is to ſay, here and there in moderate quantity, and apparently in ſome proportion to their uſe. But all theſe ſubſtances are to be conſidered as the vapours of the mineral regions, condenſed occaſionally in the crevices of the land; and it is only the rocks and ſtrata (in which thoſe mineral veins are found) that are now examined with regard to their original

compoſition at the bottom of the ſea, as well as to that operation by which thoſe bodies had been indurated in their ſubſtance, and elevated from the place in which they had been formed.

THUS, we have ſufficient reaſon to believe, that, in knowing the conſtruction of the land in Europe, we know the conſtitution of the land in every part of the globe. Therefore, we may proceed to form general concluſions, from the knowledge of the mineral region, thus acquired in ſtudying thoſe parts which are ſeen.

HAVING thus found, *firſt*, That the conſolidated and indurated maſſes of our ſtrata had ſuffered the effects of violent heat and fuſion; 2*dly*, That thoſe ſtrata, which had been formed in a regular manner at the bottom of the ſea, have been violently bended, broken and removed from their original place and ſituation; and, *laſtly*, Having now found the moſt indubitable proof, that the melting, breaking, and removing power of ſubterraneous fire, has been actually exerted upon this land which we examine, we cannot heſitate in aſcribing theſe operations as a cauſe to thoſe effects which are expoſed to our view. Now, theſe may be conſidered as conſiſting in the ſolid ſtate and preſent ſituation of thoſe ſtratified bodies, originally formed by ſubſidence in the ocean; appearances which cannot, in reaſon, be aſcribed to any other cauſe, and which, upon this principle, are perfectly explained.

IT is not meant to ſpecify every particular in the means employed by nature for the elevation of our land. It is ſufficient to have ſhewn, that there is, in nature, means employed for the conſolidating of ſtrata, formed originally of looſe and incoherent materials; and that thoſe ſame means have alſo been employed in changing the place and ſituation of thoſe ſtrata. But how deſcribe 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

is

is raiſed by a power which has for principle ſubterraneous heat; but how that land is preſerved in its elevated ſtation, is a ſubject in which we have not even the means to form conjecture; at leaſt, we ought to be cautious how we indulge conjecture in a ſubject where no means occur for trying that which is but ſuppoſition.

We now proceed, from the facts which have been properly eſtabliſhed, to reaſon with regard to the duration of this globe, or the general view of its operations, as a living world, maintaining plants and animals.

PART IV.

Syſtem of Decay and Renovation obſerved in the Earth.

Philosophers obſerving an apparent diſorder and confuſion in the ſolid parts of this globe, have been led to conclude, that there formerly exiſted a more regular and uniform ſtate, in the conſtitution of this earth; that there had happened ſome deſtructive change; and that the original ſtructure of the earth had been broken and diſturbed by ſome violent operation, whether natural, or from a ſupernatural cauſe. Now, all theſe appearances, from which concluſions of this kind have been formed, find the moſt perfect explanation in the theory which we have been endeavouring to eſtabliſh; for they are the facts from whence we have reaſoned, in diſcovering the nature and conſtitution of this earth: Therefore, there is no occaſion for having recourſe to any unnatural ſuppoſition of evil, to any deſtructive accident in nature, or to the agency of any preternatural cauſe, in explaining that which actually appears.

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 vegetation. 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, having 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 elementary 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 appearances 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 effects of ſteady cauſes; each of theſe has its proper purpoſe in the ſyſtem of the earth; and in that ſyſtem is contained another, 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 knowing 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 preſent earth was forming at the bottom of the ſea, we are now to take a very general view of nature, without deſcending into thoſe particulars which ſo often occupy the ſpeculations of naturaliſts, about the preſent ſtate of things. We are not at preſent to enter into any diſcuſſion with regard to what are the primary and ſecondary mountains of the earth; we are not to conſider what is the firſt, and what the laſt, in thoſe things which now are ſeen; whatever is moſt ancient in the ſtrata which we now examine, is ſuppoſed to be collecting at the bottom of the ſea, during the period concerning which we are now to enquire.

We have already conſidered thoſe operations which had been neceſſary in forming our ſolid land, a body conſiſting of materials originally depoſited at the bottom of the ocean; we are now to inveſtigate the ſource from whence had come all thoſe materials, from the collection of which the preſent land is formed; and from knowing the ſtate in which thoſe materials had exiſted, previouſly to their entering the compoſition of our ſtrata, we ſhall learn ſomething concerning the natural hiſtory of this world, while the preſent earth was forming in the ſea.

We have already obſerved, that all the ſtrata of the earth are compoſed either from the calcareous relicts of ſea animals, or from the collection of ſuch materials as we find upon our ſhores. At a groſs computation, there may perhaps be a fourth part of our ſolid land, which is compoſed from the matter that had belonged to thoſe animals. Now, what a multitude of living creatures, what a quantity of animal œconomy muſt have been required for producing a body of calcareous matter which is interſperſed throughout all the land of the globe, and which certainly forms a very conſiderable part of that maſs!

Therefore

Therefore, in knowing how thoſe animals had lived, or with what they had been fed, we ſhall have learned a moſt intereſting part of the natural hiſtory of this earth; a part which it is neceſſary to have aſcertained, in order to ſee the former operations of the globe, while preparing the materials of the preſent land. But, before entering upon this ſubject, let us examine the other materials of which our land is formed.

GRAVEL forms a part of thoſe materials which compoſe our ſolid land; but gravel is no other than a collection of the fragments of ſolid ſtones worn round, or having their angular form deſtroyed by agitation in water, and the attrition upon each other, or upon ſimilar hard bodies. Conſequently, in finding maſſes of gravel in the compoſition of our land, we muſt conclude, that there had exiſted a former land, on which there had been tranſacted certain operations of wind and water, ſimilar to thoſe which are natural to the globe at preſent, and by which new gravel is continually prepared, as well as old gravel conſumed or diminiſhed by attrition upon our ſhores.

SAND is the material which enters, perhaps in greateſt quantity, the compoſition of our land. But ſand is no other than ſmall fragments of hard and ſolid bodies, worn or rounded more or leſs by attrition; conſequently, the ſame natural hiſtory of the earth, which is inveſtigated from the maſſes of gravel, is alſo applicable to thoſe maſſes of ſand which we find forming ſo large a portion of our preſent land throughout all the earth.

CLAY is now to be conſidered as the laſt of thoſe materials of which our ſtrata are compoſed; but, in order to underſtand the nature of this ingredient, ſomething muſt be premiſed.

CLAY is a mixture of different earths or hard ſubſtances, in an impalpable ſtate. Thoſe ſubſtances are chiefly the ſiliceous and aluminous earths. Other earths are occaſionally mixed in clays, or perhaps always to be found in ſome ſmall portion. But this does not affect the general character of clay; it only forms a ſpecial variety in the ſubject. A ſenſible or conſidera-

ble portion of calcareous earth, in the compoſition of clay, conſtitutes a marl, and a ſufficient admixture of ſand, a loam.

An indefinite variety of thoſe compoſitions of clay form a large portion of the preſent ſtrata, all indurated and conſolidated in various degrees; but this great quantity of ſiliceous, argillaceous, and other compound ſubſtances, in form of earth or impalpable ſediment, correſponds perfectly with that quantity of thoſe ſame ſubſtances which muſt have been prepared in the formation of ſo much gravel and ſand, by the attrition of thoſe bodies in the moving waters.

Therefore, from the conſideration of thoſe materials which compoſe the preſent land, we have reaſon to conclude, that, during the time this land was forming, by the collection of its materials at the bottom of the ſea, there had been a former land containing materials ſimilar to thoſe which we find at preſent in examining the earth. We may alſo conclude, that there had been operations ſimilar to thoſe which we now find natural to the globe, and neceſſarily exerted in the actual formation of gravel, ſand and clay. But what we have now chiefly in view to illuſtrate is this, that there had then been in the ocean a ſyſtem of animated beings, which propagated their ſpecies, and which have thus continued their ſeveral races to this day.

In order to be convinced of that truth, we have but to examine the ſtrata of our earth, in which we find the remains of animals. In this examination, we not only diſcover every genus of animal which at preſent exiſts in the ſea, but probably every ſpecies, and perhaps ſome ſpecies with which at preſent we are not acquainted. There are, indeed, varieties in thoſe ſpecies, compared with the preſent animals which we examine, but no greater varieties than may perhaps be found among the ſame ſpecies in the different quarters of the globe. Therefore, the ſyſtem of animal life, which had been maintained in the ancient ſea, had not been different from that which now ſubſiſts, and of which it belongs to naturaliſts to know the hiſtory.

It

It is the nature of animal life to be ultimately ſupported from matter of vegetable production. Inflammable matter may be conſidered as the *pabulum* of life. This is prepared in the bodies of living plants, particularly in their leaves expoſed to the ſun and light. This inflammable matter, on the contrary, is conſumed in animal bodies, where it produces heat or light, or both. Therefore, however animal matter, or the pabulum of life, may circulate through a ſeries of digeſting powers, it is conſtantly impaired or diminiſhing in the courſe of this œconomy, and, without the productive power of plants, it would finally be extinguiſhed.

The animals of the former world muſt have been ſuſtained during indefinite ſucceſſions of ages. The mean quantity of animal matter, therefore, muſt have been preſerved by vegetable production, and the natural waſte of inflammable ſubſtance repaired with continual addition; that is to ſay, the quantity of inflammable matter neceſſary to the animal conſumption, muſt have been provided by means of vegetation. Hence we muſt conclude, that there had been a world of plants, as well as an ocean repleniſhed with living animals.

We are now, in reaſoning from principles, come to a point deciſive of the queſtion, and which will either confirm the theory, if it be juſt, or confute our reaſoning, 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 preſent world was forming at the bottom of the ſea.

Here the cabinets of the curious are to be examined; but here ſome caution is required, in order to diſtinguiſh things perfectly different, which ſometimes are confounded.

Foſſil wood, to naturaliſts in general, is wood dug up from under ground, without enquiring whether this had been the production of the preſent earth, or that which had preceded it in the circulation of land and water. The queſtion is important, and the ſolution of it is, in general, eaſy. The vege-

table productions of the preſent earth, however deep they may be found buried beneath its ſurface, and however ancient they may appear, compared with the records of our known times, are new, compared with the ſolid land on which they grew; and they are only covered with the produce of a vegetable ſoil, or the alluvion of the preſent land on which we dwell, and on which they had grown. But the foſſil bodies which form the preſent ſubject of enquiry, belonged to former land, and are found only in the ſea-born ſtrata of our preſent earth. It is to theſe 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 ſea, and there compoſed part of a ſtratum, which hitherto we have conſidered as only formed of the materials proper to the ocean. Now, what a profuſion of this ſpecies of foſſil wood is to be found in the cabinets of collectors, and even in the hands of lapidaries, and ſuch artificers of poliſhed ſtones! In ſome places, it would ſeem to be as common as the agate.

I SHALL only mention a ſpecimen in my own collection. It is wood petrified with calcareous earth, and mineralized with pyrites. This ſpecimen of wood contains in itſelf, even without the ſtratum of ſtone in which it is embedded, the moſt perfect record of its genealogy. It had been eaten or perforated by thoſe ſea-worms which deſtroy the bottoms of our ſhips. There is the cleareſt evidence of this truth. Therefore, this wood had grown upon land which ſtood above the level of the ſea, while the preſent land was only forming at the bottom of the ocean.

WOOD is the moſt ſubſtantial part of plants, as ſhells are the more permanent part of marine animals. It is not, however, the woody part alone of the ancient vegetable world that is tranſmitted to us in the record of our mineral pages. We have the type of many ſpecies of foliage, and even of the moſt

moſt delicate flower; for, in this way, naturaliſts have determined, according to the Linnæan ſyſtem, the ſpecies, or at leaſt the genus, of the plant. Thus, the exiſtence of a vegetable ſyſtem at the period now in contemplation, ſo far from being 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 bituminous ſtrata have had their origin from the ſubſtance of vegetable 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 ſtructure of the vegetable bodies. Conſequently, there is no doubt of foſſil coal being a ſubſtance of vegetable production, however 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 production of the preſent earth, compoſed from the materials of a former world, it muſt be evident, that here are two operations 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 natural 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

fill the mind with wonder and with doubt, we are not to ſuppoſe, that there is any violent exertion of power, ſuch as is required in order to produce a great event in little time; in nature, we find no deficiency in reſpect of time, nor any limitation with regard to power. But time is not made to flow in vain; nor does there ever appear the exertion of ſuperfluous power, or the manifeſtation of deſign, not calculated in wiſdom to effect ſome general end.

THE events now under conſideration may be examined with a view to ſee this truth; for it may be enquired, why deſtroy one continent in order to erect another? The anſwer is plain; Nature does not deſtroy a continent from having wearied of a ſubject which had given pleaſure, or changed her purpoſe, whether for a better or a worſe; neither does ſhe erect a continent of land among the clouds, to ſhew her power, or to amaze the vulgar man: Nature has contrived the productions of vegetable bodies, and the ſuſtenance of animal life, to depend upon the gradual but ſure deſtruction of a continent; that is to ſay, theſe two operations neceſſarily go hand in hand. But with ſuch wiſdom has nature ordered things in the œconomy of this world, that the deſtruction of one continent is not brought about without the renovation of the earth in the production of another; and the animal and vegetable bodies, for which the world above the ſurface of the ſea is levelled with its bottom, are among the means employed in thoſe operations, as well as the ſuſtenance of thoſe living beings is the proper end in view.

THUS, in underſtanding the proper conſtitution of the preſent earth, we are led to know the ſource from whence had come all the materials which nature had employed in the conſtruction of the world which appears; a world contrived in conſummate wiſdom for the growth and habitation of a great diverſity of plants and animals; and a world peculiarly adapted

to

to the purpoſes of man, who inhabits all its climates, who meaſures its extent, and determines its productions at his pleaſure.

THE whole of a great object or event fills us with wonder and aſtoniſhment, when all the particulars, in the ſucceſſion of which the whole had been produced, may be conſidered without the leaſt emotion. When, for example, we behold the pyramids of Egypt, our mind is agitated with a crowd of ideas that highly entertains the perſon who underſtands the ſubject; but the carrying a heavy ſtone up to the top of a hill or mountain would give that perſon little pleaſure or concern. We wonder at the whole operation of the pyramid, but not at any one particular part.

THE raiſing up of a continent of land from the bottom of the ſea, is an idea that is too great to be conceived eaſily in all the parts of its operation, many of which are perhaps unknown to us; and without being properly underſtood, ſo great an idea may appear like a thing that is imaginary. In like manner, the co-relative, or correſponding operation, the deſtruction of the land, is an idea that does not eaſily enter into the mind of man in its totality, although he is daily witneſs to part of the operation. We never ſee a river in a flood, but we muſt acknowledge the carrying away of part of our land, to be ſunk at the bottom of the ſea; we never ſee a ſtorm upon the coaſt, but we are informed of a hoſtile attack of the ſea upon our country; attacks which muſt, in time, wear away the bulwarks of our ſoil, and ſap the foundations of our dwellings. Thus, great things are not underſtood without the analyzing of many operations, and the combination of time with many events happening in ſucceſſion.

LET us now conſider what is to be the ſubject of examination, and where it is that we are to obſerve thoſe operations which muſt determine either the ſtability or the inſtability of this land on which we live.

OUR

OUR land has two extremities; the tops of the mountains, on the one hand, and the ſea-ſhores, on the other: It is the intermediate ſpace between theſe two, that forms the habitation of plants and animals. While there is a ſea-ſhore and a higher ground, there is that which is required in the ſyſtem of the world: Take theſe away, and there would remain an aqueous globe, in which the world would periſh. But, in the natural operations of the world, the land is periſhing continually; and this is that which now we want to underſtand.

UPON the one extremity of our land, there is no increaſe, or there is no acceſſion of any mineral ſubſtance. That place is the mountain-top, on which nothing is obſerved but continual decay. The fragments of the mountain are removed in a gradual ſucceſſion from the higheſt ſtation to the loweſt. Being arrived at the ſhore, and having entered the dominion of the waves, in which they find perpetual agitation, theſe hard fragments, which had eluded the reſolving powers natural to the ſurface of the earth, are incapable of reſiſting the powers here employed for the deſtruction of the land. By the attrition of one hard body upon another, the moving ſtones and rocky ſhore, are mutually impaired. And that ſolid maſs, which of itſelf had potential ſtability againſt the violence of the waves, affords the inſtruments of its own deſtruction, and thus gives occaſion to its actual inſtability.

IN order to underſtand the ſyſtem of the heavens, it is neceſſary to connect together periods of meaſured time, and the diſtinguiſhed places of revolving bodies. It is thus that ſyſtem may be obſerved, or wiſdom, in the proper adapting of powers to an intention. In like manner, we cannot underſtand the ſyſtem of the globe, without ſeeing that progreſs of things which is brought about in time, thus meaſuring the natural operations of the earth with thoſe of the heavens. This is properly the buſineſs of the preſent 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

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 agitation 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 proportional by which we are to eſtimate the age of worlds that have terminated, and the duration of thoſe that are but beginning.

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 revolution 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 attrition 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 experience 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 without

out a parallax, as to calculate the deſtruction of the ſolid land without a meaſure correſponding to the whole.

THE deſcription which POLYBIUS has given of the Pontus Euxinus, with the two oppoſite Boſphori, the Meotis, the Propontis, and the Port of Byzantium, are as applicable to the preſent ſtate of things, as they were at the writing of that hiſtory. The filling up of the bed of the Meotis, an event which, to POLYBIUS, appeared not far off, muſt alſo be conſidered as removed to a very diſtant period, though the cauſes ſtill continue to operate as before.

BUT there is a thing in which hiſtory and the preſent ſtate of things do not agree. It is upon the coaſt of Spain, where POLYBIUS ſays there was an iſland in the mouth of the harbour of New Carthage. At preſent, in place of the iſland, there is only a rock under the ſurface of the water. It muſt be evident, however, that the loſs of this ſmall iſland affords no proper ground of calculation for the meaſure or rate of waſting which could correſpond to the coaſt in general; as neither the quantity of what is now loſt had been meaſured, nor its quality aſcertained.

LET us examine places much more expoſed to the fury of the waves and currents than the coaſt of Carthagena, the narrow fretum, for example, between Italy and Sicily. It does not appear, that this paſſage is ſenſibly wider than when the Romans firſt had known it. The Iſthmus of Corinth is alſo apparently the ſame at preſent as it had been two or three thouſand years ago. Scilla and Charibdis remain now, as they had been in ancient times, rocks hazardous for coaſting veſſels which had to paſs that ſtrait.

IT is not meant by this to ſay, theſe rocks have not been waſted by the ſea, and worn by the attrition of moving bodies, during that ſpace of time; were this true, and that thoſe rocks, the bulwarks of the land upon thoſe coaſts, had not been at all impaired from that period, they might remain

for ever, and thus the ſyſtem of interchanging the place of ſea and land upon this globe might be fruſtrated. It is only meant to affirm, that the quantity which thoſe rocks, or that coaſt, have diminiſhed from the period of our hiſtory, has either been too ſmall a thing for human obſervation, or, which is more probable, that no accurate meaſurement of the ſubject, by which this quantity of decreaſe might have been aſcertained, had been taken and recorded. It muſt be alſo evident, that a very ſmall operation of an earthquake would be ſufficient to render every means of information, in this manner of menſuration, unſatisfactory or precarious.

PLINY ſays Italy was diſtant from Sicily a mile and a half; but we cannot ſuppoſe that this meaſure was taken any otherwiſe than by computation, and ſuch a meaſure is but little calculated to afford us the juſt means of a compariſon with the preſent diſtance. He alſo ſays, indeed, that Sicily had been once joined with Italy. His words are: "Quondam BRUTIO "agro cohærens, mox interfuſo mari avulſa *." But all that we can conclude from this hiſtory of PLINY is, that, in all times, to people conſidering the appearances of thoſe two approached coaſts, it had ſeemed probable, that the ſea formed a paſſage between the two countries which had been once united; in like manner as is ſtill more immediately perceived, in that ſmaller disjunction which is made between the iſland of Angleſey and the continent of Wales.

THE port of Syracuſe, with the iſland which forms the greater and leſſer, and the fountain of Arethuſa, the water of which the ancients divided from the ſea with a wall, do not ſeem to be altered. From Sicily to the coaſt of Egypt, there is an uninterrupted courſe of ſea for a thouſand miles; conſequently, the wind, in ſuch a ſtretch of ſea, ſhould bring powerful waves againſt thoſe coaſts. But, on this coaſt of Egypt, we find the rock on which was formerly built the famous tower of Pharos; and

* Lib. 3. cap. 8.

and alſo, at the eaſtern extremity of the port Eunoſte, the ſea-bath, cut in the ſolid rock upon the ſhore. Both thoſe rocks, buffeted immediately with the waves of the Mediterranean ſea, are, to all appearance, the ſame at this day as they were in ancient times *.

MANY other ſuch proofs will certainly occur, where the different parts of thoſe coaſts are examined by people of obſervation and intelligence. But it is enough for our preſent purpoſe, that this decreaſe of the coaſts in general has not been obſerved; and that it is as generally thought, that the land is gaining upon the ſea, as that the ſea is gaining upon the land.

TO ſum up the argument, we are certain, that all the coaſts of the preſent continents are waſted by the ſea, and conſtantly wearing away upon the whole; but this operation is ſo extremely ſlow, that we cannot find a meaſure of the quantity in order to form an eſtimate. Therefore, the preſent continents of the earth, which we conſider as in a ſtate of perfection, would, in the natural operations of the globe, require a time indefinite for their deſtruction.

BUT, in order to produce the preſent continents, the deſtruction of a former vegetable world was neceſſary; conſequently, the production of our preſent continents muſt have required a time which is indefinite. In like manner, if the former continents were of the ſame nature as the preſent, it muſt have required another ſpace of time, which alſo is indefinite, before they had come to their perfection as a vegetable world.

WE have been repreſenting the ſyſtem of this earth as proceeding with a certain regularity, which is not perhaps in nature, but which is neceſſary for our clear conception of the ſyſtem of nature. The ſyſtem of nature is certainly in rule, although we may not know every circumſtance of its regulation. We are under a neceſſity, therefore, of making regular ſuppoſitions,

* Lettres ſur l'Egypte, M. SAVARY.

ſuppoſitions, in order to come at certain concluſions which may be compared with the preſent ſtate of things.

It is not neceſſary that the preſent land ſhould be worn away and waſted, exactly in proportion as new land ſhall appear; or, converſely, that an equal proportion of new land ſhould always be produced as the old is made to diſappear. It is only required, that, at all times, there ſhould be a juſt proportion of land and water upon the ſurface of the globe, for the purpoſe of a habitable world.

Neither is it required in the actual ſyſtem of this earth, that every part of the land ſhould be diſſolved in its ſtructure, and worn away by attrition, ſo as to be floated in the ſea. Parts of the land may often ſink in a body below the level of the ſea, and parts again may be reſtored, without waiting for the general circulation of land and water, which proceeds with all the certainty of nature, but which advances with an imperceptible progreſſion. Many of ſuch apparent irregularities may appear, without the leaſt infringement on the general ſyſtem. That ſyſtem is comprehended in the preparation of future land at the bottom of the ocean, from thoſe materials which the diſſolution and attrition of the preſent land may have provided, and from thoſe which the natural operations of the ſea afford.

In thus accompliſhing a certain end, we are not to limit nature with the uniformity of an equable progreſſion, although it be neceſſary in our computations to proceed upon equalities. Thus alſo, in the uſe of means, we are not to preſcribe to nature thoſe alone which we think ſuitable for the purpoſe, in our narrow view. It is our buſineſs to learn of nature (that is by obſervation) the ways and means, which in her wiſdom are adopted; and we are to imagine theſe only in order to find means for further information, and to increaſe our knowledge from the examination of things which actually have been. It is in this manner, that intention may be found in nature; but this

this intention is not to be ſuppoſed, or vainly imagined, from what we may conceive to be.

We have been now ſuppoſing, that the beginning of our preſent earth had been laid in the bottom of the ocean, at the completion of the former land; but this was only for the ſake of diſtinctneſs. The juſt view is this, that when the former land of the globe had been complete, ſo as to begin to waſte and be impaired by the encroachment of the ſea, the preſent land began to appear above the ſurface of the ocean. In this manner we ſuppoſe a due proportion to be always preſerved of land and water upon the ſurface of the globe, for the purpoſe of a habitable world, ſuch as this which we poſſeſs. We thus, alſo, allow time and opportunity for the tranſlation 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 laſt began to be reſolved, it could not be from the materials of the continent immediately preceding this which we examine, that the preſent earth had been conſtructed; for the bottom of the ocean muſt have been filled with materials before land could be made to appear above its ſurface.

Let us ſuppoſe that the continent, which is to ſucceed our land, is at preſent beginning to appear above the water in the middle of the Pacific Ocean, it muſt be evident, that the materials of this great body, which is formed and ready to be brought forth, muſt have been collected from the deſtruction of an earth which does not now appear. Conſequently, in this true ſtatement of the caſe, there is neceſſarily required the deſtruction of an animal and vegetable earth prior to the former land; and the materials of that earth which is firſt in our account, muſt have been collected at the bottom of the ocean, and begun to be concocted for the production of the preſent earth, when the land immediately preceding the preſent had arrived at its full extent.

This,

THIS, however, alters nothing with regard to the nature of thoſe operations of the globe. The ſyſtem is ſtill the ſame. It only protracts the indefinite ſpace of time in its exiſtence, while it gives us a view of another diſtinct period of the living world; that is to ſay, the world which we inhabit is compoſed of the materials, not of the earth which was the immediate predeceſſor of the preſent, but of the earth which, in aſcending from the preſent, we conſider as the third, and which had preceded the land that was above the ſurface of the ſea, while our preſent land was yet beneath the water of the ocean. Here are three diſtinct ſucceſſive periods of exiſtence, and each of theſe is, in our meaſurement of time, a thing of indefinite duration.

WE have now got to the end of our reaſoning; we have no data further to conclude immediately from that which actually is: But we have got enough; we have the ſatisfaction to find, that in nature there is wiſdom, ſyſtem, and conſiſtency. For having, in the natural hiſtory of this earth, ſeen a ſucceſſion of worlds, we may from this conclude that there is a ſyſtem in nature; in like manner as, from ſeeing revolutions of the planets, it is concluded, that there is a ſyſtem by which they are intended to continue thoſe revolutions. But if the ſucceſſion of worlds is eſtabliſhed in the ſyſtem of nature, it is in vain to look for any thing higher in the origin of the earth. The reſult, therefore, of our preſent enquiry is, that we find no veſtige of a beginning,—no proſpect of an end.



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.

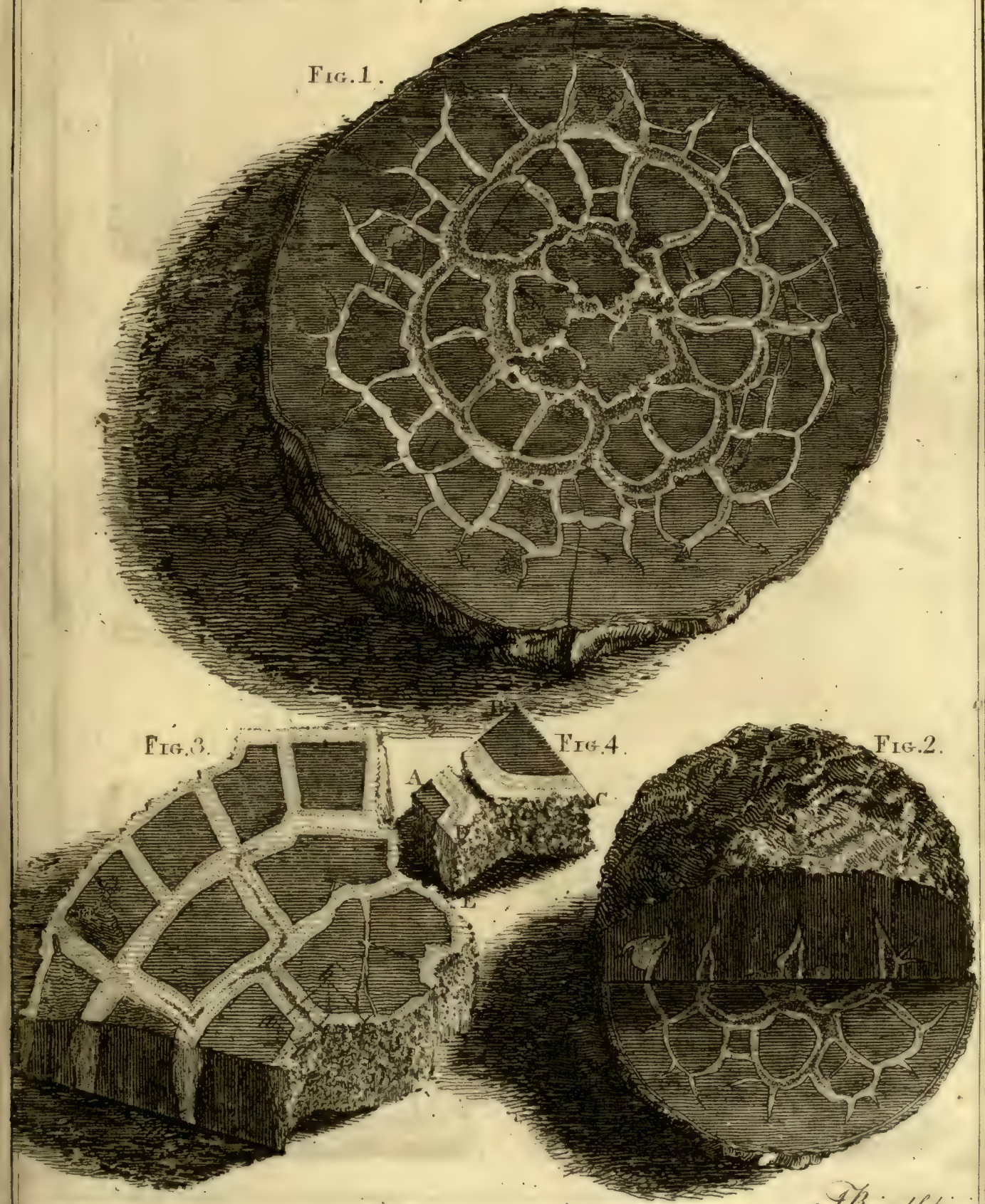


FIG. 3.

FIG. 4.

FIG. 2.

J. Bruno del. et inci.



FIG. 1.

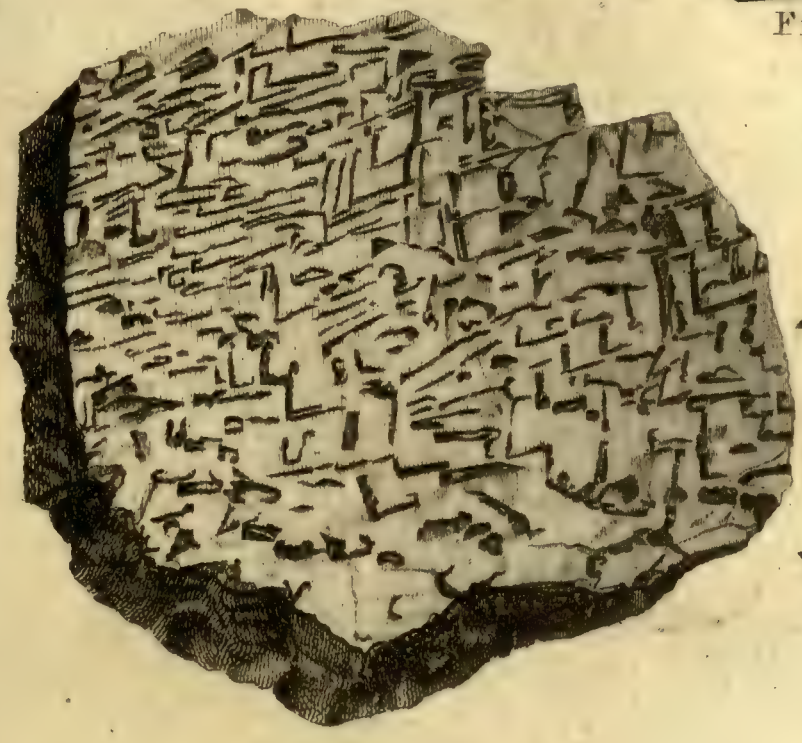


FIG. 4.



FIG. 5.



FIG. 6.



FIG. 7.

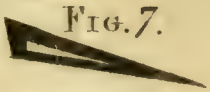


FIG. 8.



FIG. 9.



FIG. 10.

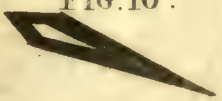


FIG. 2.

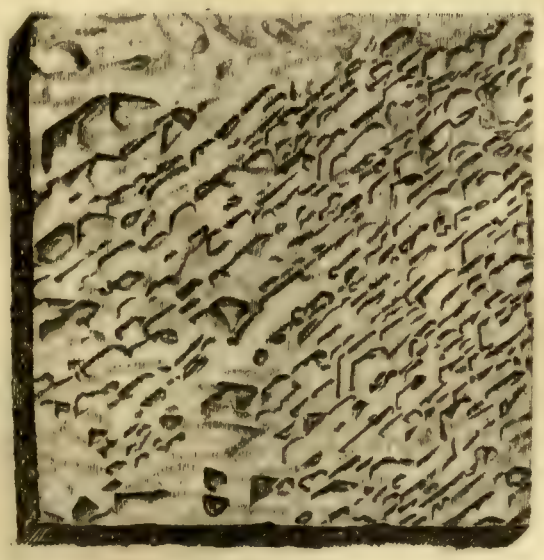
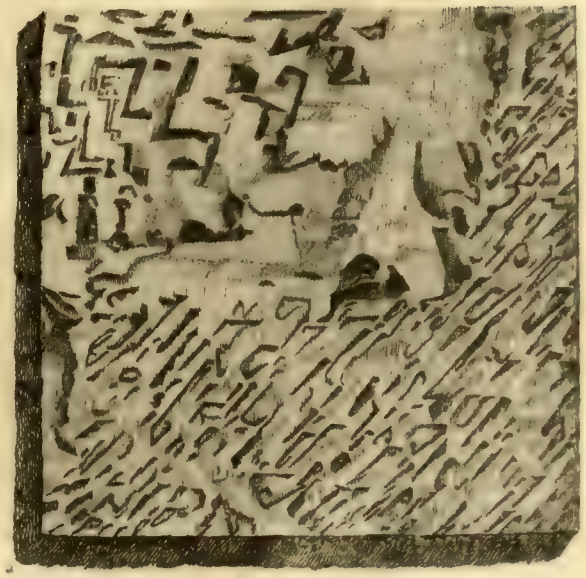


FIG. 3.




BRITISH MUSEUM
NATURAL HISTORY

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 vicinity to the Ecliptic, the direction of its motion, and its being nearly ſtationary at the time of its diſcovery, in ſuch an aſpect with reſpect to the Sun, as correſponds to the ſtationary appearance of the Planets. The French aſtronomers imagined it a Comet, although it had not that train of faint light which uſually diſtinguiſhes thoſe bodies; and, in the courſe of the year 1781, endeavoured to determine the elements of its motion on this ſuppoſition, but could not find out ſuch as would correſpond with its ſucceſſive appearances. They at laſt found themſelves obliged to ſuppoſe, that it moved round the Sun in an orbit nearly circular. Mr LEXEL, Profeſſor of aſtronomy at St Peterſburg, was the firſt who attempted a computation of its motion on this principle; and ſhowed that a circular orbit, the radius of which is about nineteen times the diſtance of the earth from the ſun, would very nearly agree with all the obſervations made during the year 1781. The firſt diſtinct information which I got of it was in June 1782, from Mr MINTO, a gentleman of this place, who communicated to me a ſeries of excellent obſervations made by Profeſſor SLOP at Piſa. This ſeries contained the means of determining with accuracy the ſtationary points of the Planet in October 1781 and March 1782, and its oppoſition in December 1781. From theſe, I was enabled to aſcertain with great eaſe, the radius of its circular orbit. For, at its ſtationary appearance, we have the ſquare of the coſine of its elongation from the Sun $= \frac{r^2-1}{r^3-1}$, r being the radius, and the earth's mean diſtance being 1. The oppoſition in December 1781, gives us one place of the Planet as viewed from the Sun, independent of all hypotheſes. With theſe data, it was eaſy for me to determine the apparent place of the Star for any time, and compare it with obſervation; and the reſult of this compariſon was ſuch as to ſhow, that the opinion was very nearly true, the greateſt errors not amounting

to

to more than what might reaſonably be attributed to the inaccuracy of obſervation.

ASTRONOMERS were every where engaged in the ſame reſearch; and it occurred to ſome of them, that the Star might poſſibly have been obſerved before, by thoſe who were employed in making catalogues of the Zodiacal Stars. Mr BODE of Berlin had juſt publiſhed a valuable work, in which all the catalogues of the Stars were included. He had recourſe to his papers, where he had marked all the difference of theſe catalogues, in order to diſcover whether any Star, obſerved by one aſtronomer, and omitted by another, might not be this Star of Mr HERSCHEL, paying attention to thoſe differences only which he could find in the parts of the Zodiac, through which the nearly determined orbit of this newly diſcovered Planet might be ſuppoſed to paſs. Among others, he found the Star, No. 964. of MAYER's Catalogue, not obſerved by others, and but once obſerved by MAYER, who could not therefore diſcover any motion in it. Mr BODE immediately examined the heavens, and could not find this Star. He farther found, that the elements of the new Planet aſſigned to it that very apparent place, in the month of September 1756, one of the years in which MAYER was occupied with theſe obſervations. On examining the regiſter of MAYER's obſervations, it was found, that he had obſerved 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 ſince been currently ſuppoſed, that the Star obſerved by MAYER was the Planet of HERSCHEL.

IT was found, even before the end of 1782, that the circular hypotheſis was not exact, and that the angular motion of the Planet round the Sun was increaſing. This ſhowed, that the Planet was not moving in a circle, but in an excentric orbit, and was approaching to the Sun. Aſtronomers, therefore, began to inveſtigate the inequality of this angular heliocentric motion, in order to diſcover the form and poſition of the ellipſe

deſcribed by the Planet. This was a very difficult taſk; for the very ſmall inequality of the motion ſhowed that the orbit was nearly circular; and the arch already deſcribed was not much more than the fiftieth part of the whole circumference. The ſolution of the problem requires us to determine, from the variation of curvature diſcoverable in this ſmall arch, to what part of the circumference it belongs. This requires the utmoſt accuracy in the obſervations, and great ſagacity 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 ſuſceptible of a very eaſy ſolution; for that Star is ſituated more than a quarter of a revolution from the place of the Planet in 1782, and ſo fortunately, that almoſt the whole effect of the excentricity and inequality of the motion is accumulated. Aſtronomers, therefore, availed themſelves of this obſervation of Mr BODE, and quickly found, by repeated trials, elements of the motions, which correſponded perfectly with MAYER's obſervation, and all thoſe made ſince Mr HERSCHEL firſt got ſight of the Planet. But they do not all ſeem diſpoſed to confeſs their obligation to Mr BODE. Some of them affect to have deduced their elements directly from obſervations, by the formulæ expreſſive of the elliptical motion of the Planets, and to be agreeably ſurpriſed with afterwards obſerving the coincidence of their elements with this obſervation of MAYER. They have not given a detail of their methods of inveſtigation.

OF

* THE firſt perſon 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 obſervations of Mr MECHAIN. His method is exceedingly ingenious, and remarkable for that ſimplicity and geometrical elegance which characteriſe all his performances. It did not come to my knowledge till the beginning of this preſent year 1787, when I found it in the Collection which he publiſhed at Baſſano, in 1785, in five volumes. He makes uſe of the ſame phyſical principles which I employed in January 1783, to determine the orbit by the two oppoſitions which had then been obſerved, combined with another obſervation, made at the diſtance of a ſydereal year from one of the oppoſitions. This method I communicated to Dr MASKELYNE in 1783.

Of all the theories of this Planet which I have ſeen, that of M. DE LA PLACE, communicated to the Royal Academy of Sciences at Paris, appears the moſt accurate, and very nearly correſponds to the obſervations which have been made ſince the time of its publication. This theory was announced to the public in the *Connoiſſance des Mouvemens Celeſtes*, as deduced directly from the recent obſervations, by a method peculiar to M. DE LA PLACE. This I hoped to find in an excellent diſſertation 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 diſappointed in my hopes of learning the proceſs by which he had deduced his theory of the new Planet. He has, indeed, inſerted in this work the elements of its orbit, and the four obſervations which he had employed for determining them, by a new method of conſidering 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 thoſe obſervations, I found ſuch differences as would have allowed him to make choice of elements conſiderably different. It appears, therefore, that, before applying his method, he has corrected the obſervations on ſome juſtifiable principle, which I regret exceedingly that he has not communicated, ſince he has been ſo ſucceſsful in the uſe of it. It would, doubtleſs, have been much more deſerving of the notice of mathematicians than the empirical one which I have adopted in the ſubſequent part of this paper.

In ſpring 1784, I framed a ſet of elements which correſponded with the obſervations made at that time with abundant accuracy. Mr MINTO, whom I have already mentioned, alſo communicated to me elements, little differing from mine, and equally accurate. Both theſe were deduced from a ſuppoſition that the Star obſerved by MAYER was the new Planet. We had, by this time, great advantages over our predeceſſors; for a much

much larger portion of the arch had been obſerved; and, which was of immenſe conſequence, three oppoſitions had been obſerved, which gave us three poſitions of the Planet, independent of all hypotheſes. The arches deſcribed between theſe oppoſitions 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 chuſing ſuch obſervations of the Star as ſhould give a great difference between the heliocentric and geocentric place, the radius of the earth's orbit became a baſe, by which we could meaſure, with conſiderable accuracy, its diſtance from the Sun. Thus, having both its poſition and diſtance from the Sun, we could aſſign its abſolute place in the heavens, and conſequently the form of its path.

In the beginning of 1785, another oppoſition was obſerved, and thus a method obtained of deducing the elements directly. But this required a proceſs ſo extremely complicated, in order to obtain tolerable accuracy in the reſult, that I had not the courage to attempt it. I waited patiently till a fifth oppoſition ſhould be obſerved with four intercepted arches. This, I ſaw, would afford a method extremely ſimple and eaſy, and, at the ſame time, ſuſceptible of conſiderable 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 ſurely deſirable not to reſt our knowledge of the motions of this Planet on mere conjecture, whatever probability there may be of its truth from the coincidence of obſervations. I muſt, at the ſame time, acknowledge beforehand, that the reſult of my inveſtigation 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 ſame with

964 of MAYER, near half a century muſt elapſe before the elements 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, within which all the circumſtances of its motion muſt be comprehended. This alone muſt be regarded as a conſiderable attainment.

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 Profeſſor SLOP at Piſa, on the 22d, 23d, 27th, and 28th. The heliocentric place at the oppoſition 1782, was determined from obſervations 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 Keplerian law, that the ſquares of the angular motions are inverſely as the cubes of the diſtances. The heliocentric angular motion, at any oppoſition, muſt be very nearly a medium between 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 accuracy,

curacy, the heliocentric angular motion at the three intermediate oppoſitions. The angular velocities at the two extreme oppoſitions were determined with equal accuracy, by ſuppoſing, 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 appoſition, and conſequently to aſſign, from each obſervation, the preciſe time and place where the Planet would be in oppoſition to the Sun. Theſe determinations differed from each other in no caſe 10″. It is demonſtrable, that the aſſumptions made for this combination of obſervations could not produce an error of 2″. I therefore, with confidence, took the means of theſe determinations for the places of the Planet, in its apparent oppoſitions to the Sun.

THE times and apparent longitudes and latitudes of the Planet are expreſſed 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 obſerving 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 ſome Stars which are to be found in MAYER's Catalogue alone. I have, therefore, always made uſe of this Catalogue. If, therefore, the following theory be confronted with an obſervation, where the geocentric place of the Planet is deduced from a compariſon 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 ſmall, or as much too great.

THE

THE manner of obſervation, and the inſtrument which I make uſe of, appear to me to have ſeveral advantages which are not unworthy of the attention of Aſtronomers. An account of them will therefore be communicated on ſome future occaſion.

FROM theſe places, it is eaſy 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:

	s.	°	″	′
Long. Node, Jan. 1. 1786.	2.	12.	48.	45
Inclin. Orbit,			46.	26

I WAS now enabled to reduce theſe Ecliptic places to the orbit itſelf, and thus to determine the arches of this orbit deſcribed during the intervals between the oppoſitions.

I THEN took the oppoſition which was obſerved on the 31ſt of December 1783 for an epoch, to which all the obſervations ſhould be reduced. The interval of time between this and the preceding oppoſition was 369 *d.* 15 *h.* 49′. 28″. I counted back another equal interval, which brought me within a few minutes of the time of oppoſition 1781, and I computed (by means of the heliocentric motion, already determined for that oppoſition with ſufficient 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, deſcribed in equal intervals of time. The differences of theſe angles ſhowed 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 theſe differences, ſtrictly taken, had irregularities which are inconſiſtent with the moſt remarkable circumſtances of the Planet's motions. It appeared, therefore, that the obſervations muſt be corrected, as far as is conſiſtent with the probability of their inaccuracy. With reſpect

to the obſervations of Dr MASKELYNE and Mr SLOP, made with inſtruments equal to any in Europe, this inaccuracy ſhould not be ſuppoſed greater than 5″. With reſpect to my own, I will allow it to amount to 10″.

THE queſtion is now, upon what good principle we may preſume to correct the obſervations. When the Planet appears ſtationary, we have the beſt opportunity of aſcertaining its diſtance from the Sun, by means of an imperfect knowledge of its angular motion, the earth's diſtance from the Sun affording a baſe moſt advantageouſly ſituated. Mr MINTO has communicated to me Mr SLOP's obſervations of the Planet when in this ſituation. On 1782, March, 6 *d.* 6 *h.* 14′. 56″. M. T. Greenwich, the apparent longitude of the Planet was obſerved 2 *s.* 28°. 49′. 27″. on the Ecliptic. The five obſerved oppoſitions give us the firſt and ſecond differences of the heliocentric motion at thoſe oppoſitions. By theſe means we obtain, by the uſual methods of interpolation, the heliocentric place of the Planet at the time of the above obſervation, and this without an error amounting to 2″. By comparing this with the geocentric place, we obtain the Planet's diſtance from the Sun = 18,9053. By making a ſimilar interpolation for March 7 *d.* 6 *h.* 14′. 56″, we obtain another heliocentric place of the Planet. The difference of theſe two places gives the diurnal heliocentric motion = 43″,4365. But a Planet deſcribing round the Sun a circle whoſe radius is 18, 9053, will have its diurnal motion = 43″,1647.

FROM this it is demonſtrable, that the Planet's diſtance from the Sun is greater than half the parameter of its orbit; and that its true anomaly, or diſtance from its aphelion, is more than 90° *. On the other hand, we find, from the continual acceleration of its motion, that, at the oppoſition 1785, the Planet had

* FOR the angular velocity of a body in an ellipſe, is to that of a body in a circle, at the ſame diſtance, in the ſubduplicate ratio of the half parameter to the diſtance.

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 $2\frac{1}{2}$″; 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

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		
	1. 54,5	
4. 29. 21		1
	1. 53,5	
4. 31. 14,5		2
	1. 51,5	
4. 33. 06		

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 ſucceſſive oppoſitions to the Sun; draw the chords AB, BC, CD, DE, AC, CE, and the radii vectores AS, BS, CS, DS, ES. We may ſuppoſe that the points χ and γ, where the chords AC, CE, are interſected by the radii vectores BS, DS, are in the middle of thoſe chords. For, let us ſuppoſe that thoſe chords are biſected in χ and γ by radii SB and SD, the rectilineal triangles ABS, BCS are equal, and the ſegments cut off by the chords AB, BC are very nearly equal; theſe ſegments are very ſmall in compariſon with the triangles ABχ, BχC, and theſe triangles are very ſmall in compariſon with the triangles AχS, χCS. Therefore, the elliptical ſectors ABS, BCS, are very nearly equal, and B is very nearly the place of the Planet at the ſecond oppoſition.

LET the angles ASB be $= u$, BSC $= v$, CSD $= x$, DSE $= y$, ASC $= w$, CSE $= z$, AχS $= \chi$, and CγS $= \gamma$.

Then,	AS : Aχ	$= \mathit{ſin.}\ \chi : \mathit{ſin.}\ u$,
and	Cχ, or Aχ : CS	$= \mathit{ſin.}\ v : \mathit{ſin.}\ \chi$.
therefore,	AS : CS	$= \mathit{ſin.}\ v : \mathit{ſin.}\ u$,
alſo,	ES : CS	$= \mathit{ſin.}\ x : \mathit{ſin.}\ y$.

THUS, we have obtained the ratio of the three diſtances AS, CS, ES, and we have the angles ASC, CSE, given by obſervation. This is all that is neceſſary for conſtructing the ellipſe, by means of the 21ſt prop. of NEWTON's Principia, B. I. or of a theorem to be delivered afterwards.

THIS ellipſe will be found to have its ſemitranſverſe axis about nineteen times the earth's diſtance from the Sun, and its excentricity about $\frac{1}{20}$ of its ſemitranſverſe axis, and the angle PSC about 73°. As it approaches very near to the form of the ellipſe really deſcribed by the Planet, we may diſcover, by its means, the errors which have ariſen from the ſuppoſition that the ſectors ASB, BSC, are equal, when Aχ is equal to χB.

FOR

For this purpoſe, biſect AE in F, draw OF$\varkappa$ and SFc; make $\varkappa$c to Cc, as cS to cF; draw CφS, and draw OK parallel AE: It is evident that $\varkappa$c may be conſidered as a ſtraight line parallel to EA; the ſegments E$\varkappa$F, F$\varkappa$A, are equal, and the triangles EFS, FSA, are equal; therefore the elliptical ſpaces E$\varkappa$FS, $\varkappa$FSA are equal; but the triangles $\varkappa$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. $\varkappa$c is to cF as OK to KF; and therefore $\varkappa$c is nearly $\frac{1}{20}$ of cF, or $\frac{1}{1600}$ of cS. Cc is $\frac{1}{80}$ of $\varkappa$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

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, $\eth$Gd, are nearly ſimilar; and therefore, cF : dG = AE^2 : CE^2 nearly; therefore the triangle $\varkappa$cF : $\eth$Gd = 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,	Cγ : Cγ = *ſin.* γ : *ſin.* x,
and	Cγ : Eγ = Cγ : Eγ,
and	Eγ : ES = *ſin.* y : *ſin.* γ,
therefore,	CS : ES = Cγ × *ſin.* y : Eγ × *ſin.* x.
Let	CS : eS = *ſin.* y : *ſin.* x,
then,	ES : eS = Eγ : Cγ,
and	ES : Ee = Eγ : Cγ — Eγ, = Eγ : 2γG.

In like manner, make CS : aS = *ſin.* u : *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 = *ſin.* z : *ſin.* w,
then, (becauſe	SE : AS = Eφ × *ſin.* w : Aφ × *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 = *ſin.* z : *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:

$$\begin{aligned} \text{Make}\quad CS : aS &= \sin. u : \sin. v, \\ CS : eS &= \sin. y : \sin. x, \\ eS : \alpha S &= \sin. w : \sin. z, \\ aS : \varepsilon S &= \sin. z : \sin. w. \end{aligned}$$

Then make $AS = aS + \frac{a\alpha}{6}$, and $ES = eS - \frac{\varepsilon e}{6}$. Then the points A, C, E, will be in the circumference of an ellipſe, of which S is the focus, and O the centre, and having the ſectors ASC, CSE, very nearly equal.

THE approximation will be much eaſier, and almoſt as accurate, if $\frac{1}{6}$ of the difference of the logarithms of aS and αS be added to the logarithm of aS, for the logarithm of AS, and $\frac{1}{6}$ 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 ſufficient to add $\frac{1}{6}$ 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 uſe for conſtructing the ellipſe, and, I believe, is new:

LET DAP be an ellipſe, (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 $=$ sx : sA, $=$ CS $-$ ES : AS $-$ ES, $= c-e : a-e$; alſo, SF $= c.\mathit{cof}, y$, SG $= a.\mathit{cof}, x$, CF $= c.\mathit{ſin}, y$, and AG $= a.\mathit{ſin}, x$; alſo, the angle FCH $=$ GAK, $=$ ESP, $= z$.

Therefore, FH $=$ CF.tan, z, $= c.\mathit{ſin}, y.\mathit{tan}, z$, and GK $= a.\mathit{ſin}, x.\mathit{tan}, z$; therefore, EH $= e - c.\mathit{cof}, y + c.\mathit{ſin}, y.\mathit{tan}, z$, and EK $= e - a.\mathit{cof}, x + a.\mathit{ſin}, x.\mathit{tan}, z$; therefore, $c-e : a-e = e - c.\mathit{cof}, y + c.\mathit{ſin}, y.\mathit{tan}, z : e - a.\mathit{cof}, x + a.\mathit{ſin}, x.\mathit{tan}, z$, and $(c-e).(e-a.\mathit{cof}, x) + (c-e).a.\mathit{ſin}, x.\mathit{tan}, z = (a-e).(e-c.\mathit{cof}, y) + (a-e).c.\mathit{ſin}, y.\mathit{tan}, z$. This gives,

$$\mathit{Tan}, z = \frac{(c-e).(e-a.\mathit{cof}, x) - (a-e).(e-c.\mathit{cof}, y)}{c.(a-e)\mathit{ſin}, y - a.(c-e).\mathit{ſin}, x}$$

Or, more conveniently for logarithms,

$$\mathit{Tan}, z = \frac{c.(a-e).\mathit{cof}, y - a.(c-e)\,\mathit{cof}, x - e.(a-c)}{c.(a-e).\mathit{ſin}, y - a.(c-e).\mathit{ſin}, x}$$

Then, by the common theorems, we have the excentricity $s = \frac{a-e}{e.\mathit{cof}, z - a.\mathit{cof}, (x+z)}$, the mean diſtance being $= 1$. The aphelion and perihelion diſtances are $1 + s$ and $1 - s$. 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.

		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

Mean Longitude, 1786 Jan. 1. Noon. M. T.	s. ° ′ ″
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 ſuppoſition of the moſt rapid decreaſe of the ſecond differences will agree very well with FLAMSTEAD's obſervation of that Star on December 13. 1690, being only 40″, or perhaps only 12″, to the weſtward of it. But the latitude differs more than two minutes from FLAMSTEAD's latitude, which is rightly deduced from the Zenith diſtance. This is too great an error for him to commit in the obſervation, and we ſhould therefore reject the ſuppoſition on this account alone. But there are ſtronger reaſons for rejecting it, ariſing from the diſagreement of thoſe elements with the obſervations made on the ſtations of the Planet in October 1781, and March and October 1782, which give us a very near approximation to its diſtance from the Sun. When compared with obſervations of the Planet near its ſtationary points in the Spring, they give the geocentric longitude conſiderably too great, while they give it too ſmall for the ſimilar obſervations in Autumn.

THE appearance of this Planet has ſerved to exerciſe the ingenuity of mathematicians, by a problem conſiderably different from that afforded by the motions of comets in very excentric orbits; and, by this means, has favoured the public with many improvements in analytical knowledge. My profeſſional duty has made me confine myſelf chiefly to the ſearch of ſuch methods as might be very intelligible to perſons poſſeſſed of ſmall 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 ſkilful mathematicians, I hope it will be uſeful, becauſe it may incite beginners to a zealous proſecution of this noble ſtudy, by ſhowing them ſome of its moſt pleaſing gratifications. I may add, that the method now exhibited is one of the moſt likely to give us an accurate knowledge of the Planet's motion. Another period of four years will enable us to apply it to arches of double extent, which will diminiſh the errors ariſing from the unavoidable inaccuracy of obſervations to one fourth of their preſent quantity, and a compariſon of the new elements with thoſe now given,

given, will enable us to diminiſh them as much again. When it is conſidered, that in thoſe elements no attention has been paid to the gravitation of the Planet to the other ſix, it will ſtill more clearly appear how abundantly accurate they are for the purpoſes of aſtronomical computation.

I TOOK another method of obtaining elements, by means of the ratio of three diſtances from the Sun; namely, by interpolating heliocentric places of the Planet, for the times of its vicinity to its ſtations, and comparing theſe with its geocentric places. It is eaſy to ſee, that this method alſo is ſuſceptible of great accuracy, after having obſerved five oppoſitions, which give us ſecond and third differences of the heliocentric places, and therefore afford a proper application of the methods of interpolation. Elements deduced in this way, almoſt perfectly coincided with the above. I alſo obtained, in January 1784, a ſet of elements very nearly the ſame, by means of the three oppoſitions which had then been obſerved, and by the help of a theorem which I make uſe of in my elements of phyſical aſtronomy, *viz.* That the velocity of a body, in any point of the path which it deſcribes by the action of a centripetal force, is that which it would acquire if uniformly impelled by the centripetal force along $\frac{1}{4}$ of that chord of the oſculating circle which paſſes through the centre of forces.

I SHALL here ſubjoin 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 Greenwich, at the beginning of the Aſtronomical Year, that is, for the Mean Noon of the 31ſt of December immediately preceding. It alſo contains the Mean Sydereal Motions of the Planet for months, days, and hours, and the preceſſion of the Equinoxes at the beginning of each month. The ſydereal motions are choſen in preference to the tropical, becauſe the motions of the aphelion and node are not yet known. One application of the preceſſion of the equinoctial points, is therefore ſufficient.

TABLE

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. ° ′ ″
1787. M. Lon. Plan.	3. 28. 00. 12,5
Jan.	0. 00. 00. 00
13. M. Mot.	9. 13,2
4	,7,1
56′	1,7
	3. 28. 09. 34,5
Eq. Orbit,	4. 36. 59,3
	3. 23. 32. 35,2
Prec.—Red.	7,4
Plan. for M. Eq^{x}.	3. 23. 32. 27,8

	s. ° ′ ″
Lon. Aphel.	11. 23. 11. 28
	3. 28. 09. 35
M. An.	4. 04. 58. 07
Log. diſt. ☉	1.2694179
Red. Log.	168
Log. curt. diſt.	1. 2694011

	s. ° ′ ″
Lon. Nod.	2. 12. 49. 35
	3. 23. 32. 35
Arg. Lat.	1. 10. 43. 00
Hel. Lat. N.	30. 15

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 o ′ ″	s o ′ ″	s o ′ ″
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.
	o ′ ″	″
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.

	O		I.		II.		
	—	Diff.	—	Diff.	—	Diff.	
°	° ′ ″	′ ″	° ′ ″	′ ″	° ′ ″	′ ″	°
0	0. 00. 00,0	5. 23,0	2. 3 5 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.	1st and 2d halfs.	1775. Therm.	Rain.	Evapor.	1776. Therm.	Rain.	
		Deg.	Inch.	Inch.	Deg.	Inch.	
January,	1	39.10			33.33		
	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		

Medium of heat for the ſix preceding years, deg. 45.06.

Greateſt

Greateſt Degrees of Cold and Heat, obſerved at Hawkhill, from 1766 to 1776 incluſive.

		Fahr. Therm.
1767. January 17.	at 8¼ 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 3¼ h. P. M. - -	81.15

Proportion of the Weſt Wind to the Eaſt for every Month, deduced 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.

N°. VII.

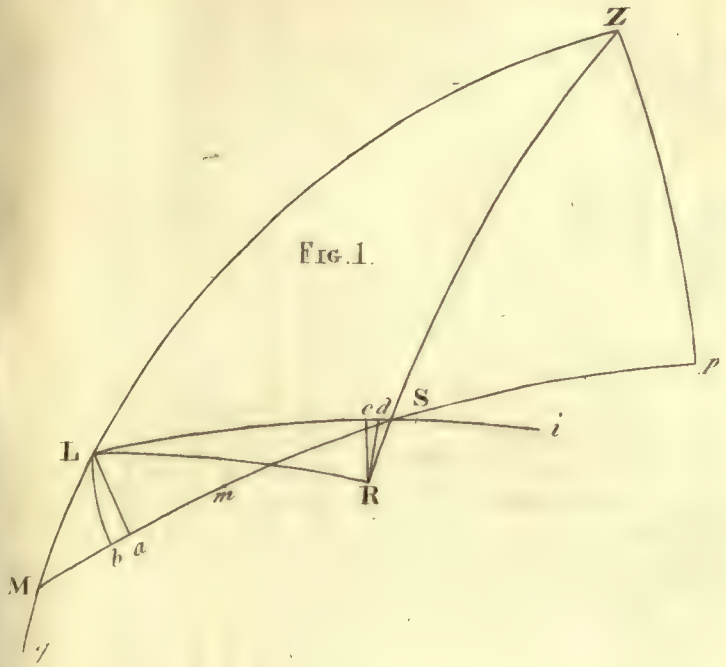


Fig. 1.

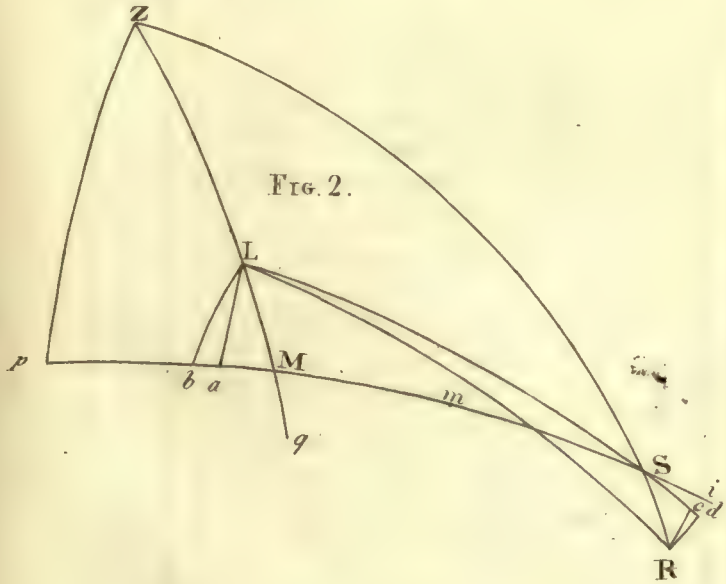


Fig. 2.

N°. XI.

To front P. 336 of Papers of the Phys: Cl:

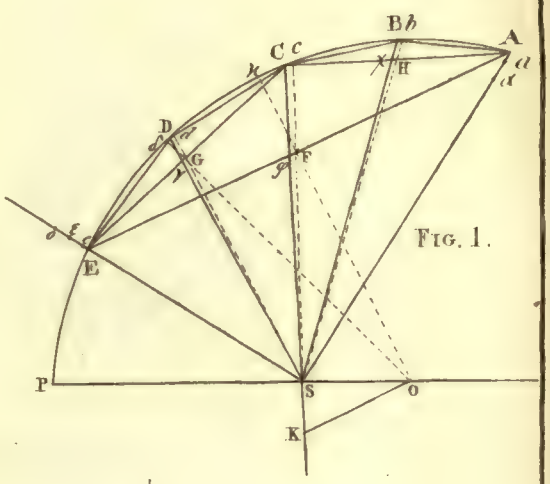


Fig. 1.

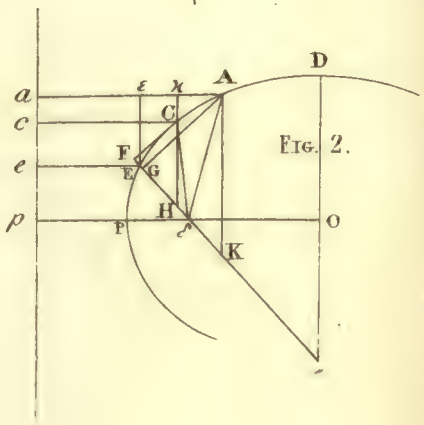


Fig. 2.

BRITISH MUSEUM
NATURAL HISTORY.

TAB. II. Elliptical Equation.

Arg. M. An.	III.	Diff.	IV.	Diff.	V.	Diff.	Arg. M. An.
	—		—		—		
°	° ′ ″	′ ″	° ′ ″	′ ″	° ′ ″	′ ″	°
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		25
		0. 11,5		3. 10,9		5. 25,1	
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		20
		0. 42,7		3. 38,0		5. 39,0	
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		15
		1. 13,1		4. 03,4		5. 50,0	
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		10
		1. 43,3		4. 27,2		5. 57,9	
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		5
		2. 12,9		4. 48,9		6. 02,5	
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.		

TAB. III. Logarithm of the PLANET's Distance from the SUN.

Arg. M. An.

	☉		☿ I.		☿ II.		
☿	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	☿
0	1.3008817		1.2984548		1.2916063		30
		27		1619		2914	
1	1.3008790		1.2982929		1.2913149		29
		82		1669		2949	
2	1.3008708		1.2981260		1.2910200		28
		137		1718		2983	
3	1,3008571		1.2979542		1.2907217		27
		192		1767		3015	
4	1.3008379		1.2977775		1.2904202		26
		246		1816		3047	
5	1.3008133		1.2975959		1.2901155		25
		300		1865		3078	
6	1.3007833		1.2974094		1.2898077		24
		355		1912		3109	
7	1.3007478		1.2972182		1.2894968		23
		410		1959		3140	
8	1.3007068		1.2970224		1.2891828		22
		464		2006		3169	
9	1.3006604		1.2968218		1.2888659		21
		519		2053		3197	
10	1.3006085		1.2966165		1.2885462		20
		573		2100		3225	
11	1.3005512		1.2964065		1.2882237		19
		626		2145		3252	
12	1.3004886		1.2961920		1.2878985		18
		680		2190		3277	
13	1.3004206		1.2959730		1.2875708		17
		734		2235		3302	
14	1.3003472		1.2957495		1.2872406		16
		788		2279		3326	
15	1.3002684		1.2955216		1.2869080		15
		842		2324		3350	
16	1.3001842		1.2952892		1.2865730		14
		895		2367		3372	
17	1.3000947		1.2950525		1.2862358		13
		948		2409		3394	
18	1.2999999		2.2948116		1.2858964		12
		1001		2452		3414	
19	1.2998998		1.2945664		1.2855550		11
		1053		2494		3434	
20	1.2997945		1.2943170		1.2852116		10
		1106		2535		3454	
21	1.2996839		1.2940635		1.2848662		9
		1160		2575		3472	
22	1.2995679		1.2938060		1.2845190		8
		1212		2615		3488	
23	1.2994467		1.2935445		1.2841702		7
		1264		2655		3504	
24	1.2993203		1.2932790		1.2838198		6
		1315		2695		3518	
25	1.2991888		1.2930095		1.2834680		5
		1366		2733		3532	
26	1.2990522		1.2927362		1.2831148		4
		1417		2770		3545	
27	1.2989105		1.2924592		1.2827603		3
		1469		2806		3558	
28	1.2987636		1.2921786		1.2824045		2
		1519		2843		3569	
29	1.2986117		1.2918943		1.2820476		1
		1569		2879		3580	
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.		IV.		V.		
°	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	°
0	1.2816896		1.2710423		1.2627235		30
		3588		3325		2010	
1	1.2813308		1.2707098		1.2625225		29
		3596		3299		1951	
2	1.2809712		1.2703799		1.2623274		28
		3602		3271		1892	
3	1.2806110		1.2700528		1.2621382		27
		3607		3240		1830	
4	1.2802503		1.2697288		1.2619552		26
		3612		3210		1767	
5	1.2798891		1.2694078		1.2617785		25
		3616		3179		1705	
6	1.2795275		1.2690899		1.2616080		24
		3619		3145		1641	
7	1.2791656		1.2687754		1.2614439		23
		3620		3110		1576	
8	1.2788036		1.2684644		1.2612863		22
		3620		3074		1511	
9	1.2784416		1.2681570		1.2611352		21
		3619		3037		1446	
10	1.2780797		1.2678533		1.2609906		20
		3616		2999		1380	
11	1.2777181		1.2675534		1.2608526		19
		3614		2960		1312	
12	1.2773567		1.2672574		1.2607214		18
		3609		2921		1245	
13	1.2769958		1.2669653		1.2605969		17
		3604		2880		1176	
14	1.2766354		1.2666773		1.2604793		16
		3597		2837		1107	
15	1.2762757		1.2663936		1.2603686		15
		3589		2793		1039	
16	1.2759168		1.2661143		1.2602647		14
		3579		2747		970	
17	1.2755589		1.2658396		1.2601677		13
		3569		2701		900	
18	1.2752020		1.2655695		1.2600777		12
		3559		2654		829	
19	1.2748461		1.2653041		1.2599948		11
		3546		2607		758	
20	1.2744915		1.2650434		1.2599190		10
		3531		2559		688	
21	1.2741384		1.2647875		1.2598504		9
		3516		2508		616	
22	1.2737868		1.2645367		1.2597888		8
		3501		2456		543	
23	1.2734367		1.2642911		1.2597345		7
		3483		2404		471	
24	1.2730884		1.2640507		1.2596874		6
		3464		2350		399	
25	1.2727420		1.2638157		1.2596475		5
		3444		2296		327	
26	1.2723976		1.2635861		1.2596148		4
		3423		2241		255	
27	1.2720553		1.2633620		1.2595893		3
		3401		2186		182	
28	1.2717152		1.2631434		1.2595711		2
		3377		2129		110	
29	1.2713775		1.2629305		1.2595601		1
		3352		2070		37	
30	1.2710423		1.2627235		1.2595564		0
	Logar.	Diff.	Logar.	Diff.	Logar.	Diff.	
	VIII.		VII.		VI.		

TABLE IV.

	0. *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.

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 the rights of the kings, of the nobility, and of the people, came to be a matter of general diſcuſſion: And as men are uſually prejudiced in favour of the wiſdom of their remote anceſtors, and derive their more common notions of their political rights from what was cuſtomary in ancient times, the merits of the diſpute were univerſally ſuppoſed to turn on the hiſtorical queſtion of fact, What conſtitution was adopted by the original founders of each particular nation.

HENCE the firſt reſearches into the ancient hiſtory of the European governments were made with a view to ſupport the tenets of political factions. Thoſe who wiſhed to gain the favour of courts laboured to prove the ancient ſovereignty of the Gothic kings, and founded their ſyſtems on the deſpotic powers of the leader of a conquering army, and the abſolute nature of a right of conqueſt; from whence they inferred, that the privileges of the ariſtocracy were uſurpations 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 underſtood and exerciſed in the fulleſt manner in the earlieſt ages of the conſtitution; and they contended, that the happineſs of thoſe times was to be reſtored only, by the people reſuming the conſtitutional powers which kings and nobles had alternately uſurped. In fine, thoſe who had imbibed from the Greek and Roman claſſics, or from family-connections, a profound reverence for ariſtocratic virtues, together with a proportionable averſion to plebeian manners, delighted to eſpouſe the cauſe of the falling nobility, to diſplay the ancient powers of the order, and to confute their antagoniſts, by tracing the circumſcribed limits of the royal prerogative in remote times, the oppreſſions under which the commons laboured, and the little importance they poſſeſſed in national affairs.

IN this way, opinions with regard to the original ſtructure of the European governments entered into the creeds of contending

ing factions; and though theſe, in courſe of time, ceaſed to be the ſubject of profeſſedly polemical writing, their influence is ſtill ſenſible in guiding the views of the hiſtorian, and blunting the diſcernment of the philoſopher and politician. The hiſtoriographer of France, even in theſe days, maintains the abſolute legiſlative authority of the Merovingian princes. The Abbé MABLY, and Engliſh authors of no inferior reputation, Lord LITTELTON, Dr STUART, *&c.* affirm the remote antiquity of the repreſentation of the commons; and MONTESQUIEU and HUME have conferred their ſanction on the ariſtocratic ſyſtem. When a controverſy is thus circumſtanced, men of information are apt to indulge ſcepticiſm, and abandon the ſubject; while ſecond-rate authors ſeize it as lawful game, court popularity, by aſſerting errors that ſuit the taſte of the times, and treat thoſe with abuſe who venture to reject them.

BUT there is, in fact, no period where there is better encouragement to hope that an enquiry may be purſued with ſucceſs. The very ſcepticiſm of the literary world, which has begun to eſcape from the factions of the laſt century, if not ſuffered to mar its induſtry, will give enlargement to its views, and candour to its diſquiſitions. Many important facts in the hiſtory of rude nations, akin to thoſe which founded the Gothic governments, have been aſcertained: Many ancient records, to which the public had formerly no acceſs, have been publiſhed; and the efforts of great men, during the preſent century, to render hiſtory an object of philoſophical ſpeculation, have rouſed a ſpirit of enlightened obſervation, and taught perſons, poſſeſſed of literary curioſity, how to direct their reſearches.

I FLATTER myſelf theſe obſervations will afford me ſome apology, for preſuming to treat of a ſubject which has formerly drawn the attention of ſo many perſons of the firſt abilities. My ſentiments on it are the reſult of an enquiry, to which duty, as well as inclination, prompted me; and, if they have no other merit, I truſt they will at leaſt be attended with the

the advantage of ſuggeſting an object for the labours of the ſociety, highly intereſting to us as citizens, as well as lovers of ſcience.

When we conſider, with impartiality, the controverſy about the ancient European conſtitutions, the firſt reflection that ſuggeſts itſelf is, that there muſt be ſome foundation in truth for the different opinions that have been adopted with regard to them. The partizans of each of the three ſyſtems produce evidence which goes a certain length in ſupporting it. There is, therefore, reaſon to ſuppoſe, that all the ſyſtems are chiefly erroneous, in ſo far as they are excluſive of each other; and that there muſt be an hypotheſis, which, if diſcovered, would ſolve every difficulty, and involve in itſelf the doctrines of all the ſyſtems, to a certain extent.

Proceeding on this idea, and reflecting what this hypotheſis may be, we are ſoon ſatisfied that it muſt be ſome very ſimple one. It is agreed on all hands, that the conquerors of the empire were in a very rude ſtate of ſociety at the æra of their ſettlements. Their diſpoſition to emigrate as nations is alone ſufficient to demonſtrate, that huſbandry was very imperfectly practiſed among them, and that their principal dependence was on their flocks and herds. In ſuch circumſtances, we may be aſſured, that the practice taken notice of by Cæsar and Tacitus, *arva per annos mutant et ſupereſt ager*, ſtill prevailed; and, of courſe, that as yet excluſive and permanent property in land had not been generally introduced, and that a ſeparation of profeſſions was unknown. Their ſituation, therefore, created no call for an improved juriſprudence, or for much exertion of legiſlative wiſdom; and without this call, laws cannot be numerous, nor government complicated *.

But

* Even ſo late as the period ſince which the Swediſh laws have been preſerved, there are traces of the ſame migratory ſtate of ſociety having prevailed. "Coluerunt diſcreti "et diverſi," ſays Sherbrook, "ædificiis tranſitoriis, et in annum aut menſem poſitis:" Wherefore

BUT it is not enough to be aſſured, that the arrangements of ſociety among the conquerors were extremely ſimple, or that an independence, natural to rude men, ſtill prevailed, and was equally inconſiſtent with deſpotiſm in chiefs, and with that ſpirit of ſubordination, and ſyſtematic ſtructure of laws, on which civil liberty depends. We muſt endeavour to learn exactly what the ſtructure of ſociety among the Gothic nations was, while ſtill remaining in their original ſeats; and to aſcertain the influence which ſettlement, in the cultivated provinces of the empire, where laws and government had been long eſtabliſhed, neceſſarily produced on the political ſituation of the conquerors.

A VERY ſlight view of the hiſtory of Europe points out abundant materials for this extenſive enquiry. The nations of this continent appear to have followed almoſt the ſame route to civilization, advancing only with more or leſs celerity, in proportion as they were ſituated in countries more or leſs fruitful, and more or leſs expoſed to foreign intercourſe. At the commencements of hiſtory, we find the riſing republics in the neighbourhood of the Mediterranean poſſeſſed of inſtitutions and traditions which indicate that they had recently emerged from that ſituation in which the more inland nations on the north of them ſtill remained. After a few centuries had elapſed, Gaul and South Britain are found, at the invaſion of CÆSAR, a tranſcript of Greece and Italy and Spain, when baniſhing their kings and eſtabliſhing republics. Germany, more inland, retained ſtill her rude form, her extenſive confederacies, and diſpoſition to emigration; while Finland, Caledonia, and Scandinavia, were little different from a North American wilderneſs. Theſe countries, however, became formidable before the fall of the weſtern empire; and Scandinavian tribes croſſed the Baltic, and

Wherefore he adds, the *leges vetuſtiſſimæ* directed the farmer to have a houſe for himſelf, and *trinas* for the ſlaves, cattle and corn, he might carry about with him in his journeyings, to be put up when he ſojourned in one place, "perinde ut ſepes 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, gradually

dually became indiſſoluble, hereditary and real. The family of MARTEL endeavoured to avail itſelf of the feudal combinations, in order to ſtrengthen its own authority, and to introduce ſome firmneſs into the ſubordination of the citizens. By theſe means, they grew into the conſtitution of the ſtate, and were enabled, during the convulſions which tore it in the fall of that houſe, to reduce every political inſtitution in the French empire, under the forms of their arrangements.

SPAIN, when advancing by ſimilar ſteps to Gaul, was overwhelmed by the Saracens, in the beginning of the eighth century. But as Catalonia ſoon after fell under the dominion of CHARLEMAGNE, the feudal tenures naturally found their way into that province, and were afterwards diffuſed through the reſt of Spain, which was reconquered piece-meal, and chiefly by combinations of adventurers, who had to defend as well as conquer their acquiſitions; and who muſt have found, that the feudal tenures were inſtitutions extremely well ſuited to their ſituation. The Anglo-ſaxons, already accuſtomed to the perſonal relation of vaſſalage, and, through their connections with the continent, beginning to employ the feudal tenures, received them, at the eſtabliſhment of the Normans, as the laws of their conqueror. The other European nations were, however, in different circumſtances. As they were poſſeſſed of little wealth, their combinations for its protection were leſs general and leſs conſolidated; and as they had eſcaped conqueſts by nations where the feus obtained, they adopted them only by ſlow degrees, and in a very partial manner. Among nations, as among individuals, the practices of the more ſkilful are imitated by thoſe who are leſs accompliſhed and informed. Hence the northern kingdoms imported the feudal laws, becauſe they were the laws of their more cultivated neighbours; becauſe they were better calculated than their own looſe cuſtoms, to aſcertain their rights; and becauſe it flattered the vanity of their grandees, to bear titles ſimilar to thoſe of the dignified nobility of France and the German em-

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 *.

PART

* 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 deſcribed by CÆSAR and TACITUS, exhibited the ſame diſpoſition for emigration and conqueſt, which afterwards, in the times of ALARIC and CLOVIS, gained them poſſeſſion of the Roman provinces. We may, therefore, look into the ſtructure of ſociety, which theſe great authors deſcribe, for the cauſes of this reſtleſs ſpirit; and we may likewiſe infer, from the permanency of a temper ſo characteriſtic of national manners, that, during this long interval, the political circumſtances of the Germans had continued nearly unchanged. Having, therefore, recourſe to the lively picture which CÆSAR and TACITUS have left us, a little attention to the general circumſtances of the Germanic nations will enable us to perceive in it, with ſufficient preciſion, the forms of their conſtitution, and the nature of their government.

THE Germans lived in a country interſected with woods, rivers and mountains. However much, therefore, they were inclined to indulge in the indolence of the paſtoral life, their country did not permit them to reſide, like Tartars, in moveable habitations. Hence they ſojourned in annual huts, and cultivated a little ſpot of ground for a crop, in aid of the produce of their cattle. Hence, too, they found it every where neceſſary to have ſtrong holds, to which they carried their property in time of danger. Theſe holds or *pagi*, as the Greeks and Romans called them, were the natural reſort of the tribes in their neighbourhood, and ſeem to have been every where the firſt embryos of the towns and little ſtates with which ancient Europe ſo much abounded. The *pagus* was uſually ſituate on an eminence, on

an iſland in a river, or in the receſſes of a wood; and it was fortified by paliſadoes and mounds of earth.

THE point of union, which was thus formed among a few tribes, neceſſarily produced aſſemblies 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; becauſe it was men almoſt independent that gave it him, who never doubted but that they could deprive him of it at pleaſure, and who continued him in it, becauſe they had no motive to change him for another *. It was likewiſe uſually conferred at his death on a perſon of his family. No diſtinction could be leſs invidious, or therefore would more readily fix the ſuffrages in favour of a candidate, than his relationſhip to a deceaſed chief. Thus it is ſaid, *Reges ex nobilitate ſumunt.* The chiefs of the tribes that reſorted to the pagus were the natural counſellors of the king, as their influence was the principal means of engaging the warriors in any common meaſure. Theſe chiefs were, no doubt, like the kings, uſually elected out of particular families. TACITUS thus mentions the election of the chiefs of the ſubordinate tribes: "Eliguntur in iiſdem conciliis principes "qui jura per pagos vicoſque reddunt. Centeni ſingulis ex plebe "comites, concilium ſimul et auctoritas adſunt." *De Mor. Germ.* c. 12.

BUT though each pagus acknowledged, in general, no ſuperior, yet the circumſtances of ſociety induced numbers of them to confederate; and, when wars happened, a common leader of the confederacy was choſen of courſe. Men who live on the produce of herds

* Dr STUART, and ſome other authors, have laid it down as certain, that theſe chiefs held their offices only for a year. I cannot, however, diſcover any good authority for this opinion, though favoured by MONTESQUIEU, contrary to the ſpirit of his ſyſtem. It is oppoſed by the univerſal practice of rude nations. The appellation of kings, applied univerſally to the chiefs of rude tribes, is inconſiſtent with it. And as the kings of modern Europe were always underſtood to hold their offices for life; and as, in general, the great provincial magiſtrates, in the ages after the conqueſt of the empire, did ſo likewiſe, unleſs deprived, there ſeems every reaſon to believe, that the office of a German chief was equally permanent.

herds can ſubſiſt together in great bodies; and the leiſure they enjoy, 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 ων αλλον χρονον "(*viz.* ειρηνην) ιδημοκρατευντο· εν δε τοις πολεμοις ἡρειτο βασιλευς, ὑπο 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 confederates 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 ſpecies of arrangement, not only in all countries where the Germans eſtabliſhed themſelves, but among the Iſraelites, as appears from the Moſaic inſtitutions; among the Tartar nations, as far back as their hiſtory reaches; among the ancient ſtates of Greece * and Italy; and the Roman legion itſelf ſeems to have derived from the ſame ſource its original form †.

It is natural to ſuppoſe, that, when a confederacy of neighbouring pagi had long ſubſiſted, a feeling of ſomewhat of national union will be apt to ariſe. The common leader, occaſionally choſen for a war, will be ſo often elected, as at laſt 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 ſeveral principes pagorum, in ſuch a ſubordination to him as the chiefs of vici, or of primary tribes, were originally to the chiefs of pagi. Theſe combined pagi again may become the allies of a great and leſs conſolidated confederacy. Thus Tacitus deſcribes particularly the great confederacy of the Suevi; and he enumerates above thirty of the nations belonging to it. Cæsar ſays ‡, That each pagus or nation belonging to this confederacy ſent forth 1000 men to war every ſummer; by which means, as it conſiſted of an hundred pagi, an allied army of 100,000 men was annually formed. But Tacitus again mentions, that, in one ſingle nation of the Suevi, *viz.* the Semnones, there were an hundred pagi. It appears, therefore, that the Semnones

* Homer ſpeaks of decuriæ as known;

Πολλαι κεν δεκαδες διιοτρεφεος αινοχοιο. Il. lib. ii. v. 128.

And he attributes to Nestor the inſtitution of the Greeks fighting by tribes and curiæ;

Κριν' ανδρας κατα φυλα κατα φρητρας Αγαμεμνον
Ως φρητρη φρητρηφιν αρηγη φυλα δε φυλοις. Il. lib. ii. v. 362.

† It is remarkable, that the nature, univerſality and antiquity of this inſtitution ſhould have eſcaped Preſident Montesquieu's obſervation. He attributes it to the Merovingian princes, Clotaire and Chilperic, and ſays, it was introduced into both France and England, in order that each diſtrict ſhould anſwer for any robberies committed in it. *Eſprit des Loix, lib.* 30. *c.* 17. Dr Stuart has entertained more juſt notions of it. Diſſertation on the Engliſh conſtitution. *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 cuneum 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 conſent 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 of

* 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 centum et octo tribubus ducenta et ſedecim millia, de unaquaque, *ſciz.* tribu, duo millia armatorum, excepto familiæ numero eduxiſſe perhibeatur." Scriptores rerum Hungaricarum, 4to, v. i. p. 100.

† Penn'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 ſame time, as TACITUS relates, that they aſſembled in arms, it can ſcarce be doubted, that, by degrees, the regularity of a military review would be introduced. It is, indeed, not eaſy to conceive, how the vaſt multitudes of armed men, mentioned as aſſembling on public affairs, could obſerve any order, unleſs arranged in regular diviſions. We know likewiſe, that the Tartars aſſembled in their *curiltay* in this manner, each tribe arranged under its proper banner. We know, that the ancient Greek eccleſia * and the Roman comitia were alſo military muſters and reviews. We know, that the aſſemblies of the Weapontact in modern Europe were likewiſe employed for this purpoſe. And we know, that the Franks, who attended the aſſemblies called *mallum*, *placitum*, and *parliament*, were obliged to appear in arms †, and thoſe who had banners, to carry them along with them. The Iriſh, in the ſame manner, wore arms in their national and provincial conventions. And I ſhall afterwards have occaſion to obſerve, that the poſpolite in Poland, and the ancient diet of the German empire, aſſembled in a military form. We may reaſonably then hold, that the ſtructure of the different gradations of aſſemblies, among the ancient Germans, was extremely uniform, and wore a military aſpect. In each aſſembly, its proper chief would preſide, accompanied with a council of the chiefs of thoſe tribes which reſorted to it; and the warriors

* HOMER thus relates the aſſembling of the Greeks in diet when beſieging Troy:

——————— ἐστιχόωντο
Ἴλιαδον ες ἀγορην. Il. lib. ii. v. 92.

† THE aſſembly of the Franks in the campus martius of the cities of Gaul, deſcribed by GREGORY of Tours, is manifeſtly a military review. "Tranſacto vero anno, juſſit "(ſciz. Clovis) omnem cum armorum apparatu advenire phalangem, oſtenſuram in cam- "po martio ſuorum armorum nitorem;" and he is mentioned as going through the ranks and examining their condition, lib. ii. c. 27. And when, under the ſecond race, the Franks were called forth to aſſemble in military array, their magiſtrates were named *capitanei*, and the meeting a *placitum*. *Capit. A. D.* 807. This military appellation is common to all the great magiſtrates in both the Gothic and Sclavonic nations. Vayvode, bannus, heretoge, are often tranſlated 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.

* 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,

* 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 buſineſs to apprehend and accuſe, to take the judgment of the judges, and to carry it into execution, the fine was no more than a neceſſary reward to ſtimulate their activity in repreſſing wrongs, and compenſate the riſk, as well as labour, which, in the infancy of government, muſt attend this duty. Independently, however, of this general preſumption, the hiſtory of all the ancient judicatures in Europe affords every where the moſt convincing evidence, that the chiefs of the German and other conquering tribes exerciſed only miniſterial powers in matters of judicature. I can, however, but juſt touch on it. In the firſt ages after the German conqueſt, we find the ſlaves of the kings, and of the provincial chiefs, exerciſing moſt frequently, in the adminiſtration of juſtice, the functions of their maſters. Theſe functions then muſt have been purely miniſterial; for we know that no ſlave, nor even an emancipated perſon, could bear witneſs where a freeman was concerned; and moſt certainly, therefore, could never have been his judge. Accordingly, the effects of this ſtate of the judicial power are equally conſpicuous and extenſive. The functions of the king in the trial of peers in a bed of juſtice in France; the functions of the high ſteward of England, the repreſentative of the king in the trial of Britiſh 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 ſheriff and hundreder in England†; in ſhort, the di-

 ſtinction

* In the eaſt, where the prieſthood has ſtripped the people of the judicial power, no part of the fines for delinquencies are paid to the judges.

† I quote the following ſtatute as evidence, not only of the diſtinction being obſerved in Scotland, but of the anxiety of our anceſtors to ſeparate the judicial and miniſterial functions: "Statuit dominus rex quod nullus juſtitiarius vicecomes vel ballivus, ſedeat "ad judicium faciendum ſuper appellatione et reſponſione coram eis facta. Sed cum ad "judicium venerint; exeant de curia; et libere tenentes de curia judicium faciant; et re-"vocato juſticiario, vicecomite vel ballivo, in curiam, judicium penes eos factum coram "ipſo judice reddatur." *Quon. attach. cap.* 66. There is a ſimilar regulation in the eſtabliſhments of St Lewis, from which, no doubt, the law of the Scottiſh 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 conſequence, 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 interpretation 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 proceſs of time, however, as law becomes complicated, there is room for doubt as to its interpretation, and the chief has recourſe to the aſſiſtance of aſſeſſors or deputies for this purpoſe. Hence it happens, that the king, in almoſt all countries, is naturally 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, committed the wrongs of which they are accuſed. We have examples 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 national aſſemblies in modern Europe; and in thoſe by the διαιτηται or arbiters, delegated from the tribes in Greece, the judices pedanei, delegated from the Roman tribes, the ſcabini from the Gothic and French tribes, the nembda from the Swediſh, hered 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 conſtitutional authority of the German chiefs was probably not more extenſive in political than in judicial affairs. It appears from CÆSAR, that they had the prerogative of regulating the annual eſtabliſhments of the tribes *. This, however, it is likely, was no more than one of thoſe res minores, about which, TACITUS ſays, the chiefs alone conſulted: "Facilitatem partiendi camporum ſpatia preſtant, arva per annos mutant et ſupereſt ager." In ſuch a country, it was no greater prerogative in a king to diſtribute the lands, than to chooſe a camp for an army is in a general. It was, beſides, 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 diſcretion of the chief, who would, however, conſult, of courſe, with the ſubordinate chiefs on the buſineſs. The neceſſity of obſerving an order in the poſition of the tribe is likewiſe proved by the old laws of Sweden, which directed, with anxiety, the arrangement (ſitus and ordo) of the cottages of villagers; and that they ſhould be ſurrounded with a palliſado, in order, no doubt, that the inhabitants might make their defence with greater facility and effect, in caſe of an attack. *Shernhook*, 295.

IN military affairs, the power of the chiefs would be moſt conſpicuous. Although the choice of peace or war lay with the people, the conducting of military operations was neceſſarily committed to the chiefs. "De majoribus rebus omnes conſultant, ita tamen ut ea quoque, quorum penes plebem arbitrium eſt, apud principes pertractentur," *Mor. Germ. c.* 11. A conſiderable

me to have ariſen from not making ſufficient allowance for thoſe varieties which ought to be expected among inſtitutions of the ſame kind in different countries, eſpecially when the compariſon is made at different ſtages of their progreſs.

* "NEQUE quiſquam agri modum certum aut fines proprios habet; ſed magiſtratus ac "princeps in annos ſingulos gentibus cognationibuſque hominum qui una coierunt quantum eis et quo loco viſum eſt attribuunt agri, atque anno poſt alio tranſire cogunt." *Bell. Gall. c.* 21. "Agri pro numero cultorum, ab univerſis per vicos occupantur, quos mox inter ſe ſecundum dignationem partiuntur." *Mor. Germ.* 26.

conſiderable degree of coercion muſt be exerciſed by a leader, in a warlike expedition that continues for any length of time, and the natural privilege of diſtributing the booty, and the mere ſplendor of precedence, muſt augment greatly his influence.

THESE remarks, I flatter myſelf, will ſufficiently point out my idea of the general ſtructure of the German governments. Men, ſtill cheriſhing the independence of the ſavage ſtate, were forced to take meaſures for the defence of their riſing property. That property occaſioned wars, and wars introduced confederacies, military arrangements, and ſome degree of ſubordination. This ſubordination, however, did not deprive the minute tribes, of which the confederacies ultimately conſiſted, of their internal powers. A petty chief, with his tribe, formed by intermarriages into a clan, which claimed a common blood, were like the ancient φρατριαι of Attica, or tribules of Italy; ſo many communities, poſſeſſed of judicative, legiſlative and executive powers, within themſelves, ſimilar to thoſe exerciſed by the national confederacy. In this way, the form of ſociety was nearly indeſtructible; and even thoſe revolutions which wars occaſion would probably contribute to preſerve it. When a nation proved unfortunate, its parts coaleſced 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 diſtinguiſhed the conquerors of the empire. But, in his time, they, in general, were the names of only remote and inconſiderable ſtates, which aroſe not to conſequence till the confederacies, that were then predominant, had given way in the courſe of contending with the Roman arms. And again it ſeems reaſonable to conjecture, that this warfare was the principal cauſe of preſerving in vigour, during ſo many centuries, the ſpirit of emigration and conqueſt in Germany. By diſcouraging agriculture, it retained the Germans in the paſtoral life, and, of conſequence, cheriſhed in them the inclination, as well as ſupplied the means for great enterpriſes. Hence thoſe extenſive confederacies, ſo

eſſential

eſſential to ſuch enterpriſes, and eſpecially to wars carried on by barbarous tribes againſt the Roman legions, remained in full energy; and that progreſs in the arts of induſtry was prevented, which otherwiſe, in the courſe of a few centuries, would naturally have transformed every pagus into a little republic, and its ardent and active aſſociations with its neighbours, into the cold alliances of agricultural ſtates.

THE foregoing idea of the general form of the government of the Germans is ſtrongly confirmed by what we know of the ancient conſtitution of Sweden and Iceland. Iceland was peopled by a ſeries of Norwegian colonies, who fled their country, on the conqueſt of it by HAROLD *with the beautiful hair*, in *A. D.* 878. The colonies formed little communities with elective chiefs. Theſe, by degrees, combined together, and held aſſemblies, under a common leader, in each of the four great provinces into which the ridges of mount Hecla divide the iſland: And, at laſt, theſe four provinces likewiſe confederated, and formed a republic, under one chief magiſtrate, in *A. D.* 928. The whole country was arranged into regular diviſions, called provinces, hundreds, and reeps. The magiſtrates held their offices for life. At the diets, whether of the diſtricts or of the nation, the magiſtrate celebrated religious rites; and it is, in particular, mentioned, that the lagman, or chief of the nation, performed human ſacrifices at the alting, or great annual aſſembly. In it too, beſides the arrangement of political matters, appeals were received from the provincial courts, and rejudged in its preſence, and under its inſpection, by the former judges; and the lagman's buſineſs was to carry into execution what the alting ordered. The judges of each diſtrict were called repſtiorar; and choſen, by the diet, among the wealthieſt and moſt reſpectable of its members *. There was a ſucceſſion of thirty-eight lagmans, which continued till 1262, when the republic was

* THESE probably correſponded to the ſcabini and red boran, or lawmen of the Franks and Saxons.

was deſtroyed by the Danes. I have taken this account from the Icelandic hiſtorian ARNGRIMUS JONAS, a native of the iſland, and a perſon who appears to have had abundance of authentic materials for his work.

THE Swediſh government ſeems to have ariſen in the ſame manner as that of Iceland, without the intervention of foreign conqueſt, or any very violent domeſtic revolution. The moſt 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 ſucceſſively into different codes, and, though not entirely the ſame, reſembled each other extremely. SHERNHOOK ſays, that the original courts of juſtice were the provincial aſſemblies or lagmanſting, but that, in proceſs of time, the provinces were divided into hæredas or trientes, and theſe again into fierdings or quadrantes. He ſays, 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 diſtrict, whether hæreda or fierding, had chiefs *. The chief of the province was called lagman, which he tranſlates legumvir, and was ſupreme magiſtrate, in both civil and religious affairs, as long as the provinces remained independent. The lagmanſting judged appeals, and puniſhed the chiefs and judges of hæredas and fierdings, who judged corruptly, or refuſed juſtice; and groundleſs appellants were likewiſe puniſhed. After the provinces confederated, a common chief, or king, aroſe, and a national diet, called the landſting, was annually held. The lagmans and the dignified clergy, after the nation became Chriſtian, formed the ſenate in this aſſembly. The people at firſt choſe the lagmans. After the riſe of a king, it appears from the ancient laws, that he had a right to ſelect the lagmans out of leets, preſented to him by the people of the reſpective diſtricts. In ſome provinces, however, the lagman had rendered his office hereditary, had aſſumed

* THIS is preciſely the arrangement of Denmark.

ſumed the title of duke, and had uſually named a deputy, who had the title of lagman. But GUSTAVUS ERICSON deprived both the people and the dukes of their privileges in this particular; and, of conſequence, the lagmans ceaſed to form the ſenate of the national diet. "Ut enim ex judicibus his, (ſo "SHERNHOOK terms the lagman), olim ſenatores, ita hodie ex "ſenatoribus his, judices provinciales conſtituuntur."

I SHALL not detain the Society with pointing out the perfect coincidence between the general ſtructure of the ancient Swediſh and Icelandic conſtitution, and that which I have attributed to the Aborigines in Germany; nor, after what is ſtated in the introduction to this paper, do I think it neceſſary to make any remarks to ſhow, that I am entitled to avail myſelf of the reſemblance in ſupport of my opinion *.

INDEPENDENTLY, however, of the general form of the German governments, there were ſome circumſtances in the national manners, which, though not immediately entering into the ſtructure of the conſtitution, demand particular attention, becauſe they contained ſources of future revolutions. In the ſtate of ſavages, or when men ſubſiſt on ſpontaneous produce, the political union hardly exerciſes any control over individuals. Nothing is more common than for a ſingle perſon to propoſe to his tribe to make war; and, though the tribe reject the meaſure, to perſiſt and go to war, either by himſelf, or with the aſſiſtance of a few that reliſh his propoſal. Afterwards, when farms and herds are known, men ſtill retain the right of avenging their own wrongs; and their new poſſeſſions are a ſort of dominions, which they rule with a ſpecies of that

* WHAT we know of the rude governments of the Welſh, Iriſh, Danes, and Caledonians, correſponds with the idea of that of the Germans, given in the text. Every where the clans choſe their chiefs from particular races, and confederated clans choſe their *reguli* and *ſubreguli* in the ſame manner. L. L. WALLIÆ, 164. and 184. Tractat. varii de Reg. Dan. WARE's antiquities of Ireland. LESLIE, BUCHANAN, *paſſim*. The taniſt was choſen in the lifetime of the chief, and ſucceeded him at his death. Even at this day the Scots clans conceive they are entitled to change their chief, if he act diſgracefully.

independent ſovereignty, with which, in the ſavage ſtate, they governed their own conduct. The jus vitæ et necis, competent to the Germans over wives, children and ſlaves, is mentioned by TACITUS. And we find, after the conqueſt of the Roman provinces, the rights of making war and levying troops every where recogniſed, as one of the powers of the private proprietor. It has been thought, that this right of waging war was a privilege uſurped by the feudal nobles; but a further enquiry has fully proved, that it was an inheritance tranſmitted down to them from the origin of the nation. And, in fact, it was not an inheritance which had been preſerved by them entire; for, either from apprehenſion of the end of the world approaching, or other cauſes of more ſteady operation, they had gradually ſubmitted it to various reſtrictions; and, in particular, that they ſhould only uſe it in revenge for perſonal injuries, and not on account of property or intereſt*. 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 ſtranger that acquired vaſt eſtates to himſelf in Iceland, during the ſubſiſtence of the Icelandic republic, by a ſort of right of conqueſt, reſulting from his victories in wars with individuals ‡.

IN a ſtate of ſociety where men retained ſuch a degree of independence, it is manifeſt, that, in proportion as property became

* 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. 1. Reg. Hungar. cap. 33. Codes of the Barbarians, *paſſim.* where family wars are ſuppoſed. L L. Roberti i. c. 20. Eſtabliſhments de St LOUIS, et Ordinances des ROIS de France, *paſſim.* But, eſpecially, BEAUMANOIR, loc. cit. where he enters into a full detail about it.

‡ In COOK's laſt voyage, the following cuſtom among the iſlanders of the Pacific ocean is mentioned: "If a perſon kill another in a quarrel, the friends of the deceaſed "aſſemble and engage the ſurvivor and his adherents. If they conquer, they take poſ- "ſeſſion of the houſe, lands and goods of the other party; but, if conquered, the reverſe "takes place." *Vol.* ii. *p.* 173.

came conſiderable, it would be employed as means to gain power and protection. It is remarked by travellers, that all ſavage nations are hoſpitable, fond of interchanging preſents, and of public feaſting; but, among them, ſuch indulgences are practiſed merely on account of the pleaſure they afford, whereas the introduction of wealth in the ſources of ſubſiſtence produces a variety of intereſts formerly unknown, and hoſpitality is practiſed, and preſents beſtowed, as the means of procuring ſecurity, diſtinction, or power. Hence among the Germans, every wealthy perſon had his retainers that frequented his table, and received from him protection, and various favours, in return for their aid, and for the preſents they gave him. The chiefs, in particular, whoſe hoſpitality was ſupported by preſents from the whole members of their tribes, naturally ſtrove to diſtinguiſh themſelves by their followers, and to attract around them the enterpriſing youths of the firſt families in the ſtate. TACITUS * makes particular mention of this inſtitution, and terms the retainers comites, probably a literal tranſlation of the German *leuch* or *leude*. Authors have very frequently confounded theſe with the principes vicorum et pagorum which, in the preceding chapter, he diſtinguiſhes by the ſame name of comites; and where perhaps they have not confounded them, they have never, as far as I recollect, pointed out clearly the diſtinction between them. No two orders of men, however, could be more different; and the deſcription of both is ſo accurate, that there ſeems to be no room for miſtake. The chiefs of diſtricts were elders, were civil magiſtrates, were military leaders, the heads of the nation, and the natural counſellors both of prince and people †, reſpectable by their experience, gravity and authority. But the retainers of the king were young men, his guards, his own perſonal partizans, ſupported by his munificence, courters of his favour, expectants of promotion from it, and ſworn to maintain his

* 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 introduced into the diets, and there armed, TACITUS obſerves in ſubſtance †, that it was no ſhame to be numbered among the retainers of a great man. Diſtinction and power conſiſted in being always ſurrounded with a circle of choſen youths. They were an ornament in peace, and in war a ſafeguard. It was a matter of great emulation among the chiefs, which ſhould have the braveſt and moſt numerous retainers. The fame, merely of a ſuperiority in this reſpect, was often deciſive of a war. It was alſo a matter of emulation among the retainers, which ſhould be firſt in favour with his chief; for there were different ranks among them according to that favour ‡. Their ſervice was proportionably zealous. To have ſurvived their chief in battle was an indelible diſgrace. Their moſt ſacred obligation

* I WILL not, however, preſume to determine, that, even ſo 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 eſtabliſhing a domeſtic relation between them and the ſons of the chiefs of tribes; and theſe, when promoted to be chiefs, might, though abſent, preſerve their claim to this relation, while younger men, or perſons of leſs conſequence, would attend in the royal houſehold.

† NEC rubor inter comites aſpici. Gradus quinetiam et ipſe comitatus habet, judicio ejus, quem ſectantur: Magnaque et comitum emulatio, quibus primus apud principem ſuum locus; et principum, cui plurimi et acerrimi comites. Hæc dignitas, hæ vires, magno ſemper electorum juvenum globo circumdari, in pace decus, in bello præſidium. Nec ſolum in ſua gente cuique, ſed apud finitimas quoque civitates id nomen, ea gloria eſt, ſi numero ac virtute comitatus emineat: Expetuntur enim legationibus, et muneribus ornantur, et ipſa plerumque fama bella profligant. Cum ventum in aciem, turpe principi virtute vinci; turpe comitatui, virtutem principis non adæquare. Jam vero infame in omnem vitam ac probroſum, ſuperſtitem principi ſuo ex acie receſſiſſe. Illum defendere, tueri, ſua quoque fortia facta gloriæ ejus adſignare, præcipuum ſacramentum eſt. Magnumque comitatum non niſi vi belloque tuere: Exigunt enim principis ſui liberalitate illum bellatorem equum illam cruentam victricemque frameam. Nam epulæ, et quamquam incompti, largi tamen apparatus pro ſtipendio cedunt. Materia munificentiæ per bella et raptus. Nec arare terram, aut expectare annum, tam facile perſuaſeris, quam vocare hoſtes et vulnera mereri: Pigrum quinimmo et iners videtur ſudore adquirere, quod poſſis ſanguine parare. *De Mor. Germ. c.* 13. 14.

‡ Somewhat probably like thoſe of DAVID's mighty men.

tion was to defend him, and to promote his glory. War was, however, eſſential to retain them. The battle-horſe, the victorious ſpear, were preſents that they expected, and a plentiful and open board was the wages of their ſervice. But it was to war alone that recourſe could be had for the means of this munificence; for war, and not labour, ſuited the national temper, and furniſhed a neceſſary occupation to a numerous youth, averſe to induſtry, and fond of adventure.

SUCH a body poſſeſſed the ſame reſemblance to the chiefs of pagi, that the celeres and ἱππεις of the Roman and Lacedemonian kings bore to the ſenators of Rome and Sparta. DIONYSIUS, after deſcribing the celeres, gives the following account of the ἱππεις, which may be properly enough ſubjoined to TACITUS's picture of the German leuchs: "Παρ εκεινοις (τοις Λακεδαιμονιοις) οἱ γεναιοτατοι των νεων φυλακες ησαν των βασιλεων. Οἱς εχρωντο κατα τας πολεμιας παραστασεις, ἱππευσι τε ασι ϗ πεζοις." *Dionyſ. 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 eſtabliſhment in the empire, I ſhould take notice of certain opinions, entertained by authors of eminence, which are extremely adverſe to the foregoing account of its original ſtructure. It has been very generally thought, that, immediately upon the conqueſt, the governments became feudal; and M. DE MONTESQUIEU, and many others, hold, that the feudal ſubordination, and that hereditary nobility which made ſo diſtinguiſhed a figure under the

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 return,

* 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 aſſiſt them in their wars. But, in every age, nations find it expedient to arrange themſelves under the protection of their more powerful neighbours; and where an alliance on equal terms is not to be obtained, the protection muſt be paid for by a tribute in money, or a contingent of troops, to be employed in executing the meaſures of the more powerful ſtate. If ſuch a ſtipulation 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 evidence, that alliances of this ſort had been formed by a ſurrender of the territory of the protected to the dominion of the protector, or that territories were conceived to have been pledged in ſecurity of theſe treaties, then, no doubt, a ſtriking reſemblance between them and the feudal relation of modern times would be eſtabliſhed. But no ſuch evidence has been produced; and the fluctuating ſtate of theſe alliances in Gaul, and the little progreſs the Germans had made in municipal law, can leave no doubt, that they were conſidered as merely perſonal contracts, and, in truth, poſſeſſed neither the ſolidity of a real vaſſalage, nor any connection with the ſubtile diſtinction between the dominium directum and dominium utile of land *.

Mr MILLAR has treated, with much ingenuity, the argument founded on the natural progreſs of rude nations †. He ſuppoſes, that the chief will naturally, at the ſeparation of farms, have very large domains aſſigned him, great part of which he will employ in creating eſtates *at will* for his retainers, who, in return for this precarious poſſeſſion, muſt labour or fight for him

* 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, ſo got the better of the Ædui, "ut magnam partem clientium ab Æduis ad ſe tranſducerent obſideſque, ab "iis principum filios acciperint, et publice jurare cogerent, *Nihil ſe contra Sequanos* "*concilii moturos, et partem finitimæ agri per vim occupatam poſſiderunt.*" 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 ſurrender thus occaſioned, of the eſtates of ſmall proprietors, in conſideration of protection, he explains the riſe of a feudal relation in many diſtant countries, and that right of property and inheritance over their dominions, which travellers have aſcribed to ſeveral kings in Africa and the eaſt *, as Benin, Congo, &c.

I HAVE not, however, been able to diſcover 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 eſtates of their patrons were theirs. The Italian equites received a war-horſe and a ring, which may probably, at firſt, have been marks of royal favour, but we do not hear of uſufructuary eſtates being allotted for them. Beſides, we may be very certain, that, long after farms are ſeparately cultivated, land is in great abundance, and to be got for the occupying. To preſent, therefore, in ſuch times, a retainer with uncultivated land would be no favour; and as to lands which

* IN the quarto edition, Mr MILLAR ſtated this doctrine more ſtrongly. He there lays it down, that the chief, in conſequence of his ancient prerogative of preſiding over the joint labours of the community, will, at the ſeparation of farms, impoſe ſuch conditions and limitations on the ſhares of individuals, as render them dependent on him for the continuance of their poſſeſſion: And that, in this way, and by the extent of his peculiar domains, his authority becomes almoſt unlimited. It is evident, that, if this opinion were well founded, the government of all ſmall and rude communities of huſbandmen would be deſpotic, which is certainly not the caſe. And, accordingly, the argument on which it reſts, though ingenious, admits of being obviated. The chief arranges the annual farms of rude tribes, and poſſibly, too, may preſide over the labour of the tribe, if employed on a common farm; but, as may be reaſonably conjectured from the independent ſpirit of uncultivated men, and, as is proved by the ſales of lands by the American tribes, the chief is not, on that account, reckoned the proprietor of their territory. That, like the ſpontaneous 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 ſeized upon by individuals, land is ſtill in ſuch vaſt abundance, that the ſpots, thus occupied, are naturally conſidered as the right of the poſſeſſor, as abſolutely as the crop which he formerly reaped from his annual farm, or the prey which he ſeized in the ſports of the field. Accordingly, we do not find, that, in any of the original monarchies of Greece, Italy and Gaul, the kings were ever conſidered as the proprietors of their dominions.

which a petty chief had ſlaves to cultivate, he would always find it prudent to retain the whole produce of them; becauſe, if beſtowed in hoſpitality, it would procure him much greater influence, than if the poſſeſſions, which yielded it, were diſtributed among a few individuals. Afterwards, again, when the greater part of the ſoil is appropriated by individuals, the diſtricts which remain uncultivated are commons, over which the neighbouring inhabitants have eſtabliſhed rights of ſervitude, and cannot be touched by a chief, till government is armed with all its powers *. Forfeitures and conqueſts are the true ſource of the overgrown domains of princes; and, where the latter have not happened, the former are ſcarcely able to compenſate thoſe diſmemberments, which proviſions for younger branches of the royal family neceſſarily occaſion †.

With regard to the powers of certain African and Aſiatic kings, and the circumſtances of reſemblance, obſerved by travellers, between the ſtate of property in their dominions and the feudal arrangements of it in Europe, I ſhall only remark, that there are many particulars, connected with the feudal ſyſtem, which are not characteriſtic of it; and, therefore, though diſcovered elſewhere, will not juſtify the inference that they reſulted from feudal inſtitutions. Thus, in many countries, armies are paid in lands; in many, every proprietor yields military ſervice; and, in many, the opulent acquire conſequence by means of clients and retainers. But the ſingular and diſtinguiſhing circumſtance from which the feudal law acquired its character, and to which its more remarkable effects are to be aſcribed, (ſuch as, patrimonial magiſtracies, titles of honour, ſcale of ſubordination, and all

e thoſe

* In Sweden, the king is veſted with the diſtricts which were formerly the common domains of communities. But no ſingle community would beſtow ſuch 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 ſupported, by means of ſimilar conceſſions from the reſt.

† Even confiſcation for capital crimes ſeems to have been unknown to the Romans before the Lex Cornel. de proſcrip. Cicero pro domo. Breach of fidelity was capital in both patron and client, but ſurely was not attended with forfeiture of eſtates.

thoſe various ſhackles, by which it ſeparated ranks, and rendered governments at once feeble and indiſſoluble) 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 intereſts of both parties in a land eſtate rendered dependent on their fidelity in fulfilling its duties *.

II. The feudal nobility make ſo conſpicuous a figure in the hiſtory of the middle ages, that it is nowiſe ſurpriſing authors ſhould have judged, that the German conquerors were originally ſubject to an ariſtocracy, which afterwards became the rulers of their new eſtabliſhments. Accordingly, Mr Hume has held, that the principal proprietors of land were, without any election, the conſtituent members of the legiſlative aſſemblies of the Anglo-ſaxons. Moſt authors of eminence that treat of the feudal inſtitutions have reaſoned on the ſuppoſition, that there was an order of nobles which enjoyed the firſt rank of ſociety among the German nations, at the period of their emigration. And M. de Monteſquieu has ſpecified the leudes or fidels (appellations which he conſiders as ſynonimous) as forming this order, and enjoying the excluſive capacity of being eligible to offices, and of receiving from the crown uſufructuary grants of land, (called fiſcs or benefices) on condition of military ſervice. And while he conſiders the leudes as the ſame with thoſe perſonal friends and retainers of the kings, termed comites by Tacitus, (an opinion which is now, I believe, univerſally admitted to be juſt) he repreſents them as a *nobleſſe d'origine* or patrician order, in which the antruſtions, or thoſe leudes who attended more particularly on the court, formed the firſt claſs. He quotes expreſſions, employed in the codes

* I am beſides apt, in the preſent caſe, to believe, that the hiſtorical facts reſorted to have been miſunderſtood. Hiſtoire générale des voyages, t. 6. p. 28. Ibid, p. 255. 263. 265. 264. 321. 318. The governments on the Gold Coaſt are obviouſly the production of conqueſt and ſuperſtition, and the nobles appear to be very independent, and to be proprietors of their eſtates.

codes of the Barbarians, or other ancient works, as evidence of his opinion; and he confirms it, by attempting to ſhow its fitneſs to explain circumſtances in the hiſtory of the Franks. I ſhall, with due reſpect, ſtate a different opinion, conſider the evidence that ſtands againſt it, and ſupport it by evidence which appears to me concluſive in its favour.

If the Germans were diſtributed into clans, as the terms *cognationes*, *gentes*, *familiæ*, *et propinquitates*, uſed by Cæsar and Tacitus as deſcriptive of their arrangements, clearly import, and as the laws in their codes, with reſpect to family feuds, prove, I think we may be certain, that no ſuperior claſs of men, ſeparated in blood from other freemen, was recogniſed among them. A clan always eſteems itſelf of the blood of its chief. He is no more than the elder branch of a family, from which the meaneſt of his followers, as well as himſelf, are vain of deriving their deſcent. He owes their attachment to this prejudice; and he knows too well the value of it, and how much his influence depends on the ſtrength of it, to attempt weakening it, by laying claim to a diſtinction from ſuperiority of blood, till combinations with his equals, or the progreſs of laws, inſpire him with different views.

Among the Germans, no doubt, as well as every where elſe, the virtues and eminence of the parents reflected luſtre on their progeny. And this, I conceive, is all that we ought to underſtand by the nobility of race, which is ſo often mentioned as belonging to individuals*; though we believe, that the perſonal honour of being admitted among the domeſtic companions

* The ranks among the Iſraelites, before the captivity, illuſtrate this opinion. The whole freemen of every tribe held that they were deſcended of the ſame blood; but each conſiderable branch of a tribe had a head, and each tribe a prince or chief; and theſe elders, as they were called, being uſually choſen from particular families, formed numbers of diſtinguiſhed races in the nation.

It may alſo be obſerved, that, in rude times, men are determined, in their marriages, more by the perſonal attractions of women than by thoſe of wealth, rank, and intereſt, which dictate ſo powerfully in cultivated ages. Hence, as in early times, women of the higheſt perſonal endowments will uſually fall to the lot of men who have attained diſtinction;

of the king was frequently conferred on the ſons of thoſe who had enjoyed it; and that the ſons of the ſubordinate chiefs, when candidates for the offices of their deceaſed fathers, derived great advantages from their deſcent.

The arguments which have been uſed for a *nobleſſe d'origine*, neither aim at obviating the foregoing obſervations, nor reſt on circumſtances that have been found to bear examination. The monopoly of offices which the fidels enjoyed is evidently of no conſequence, when it is underſtood, that the term *fidel* was applied to every perſon that took the oath of allegiance *. The leudes were certainly, in their origin, the perſonal companions of the kings; and there is ſurely neither evidence nor argument for their having become a hereditary order previous to the Gothic conqueſts †. The high compoſitions, afterwards preſcribed for wrongs committed againſt them, and ſtill higher for thoſe againſt the upper claſs of them, called *antruſtions*, were no more than conſequences of their perſonal connection with the ſovereign, and their reſidence at court, where crimes incurred a triple penalty ‡. And the expreſſions, which are frequently to be found, relative to diſtinctions of rank among the freemen, inſtead of vindicating the exiſtence of a patrician order, do, in fact, ſhow, from the looſeneſs with which they are uſed, that no ſuch order was recogniſed in the ſtate. Nothing may more ſafely be depended on as evidence that orders of nobility were unknown, than the want which authors betray of preciſe terms

ſtinction; the families of chiefs will naturally, in the courſe of a few generations, acquire that marked ſuperiority in character and figure, which travellers have often obſerved and miſtaken for an indication of an original diverſity in the race, and for the remains of ancient conqueſts and intermixtures of nations.

* Bouquet Droit publique, p. 105.

† On the contrary, it is remarkable, that the ſignification of the term ſeems to have been enlarged on the continent till it loſt its peculiar import, and became at laſt co-extenſive with that of *fidelis*. Thus we read, "Cumque Lingonas civitatem veniſſet Dagobertus, tantam "in univerſis Leudibus ſuis, tam ſublimibus quam pauperibus juſtitiam," *&c.* Fredeg. Chron. § 58. See alſo § 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 diſtinguiſhing the ſuperior ranks of perſons. And accordingly, we have full evidence, that even the terms expreſſive of free birth and noble deſcent continued to be uſed indiſcriminately, low down in the feudal times *.

This laſt circumſtance, I apprehend, while it proves there was no patrician order among the conquerors, indicates alſo the origin of the genuine nobility of Europe. That nobility, as it is deſtitute of all titles of office or honour, exhibits no trace of owing any part of its luſtre to the favour of kings, or to uſurpations of magiſtracy. But its numbers, its prerogatives, the documents of its hiſtory, and its character, concur to prove, that it is the remains of nations of freemen, and derives its honours from having preſerved, uncontaminated by ſervile or ignoble occupations, that high ſpirit which, as independent warriors, and as equals, the conquerors of Europe received pure and unadulterated from the bounty of nature.

The ſtate of perſons in thoſe European nations which have been fartheſt removed from innovation is entirely agreeable to this opinion. In *A. D.* 1480, about 300,000 nobles aſſembled in the diet of Poland. The Poliſh poſpolite, or comitia paludata, is, in truth, an aſſembly of the freemen and warriors of the nation †. The ſimple burgeſſes can hardly be ſaid to be as

* Montesquieu quotes the term *optimates*, in the Burgundian laws, as evidence of a hereditary nobility. But it might expreſs magiſtrates, or antruſtions, or men of wealth. Nothing can be more looſe than the manner in which terms of this kind were employed. Gregory of Tours often applies the term *valde ingenuus* to perſons; and he ſeems to have no word for characteriſing the deſcendents of the priores regni, or ſeniores civitatum. Again, he ſays of one of his predeceſſors, "Civis Turonicus de inferioribus populi ingenuus ta-" men." In a charter of Carloman, it is ſaid, "Et congruum obſequium ſicut homines in-" genui exhibeant, ne eorum ingenuitas, vel nobilitas vileſcat." See alſo Heinec. Antiq. Germ. v. ii. p. 52. *et ſeq.* 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 deſcribing perſons of more conſequence than others. Baluz. p. 278. 334. *&c.* L L. Viſig. lib. 6. t. 1. c. 2. Mention is often made of the *ingenuitas regni* aſſembling. Hoody, p. 188. *Francs hommes* was, even in feudal times, a term ſynonimous with gentlemen or nobleſſe. Thaumassiere Notes on Aſſiſes de Jeruſ. p. 270.

† Cromer, biſhop of Warne, ſays, "Eſt pari dignatione Polonica nobilitas, nec eſt " ulla in ea patritiorum comitumve diſcrimen." And Prochniekego ſays, in his deſcription

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

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 ſubdivided into diſtricts, diſtinguiſhed by theſe or correſponding names; and that, in each of theſe diſtricts, the former ſpecies of ſubordination remained, *viz.* a chief, who was magiſtrate in peace, and leader in war, and an aſſembly of the warriors of it, competent equally for deliberation and action. The chiefs, or governors of pagi or large diſtricts, were called, in the Latin of thoſe times, duces, comites, gardingi, banni, vaivodæ, heretogæ, aldermanni. The heads of ſubdiviſions were named after them reſpectively, quingentenarii, centenarii, decani. The higher magiſtrates had deputies that aſſiſted them in their functions. Theſe were called in Latin vicarii, and ſometimes 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, ſcyregraffs, margraffs, thiuphads, laghmans, *&c.*

In proceſs of time, the military and enterpriſing ſpirit of the conquerors was greatly damped, by the influence of their new ſituation, and various regulations were thought of to enforce compliance with their common duty, as defenders of their acquiſitions. Among theſe, we find, in the code of the Viſigoths, called the fuerojuſgo †, a law which enacts, that, if the duke, count, or warden, failed in their duty, they forfeited their goods, and were liable to puniſhment; and that, as to all inferior perſons, *viz.* thoſe who called out the army, or thoſe who were called out, then, "Non ſolum ducentis ictibus flagellorum "verberati, ſed et turpi decalvatione fœdati ſingulas inſuper li-"bras auri cogantur exſolvere;" and that, if they had not ſubſtance to defray this fine, they ſhould be condemned to ſlavery.

* Pagus is uſed in the ancient codes and early writers as ſynonimous with civitas and comitatus. Civitas ſometimes is employed for urbs, but generally in the ſenſe of municipium, or of a ſubordinate ſtate, comprehending a town and territory. *Greg. Tur. lib.* 7. § 6. 12. 13. 33. *&c.* Cæsar, *&c.* uſes pagus in this way, ſeptem Helvetiorum pagi, *&c.* The French pais, and German termination gaw, are ſuppoſed to be derived from it.

† Lib. 9. tit. 2. l. 9.

ſlavery. We have it, in the ſame law, ſpecifically pointed out, that the perſons ſubject to this puniſhment were the leaders of the ſubdiviſions of counties, *viz.* the decani, centenarii, quingentenarii, thiuphadi, together with the ſervi dominici, or under-ſtewarts and ſervile inhabitants of the royal domains, and all the freemen, arranged by their diſtricts, whether Goths or Romans. Nor were the moſt conſiderable proprietors not included in this enumeration; for we find it directed, that thoſe who are included in it ſhould bring with them to the army the tenth part of their ſlaves in arms; and, in the preamble, it is complained, that people conceal their ſlaves, though poſſeſſed 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 ſhows, that it was deſtined to extend to every perſon, *cunctis populis regni*, but it ſpecifies the majoris loci perſonæ to be the dux, comes, ſive etiam gardingus, all others being claſſed as inferiores perſonæ, although mention is notwithſtanding made of ſeniors leading their vaſſals and commanding them in the army. Thus the circumſtance, *viz.* ſuperiority over vaſſals, that was afterwards ſo characteriſtic of feudal greatneſs, was not then held to diſtinguiſh a perſon from the reſt of the nation; but a feudal lord is claſſed as a perſona inferior, and is menaced with fine, whipping, and even ſlavery, equally with the loweſt freeman.

We have here, therefore, a very clear deſcription of the ranks of perſons, *viz.* magiſtrates, freemen, and different claſſes of men of ſervile condition *; and we are ſure, that there was no patrician order diſtinct from the other freemen, for ſeveral reaſons: 1*ſt*, No claſs of perſons is mentioned which could form ſuch an order; whereas, in a law framed for calling forth the nation

* We find the ſame orders ſpecified in the following paſſage of an ancient author: "Vetus conſuetudo pro lege apud Francos et Suevos inolevit, ut ſi quis nobilis, miniſteri-"alis, vel colonus, coram ſuo judice pro hujuſmodi exceſſibus reus inventus fuerit, an-"tequam mortis ſententia puniatur, ad confuſionis ſuæ ignominiam, nobilis canem, mini-"ſterialis ſellam, ruſticus aratri rotam, de comitatu in proximum comitatum geſtare co-"gatur." *Lib.* 2. *de Geſt. Federic. c.* 18. See alſo *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 loweſt 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 imagine, that it is poſſible to diſcover it at the emigration from Germany, 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 Europe till the twelfth century †. And we find, that the nobili-

* 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 disputed, that, till the Greeks were possessed of the art of writing, they could have nothing that deserved the name of history. When that art was introduced among them is uncertain; but there is reason 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 speaks in one passage, did not contain any writing, but only marks or signs *. At any rate, it cannot be supposed, that writing was much known or practised, at that time, or indeed for long after. It appears from many charters, and other deeds, in this country, that men of the first families and fortunes in it could not, a few centuries ago, write their

 names;

* Iliad. vi. 168. So EUSTATHIUS says expressly; and the reason he assigns, is, that letters were the invention of later times. He might have added, that it appears from several other passages in HOMER, that with him γραφειν does not signify *to write*, but *to trace* or *mark*; nor σημα *a letter*, but *a mark*, or *sign*, or *credential*. Iliad vii. 175. 187. 188. 189.; and Odyss. xxiv. 328. And σημα has unquestionably this signification in xxiii. 206. In this passage respecting *Bellerophon*, had Madam DACIER and Mr POPE adverted to this, they would not have translated this passage as they have done. Πορε δε οι σημαλα λυγρα, clearly means, that he gave him a token or credential that was meant to be destructive to him; and γραψας θυμοφθορα πολλα, that he traced in these folded tables many marks or signs, that gave to understand he was desirous of his death. There is, likewise, no mention of writing in the Æneid; which shews, 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 ſtory of HARMODIUS and ARISTOGITON. Of this he gives the detail in his ſixth book; "Becauſe neither the "Athenians, or others, knew who was the tyrant at the time, "or what was the real fact that happened." Poems had been compoſed, and ſtatues erected, in honour of thoſe men, as being the champions of liberty, and the deliverers of their country, by a bold ſtroke, in putting its tyrant to death; but it appears, from the narrative of THUCYDIDES, that all this was undeſerved, and proceeded from a groſs miſtake; 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 moſt enlightened people of Greece, could be ſo miſled as to an event which happened but eighty-two years before the Peloponneſian war, what liberties might not HOMER take, in relating the circumſtances 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, ſuppoſed by the author of the life of HOMER, commonly aſcribed to HERODOTUS, that he was only 168 years later than the Trojan war; but, from what THUCYDIDES ſays, it ſhould ſeem that he thought he was long poſterior † to it; and that, in fact, he was ſo, is apparent from ſeveral paſſages in his works. In one place, he ſays, that DIOMEDE lifted, brandiſhed, and threw a ſtone, which two men, ſuch as men are now-a-days, would not be able to carry; and, in another, that HECTOR lifted, brandiſhed, and threw a ſtone, which two men, ſuch as men are now-a-days, would not be able to heave from the ground into a cart; but ſo great a degeneracy could not have

* IT took its riſe from παιδικα. THUCYDIDES ſays ARISTOGITON ειχεν αυτον.

† Πολυ υστερον.

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 *.

2*dly*, 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 expoſed

* 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. ‡ Μυθικος λογος.

expoſed his kingdom to deſtruction for a woman, if he had had her to deliver up.

THIS is a very curious paſſage. It proves clearly, that HERODOTUS, before he converſed with the Egyptian prieſts, doubted extremely of the account given by the Greeks of the Trojan war. He ſeems, however, to have altered his opinion, in conſequence 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 refuſal to reſtore HELEN, when demanded by the Greeks; but, if he had reflected a little, he muſt have been ſatisfied, that it could not be true that HELEN was not in Troy during the ſiege. If ſhe had not been there, it is impoſſible to believe that the Greeks would not have diſcovered this in leſs than ten years. They muſt very ſoon 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, ſuppoſing that the hope of plunder would have made them continue it, yet MENELAUS ſurely would have gone for her to Egypt himſelf, or, at leaſt, ſent ſome perſon thither to enquire about her. Indeed, the aſſertion of the Trojans was, of itſelf, ſufficient to have induced him to take that trouble. This has been remarked by RICCIUS*, who juſtly maintains, that HOMER's ſtory as to this point is the more credible of the two: "Quis vero non "videat, magis præ ſe ferre ſpeciem fabulæ id quod narrabant "ſacerdotes, quam quod habet HOMERUS; eſtne, quæſo, veri"ſimile in ea ambiguitate perdurare voluiſſe Græcos decem "annos? Cum recipiendæ HELENÆ tam eſſet cupidus MENE"LAUS, non mitteret ſtatim aliquos in Ægyptum qui exquire"rent, an vere apud PROTEUM illa detineretur? Non id om"nino faciendum cenſerent frater AGAMEMNON ſupremus co"piarum imperator, NESTOR aliique duces? Quæ major abſur"ditas, quæ inſignior imprudentia, quæ craſſior ſtoliditas de "Græcis

* Diſſert. HOMER. vol. ii. diſſ. 40. p. 216.

" Græcis ducibus virtute et conſilio celeberrimis confingi un-
" quam poſſit?"

SEVERAL ancient authors thinking it improbable that HELEN was in Troy, and ſeeing the force of the argument againſt the ſuppoſition of her not having been there, contrived a fiction to reconcile the two accounts, *viz.* That VENUS had created a ſhape or figure ſo exactly like HELEN, that PARIS carried the counterfeit* with him to Troy, believing it to be the celebrated Beauty herſelf. EURIPIDES's tragedy of HELEN turns entirely upon this; and MUSGRAVE, in his notes, conjectures, that the ſtory had been contrived by HELEN, in conjunction with the Egyptian prieſts, to re-eſtabliſh her character after her return to Greece. It is plain, however, that, according to the Egyptian prieſts and HERODOTUS, HOMER has falſified the ſtory in one material circumſtance; if ſo, it is impoſſible to ſay where he would ſtop.

3*dly*, Although THUCYDIDES, in his introduction, does ſuppoſe the truth of the Grecian expedition againſt Troy, and refers to HOMER for ſeveral particulars, yet he once and again enters the caveat, " if any credit is to be given to his poems."

Laſtly, PAUSANIAS ſays, in ſo many words, that he gives more credit to HOMER than the *generality* of people do. The expreſſion in the original† is rather ſtronger; and it is certain, that ſeveral ancient authors, whoſe works unfortunately have not reached us, arraigned HOMER of falſehood, in treatiſes written on purpoſe to convict him of it §. I will not quote from LUCIAN, as his levity might be objected to, but only obſerve, that, if the common chronology be juſt, he had good reaſon to laugh at the ſuppoſition of PARIS falling in love with HELEN, or of her being an object of contention to Aſia and Greece, as it is demonſtrable that ſhe muſt have been about an hundred years of age when Troy was taken; for, according to

* Εἰδωλον. † Οἱ λοιποι, p. 160. edit. 1696.

§ See an enumeration of them in the preface to Philoſtr. Heroica, p. 603. edit. 1709.

the common chronology, ſeventy-nine years elapſed between the Argonautic expedition and the taking of Troy; now ſhe was the twin-ſiſter of POLLUX, who was one of the Argonauts, and who fought and beat a famous boxer in the paſſage to Colchis, and therefore cannot be ſuppoſed, 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 aſſignation on the day ſhe entered her eightieth year. But this ridicule ſtrikes only againſt the common chronology; for HOMER ſays nothing to aſcertain the period of time that elapſed between the two expeditions. From a circumſtance, however, which he does mention, and which will be taken notice of by and by, it appears, that ſhe could not be under forty when Troy was taken.

AFTER what has been ſtated, I may venture, I imagine, to proceed with leſs timidity than I otherwiſe could have done, to endeavour to ſhew, that the account given by the Greeks of their expedition againſt Troy is incredible and inconſiſtent with itſelf; and that (if ever there was at all a Trojan war) Troy was not taken by them, but that they were obliged, by thoſe who defended it, to raiſe the ſiege, and retire with loſs and diſgrace.

SEVERAL of the arguments to be urged in the ſequel upon this ſubject are taken from a very curious diſſertation 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 ſtyle, and the elegance and depth of his ſentiments and reflections. He has written two diſſertations upon HOMER; in one of them *, he makes his panegyric as a poet; but, in the other †, takes him ſeverely to taſk as an hiſtorian. The firſt mentioned, which is in praiſe of the poet, is taken notice of by almoſt every commentator who has publiſhed an edition of his works; but not one of them makes the leaſt mention of the other. Hence it is not much known.

THIS

* Orat. lv. † Orat. xi.

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

Troas. Many auxiliaries came to the aſſiſtance of PRIAM, and an obſtinate and bloody war enſued, in the courſe of which great numbers fell on both ſides; but the Greeks had all along the worſt of it. They loſt a great number of troops, and ſome of their braveſt commanders. HECTOR, according to this author, inſtead of being ſlain by ACHILLES, himſelf ſlew both ACHILLES and AJAX; though HOMER, to cover this diſgrace, has made the former, who was the braveſt of the Greeks, periſh by the hand of PARIS, the moſt daſtardly of the Trojans, the latter by his own. At laſt, after ſuffering an infinity of hardſhips and loſſes, the Greeks were glad to retire as they beſt could. He gives a very long detail of the war; but, for the reaſon already mentioned, I enter not upon it, but proceed to the real evidence he offers of the falſity of the common ſtory.

IN conſidering this matter, it will be proper to view the circumſtances and ſituations of perſons and affairs, as at four different periods: *1ſt*, Before the voyage of PARIS to Sparta. *2dly*, As at the time of his arrival there. *3dly*, During the war. And, *laſtly*, After the taking and ſacking of Troy.

IT is, by no means, probable that PARIS would fall in love with a woman whom he had never ſeen; and ſtill leſs ſo, that he would form the deſperate and nefarious project of carrying her off from her huſband, a powerful king, who lived at a conſiderable diſtance, and beyond ſeas.

CHRYSOSTOM might have added, that the force of this objection was foreſeen; and that to obviate it, was invented what is called the *judgment of* PARIS; for it was not the ſhepherd of Ida that conceived this plan; he was put upon it by VENUS, who promiſed him ſucceſs in reward of his having adjudged the apple to her.

BUT further, PARIS could not get a ſhip, or a crew, without the conſent or connivance of his father; yet it cannot be believed, that PRIAM, an old, wiſe and good king, would give any countenance to ſuch an undertaking.

LET

LET it be ſuppoſed, however, that PARIS, ſomehow or other, got a ſhip and crew, and arrived at Lacedæmon, when MENELAUS and her brother were abſent, (for it is ſurely neceſſary to ſend them away); and let it be ſtill further ſuppoſed, that he had been able to perſuade her to forſake her huſband, her child, and her country, and to follow, to her own eternal diſgrace, a young adventurer to a ſtrange land; yet ſtill inſurmountable difficulties ſtood in the way of his carrying her off. For it muſt be obſerved, that Lacedæmon was not a ſea-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 conſiſted in bulky goods, ſuch as, wearing apparel, carpets, tapeſtry, and veſſels of different kinds. It was impoſſible, therefore, for PARIS to carry her off ſecretly. He muſt have done it openly and avowedly, and in the face of the ſun; and a number of horſes and carriages were neceſſary to tranſport the lady and her baggage from Lacedæmon to the ſea-port. Now, ſuppoſing MENELAUS abſent, is it poſſible to believe that his ſubjects would have ſat with their arms acroſs, and beheld the wife and the wealth of their king carried off by a handful of banditti?

IT is not eaſy to figure a tolerable anſwer to this objection. The author of one of the ſpurious hiſtories of the Trojan war in Latin felt its force, and to avoid it, pretends, that PARIS met with HELEN in the iſland of Cythera, near the coaſt of Sparta. But this is inadmiſſible; for, in the *firſt* place, HOMER expreſsly ſays, in a variety of paſſages, that HELEN was brought from Lacedæmon to Troy; and, 2*dly*, Not only ſhe, but all her valuable effects were carried off; and ſhe certainly would not have theſe with her, when upon an excurſion to an iſland in the neighbourhood.

WE come now to the period of the war. It is very ſurpriſing that the Trojans did not deliver up HELEN to the ambaſſadors ſent

ſent from Greece, as the demand was not only founded in juſtice, 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.

THE

* 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, repreſented as perfectly irreſiſtible to the Trojans. How then came it about that the war laſted ſo long?

THE only anſwer that can be made to this is, that the Trojans kept within their walls as long as ACHILLES appeared; and this HOMER himſelf ſuggeſts †, though it is contradictory to ſeveral other paſſages, where it is ſaid, that many battles had been fought, and great numbers ſlain on both ſides.

BUT this will not prove ſatisfactory, when it is conſidered, that ANDROMACHE, in the interview ſhe has with HECTOR in the ſixth book, tells him, that the city was to be come at, and the wall eaſily ſcaled ‡; and that AJAX, AGAMEMNON, MENELAUS, and DIOMED, had three times attempted it. If ſo, what hindered ACHILLES to ſtorm the town the day after he landed? How came AJAX, and the other chiefs, to be ſo long in threatening an aſſault? Madame DACIER, in a note on this paſſage, ſays, That the art of reconnoitering was not known, at this time, even to the Greeks. The abſurdity of the anſwer ſhews the force of the obſervation. A wolf, fox, or other beaſt of prey, that wants to get into a fold or cloſe where ſheep or cattle are confined, would walk round it to diſcover at what place the fence was loweſt.

BUT further, ſuppoſing the town to have been impregnable, how came the Greeks not to take it by blockade? They had a powerful fleet, the Trojans none; ſo that it was eaſy to hinder the town from being ſupplied with proviſions by ſea; and it was equally eaſy to have drawn lines around it, which would have cut off all communication between it and the country; the infallible conſequence of which would have been, that the Trojans muſt have ſurrendered as ſoon as their ſtock of proviſions

* Il. viii. 558. † Il. vii. 352.; xviii. 287. ‡ Il. vi. 434.

ſions was conſumed. As the Greeks did not draw lines around the town, whilſt, at the ſame time, we are told they threw up a rampart before their own ſhips, and as the Trojans received ſuccours from their neighbours at different times, the fair concluſion is, that the Greeks were not maſters of the country, nor ſuperior to the Trojans in the field, but, on the contrary, found themſelves overmatched. If it ſhall be ſaid, that the art of drawing lines was not known to the Greeks, I anſwer, that the method they took to ſecure their ſhips proves the contrary to be true; and, had they been ignorant of that art, (if ſo ſimple an operation deſerves that name), they never would have thought of the ſiege, as they had no artillery or machinery of any kind for making a breach in the walls: Beſides, without any art or labour, they could have placed bodies of troops ſo as to intercept all the Trojan convoys.

HOMER admits, that the Greeks ſuffered more before Troy than any mortal man could relate*: That they loſt a great number of men, many excellent officers, and that AJAX, ANTILOCHUS, PATROCLUS, and ACHILLES, the greateſt hero of them all, periſhed in the expedition. This, of itſelf, affords a preſumption that they were not ſucceſsful. It is very improbable that ACHILLES fell by the hand of PARIS; the truth ſeems to be, that he died by that of a better man. HECTOR poſſeſſed himſelf of his armour, which is not at all ſurpriſing, if he ſlew its owner; but cannot otherwiſe be explained: For, as to the ſtory of PATROCLUS dreſſing himſelf in the armour of ACHILLES, and being ſlain and ſtripped by HECTOR, it cannot poſſibly be true. ACHILLES was by far the ſtrongeſt and ſtatelieſt 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 uſe it; and, therefore, HOMER† makes

* Odyſſ. iii. 105. † Book xvii. 210.

JUPITER interpoſe to fit it to his body; though, after all, the god did not perform the work ſufficiently; for HECTOR owed his death to fighting ACHILLES in that armour, as an aperture ſtill remained near the throat, through which ACHILLES drove his ſpear. If then the armour of ACHILLES could not be uſed by HECTOR, how is it poſſible, that it could be uſed by PATROCLUS, who was ſo much inferior to him? It is palpable, that he muſt have been almoſt as ill fitted with it as DAVID was with SAUL's. HOMER himſelf admits *, that PATROCLUS could not wield ACHILLES's ſpear, how then could he ſupport, not to ſay march and fight, under the load of his armour?

IT cannot be denied, that ACHILLES fell during the ſiege; and it is evident the Greeks muſt have been leſs able to take the town, after this and their other loſſes, than before. Accordingly it is admitted by HOMER and his followers, that they did not take it by *force*, but it is pretended they took it by ſtratagem. HOMER's account of which, is preciſely as follows †: EPEUS made a wooden horſe, into which ULYSSES and the Grecian chiefs went with a body of troops; the reſt of the Greeks burnt their tents, and ſet ſail. Upon this, the Trojans came down, and, along with them, HELEN. She, attended by DEIPHOBUS, went three times round the horſe, calling each of the Grecian leaders by his name, and mimicking the voice of his wife. This made them all, except ULYSSES, deſirous to get out, or return an anſwer; but he reſtrained them, and clapped his hand on the mouth of one of them, who was more eager to ſpeak than the reſt, and kept him gagged in that manner till HELEN retired. The Trojans then drew up the machine to their citadel, and held a conſultation as to what they ſhould do with it. Some were for cutting it up; ſome for precipitating it from the rock; but others thought it ought to be allowed to remain as a propitiatory figure. This laſt opinion prevailed, and the Greeks came out

* Il. xvi. 140.

† Odyſſ. 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

* Æneid. ii. † In conſpectu. ‡ Condunt.

at leaſt. If ſo, it cannot be believed, that they would have made a large breach in their wall, when the enemy was ſo near. But it would be improper to dwell longer here. Since the town, it is admitted, was not taken by force, and ſince the ſtratagem by which it is alleged to have been taken is abſurd and impracticable, the fair concluſion is, that it was not taken at all, and that we ſhould have read the repulſe of the Greeks in verſe, if time had not envied us the works of the poets of Troy.

LET us now ſee what happened, according to the Greek writers, after Troy was, as they pretend, taken and ſacked. If the Greeks had been, in reality, victorious, it is natural to ſuppoſe that they would have returned home in a body, in good order, obſerving due diſcipline and obedience to their general. But, inſtead of doing ſo, HOMER tells us *, that they quarrelled among themſelves, differed about the courſe they ſhould ſteer; that ſome went one way, ſome another, and that ſeveral were ſhipwrecked.

BUT this is not all: If the Greeks had been, in reality, victorious, thoſe who returned would have been received as conquerors, with open arms by their families, and with acclamations by their ſubjects. But the reverſe of this confeſſedly happened. AGAMEMNON, their captain-general, upon his arrival, was ſlain in his own houſe, by a villain who had debauched his wife in his abſence. Would ſuch have been his fate, had he appeared at the head of an army of conquerors? And not only was he himſelf ſlain, but, according to HOMER, all thoſe who returned with him; yet this exploit was performed, he ſays, by ÆGISTHUS, with no more than twenty men; and he reigned ſeven years in AGAMEMNON's ſtead †, till he was aſſaſſinated, in his turn, by ORESTES. DIOMED was ſoon driven from his country, and NEOPTOLEMUS from Peloponneſus; and, according to the account of the former in VIRGIL, all who were concerned in the expedition

* Odyſſ. iii. 136.

† Ibid. iv. 530.

expedition againſt Troy were diſperſed over the earth, and ſuffered 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 affairs of the Greeks before Troy were deſperate, no ſet of men would have dared to have poſſeſſed themſelves of his houſe, inſulted his wife, and devoured his ſubſtance, as he could have returned 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 obtained a very good ſettlement indeed, for himſelf and his followers. So did ANTENOR; and, what is ſtill more wonderful, HELENUS goes and occupies a part of Greece, eſtabliſhing himſelf in Epirus. It certainly never was before heard of, that a conquered 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 partly

* 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 ſettlement 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 reſearches on this queſtion; but, were I to do ſo, this paper would ſwell to a treatiſe: Beſides, I have ſaid enough, I imagine, 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 undeceive themſelves.

To conclude: As it is a matter of indifference to us now-a-days, whether the Greeks or Trojans prevailed, there is no reaſon why the foregoing argument ſhould be read with diſlike or regret: On the contrary, it is the favourable ſide of the queſtion; for, if it leſſens ACHILLES, who had nothing but perſonal courage and ſtrength to recommend him, it exalts HECTOR, 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 character 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, *conſidered 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. *Miniſter of* INVERESK, *and Chaplain in ordinary to his* MAJESTY.

INTRODUCTION TO THE POEM.

AT a meeting of the Literary Claſs of the Royal Society, held on Monday 19th April 1784, the Reverend Dr CARLYLE read an ode, written by the late Mr WILLIAM COLLINS, and addreſſed to JOHN HOME, Eſq; (author of DOUGLAS, *&c.*) on his return to Scotland in 1749. The committee appointed to ſuperintend the publication of the Society's Tranſactions, having judged this ode to be extremely deſerving of a place in that collection, requeſted Mr ALEX. FRASER TYTLER, one of their number, to procure from Dr CARLYLE every degree of information which he could give concerning it. This information, which forms a proper introduction to the poem itſelf, 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 deſire of the Committee for publiſhing the Royal Society's Tranſactions, I wrote to Dr CARLYLE, requeſting of him an account of all ſuch 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 incloſed

incloſed anſwer, and he tranſmitted to me, at the ſame time, the original manuſcript in Mr COLLINS's handwriting. It is evidently the *prima cura* of the poem, as you will perceive from the alterations made in the manuſcript, by deleting many lines and words, and ſubſtituting others, which are written above them. In particular, the greateſt part of the twelfth ſtanza is new-modelled in that manner. Theſe variations I have marked in notes on the copy which is incloſed, and I think they ſhould be printed: For literary people are not indifferent to information of this kind, which ſhews the progreſſive 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 viſit made by Dr WARTON and his brother to the poet in his laſt illneſs, ſays, "He ſhewed them, at the ſame time, an ode, inſcribed to "Mr JOHN HOME, on the ſuperſtitions of the Highlands, "which they thought ſuperior to his other works, but which "no ſearch has yet found." COLLINS himſelf, it appears from this paſſage, had kept a copy of the poem, which, conſidering the unhappy circumſtances that attended his laſt illneſs, it is no wonder was miſlaid or loſt; and, but for that fortunate hint given by JOHNSON, it appears from Dr CARLYLE's letter, that the original manuſcript would, in all probability, have undergone the ſame fate.

STRUCK with the ſingular beauty of this poem, of which, I believe, no man of taſte will ſay 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 ſubject to my friend Mr HENRY MACKENZIE of the Exchequer, (a gentleman well known to the literary world by many ingenious productions) I propoſed to him the taſk of ſupplying the fifth ſtanza, and the half of the ſixth, which were entirely loſt. How well he has executed that taſk, the public will judge; who, unleſs warned by the inverted commas that diſtinguiſh the

the ſupplemental verſes, would probably never have diſcovered the chaſm. Several hemiſtichs, and words left blank by Mr COLLINS, had before been very happily ſupplied by Dr CARLYLE. Theſe are likewiſe marked by inverted commas. They are a proof that this poem, as Dr CARLYLE has remarked, was haſtily compoſed; but this circumſtance evinces, at the ſame time, the vigour of the author's imagination, and the ready command he poſſeſſed of harmonious numbers.

I am, dear Sir,

Yours, *&c.*

To ALEX. FRASER TYTLER, *Eſq;*

SIR,

I SEND you incloſed the original manuſcript of Mr COLLINS's poem, that, by comparing with it the copy which I read to the Society, you may be able to anſwer moſt of the queries put to me by the Committee of the Royal Society.

THE manuſcript 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 ſhewed it to Mr HOME, who told me that it had been addreſſed to him by Mr COLLINS, on his leaving London in the year 1749: That it was haſtily compoſed and incorrect; but that he would one day find leiſure 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 firſt ſtanza), who had been, for ſome time, at the univerſity of Edinburgh; had been a volunteer, along with Mr HOME, in the year 1746; had been taken priſoner with him at the battle of Falkirk, and had eſcaped, together with him and five or ſix other gentlemen, from the caſtle of Down. Mr BARROW reſided in 1749 at Wincheſter, where Mr COLLINS and Mr HOME

were, for a week or two, together on a viſit. Mr BARROW was paymaſter 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 verſes which he mentions, which he ſays was much prized by ſome of his friends, and for the loſs of which he expreſſes regret. I ſought for it among my papers; and perceiving that a ſtanza and a half were wanting, I made the moſt diligent ſearch I could for them, but in vain. Whether or not this great chaſm was in the poem when it firſt came into my hands, is more than I can remember, at this diſtance 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 moſt obedient ſervant,

ALEX. CARLYLE.

An

An ODE *on the* POPULAR SUPERSTITIONS *of the* HIGHLANDS *of* SCOTLAND, *conſidered 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;

* See the preceding letter from Dr CARLYLE.

By night they ſip it round the cottage-door,
While airy minſtrels warble jocund notes.
There every herd, by ſad experience, knows
How, wing'd with fate, their elf-ſhot arrows fly;
When the ſick ewe her ſummer food foregoes,
Or, ſtretch'd on earth, the heart-ſmit heifers lie.
Such airy beings awe th' untutor'd ſwain:
Nor thou, though learn'd, his homelier thoughts neglect;
Let thy ſweet muſe the rural faith ſuſtain:
Theſe are the themes of ſimple, ſure effect,
That add new conqueſts to her boundleſs reign,
And fill, with double force, her heart-commanding ſtrain.

III.

Ev'n yet preſerv'd, how often may'ſt thou hear,
Where to the pole the Boreal mountains run,
Taught by the father to his liſt'ning ſon
Strange lays, whoſe power had charm'd a SPENCER's ear.
At ev'ry pauſe, before thy mind poſſeſt,
Old RUNIC bards ſhall ſeem to riſe around,
With uncouth lyres, in many-coloured veſt,
Their matted hair with boughs fantaſtic crown'd:
Whether thou bid'ſt the well-taught hind repeat *
The choral dirge that mourns ſome chieftain brave,
When ev'ry ſhrieking maid her boſom beat,
And ſtrew'd with choiceſt herbs his ſcented grave;
Or whether, ſitting in the ſhepherd's ſhiel †,
Thou hear'ſt ſome ſounding tale of war's alarms;
When, at the bugle's call, with fire and ſteel,
The ſturdy clans pour'd forth their bony ſwarms,
And hoſtile brothers met to prove each other's arms.

'TIS

* Firſt written, *relate*.

† A kind of hut, built for a ſummer habitation to the herdſmen, when the cattle are ſent to graze in diſtant paſtures.

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

* 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 muſings rapt, they ſit to mark
" The labouring moon ; or liſt the nightly yell
" Of that dread ſpirit, whoſe gigantic form
" The ſeer's entranced eye can well ſurvey,
" Through the dim air who guides the driving ſtorm,
" And points the wretched bark its deſtin'd prey.
" Or him who hovers, on his flagging wing,
" O'er the dire whirlpool, that, in ocean's waſte,
" Draws inſtant down whate'er devoted thing
" The failing breeze within its reach hath plac'd—
" The diſtant ſeaman hears, and flies with trembling haſte.

VI.

" Or, if on land the fiend exerts his ſway,
" Silent he broods o'er quickſand, bog, or fen,
" Far from the ſhelt'ring roof and haunts of men,
" When witched darkneſs ſhuts the eye of day,
" And ſhrouds each ſtar that wont to cheer the night ;
" Or, if the drifted ſnow perplex the way,
" With treach'rous gleam he lures the fated wight,
" And leads him flound'ring on, and quite aſtray."
What though far off, from ſome dark dell eſpied
His glimm'ring mazes cheer th' excurſive ſight,
Yet turn, ye wand'rers, turn your ſteps aſide,
Nor truſt the guidance of that faithleſs light ;
For watchful, lurking 'mid th' unruſtling reed,
At thoſe mirk * hours the wily monſter lies,
And liſtens oft to hear the paſſing ſteed,
And frequent round him rolls his ſullen eyes,
If chance his ſavage wrath may ſome weak wretch ſurpriſe.

VII.

Ah, luckleſs ſwain, o'er all unbleſt indeed !
Whom late bewilder'd in the dank, dark fen,

Far

* Firſt written, *ſad.*

Far from his flocks and ſmoking hamlet then!
To that ſad ſpot " his wayward fate ſhall lead * :"
On him enrag'd, the fiend, in angry mood,
Shall never look with pity's kind concern,
But inſtant, furious, raiſe the whelming flood
O'er its drown'd bank, forbidding all return.
Or, if he meditate his wiſh'd eſcape
To ſome dim hill that ſeems upriſing near,
To his faint eye the grim and griſly ſhape,
In all its terrors clad, ſhall wild appear.
Meantime, the wat'ry ſurge ſhall round him riſe,
Pour'd ſudden forth from ev'ry ſwelling ſource.
What now remains but tears and hopeleſs ſighs?
His fear-ſhook limbs have loſt their youthly force,
And down the waves he floats, a pale and breathleſs corſe.

VIII.

For him, in vain, his anxious wife ſhall wait,
Or wander forth to meet him on his way;
For him, in vain, at to-fall of the day,
His babes ſhall linger at th' uncloſing † gate.
Ah, ne'er ſhall he return! Alone, if night
Her travell'd limbs in broken ſlumbers ſteep,
With dropping willows dreſt, his mournful ſprite
Shall viſit ſad, perchance, her ſilent ſleep:
Then he, perhaps, with moiſt and wat'ry hand,
Shall fondly ſeem to preſs her ſhudd'ring cheek ‡,
And with his blue ſwoln face before her ſtand,
And, ſhiv'ring cold, theſe piteous accents ſpeak:
Purſue ‖, dear wife, thy daily toils purſue
At dawn or duſk, induſtrious as before;

Nor

* A blank in the manuſcript. The line filled up by Dr Carlyle.
† Firſt written, *cottage.*
‡ Firſt written, *Shall ſeem to preſs her cold and ſhudd'ring cheek.*
‖ Firſt written, *proceed.*

Nor e'er of me one hapleſs thought renew,
While I lie welt'ring on the ozier'd ſhore,
Drown'd by the KAELPIE's * wrath, nor e'er ſhall aid thee more!

IX.

UNBOUNDED is thy range; with varied ſtile
Thy muſe may, like thoſe feath'ry tribes which ſpring
From their rude rocks, extend her ſkirting wing
Round the moiſt marge of each cold Hebrid iſle,
To that hoar pile which ſtill its ruin ſhows †:
In whoſe ſmall vaults a pigmy-folk is found,
Whoſe bones the delver with his ſpade upthrows,
And culls them, wond'ring, from the hallow'd ground!
Or thither where beneath the ſhow'ry weſt
The mighty kings of three fair realms are laid ‡:
Once foes, perhaps, together now they reſt.
No ſlaves revere them, and no wars invade:
Yet frequent now, at midnight's ſolemn hour,
The rifted mounds their yawning cells unfold,
And forth the monarch's ſtalk with ſov'reign pow'r
In pageant robes, and wreath'd with ſheeny gold,
And on their twilight tombs aerial council hold.

BUT

* A name given in Scotland to a ſuppoſed ſpirit of the waters.

† ON the largeſt of the *Flannan iſlands* (iſles of the Hebrides) are the ruins of a chapel dedicated to St FLANNAN. This is reckoned by the inhabitants of the Weſtern Iſles a place of uncommon ſanctity. One of the Flannan iſlands is termed the *Iſle of Pigmies*; and MARTIN ſays, there have been many ſmall bones dug up here, reſembling in miniature thoſe of the human body.

‡ THE iſland of *Iona* or *Icolmkill*. See MARTIN's Deſcription of the Weſtern Iſlands 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 iſland. There were two churches and two monaſteries founded there by St COLUMBUS about *A. D.* 565. BED. *Hiſt. Eccl. l.* 3. COLLINS has taken all his information reſpecting the Weſtern Iſles from MARTIN; from whom he may likewiſe have derived his knowledge of the popular ſuperſtitions of the Highlanders, with which this ode ſhows ſo perfect an acquaintance.

X.

BUT O! o'er all, forget not KILDA's race*,
On whoſe bleak rocks, which brave the waſting tides,
Fair Nature's daughter, Virtue, yet abides.
Go, juſt, as they, their blameleſs manners trace!
Then to my ear tranſmit ſome gentle ſong
Of thoſe whoſe lives are yet ſincere and plain,
Their bounded walks the rugged cliffs along,
And all their proſpect but the wintry main.
With ſparing temp'rance, at the needful time,
They drain the fainted ſpring, or, hunger-preſt,
Along th' Atlantic rock undreading climb,
And of its eggs deſpoil the Solan's neſt.
Thus bleſt in primal innocence they live,
Suffic'd and happy with that frugal fare
Which taſteful toil and hourly danger give.
Hard is their ſhallow ſoil, and bleak and bare;
Nor ever vernal bee was heard to murmur there!

XI.

NOR need'ſt thou bluſh, that ſuch falſe themes engage
Thy gentle mind, of fairer ſtores poſſeſt;
For not alone they touch the village breaſt,
But fill'd in elder time th' hiſtoric page.
There SHAKESPEARE's ſelf, with ev'ry garland crown'd†,
In muſing hour, his wayward ſiſters found,
And with their terrors dreſt the magic ſcene.
From them he ſung, when mid his bold deſign,
Before the Scot afflicted and aghaſt,

* The character of the inhabitants of St Kilda, as here deſcribed, agrees perfectly with the accounts given by MARTIN and by MACAULAY, of the people of that iſland. It is the moſt weſterly of all the Hebrides, and is above 130 miles diſtant from the main land of Scotland.

† THIS ſtanza is more incorrect in its ſtructure than any of the foregoing. There is apparently a line wanting between this and the ſubſequent one, *In muſing hour*, &c. The deficient line ought to have rhymed with *ſcene*.

The ſhadowy kings of BANQUO's fated line,
Through the dark cave in gleamy pageant paſt.
Proceed, nor quit the tales which, ſimply told,
Could once ſo well my anſw'ring boſom pierce;
Proceed, in forceful ſounds and colours bold
The native legends of thy land rehearſe;
To ſuch adapt thy lyre and ſuit thy powerful verſe.

XII.

IN ſcenes like theſe, which, daring to depart
From ſober truth, are ſtill to nature true,
And call forth freſh delight to fancy's view,
Th' heroic muſe employed her TASSO's art!
How have I trembled, when at TANCRED's ſtroke,
Its guſhing blood the gaping cypreſs pour'd;
When each live plant with mortal accents ſpoke,
And the wild blaſt up-heav'd the vaniſh'd ſword *!
How have I ſat, when pip'd the penſive wind,
To hear his harp, by Britiſh FAIRFAX ſtrung.
Prevailing poet, whoſe undoubting mind
Believ'd the magic wonders which he ſung!
Hence at each ſound imagination glows;
Hence his warm lay with ſofteſt ſweetneſs flows;
Melting it flows, pure, num'rous, ſtrong and clear,
And fills th' impaſſion'd heart, and wins th' harmonious ear †.

ALL

* THESE four lines were originally written thus:

How have I trembled, when, at TANCRED's *ſide,*
Like him I ſtalk'd, and all his paſſions felt;
When charm'd by ISMEN, *through the foreſt wide,*
Bark'd in each plant a talking ſpirit dwelt!

† THESE lines were originally written thus:

Hence, ſure to charm, his early numbers flow,
Though ſtrong, yet ſweet ————
Though faithful, ſweet; though ſtrong, of ſimple kind.
Hence, with each theme, he bids the boſom glow,
While his warm lays an eaſy paſſage find,
Pour'd through each inmoſt 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

* PULCHRUM imprimis videtur, non pati occidere quibus æternitas debeatur, aliorumque famam cum ſua extendere. PLIN. *lib.* 5. *epiſt.* 8.

view his mind then in reſpect to *Feeling*, to *Imagination*, and to *Judgment*; and conſider them as the leading powers to which ſubordinate ones are to be referred. The due union and the due extent of theſe conſtitutes that mental temperament, which, by making beauty the vehicle of inſtruction, muſt, at once, pleaſe the taſte and inform the underſtanding.

It may be thought, perhaps, that, as the three powers mentioned cannot be ſuppoſed requiſite in the hiſtorian alone, ſo no analyſis referring to them can be held truly deſcriptive of his character. All the fine arts, however, are cloſely allied. "Habent quoddam commune vinculum (ſays CICERO), et quaſi "cognatione quadam inter ſe continentur." Though the conſtituents of eminence be the ſame in the whole, yet theſe are highly diverſified by the applications and the balance required in each. A ſlight difference in the leading powers of mind forms all the variety which genius in the different arts exhibits. If thoſe principles then that are, at any time, adopted to form a ſtandard for juſt execution in any one of them be not, in ſome degree, general, it may be held as certain that they are not ſound.

By feeling is to be underſtood that nice ſenſibility which catches even the ſlighteſt impreſſion, and in which there ſubſiſts a due proportion between the emotion and the cauſe of its excitement. Thoſe characters of feeling that are adverſe to juſt execution in the works of taſte ariſe both from its deficiency and its exceſs. In the one caſe, nature has done too little, in the other ſhe has done too much. That callouſneſs which proceeds from the want of feeling excludes impreſſions of which others are conſcious, and thoſe falſe irritations which proceed from its exceſs ſuggeſt emotions which, by the ſober, are deemed unnatural, becauſe they were never felt by them. It is in that juſt medium, which is equally removed from the extremes mentioned, that feeling becomes the inſtrument of genius. The maſterly execution of an able writer pleaſes and even improves

that

that taſte, in which the balance is not delicate; and the enjoyment of the reader is jointly proportioned to the abſolute juſtneſs of the author's feelings, and to the correſpondence between them and his own.

By perceptions thus delicate, the hiſtorian's character muſt be highly improved. His deſcriptions muſt be tender, as being founded on thoſe nice circumſtances that eſcape an ordinary eye; and though his ſenſibility muſt multiply the grounds of deſcription, yet the correctneſs of his feeling leads him to ſuch only as are juſt. Hiſtorical narration is more frequently faulty from that bluntneſs of perception, by which the minute qualities of objects are concealed, than from that defect in judgment, by which the leaſt proper are ſelected. The detail often becomes prolix from the dulneſs of the writer. One of true feeling adopts a conciſe energy, which reaches both the heart and the underſtanding. He permits his reader to paſs little that is worthy of his notice, and he with-holds it from that only which is really beneath it.

From an hiſtorian of this deſcription a delicate ſenſe of what he owes to himſelf and to his reader is expected. If the ſtrain of his narration ceaſes, at any time, to be dignified, it is to remove, by variety, what would otherwiſe become tireſome. Quaint ornaments in his ſtile he rejects as deformities. To the approbation of the judicious, he cannot be ſuppoſed indifferent; but he ſcorns thoſe condeſcenſions with which the herd of readers is pleaſed*. A remark that is obvious and common finds no place in his narration; and, from a ſenſe of perſonal dignity, he would rather leave the more ignorant uninformed, than diſguſt the diſcerning. His ſenſibility to every moral ſentiment, not only detects the leaſt ſymptom 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 ſcires 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

* Ὁτι καθαπερ εμψυχῳ σωματος των οφθεων εξαιρεθεισων αχρειωται το ὁλον, ὁτως εξ ἱστοριας ταν φρης την αληθειαν, το καλαλειπομενον αυλης αναφελες γιγνεται διηγημα.

rous inſtrument in the hands of the unwary, but it is a powerful one in the hands of the judicious. He who relates thoſe great tranſactions, in which the paſſions of men have been intereſted, muſt enter into the ſcenes which he deſcribes, and muſt ſpeak the language of thoſe who bore a part in them. A cold narrative that is literally true would often be a falſe picture. Expreſſion, beſides, is as ſuſceptible of modifications as the ſentiment to which it gives vent. During the influence of paſſion, figurative language indicates the degree of emotion excited in the ſpeaker, and ſtimulates the hearer's feelings till they accord with his own. Even the illiterate ſuffer no deluſion by that play of fancy which gives energy to ſpeech. They, as well as the learned, inſtinctively ſtrip the animated conception of what is adventitious, and interpret meaning with the moſt preciſe exactneſs.

ALTHOUGH the hiſtorian, by the exertions of his fancy, may often introduce ornament with advantage, yet he muſt beware of employing it to exceſs. An impertinent profuſion of beauties tallies not with that dignity of manner which he ſhould aſſume and maintain. It is either the ſign of that flippant character, which is beneath him, or it is the reſource of one, conſcious of his own coldneſs, and borrowing from art the ſigns of that animation which nature has denied him.

BUT imagination is of uſe to the hiſtorian, not only when he is heated with his ſubject, and thereby led to adopt figurative language, but alſo when he means to deſcribe. The vivacity of thoſe conceptions which he is able to excite in others may equal, but will never ſurpaſs the vivacity of his own. By means of fancy, he can ſeize the circumſtance moſt characteriſtic of each object. From a juſt conſciouſneſs of the laws of aſſociation in his own mind, he diſcovers what theſe ſhould be in thoſe of others who have an equally correct taſte. By laying hold of one or a few circumſtances wiſely, he may produce a very powerful effect. He may give exiſtence to animated deſcription, inſtead of a lifeleſs, becauſe a verboſe detail.

THIS double uſe of imagination in the compoſition of hiſtory is perfectly conſiſtent 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 deſtroyed. Principles ſtrictly logical are not to be applied to terms denoting an exertion of fancy; becauſe they carry along with them more or leſs latitude, according to the intention of the ſpeaker at the time. The aggregate of theſe terms ſuggeſts ſomewhat different from that which it naturally excites. It only begins the picture which the fancy of the hearer muſt complete, and leaves that taſk to be performed by this delicate faculty, for which the powers of expreſſion ſimply are unfit.

BY a fine imagination, then, the hiſtorian's language acquires energy, and his deſcriptions livelineſs. The power may improve his expreſſion (we have found) without adulterating his matter. It may, in ſome inſtances, be too ſtrong, and, in others, too weak. In either caſe, the feelings of the writer and the reader may be in uniſon, without hitting their due pitch; and the high purpoſes of language, as the inſtrument of nice interpretation, muſt be thereby defeated.

IN the account already given of the powers of feeling and imagination, a reference has been made to another one, whoſe province it is to control the exceſſes of both. When the two former are feeble, the perſon in whom this is the caſe, muſt, for ever, keep the rank which nature has aſſigned him. No proviſion is made for multiplying the avenues by which perceptions can enter his mind, nor for increaſing his power of forming ideal combinations of ſuch as do. By means of judgment, however, luxuriance may be corrected, though deficiency cannot be ſupplied; and ſuch a balance may be eſtabliſhed among the different powers, as will conſtitute 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-

* 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 maintaining 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

* Tu tamen jam nunc cogita, quæ potiſſimum tempora aggrediar. Vetera et ſcripta aliis? parata inquiſitio ſed oneroſa collatio: Intacta et nova? graves offenſæ, levis gratia. Nam præter id, quod in tantis vitiis hominum plura culpanda ſunt, quam laudanda, tum ſi laudaveris, parcus: Si culpaveris, nimius fuiſſe dicaris: Quamvis illud pleniſſime, hoc reſtrictiſſime feceris. PLIN. *lib.* 5. *ep.* 8.

cauſes and effects as diſcernible in the hiſtory as it before was in the ſcenes to which it refers. An hiſtorian's buſineſs, according to LUCIAN, is to relate things as they were done *. The reader's experience is thus increaſed, 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 otherwiſe embarraſſed †.

THE hiſtorian's impartiality, which is a quality of the higheſt importance, is always proportioned to the ſtrength of his judgment. Fidelity and impartiality are ſometimes confounded, though the one is an attribute of the heart, and the other of the underſtanding. An hiſtorian of fidelity never means to deceive; an hiſtorian that is impartial is not apt to be deceived by circumſtances that relate either remotely or immediately to himſelf. In the relations of the former, we look for what is ſtrictly true; in thoſe of the latter, for ſuch a ſtate 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 deſigned violation of truth; but we pity the weakneſs that would miſlead involuntarily, and is biaſſed by circumſtances that are purely perſonal. LUCIAN requires of the hiſtorian to diveſt himſelf of every poſſible ground of partiality; "to have the indifference of a ſtranger in judging of his own works; to be of "no ſtate; to form his own laws; to acknowledge no king, and "to ſpeak the truth without regard to the opinion of parties ‡."

BUT judgment not only diveſts the hiſtorian of any unjuſtifiable attachment to what concerns himſelf, but enables him to ſee even indifferent objects in their true light. By means of this, he is diſpoſed neither to depreciate what is really important, nor to over-rate what is really mean. In examining the probability

* Τῳ δη Συγγραφεως ἐργον ἐν, ὡς γενομενα ειπειν.

† OCCASIONES autem redeunt in orbem, et quod olim erat commodum rurſus adhiberi et prodeſſe poteſt. BACON *de Aug. Scient. lib.* 2. *c.* 12.

‡ Ξενος εν τοις βιβλιοις, και απολις, αυτονομος, ἀβασιλευτος, ὑ τι τωδε η τωδε δοξει λογιζομενος, αλλα τι πεπρακται λεγων. Πως δει ἱστορ. 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

* BACON de Aug. Scient. l. 2. c. 10.

The characters of an author's ſtyle, too, are fixed by thoſe of his mind. It is delicate, lively and accurate, according to his ſenſibility, his fancy, and his judgment; and its comparative excellence is determined by the abſolute ſtrength of each power, and the general balance that ſubſiſts among the whole.

AFTER attempting to eſtabliſh a ſtandard, by which the merit of any hiſtorical work is to be tried, I mean now to apply it particularly to the writings of TACITUS. In doing ſo, I propoſe to give examples that will indicate the ſtrength of the three powers ſtated, taken ſeparately, and in the order in which they have been defined. After contemplating certain inſtances, in which our author's ſuperiority, with reſpect to each, will be evident, others may perhaps be ſuggeſted, in which his greateſt admirers cannot free him from cenſure.

THOUGH it is difficult to determine which of the three powers mentioned predominated in the mind of TACITUS; yet, from the nature of his ſubjects, his ſenſibility was often exerciſed in an uncommon degree. Inſtances of this are ſo numerous, that we muſt ſelect a few only of the moſt ſtriking. Let us take that of the death of GERMANICUS, and of the ſtate of his widow AGRIPPINA, in the end of the ſecond and beginning of the third book of the Annals.

THE ſituation of GERMANICUS, juſt before his death, (it muſt be remembered), was ſingular. He had long been the favourite of the Romans, on account of the agreeableneſs of his manners, and the high military character that he had acquired at a very early period of life. He was the adopted ſon of TIBERIUS, who, having become jealous of his popularity, had called him from the conqueſt of Germany, which he had nearly completed. He was diſmiſſed from Rome, under pretence of ſettling certain differences in the eaſt. His conduct there was invidiouſly 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 poiſoned by PISO; and, while he complains

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, proſequi defunctum ignavo
" queſtu; ſed quæ voluerit meminiſſe, quæ mandaverit exſe-
" qui. Flebunt GERMANICUM etiam ignoti: vindicabitis vos,
" ſi me potius quam 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, ſurrounded with her children, and carrying the aſhes of her huſband. The ſight 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 circumſtance is very happily laid hold of. The number of AGRIPPINA'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 preſents 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 diſcerneres proximos, alienos, viro-
" rum feminarumve planctus: Niſi quod comitatum AGRIPPINÆ
" longo mœrore feſſum, obvii et recentes in dolore anteibant."

THE death of OTHO, in the 48th chapter of the ſecond book of the hiſtory, preſents another ſcene, in which the delicacy of our author's feelings is manifeſt. In both caſes, by a previous narration, in which the art of the writer is judiciouſly concealed, he prepares the reader completely for thoſe ſtrokes in which his genius is to break forth. OTHO, after the defeat of his army, is repreſented as deſpairing of future ſucceſs, and as having formed the reſolution of putting an end to his exiſtence. He announces this reſolution to his friends, with ſuch art, as at once to maintain his own dignity, and to move their compaſſion. He reproves his nephew SALVIUS COCCEIANUS for dreading the vengeance of VITELLIUS, upon whoſe generoſity (he thought) he might throw himſelf with confidence; and finiſhes his advice thus: " Proinde erecto animo capeſſeret vitam, neu
" patruum ſibi OTHONEM fuiſſe, aut obliviſceretur unquam, aut
" nimium meminiſſet."

THE exhortation of ÆNEAS to his ſon ASCANIUS has been much admired:

> *Et te animo repetentem exempla tuorum,*
> *Et pater* ÆNEAS *et avunculus excitet* HECTOR*.

IN point of delicacy, in a ſimilar ſituation however, the hiſtorian has got beyond the poet. By the uſe of the adverb *nimium*, OTHO not only ſuggeſts to COCCEIANUS what the world would expect from him as his relation, but delicately inſinuates, that the remembrance of the uncle's virtues would furniſh no apology for the nephew's defects.

THE ſtrength of feeling exhibited by TACITUS always keeps pace with the trying circumſtances in which his characters are placed. Of this we have a ſtriking example in the account given of the trial of SORANUS and his daughter SERVILIA, in

* VIRG. Æn. xii. 439.

the 30th chapter of the 16th book of the Annals. During the many unjuſt proſecutions under NERO, SORANUS was accuſed of intimacy with RUBELLIUS PLAUTUS, who had been baniſhed, and alſo of miſbehaviour as a proconſul. His daughter, from ſtrong affection to her injured father, had ſold her clothes and jewels, in order to conſult the magicians as to the event of his trial. On this account, ſhe, too, was ordered to appear before the ſenate. " Igitur accita eſt in ſenatum, ſteteruntque di-
" verſi ante tribunal conſulum, grandis ævo parens; contra fi-
" lia intra viceſimum ætatis annum, nuper marito ANNIO POL-
" LIONE in exilium pulſo, viduata deſolataque: Ac ne patrem
" quidem intuens, cujus oneraſſe pericula videbatur. Tum in-
" terrogante accuſatore, an cultus dotales, an detractum cervici
" monile venum dediſſet quo pecuniam faciendis magicis ſacris
" contraheret? Primum ſtrata humi, longoque fletu et ſilentio,
" poſt 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 ſer-
" varetis incolumem. Sic gemmas et veſtes et dignitatis inſignia
" dedi, quomodo ſi ſanguinem et vitam popoſciſſent. Viderint
" iſti, antehac mihi ignoti, quo nomine ſint, quas artes exerce-
" ant: Nulla mihi principis mentio, niſi inter numina fuit.
" Neſcit tamen miſerrimus pater: Et ſi crimen eſt, ſola deliqui."
" Loquentis adhuc verba excipit SORANUS proclamatque, " Non
" illam in provinciam ſecum profectam, non PLAUTO per ætatem
" noſci potuiſſe; non criminibus mariti connexam; nimiæ tan-
" tum pietatis ream, ſepararent a ſe quamcunque ſortem ſubi-
" ret." Simul in amplexus occurrentis filiæ ruebat, niſi inter-
" jecti lictores utriſque obſtitiſſent."

A BEAUTIFUL conteſt is here preſented between the ſtrongeſt parental and filial attachments. The deſcription is the language of nature throughout. Every circumſtance is carried its due length, without bordering upon extravagance. No tragic poet, whoſe fancy is allowed a latitude which is denied the hiſtorian,

ſtorian, could exhibit even the ſcene he had created, with more exquiſite delicacy than TACITUS deſcribes this that had actually taken place.

BUT the fine feeling of our author is apparent, not only upon ſuch gloomy and ſuch trying occaſions as thoſe mentioned, but in the more ordinary tranſactions of life. When HORTALUS, a deſcendant of the great HORTENSIUS, applied to the ſenate, 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 ſervile ſenators were ſhocked with TIBERIUS's refuſal. The emperor perceiving this, agreed to give a paultry donative to his male children. Some of the ſenators indeed expreſſed their thankfulneſs; but HORTALUS was ſilent. "Egere alii grates; ſiluit HOR-" TALUS, pavore, an avitæ nobilitatis etiam inter anguſtias for-" tunæ retinens." This laſt conjecture, as to the cauſe of HORTALUS's ſilence, could be formed only by a perſon delicately ſenſible of what was due to himſelf. More than ſufficient violence had been done to the feelings of HORTALUS, when he confeſſed his poverty and begged relief. The niggardly behaviour of TIBERIUS gave him a right to inſult the emperor, and, by an expreſſive ſilence, to tell him, in the face of his ſenate, that though he had been forced to implore his bounty, yet he deſpiſed his character.

That TACITUS was a ſtrictly moral writer, and expreſſed, at all times, the ſtrongeſt love of virtue and deteſtation of vice, is evident throughout his works. A ſenſe of his duty as an hiſtorian ſeems often to have forced him to relate what he would have wiſhed to conceal. He appears to feel for thoſe miſeries of others, which, as a rigid moraliſt, he allows to be the juſt conſequence of their vices. In the 6th chapter of the 6th book of his Annals, he deſcribes TIBERIUS as completely wretched, and agrees with SOCRATES as to the cauſe of this unhappineſs. " Neque fruſtra præſtantiſſimus ſapientiæ firmare ſolitus eſt, ſi

" recludantur tyrannorum mentes, poſſe aſpici laniatus et ictus;
" quando ut corpora verberibus, ita fævitia, libidine, malis con-
" ſultis animus dilaceretur. Quippe TIBERIUM, non fortuna
" non ſolitudines protegebant, quin tormenta pectoris ſuaſque
" ipſe pœnas fateretur."

THE high independence of ſpirit poſſeſſed by TACITUS, may be inferred from what he ſays both of himſelf and of others. In the 63d chapter of the 2d book of the Annals, he condemns MAROBODUUS for continuing in exiſtence as the priſoner of TIBERIUS. " Conſenuitque multum imminuta claritate, ob
" nimiam vivendi cupidinem."

THIS ſame independent ſpirit is ſometimes ſeen conjoined with his love of truth. As the reign of NERO was not very diſtant from the times in which he wrote, of courſe, by attacking the ſervility of the ſenate, he muſt have offended many people of the firſt rank. Their diſpleaſure, however, he deſpiſed, when put in competition with his own honour and veracity. " Neque tamen ſilebimus, ſi quod ſenatuſconſultum adulatione
" novum aut patientia extremum fuit*."

FROM the inſtances quoted, it appears, that TACITUS poſſeſſed, in no ordinary degree, thoſe qualities of an hiſtorian, that are dependent upon feeling. Few circumſtances, from their minuteneſs, could eſcape his obſervation. He felt ſtrongly the fineſt emotions, which the moſt trying ſituations of his characters could excite. He was, at all times, the friend of virtue. A regard for poſterity ſeems chiefly to have prompted him to exert his powers as an hiſtorian; and, from the ſame benevolent principle, he is always ſcrupulouſly careful, not to affirm with certainty when there could be the leaſt reaſon for doubt.

THE power of imagination, as we obſerved, enables the hiſtorian to write with energy, by the proper uſe of figurative language, and to ſelect thoſe figures that are the fitteſt for deſcription. Upon examining the ſtyle of TACITUS attentively, it will

* Ann. l. 4. c. 64.

will appear, that he uſes figures more ſparingly than is commonly imagined. Though the general train of his narrative be nervous, yet few parts of it are highly embelliſhed. The figures that he employs are uſed more frequently with a deſign to explain his idea, than to announce the ſtrength of his emotion; and even when he has this laſt purpoſe in view, he often employs interrogations, and ſuch other modes of ſpeech, as are the ordinary language of paſſion.

FROM the juſtneſs of TACITUS's diſcernment, his ſimiles are remarkably happy. They are, indeed, rarely, but they are always judiciouſly introduced. It is, in every inſtance, clear, that he had perceived the reſemblance ſtrongly and diſtinctly himſelf; and, by making the alluſion, ſome good purpoſe is completely ſerved. Thus, to give a lively idea of the torpid indolence of VITELLIUS, in the 36th chapter of the 3d book of his Hiſtory, he compares him to thoſe lazy animals, which, when the calls of nature are ſatisfied, have no other object of deſire. "Sed umbraculis hortorum abditus, ut ignava animalia, quibus ſi cibum ſuggeras jacent torpentque; præterita, inſtantia, futura pari oblivione dimiſerat." The expreſſion in the end of this ſentence is both bold and happy. The term *dimiſerat* intimates a kind of activity even in the indulgence of ſloth; and the term *oblivio*, applied to the preſent and the future, inſinuates, that both perception and foreſight were extinguiſhed, like the impreſſions of memory when effaced.

ONE of the boldeſt, and, at the ſame time, one of the happieſt figures to be found in TACITUS, is that at the end of his life of AGRICOLA. It is, at once, an inſtance of the proſopopeia and the apoſtrophe, as it ſuppoſes life in his father-in-law who was dead, and gives preſence to a perſon who was abſent. The high reſpect entertained for the memory, and the deep grief felt for the death of AGRICOLA, juſtified the uſe of theſe bold figures; and, as they are introduced with propriety, ſo they are ſupported with the utmoſt art. "Tu vero felix

"AGRICOLA

" AGRICOLA non vitæ tantum claritate, ſed etiam opportunitâ-
" te mortis. Ut perhibent qui interfuerunt noviſſimis ſermo-
" nibus tuis, conſtans et libens fatum excepiſti, tanquam pro
" virili portione innocentiam principi donares. Sed mihi filiæ-
" que præter acerbitatem parentis erepti, auget mœſtitiam, quod
" aſſidere valetudini, fovere deficientem, ſatiari vultu, complexu,
" non contigit. Excepiſſemus certe mandata voceſque, quas
" penitus animo figeremus. Noſter hic dolor, noſtrum vulnus:
" Nobis tam longæ abſentiæ conditione ante quadriennium
" amiſſus es. Omnia ſine dubio, optime parentum, aſſidente
" amantiſſima uxore, ſuperfuere honori tuo: Paucioribus tamen
" lacrymis compoſitus es, et noviſſima in luce deſideravere ali-
" quid oculi tui."

THE delicacy, joined to the ſtrength of painting, which is diſcernible in the paſſage now quoted, ſhows ſufficiently, that though TACITUS employs figures ſeldom, yet his doing ſo ariſes from no defect in his powers. The frequent uſe of theſe is, in fact, a ſtratagem to which writers of ordinary genius feel themſelves driven. They wiſh to borrow a device from art, to conquer a barrier eſtabliſhed by nature. For a device of this kind, TACITUS had no occaſion. The ordinary train of his narration is ſufficiently animated to ſummon and to retain his reader's attention; and, when he chuſes to leave this train, he knows perfectly how to riſe with propriety, and to deſcend without falling.

THE inſtances of fine deſcription are ſo numerous in TACITUS, that it is not eaſy to determine which ought to be ſelected. In all his attempts to deſcribe, brevity is ſtudied. When he deſcribes the plague at Rome, in the 13th chapter of the 16th book of his Annals, he employs a few ſentences, but each ſentence is full of meaning. " Omne mortalium genus
" vis peſtilentiæ depopulabatur, nulla cæli intemperie quæ oc-
" curreret oculis. Sed domus corporibus exanimis, itinera fu-
" neribus complebantur. Non ſexus, non ætas periculo vacua.

" Servitia

" Servitia perinde ac ingenua plebes raptim extingui, inter con-
" jugum et liberorum lamenta, qui dum aſſident, dum deflent,
" ſæpe eodem rogo cremabantur. Equitum ſenatorumque inte-
" ritus, quamvis promiſcui, minus flebiles erant, tanquam com-
" muni mortalitate, ſævitiam principis prævenirent."

THIS deſcription we muſt own to be inferior to that of the plague at Athens by THUCYDIDES. But the Greek hiſtorian (it muſt be remembered) had ſuffered from the diſeaſe himſelf; had ſeen its direful effects, combined with thoſe of war; and had reſolved to enumerate its ſymptoms, for the benefit of poſterity, in the courſe of ſix chapters. TACITUS means to relate only what he had heard. He does not ſeem to have copied THUCYDIDES; though he, too, mentions, that numbers of carcaſes lay neglected in private houſes, upon the ſtreets, at the ſides of fountains, and in the temples. " Ὁ φθορὸς ἐγιγνετο ἀδενι κοσμῳ,
" αλλα και νεκροι επ αλληλοις αποθνησκοντες εκειντο. και εν ταις ὁδοις ἐκυλινδουντο και
" περι τας κρηνας ἁπασας ἡμιθνητες τῃ τυ ὑδατος επιθυμιᾳ. τα τε ἱερα εν ὁις ἐσκηνην-
" το νεκρων πλεα ἠν, αυτε εναποθνησκοντων *."

LUCRETIUS, in the deſcription he gives of the plague at the end of his ſixth book, has copied THUCYDIDES cloſely, but ſeems to have come ſhort of the ſimplicity and maſterly elegance of the hiſtorian.

THE ſituation of OCTAVIA, after her divorce from NERO, forms one of the moſt highly finiſhed deſcriptions in the writings of TACITUS. After the tyrant had eſpouſed POPPÆA, under the appearance of gratifying the wiſhes of his people, whoſe reſentment he in fact dreaded, he took back his injured wife. By the arts of POPPÆA, however, which were ſkilfully directed againſt his weakneſſes, he diſmiſſed OCTAVIA again, and bribed one of his minions, to ſcreen his injuſtice, by declaring that ſhe had been guilty with him. Upon this, the innocent OCTAVIA was baniſhed to the iſland of Pandateria, and the ſentiments of the ſpectators upon this undeſerved ſeverity, are the ground of the deſcription mentioned. " Non alia exſul viſen-
" tium

* Θουκυδ. το δευτ. κεφ. νδ.

" tium oculos majore miſericordia affecit. Meminerant adhuc " quidam AGRIPPINÆ, a TIBERIO, recentior JULIÆ memoria " obverſabatur, a CLAUDIO pulſæ. Sed illis robur ætatis af- " fuerat. Læta aliqua viderant, et præſentem ſævitiam me- " lioris olim fortunæ recordatione allevabant. Huic primus " nuptiarum dies loco funeris fuit, deductæ in domum, in qua " nihil niſi luctuoſum haberet, erepto per venenum patre, et " ſtatim fratre. Tum ancilla domina validior. Et POPPÆA " non niſi in perniciem uxoris nupta. Poſtremo crimen omni " exitio gravius *."

THIS deſcription is as artful in fact, as it is artleſs in appearance. The circumſtances ſaid to move the compaſſion of the ſpectators, are marked with wonderful judgment; and the beautiful climax exhibited in the arrangement of them, produces a very uncommon effect. Their feelings firſt reſt upon the difference between the ſituation of OCTAVIA, and that of other women of diſtinction who had been ſubjected to the like fate. They next reſt upon her perſonal diſgrace, as an empreſs, becoming ſubject to a ſervant; next upon the immediate deſtruction threatened her by this marriage of POPPÆA; and laſt of all, upon the falſe accuſation of having been unfaithful to her huſband, and guilty with a miſcreant, which no form of deſtruction could equal. The conditions upon which the fancy operates ſucceſsfully are here fulfilled. It has full room to work, and its exertions are not clogged by an unmeaning verboſeneſs.

FROM fulfilling the conditions now mentioned, THUCYDIDES has acquired immortal honour by his deſcription of the retreat of the Athenian army, in the 7th book of his Hiſtory. The barbarity of the conquerors and the diſtreſs of the vanquiſhed appear equally incredible, though a few circumſtances only are employed to ſuggeſt theſe. During the paſſage of the Athenians over the river Aſſinarus, from the extremity of fatigue

* 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. "και το ὑδωρ ευθυς διεφθαρτο· αλλ ὡδεν ἡσσον επινετο τε ὁμου τῳ πηλῳ ἡματωμε-
"νον και 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-

* Θουκυδ. το ιϛδ. κεφ. πδ'. † Hiſt. l. 3. c. 85.

" tiam, minantibus intrepidus, adverſus blandientes incorrup-
" tus."

In point of imagination, then, the genius of Tacitus is by no means deficient. Though he uſes figurative language ſparingly, yet he is highly ſucceſsful when he does. Many of his deſcriptions may be held perfect in their kind, and will bear a compariſon with thoſe of the moſt diſtinguiſhed hiſtorians of Greece. In all of them brevity is ſtudied, and ſtriking circumſtances judiciouſly ſeized. Theſe are held forth to the reader with ſuch art, as neither to check the operations of his fancy, by ſuggeſting too extenſive a ſubject, nor to ſtop thoſe operations completely, by ſuggeſting one that is too narrow.

In the ſequel of this paper, I ſhall produce ſome proofs of that ſoundneſs of judgment in Tacitus, which is the diſtinguiſhing quality of a great hiſtorian. I ſhall afterwards point out his ſuppoſed faults, in certain reſpects, by an application of that criterion which may have evinced his merits in others; and ſhall try to mark particular deviations in his ſtyle, from that pure ſtandard which was exhibited during the Auguſtan age *.

* 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 earlieſt hiſtorians were mere narrators of facts. They were not very anxious either about inveſtigating cauſes or tracing effects. If they were deſirous of inſtructing their readers or hearers, (for the earlieſt hiſtories were often recited to a numerous audience), they were no leſs deſirous of amuſing them. In ſuch compoſitions, therefore, they were led to imitate converſation. Their hiſtories were, in truth, no other than oral narratives and ſtories committed to writing. But, in converſation, the narrator of an intereſting ſtory becomes animated in his narrative; and if, like the ancient Greeks, he poſſeſs ſenſibility, the ſpirit exhibited in his ſtory will be proportioned to the vivacity of his feelings. Lively feelings, however, lead perſons, in relating or deſcribing the actions or conduct of others, to become dramatic; that is, to tell us the very words or ſayings of the perſon they deſcribe; and not only ſo, but to recite them as if he himſelf were the ſpeaker. Now this animated mode is imitated by the earlieſt writers who deſcribe human actions. They do ſo at firſt, becauſe it is done in converſation; they continue the practice, becauſe it is lively and intereſting. As, in converſation, the ſpeeches or ſayings attributed to the perſon whoſe conduct was delineated, were ſhort; they were alſo ſhort in the earlieſt, and perhaps moſt agreeable form of written hiſtory. Of this the ſacred hiſtorians and HERODOTUS afford us ſufficient proof. It was not till after hiſtorical compoſition had been ſome time in uſe, that it preſented to us long ſpeeches and elaborate declamation. Its earlieſt ſpecies, therefore, may be termed colloquial, as diſtinguiſhed from that which, belonging to the claſs of dramatic hiſtory, followed ſoon after, and may be termed oratorial. Perhaps there was an intermediate ſtep. Poets were earlier than hiſtorians; and, in their repreſentations of human actions, were, for the reaſons above mentioned, colloquial and dramatic. Such are the poems of HOMER. The propenſity, therefore, which early hiſtorians had to aſſume the dramatic form was, by the practice of their predeceſſors,

predeceſſors, both juſtified and enforced. Hiſtorians, from imitating converſation, came to imitate public ſpeaking, and became oratorial. This change, however, was not merely an extenſion, ſo to ſay, of the preceding method. It was produced by other cauſes. The earlieſt ancient hiſtorians were natives, or recorded the deeds and revolutions, of independent republics. In theſe ſtates, public ſpeaking was very generally practiſed, and was often the cauſe of important events. The war between Athens and PHILIP, promoted by the oratorial powers of DEMOSTHENES; and the flight of CATILINE from Rome, occaſioned by the eloquence of CICERO, are illuſtrious proofs. But not only did ſpeeches, delivered in legiſlative or deliberative aſſemblies, in the ſenate or in the forum, produce important effects; other ſpeeches, funeral orations and allocutions, were ſometimes followed by very ſignal conſequences. Ancient hiſtorians, therefore, were obliged to give us an account of ſuch ſpeeches; and, having before them the example of poets and very early hiſtorians, they adopted their method. They had alſo ſome other inducements. In the progreſs of improvement, the art of public ſpeaking came to be highly cultivated. Rhetorical talents conferred great reputation, and the ſtudy of oratory became univerſal. It is not ſurpriſing, therefore, that hiſtorians ſhould embrace ſuch obvious opportunities as their ſubjects afforded them, of diſplaying their abilities in a ſpecies of compoſition ſo much eſteemed. It has been remarked, that ſymptoms of this paſſion for oratory, ſo prevalent in Greece and Rome, may be diſcovered, even in ſome of their poets. Such was the origin, and ſuch the different kinds of dramatic or rhetorical hiſtory.

II. IT is obvious, that, ſo far as amuſement is concerned, the method practiſed by LIVY, THUCYDIDES, and other ancient hiſtorians, has great advantages. It is a livelier method. It brings us, as it were, to the very ſcene of action. We are witneſſes

neſſes of the "very deed;" we are preſent in the ſenate, in the forum, or on the field of battle. Nor is this effect wonderful; for hiſtorians, by adopting the dramatic method, have an opportunity of diverſifying their labours, not only with the ornaments, but with the impetuoſity of rhetorical diction. Some of the ſpeeches in LIVY are as animated and deſcriptive as the pleadings of CICERO. The advantages of the rhetorical form, in point of vivacity and amuſement, are particularly manifeſt, when an hiſtorian, in relating an important event, has occaſion to explain the ſtate of parties, with the particular views and intentions of ſuch leading men, eſpecially in civil diſſenſions, as may have oppoſite intereſts. Such detail in modern hiſtory becomes often very tedious and unengaging, though it may have coſt the writer much laborious reſearch, and may be in itſelf important; yet the reader very frequently tires, and counts the pages. How much more intereſting is it, when this information is conveyed to us indirectly, in an eloquent ſpeech, and with all the graces of rhetorical expreſſion! It was neceſſary for THUCYDIDES to inform his reader, that the ſtate of Athens was accuſed by their neighbours of depredation, and to ſet before him the various intereſts, views or condition of thoſe Grecian republics that entered early into the Peloponneſian war; and this he does in the moſt agreeable manner, in the ſpeeches he attributes to ambaſſadors, or other perſons in high office, among the Spartans, Corinthians, and Athenians. How diſtinctly, and with how much ſpirit does LIVY ſet before us the different rights, powers and pretenſions 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 intereſting diſplay of character. Who is not more ſtruck with the character of a Lacædemonian, in the following ſpeech attributed to STHENELAIDAS *, than if it were deſcribed in a more direct, and even in a more circumſtantial narrative! The Corinthian ambaſſadors at

* THUCYD. lib. 1.

at Lacædemon had repreſented, that the prevailing power of Athens had rendered it neceſſary for the Spartans to interpoſe. The Athenian ambaſſadors, then preſent, reply to them in a long harangue: They wiſh to hinder the Lacædemonians from entering immediately into hoſtile meaſures; and take occaſion to magnify and enumerate the mighty deeds of the Athenians, their power, and the ſervices they had done to the Greeks. Thereupon STHENELAIDAS tells them, "I really do not under-
"ſtand the long harangue of the Athenians. They expatiate in
"their own praiſes; but ſay not a ſingle word about the wrongs
"they have done to our allies, and to Peloponneſus. If they
"behaved well on a former occaſion againſt the Medes, they
"behave ill at preſent, and deſerve the ſeverer correction, that,
"having known and practiſed 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 preſent, we ſhall neither
"neglect the wrongs ſuffered by our friends, nor delay to aſſiſt
"them; for, in their ſufferings, there is neither delay nor re-
"ſpite. Other ſtates may have money, and ſhips, and horſes;
"but we have good friends, whom we muſt not abandon to the
"Athenians. Nor is there any need for enquiries, or diſcuſ-
"ſions in words; it is not by words alone that we and our
"friends are injured. Forthwith, and with all our might, we
"muſt give them aid. Nor let any one tell us, when we ſuffer
"injury, that we ought to reflect and deliberate. It is the bu-
"ſineſs of thoſe who meditate injury to reflect. Therefore,
"Lacædemonians, let us act conſiſtently with the dignity of
"Sparta: Let us reſolve on war; nor allow the Athenians to
"become too powerful, nor ſuffer our allies to be oppreſſed;
"but, confident in the favour of Heaven, let us take up arms
"againſt the guilty."

III. SINCE, therefore, the dramatic form has ſo many advantages; ſince it animates a narrative; gives an opportunity to the

the hiſtorian of borrowing aſſiſtance from the graces of eloquence; imparts ſpirit to details, otherwiſe unengaging; and gives an intereſting diſplay of character; why ſhould it be given up by the moderns? Do they acknowledge themſelves more deſtitute of fancy, ſenſibility, and powers of eloquent diction than SALLUST or TACITUS? Other reaſons have been aſſigned, and they deſerve to be examined.

"TRUTH," it may be ſaid, "is the foundation of hiſtory. An hiſtorian muſt give a faithful account of facts, elſe he is no hiſtorian; he is a noveliſt, a teller of tales, a romance-writer, and that of the worſt kind; for he would impoſe upon us as actual truth, what is even deſtitute of probability. Now, as it is not probable, that the ſpeeches aſcribed by ancient hiſtorians, to the great perſons of whom they write, were ever delivered by them in the very form their hiſtorians have given them, they are guilty of deviation from truth and incur the cenſure we have expreſſed. Though CÆSAR and CATO might have delivered ſuch orations as SALLUST has aſcribed to them, it is not very likely that GALGACUS and CORIOLANUS ſhould have delivered the long ſpeeches attributed to them by TACITUS and DIONYSIUS. The Romans and Caledonians, at the period when theſe men appeared, were illiterate and unimproved. The practice ſeems to have ariſen among the loquacious Greeks, and to have been copied by the imitative Romans. It is, as was mentioned, a manifeſt violation of truth; and if an hiſtorian, in any caſe whatſoever, appears regardleſs of veracity, how can we depend upon him on other occaſions? He impairs his own credit, and the whole of his evidence becomes ſuſpected. Therefore, according to this view of the matter, the ſelf-denial of modern hiſtorians does them great honour. Rather than treſpaſs againſt the truth, and weaken the force of their evidence in matters ſo highly important, as the knowledge of paſt events, they deny themſelves all the ornaments they might derive from the diſplay of eloquence; and,

and, with a manly conſciouſneſs of the dignity conferred by their great office, they deſpiſe the praiſe of rhetorical ingenuity."

THIS argument ſeems very weighty. I ſhall, therefore, conſider, in the *firſt* place, How far the dramatic form may be called a deviation from truth or probability; and, *2dly*, Suppoſing it to be ſo, whether the ſeverity of the rule has not been relaxed in other particulars of higher moment, both by ancient and modern hiſtorians, but without deſtroying, or even weakening their credit.

1. How far, then, may the dramatic form be conſidered as a deviation from truth or probability? Were there no public ſpeakers in Greece or in Rome? In the deliberations of Athenians and Romans, concerning affairs of the laſt importance, were there no public orators? Were there no funeral harangues? And were there no allocutions? Was it not cuſtomary for a commander, about to engage in battle, to aſſemble his army, and pronounce, in their hearing, ſuch animated ſpeeches as tended to rouſe and preſerve their ſpirit? Did not ambaſſadors pronounce elaborate orations? When the Ionians ſolicited aſſiſtance from the Greeks againſt the Perſians, are we not told by HERODOTUS, that PITHERMUS, deputed for that purpoſe, arrayed himſelf in purple, and delivered an eloquent oration to the people of Lacedæmon? Ambaſſadors among the Romans were originally termed *pleaders* *; they are ſo termed by VIRGIL, who never, ſo far as I know, deviates from the truth of nature in his delineation of manners. And ILIONEUS, who ſeems to have been the chief ſpeaker among the Trojans, delivers himſelf with great eloquence both at Carthage and to King LATINUS. Or can we ſuppoſe, that thoſe ſpeeches, delivered ſo frequently, and on ſo many occaſions, had not very

* TUM ſatus ANCHISA delectos ordine ab omni
Centum *oratores* auguſta ad mœnia regis
Ire jubet,— *Æn.* vii. 150.

powerful effects in the great intereſts of republican ſtates? Theſe are facts which cannot be denied. If ſo, they ought certainly to be recorded. But are they to be recorded in the very general manner now mentioned? Is the hiſtorian to do no more than ſimply tell us, that certain perſons, upon certain occaſions, delivered ſpeeches, on one ſide or other, in ſome momentous debate? A reader, entering with ſpirit into the narrative, would be deſirous of knowing what arguments were employed; for if an effect, worthy of being tranſmitted to poſterity, was produced by ſuch ſpeeches, the arguments they contained were, without doubt, its efficient cauſe. Therefore, if they are known, a faithful and intelligent writer will be very loath to ſuppreſs them, otherwiſe he becomes unfaithful. The hiſtorian, then, muſt give us an account of ſpeakers, and of ſpeeches, and of the arguments which they contain; but muſt he proceed no farther? The rigid ſeverity of modern criticiſm, and the laudable love of truth, ſo peculiar to the moderns, pronounce an inviolable prohibition. He muſt not pretend to tell us, nor even to conjecture the method or arrangement obſerved by the ſpeaker, and much leſs the words of the ſpeech. It is, then, about the mere words of the ſpeaker, or perhaps his method, that there is any diſpute; and all the charge brought againſt ancient hiſtorians amounts to no more than that they alter the expreſſion, and give the arguments of a ſpeaker in the firſt perſon, rather than in the third. If they had done, as has been practiſed in ſome hiſtories of England; if they had told us, that ſome peer or commoner had ſaid *That* ſuch and ſuch were his views and concluſions, there would have been no tranſgreſſion; and LIVY and THUCYDIDES are no otherwiſe blamed, than for exhibiting their ſpeakers in the firſt perſon: Yet, ſurely, the faithful hiſtorian is a recorder of facts rather than of words. HERODOTUS in one inſtance, has done the very thing which this criticiſm requires. He has given us the inelegant, though figurative language, ſpoken by ſome Perſian ambaſſadors at

at the court of a Macedonian prince*; and has accordingly incurred 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 public ſpeaker, as delivered by himſelf, or as related by an hiſtorian. Add to all this, that there can be no violation of veracity, 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 himſelf 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 diſſeruit," "thought proper 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," "he

* Lib. v. 18.

† De Sublim. ſect. 3.

‡ MASON's Memoirs of the life and writings of Mr GRAY, p. 296. edit. 4to.

" he ſpoke to the Lacedæmonians in this manner." SALLUST's introduction to the ſpeech of CÆSAR is of the ſame kind; and the ſame obſervation may be illuſtrated in a variety of paſſages in LIVY. To what has been offered on this head, I ſhall add the following advice from LUCIAN, a writer of conſiderable judgment, and who treated fabulous hiſtory with very little indulgence. " When it is neceſſary to make any one ſpeak, you " muſt take care to let him ſay nothing but what is ſuitable to " the perſon, and to what he ſpeaks about, and let every thing " be clear and intelligible: Here, indeed, you may be permit- " ted to play the orator, and ſhew 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 hiſtorical compoſition, is ill-founded, or admits of great palliation.

2. BUT, ſuppoſing the caſe were otherwiſe, " Has not the ſtrict rule of veracity been relaxed in other particulars of higher moment, both by ancient and modern hiſtorians, without deſtroying or even weakening their credit?" And, if ſo, why may not ſome indulgence be ſhewn to thoſe writers who would enliven the detail of facts with the ſpirit of oratorial language?

HISTORIANS, very frequently, not only record facts and events, but endeavour to trace and explain their cauſes. The cauſes, however, of great events often lie in the human mind; in the paſſions and judgments of powerful men. It thus becomes neceſſary to inveſtigate motives, detect inclinations, and explore the labyrinths of the human heart. How difficult a taſk! How difficult, on many occaſions, to diſcover the motives of our own conduct! How difficult to aſcertain the principles of action that inſtigate thoſe perſons with whom we are daily converſant! How much more difficult to aſcertain the motives of men who lived many centuries ago, and with whoſe 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 theſe illuſtrations, the various accounts given us by different hiſtorians, of the motives that influenced LUTHER in caſting off his allegiance to the pope of Rome. By ſome, he is repreſented as being actuated ſolely by the love of truth, and, according to others, by reſentment. In theſe, and a variety of other inſtances, we ſee hiſtorians of the higheſt reputation advancing their own opinions and conjectures, as matters of fact. This practice, indeed, is much more common, and more unreſtrained among modern than among ancient writers, and is uſually conſidered as a great improvement in hiſtorical compoſition. It is for this, more than for any thing elſe, that TACITUS is ſo much an object of adoration. Yet this practice, ſo very faſhionable at preſent, often leads an hiſtorian into more flagrant violations of truth, and into bolder aſſumptions, than if he pretended to give us the language ſpoken by ſome famous ſpeaker. The dramatic hiſtorian aſcribes to his illuſtrious perſons, probable words and phraſes. The narrative hiſtorian, with intrepid boldneſs, aſcribes to them probable motives, paſſions and inclinations. The firſt indulges conjecture in thoſe things merely that are external, and that regard the form and manner. The ſecond is indulgent to himſelf in thoſe that are material and internal, and advances, as facts, his own gueſſes concerning the moſt delicate ſprings of action. Since, therefore, the ſtrict rule of veracity is tranſgreſſed in this particular, with ſo much applauſe, why, in an inſtance of leſs importance, and when the tranſgreſſion would be attended with advantages of another kind, may not criticiſm abate ſome of its rigour? Nay, in comparing what was formerly ſaid with what has now been obſerved, the dramatic hiſtorian ſeems to have the higher title to this indulgence, that he ſeems, in truth, to be the more faithful writer of the two. The narrative hiſtorian gives you his facts and conjectures mingled together,

and

and with equal authority; ſo that it requires more patience and diſcernment than belong to a great many readers, to diſtinguiſh what ought to be received with immediate belief, from thoſe things that depend for their evidence on the conjectural judgment of the narrator. Hiſtorians of another kind, (and this, in general, is the practice of XENOPHON and LIVY), give you their facts and their conjectures apart. Their facts conſtitute the narrative, and their views of characters and motives are thrown into thoſe ſpeeches, which, as we have ſeen, are not offered by the writers themſelves as of equal authority with their relation of external events.

I HAVE thus endeavoured to point out the cauſe of the difference, ſtated at the beginning of this diſcourſe, between the ancient and modern forms of hiſtorical compoſition, and have ſuggeſted ſome conſiderations by which the practice of antiquity may be juſtified. The ſame conſiderations do not extend to the hiſtory of modern European nations; for the practice could not be ſupported by the ſame views of probability. In the revolutions of modern nations, public ſpeaking has been of little importance. We have not now any funeral orations for political purpoſes; other circumſtances of military diſcipline have ſuperſeded the uſe of allocution; our ambaſſadors have little occaſion for rhetorical powers; and we may add, that the deliberations of the Britiſh parliament are not much influenced by the oratory of even the moſt eloquent ſpeakers. We may alſo obſerve, that the object of modern hiſtorians ſeems a good deal different from that of the ancient: They are become more philoſophical; they diſcover more accuracy in explaining cauſes, and more penetration in deducing effects. Oratory was the faſhion in ancient times; philoſophy is the faſhion at preſent. The ancient hiſtorian was often deſirous of exciting ſympathetic feelings, and of pleaſing the fancy; the modern hiſtorian is chiefly deſirous of informing the underſtanding. 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* ΔΕ. *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 ſpectentur, 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 effect ought not to be "aſcribed to the joint operation of many cauſes, if fewer "are adequate to the production 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 *Conjunctions.* The word AFTER is, however, the ſame in both ſentences; its *meaning* is the ſame, and its *effect* preciſely the ſame. The only circumſtance of diſcrimination is, that, in the firſt example, it is prefixed to a noun ſubſtantive,

—*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 conſtitute a propoſition; they do not contain an independent aſſertion; they expreſs no more than a ſpecifying circumſtance annexed to the other propoſition, "*I came*;" and, whenever they are rightly apprehended by the mind, they are ſtript of their propoſitionary form, and ſtated *abſtractly* under a new phaſis—*his departure*. Thus conſidered, then, the two propoſitions are ſynonymous in every reſpect, excepting the *apparent* grammatical nature of the words—*his departure*, and—*he departed*; and even theſe are reduced to one grammatic form in the mind, whenever the import of the propoſitions is rightly apprehended.

FROM theſe obſervations it ſhould ſeem that there is no ſufficient reaſon for claſſing the word AFTER, in the one caſe, with the *Prepoſitions*, and, in the other, with the *Conjunctions*; ſince, by the ſeeming change of its regimen, no real change is made, either in its grammatical nature, or in its ſignification.

OF this unphiloſophical method of arranging the ſame words in different claſſes, I ſhall mention *two* other inſtances, 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 inſtances will ſerve to illuſtrate and confirm that conjecture, and will, in their turn, be illuſtrated by it*.

I. THE Engliſh prepoſition TO is very variouſly applied. Being extremely *general* in its ſignification, it is conſequently capable of various *ſpecial* applications. One of its ſpecial uſes is to mark *addition* TO. Thus DENHAM,

> "Wiſdom he has, and, TO his wiſdom †, courage;
> "Temper TO that, and, UNTO all, ſucceſs."

In this example, every ſucceeding circumſtance is, by the prepoſition

* IN the progreſs of the eſſay, it will appear, that the reaſoning proceeds upon an analogy much more ſtrict and cloſe than here it ſeems to do.

† ΠΡΟΣ τῃ σοφιᾳ.

poſition TO, marked as an *addition to* the preceding. " Wiſdom " he has, and courage *additional to* his wiſdom," *&c.* In this acceptation of the word TO, the object which it governs, or to which it marks ſomething elſe as *added*, is frequently *not expreſſed*, or not formally ſtated along with the prepoſition. The reaſon is, that it readily occurs to the mind, being mentioned in the context immediately before. Thus DENHAM might, with equal propriety, have ſaid,

" Wiſdom he has, and courage TOO," *&c.*

This mode of expreſſion would have been more conciſe and equally intelligible as the other, " Wiſdom he has, and cou- " rage TO *his wiſdom*," *&c.*

NOT only is the object governed by TO omitted, when it is repreſented by a noun ſubſtantive in the context, but alſo when it is involved in a propoſition. Thus Mr POPE,

——— " Let thoſe eyes that view
" The daring crime, behold the vengeance TOO."

So " He made him priſoner, and killed him TOO." In the one example, the circumſtance of *beholding the vengeance* is ſtated as an *addition to* the *viewing the crime;* and, in the other, the *killing him* is ſtated as an *addition to* the *making him a priſoner*. In both examples, the object governed by TOO is not formally ſtated; and, in both alſo, it is involved in a preceding propoſition. It is the *amount* of that propoſition taken *abſtractly*, or as a *Noun ſubſtantive*.

ALTHOUGH all theſe uſes of the word TO are really one and the ſame, differing in nothing but this, that the object governed by it is, in ſome of them, *expreſſed*, and, in others, *not expreſſed*; yet the grammarians have conſidered them as different, and have claſſed TO, in the one caſe, with the *Prepoſitions*, and, in the other, with the *Conjunctions*, or with the *Adverbs*. This circumſtance, together perhaps with the accented pronunciation

of TO, when the object governed by it is not expreſſed, has given riſe to a difference in its orthography, the writing it with two *O*s inſtead of one. And the two words have ultimately come to be univerſally conſidered as *different*, inſomuch that even the ſuppoſition of their being the *ſame* is not likely to be liſtened to without prejudice.

IN the parent Saxon language, however, both uſes are compriſed under one form, TO; and, even in the Engliſh, as late as the reign of Queen ELIZABETH, they were both written with one *O*. This appears from the ſpecimens prefixed to Dr JOHNSON's Dictionary, as a hiſtory of our language previous to that period. Thus, Sir THOMAS MORE, ſpeaking of fortune and one of her quondam favourites,

> " She glydeth from hym, and her giftes TO;
> " And he her curſeth, as other fooles do."

And to the accented pronunciation of TO, when its object is not expreſſed, that is, by no means, a ſufficient reaſon, either for claſſing or for writing it differently, being a circumſtance common to it with every prepoſition whatſoever. All of them, when their objects are expreſſed, may be accented or not accented, according to the meaning, or ſhade of meaning, intended to be conveyed. But, when their objects are not expreſſed, they are *commonly* * accented: " To ſtand *by*," " to come *on*," " to " run *in*," " to ruſh *out*," &c.

FROM theſe obſervations, it ſhould ſeem, that the word TOO, though generally conſidered as different, and though ranked by grammarians in a different claſs of the parts of ſpeech, is really the ſame with the prepoſition TO, in its ſpecial meaning of *additional to*. This has been ſhown from the ſameneſs of their *meaning* and *effect*, as well as of their *original orthography*, and the

* IN fact they are *always* accented, though their accent may ſometimes be obſcured by an equal or ſuperior accent given to an adjoining word, as, " He did not *walk in*, " but *ruſhed 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.

* *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 *diligence* 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 prepoſition 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 *incongruous*, 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 objects 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 inſtance: " 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 prepoſition AD is employed to mark their *union*. From our knowledge, however, of the power veſted in the Roman dictator, we perceive, 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 commonly 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 poſition—"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 †.

THE

* 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 formed, 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 occur,

THE word AT is indeed called an *adverſative*, and is commonly imagined to mark, not the *union*, but the *oppoſition* of objects. But,

I. THE authority of QUINCTILIAN is explicit in favour of our hypotheſis. In treating of the Latin orthography, he has the following obſervation: " Illa quoque ſervata eſt a *multis* " differentia, ut AD, quum eſſet *præpoſitio*, D literam; quum " autem

occur, it is evidently expreſſive, not of *oppoſition*, but of *union*. When there is no incongruity in the objects united, and conſequently nothing unexpected in their union, the effect of it will be perceived by rendering it TO ſimply; and, when the objects united appear incongruous, by rendering it TO with emphaſis, or EVEN TO.

I. To ſimply—as in the form of ſurrender recorded by LIVY, [*Lib.* I. *cap.* 38.] " Deditiſne vos populumque Collatinum in meam populique Romani ditionem? De- " dimus. AT ego recipio;" " *Joined* TO that, I receive them." ET might have been uſed in this inſtance. In imprecations, and the like, it repreſents the amount of the prayer, as *joined to* an action *mentioned, perceived, dreaded, &c.* 1. To an action *mentioned*; as in TERENCE; " CH. Factum eſt 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 *ſeeing* his ſon killed by PYRRHUS, exclaims:

" AT tibi pro ſcelere, exclamat, pro talibus auſis,
" Dî, ſi qua eſt cœlo pietas, quæ talia curet,
" Perſolvant grates dignas, et præmia reddant
" Digna,—qui nati coram me cernere letum
" Feciſti, et patrios fœdaſti funere vultus." [*Æn.* ii. 535.]

II. EVEN TO—as in TERENCE; " Si ego digna hac contumeliâ ſum 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 circumſtances tending to prove that PAMPHILA is his daughter, ſays, " AT mihi unus ſcrupulus etiam reſtat." " Joined EVEN " TO [what I have heard] there ſtill remains one difficulty." *i. e.* " All I have heard is " not ſufficient to remove it." It is uſed preciſely in this manner, when it introduces an *objection*, or the *anſwer* to an *objection*. 1. An *objection*; as in CICERO pro MILONE; " AT valuit odium, fecit iratus, *&c.*" " Joined EVEN TO [what you have ſaid] his hatred " got the better of him, he acted from paſſion:" *i. e.* " For all that you have ſaid," *&c.* " All that you have ſaid does not hinder the deed to have proceeded from hatred or paſ- " ſion." 2. The *anſwer* to an *objection*; as, " Domus tibi deerat? AT habebas. Pecu- " nia ſuperabat? AT egebas." " You will ſay you wanted a houſe; joined EVEN TO " that, you had one," *&c.* It is uſed in this manner too, when it introduces the *circumſtances* of an action which tend to heighten our ſurpriſe. " Vidit CLODIUS neceſſe eſſe " MILONI proficiſci Lanuvium illo ipſo, quo profectus eſt, die; itaque antevertit. AT " quo

" autem *conjunctio*, T acciperet *." From this paſſage, it is evident, 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 difference 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 *orthography* has at laſt obtained to diſtinguiſh the *conjunction* from the *prepoſition*.

2. THE propoſitions, whereof AT is ſaid to mark the oppoſition, 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* incompatible, 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 incongruous 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*. Accordingly, we find, in fact, that thoſe of the conjunctions call-

" 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, TOO?" *&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 " TOO 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 connected by it.

* Lib. i. cap. 7.

ed *adverſative*, whoſe ſignification can be aſcertained, are ſignificant, not of *oppoſition*, but of *union*, or ſomething that is equivalent. Of this kind are the Greek, ὅμως, accented on the penult, and ἀλλ; the Latin, *etſi*, *verum*, *vero*, *tamen*, *verum tamen*; the French, *cependant*, and perhaps *encore*; the Engliſh, *yet*, *neverthelefs*, *notwithſtanding*, &c. It might, however, be reckoned tedious, were I to attempt to ſtate the preciſe import of each of theſe, and to ſhow, that their effect, in a ſentence, is conſonant to their ſignification, and ariſes out of it.

3. THE adverſative *appearance* of AT ſeems to have ariſen from the circumſtance of its raiſing an *expectation*, that ſomething ſeemingly oppoſite, or incongruous, is to follow. Thus, when it is ſaid, "CÆSAR fuit vir fortis, prudens, clemens; "AT ———," the word AT is no ſooner heard, than an expectation is raiſed, that ſomething oppoſite to the qualities previouſly mentioned—ſomething diſadvantageous to the character of CÆSAR, is to follow. And hence, from its raiſing this expectation, it has been concluded, that AT itſelf is ſignificant of oppoſition: But that this concluſion is by no means *neceſſary*, will appear from the following obſervations.

WHEN objects or qualities, conſidered as in their own nature oppoſite or incongruous, are obſerved to co-exiſt, it ſeems more neceſſary to *intimate their co-exiſtence*, than if no ſuch oppoſition 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 ambitioſus, patriæ proditor," *&c.* It might have been imagined, that ſuch oppoſite qualities could not unite in the ſame perſon; and, therefore, it appeared neceſſary, that pointed intimation ſhould be given of their union; and, for that purpoſe, the word AT is employed. The ſame circumſtance, *viz.* the perception of the incongruity, alſo leads the hearer to *interpret* the ſymbol of union in the ſame *emphatic* manner; that is, to give to AT the force, not of TO ſimply, but

but of TO with emphaſis, or EVEN TO. "CÆSAR poſſeſſed "fortitude, prudence, clemency; joined EVEN TO that, he "was ambitious, and a traitor to his country."

NOW, this emphatic meaning, which men were *accuſtomed* to annex to AT, in conſequence of its being ſo very frequently employed to mark the union of incongruous objects, will ſufficiently account for its raiſing an expectation that ſomething apparently oppoſite, or incongruous, is to follow: For, no ſooner is this emphatic meaning given to it, than ſuch an expectation is raiſed,—and *muſt* be raiſed, becauſe an emphatic intimation of union *ſuppoſes* an incongruity in the objects united, and is given in conſequence of a perception of that incongruity. Thus, "CÆSAR poſſeſſed fortitude, prudence, clemency; joined EVEN "TO that ———." When theſe laſt words are heard, we immediately expect that ſomething is to follow, apparently oppoſite to what is contained in the firſt member of the ſentence. We are prepared for ſuch attributes as—*ambitious* and a *traitor* to his country. Thus, then, from the emphatic meaning given to AT, an expectation was raiſed that ſomething incongruous was to follow; and, from its raiſing this expectation, the word has prepoſterouſly been imagined to *expreſs* that incongruity or oppoſition, which it only *preſuppoſes*.

ANY emphatic intimation of union, thrown into a ſentence, will raiſe an expectation that ſomething incongruous is to be ſubjoined; and the reaſon is the ſame in them all, namely, that every ſuch intimation is given on the ſuppoſition, that the objects are perceived to be naturally incongruous. "CÆSAR was "brave, prudent, merciful; *at the ſame time*, he was ———." Or, "CÆSAR was brave, prudent, merciful; *notwithſtanding that*, "he was ———." In theſe, as well as in the Latin example, we are led to expect that ſome circumſtance in the character of CÆSAR is to follow, which we ſhould not have expected to be united with the qualities, bravery, prudence, and clemency. Yet the words, *at the ſame time*, do *not* expreſs *oppoſition*, and *not-*

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 elſe of a like nature. " AD imperium dictatoris diſcedere nolebant." " EVEN " AT the command of the dictator, they refuſed to depart."

NOW, in this laſt example, and in every other of the ſame kind, by varying the ſtructure of the ſentence, AT may be introduced inſtead of AD, without even the ſlighteſt variation in the meaning. " Dictator imperabat ; AT diſcedere nolebant." Wherein, then, does this laſt mode of expreſſing the idea differ from the former? In the former, the dictator's giving the command is *not aſſerted ;* it is preſuppoſed, and appears only in the *abſtract* form of *imperium dictatoris*, governed by AD ; whereas, in the latter, it is formally *aſſerted*; " *Dictator imperabat* ;" but the *abſtract amount* of the aſſertion, *viz.* " *imperium dictatoris*," is not repeated as the object governed by AT. In the one, the *formal aſſertion* is *omitted*, and the *abſtract amount* of the aſſertion is *expreſſed*; in the other, the *abſtract amount* is *omitted*, and the *formal aſſertion* is *expreſſed*. In theſe circumſtances, and in theſe only, the two modes of expreſſion ſeem to differ.

FROM the preceding obſervations and examples, it appears, that AT is nothing elſe but the prepoſition AD, taken in the ſpecial meanings—*added to—joined to*, and not having the object which it governs formally expreſſed ; and that however oppoſite the objects may appear to be which it unites, yet it does not *expreſs* their oppoſition.

THE word AT, as it denotes addition, might, indeed, be conſidered as implying *difference*; for if an object is ſtated as additional to another, it muſt be at leaſt *numerically* different from that other. And, indeed, AT agrees with the Greek αλλα, the Latin *cæterum*, and the French *mais*, in this reſpect, that all of them imply *difference*, but none of them *oppoſition*. The laſt of them particularly, *mais*, (*magis*), like the Latin AT, implies *difference*, only becauſe it denotes *addition*.

WE have now ſeen, that the Engliſh TOO and the Latin AT, are really the ſame with TO and AD ; that they are, in truth, nothing

nothing more than ſpecial applications of theſe; and we have ſhown on what theſe ſpecialities depend, and that their effect in a ſentence is actually ſuch as, by their original ſignification, they may be ſuppoſed to produce; or, what amounts to the ſame thing, that the effect of them may be ſatisfactorily explained, by reſorting to their proper and primitive ſignification.

III. LET us next enquire, whether the preceding obſervations can throw any light on the nature and import of the Greek particle ΔΕ, for the ſake of which, chiefly, they have been premiſed.

1. THIS particle is, not uncommonly, found after the accuſative caſe of *proper* names of places, when motion TO theſe places is expreſſed. " ΙλιονΔΕ,"—" *To* Troy," &c.

2. NOT only is it thus affixed to proper names, but alſo to *common*, or appellative, nouns, and in the ſame ſenſe; " οἶκονΔΕ,"—" *To* a houſe." " ἀγορὴνΔΕ,"—" *To* the forum." " ἅλαδΕ,"—" *To* the ſea," &c.

3. IT is not affixed to the accuſative ſingular only, but frequently alſo to the accuſative plural, " οἴκαΔΕ." When, however, the accuſative plural ends in ς, it is often diſguiſed by a tranſpoſition, the letters δ and σ being tranſpoſed for the ſake of the ſound. Thus, " ΑθηναςΔΕ,"—" *To* Athens," is commonly written " ΑθηναΖΕ." So " χαμαΖΕ,"—" *To* the ground;" " ΘηβαΖΕ,"—" *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 terminate, but alſo to that object, whatever it be, *to* which any action is directed as a *final cauſe*. Thus HOMER *, " Μὴ ἀγορεύε φόβον-" Δ·"—literally, " Do not ſpeak *to* flight." Let not your ſpeech tend to flight; let not flight be the *object*, or *final cauſe*, *to which* it is directed. The Latins uſe *ad*, and the Engliſh *to*, in the ſame manner. " Hoc fecit *ad* honorem meum,"—" He did " this *to* my honour;" where his *doing this* is, in like manner, conſidered as *tending to* my honour.

THE

* Iliad. ι'. 252.

THE word ΔΕ was, indeed, but ſeldom joined with an accuſative caſe by the *Attic* writers, and only in ſome expreſſions which the grammarians conſider as *adverbial.* May we not, however, conclude from the facts juſt now ſtated, that, with the more early Greeks, and even with HOMER, it was conſidered as a *prepoſition* governing the accuſative, and equivalent to the Latin AD, or the Engliſh 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*-poſition put *after*, is, in truth, a contradiction, yet it is no uncommon occurrence in moſt languages. The Latins uſe nobiſ-*cum*, tantiſ-*per*, &c. and we there-*to*, where-*to*, and others ſimilar. Theſe laſt alſo our grammarians conſider as *adverbs*; but they are compound words, in which the prepoſition TO is palpably one of the component parts. And the facts before ſtated render it, in ſome degree, probable, that the Greek ΔΕ is ſometimes, in like manner, a prepoſition put after the word which it governs, and equivalent to TO.

ON this hypotheſis, then, that ΔΕ is a prepoſition ſignifying TO, it is reaſonable to imagine—1. That, though it is, in itſelf, extremely *general*, yet, like the correſponding word in other languages, it may be uſed in the *ſpecial* meanings of *—added to—joined to*, &c. And—2. That the object, governed by it, may be not formally ſtated, but left to be collected from a preceding *noun* or *prepoſition.* In ſhort, that it ſhould follow the ſame analogy of application as the Latin AD and the Engliſh TO, when they are called *conjunctions.* Accordingly we find, that it does ſo in fact. When ULYSSES, in the 9th book of the Iliad, enumerates to ACHILLES the preſents intended for him by AGAMEMNON, he does it in this manner:

——————— " εγω τοι καταλεξω
" Οσσα τοι εν κλισιησι υπεσχετο δωρ' Αγαμεμνων·
" Επτ' απυρους τριποδας, δεκα ΔΕ χρυσοιο ταλαντα,
" Ανδρωνας ΔΕ λεβητας εεικοσι, δωδεκα Δ' ιππους *."

In

* V. 265.

In this example, by means of δὲ, each ſucceeding article is repreſented as TO, *i. e. additional to* the preceding article. "Seven 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,—"Διδασκουσι τους παιδας σωφροσυνην· διδασκουσι ΔΕ πειθεσθαι τοις αρχουσι."—"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*—διδασκουσι τους 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' ιφθιμους ψυχας αϊδι προιαψεν
"Ηρωων."——————

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 δὲ, 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 δὲ is not expreſſed. It is, however, obviouſly ſuggeſted by the context; being the amount of the preceding propoſition taken *abſtractly*, 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 δὲ—*and*.

BUT δὲ 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 δὲ does not intimate their being ſo: It only marks the one as *added*, or *united*, to the other. This I am warranted in affirming, by the authority 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:—" Δὲ ponitur et pro " ΑΛΛΑ διαφορικῶ και ενανλιωματικῶ, ſive MEN præcedit, ſive non. vel " *potius* dicam ſententiæ diverſæ aut adverſanti additur, ita ut " vicem τὸ ΑΛΛΑ explere *videatur*; *non* enim *ipſi particulæ* δὲ ea " poteſtas attribuenda eſt, ſed *ſententiæ* cui apponitur *."

FURTHER,—That the ſame word ſhould be employed to denote 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 determine which of theſe ſignifications we ought, in any particular inſtance, to affix to it; and, if ſo, their oppoſition might be diſcovered without the help of this ambiguous ſymbol of it. Δὲ, 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.

* Doctr. Particul. L. Gr. p. 245.

poſes. Thus, when ORESTES, in EURIPIDES, makes the following obſervation—

" Ονομα γαρ, εργον ΔΕ ουκ εχουσιν οι φιλοι,
" Ὁι μη επι ταισι συμφοραις ωσιν φιλοι *,"—

it is ſaid, that δε ſtates an oppoſition between the *name* and the *reality* of friendſhip: But, when the obſervations formerly made on AT, and the ſignification of δε, *aſcertained* by the preceding examples, are taken into conſideration, it ſeems much more reaſonable to ſuppoſe, that, even here, it retains its proper ſignification of *union*. Literally thus—" For the friends that are " not friends in adverſity have the *name* of friends, not the *reality* " TOO." " *Nomen*, AT non *rem* habent." Two propoſitions in fact are ſtated, *viz.* " That the friends that are not ſuch in " adverſity have the name of friends;" and ſecondly, " That " they have not the reality:" And, by the means of δε, intimation is given, that—(whatever *might* have been expected) the latter is *united* to the former. This ſeems to be the preciſe meaning of the paſſage; and it is elicited without departing from the *known* ſignification of δε. Let us take an example ſtill more ſtriking. Suppoſe that it is ſaid of a perſon—" εστι μεν νεος, εστι ΔΕ σοφος"—" He is young, but he is wiſe." The ſame perſon is repreſented as poſſeſſing *at once* the two ſeemingly incongruous qualities of *youth* and *wiſdom*. Can any perſon allege, that, in this example, it is reaſonable to depart from the *known* ſignification of δε, and to conſider it as denoting *oppoſition?* The oppoſition between *youth* and *wiſdom* is ſufficiently apparent, without any expreſſed ſymbol of it. Is it not more reaſonable to ſuppoſe δε to give notice, that—(whatever might have been expected—however oppoſite or *incongruous* theſe qualities may *ſeem* to be) they are (in this particular inſtance) *united*: That *his being wiſe* is repreſented as joined EVEN TO his *being young?* This, at leaſt, is the intimation that every perſon *feels*

* Oreſt. 455.

feels himſelf prompted to give, when he obſerves the *union* of ſuch incongruous qualities.

IT ſhould ſeem, then, that the conjunction δὲ, even when it is ſaid to mark oppoſition, and tranſlated *but*, ſtill retains its genuine ſignification of *union*,—with this variation, however, that from the perceived incongruity of the objects, and the unexpectedneſs of their union, we ought to give it, in ſuch inſtances, the force, not of TO ſimply, but of TO with emphaſis, or—EVEN TO.

BUT δὲ, when it appears in the form of a *prepoſition* governing the accuſative, is not accented,—κλυμπονΔΕ—κλισινΔΕ, *&c.*; whereas δὲ the *conjunction* is always accented. If they are one and the ſame, whence ariſes this difference? This circumſtance, 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 ΔΕ ἐγκλινέσι, "non conjunctio eſt, ſed ſyllabica adjectio, nec *quicquam* cum "particula δὲ *commune* habet *. But, notwithſtanding this ſeeming difference between them, and notwithſtanding the great authority now quoted, we cannot heſitate to regard them ſtill as the *ſame* word. For, if rightly conſidered, this difference as to accent, in the pronunciation at leaſt †, inſtead of being an objection, is really a confirmation of our hypotheſis ‡. We have ſeen already, that the prepoſitions, when the object which they govern is expreſſed, are commonly *not* accented,—"He came *to* "Rome." In like manner δὲ, when its accuſative is expreſſed, ought, upon this analogy, *not* to be accented,—"κλυμπονΔΕ:" That, on the other hand, when the object governed by them is not expreſſed, or not formally ſtated, the prepoſitions are then *accented*, "Wiſdom he has, and courage *too*." Δὲ, therefore, when

 the

* Doctr. Particul. L. Gr. p. 262.

† WITH regard to the accentual *marks*, they ſeem to have owed their origin to an unſucceſsful attempt to perpetuate a particular *mode* of pronunciation.

‡ As far at leaſt as a thing ſo little known as the nature of Greek accent can be allowed to have weight in the preſent caſe.

the object which it governs, or to which it marks ſomething as *united* or *added*, is not expreſſed,—that is, δὲ 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 Δὲ the *conjunction* is not a different word from Δε 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 Δὲ; 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 Δὲ, 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———

1. THAT

* 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 *Prepoſitions*, in various languages, govern not only nouns ſubſtantive, but alſo clauſes of ſentences bearing the form of propoſitions; but that ſuch clauſes are then equal to nouns in their *effect*, the *abſtract amount* of them only being regarded: And, conſequently, that, by this *ſeeming* change of their regimen, no *real* change is made, either in the grammatical nature, or in the ſignification of the prepoſitions themſelves.

2. THAT, whether the object governed be a noun ſubſtantive, or the amount of a propoſition taken as a noun ſubſtantive, that object is often not formally ſtated, being obvious from the context; but that neither does the *formal ſtatement*, or the *omiſſion* of the governed object, make any change, either in the grammatical nature, or in the ſignification of the prepoſitions.

3. THAT the ſpecialities attending theſe *prepoſitions*, when they are called *conjunctions*, depend, in as far as the *expreſſion* is concerned, on one or other, or both of the following circumſtances, *viz.* the governed objects *being involved in a propoſition*, or its *not being formally ſtated.*

4. THAT the adverſative *appearance* of *ſome* of the conjunctions called *adverſative*, ariſes ſolely from the *emphatic* meaning given to them, when employed to mark the union of objects *ſeemingly* oppoſite or incongruous; but that, though they may *preſuppoſe*, they do not *expreſs* ſuch incongruity or apparent oppoſition.

5. BY having ſhown that the conjunctions *Too*, *At*, and Δι, are the ſame with the prepoſitions *To*, *Ad*, and Δε, we have diſcovered their ſtrict and proper ſignification, and are thereby enabled to annex to each of them a *preciſe idea*, inſtead of having a vague and confuſed *feeling* of their *effect*.

Laſtly, BY having aſcertained the grammatical nature of *certain* conjunctions, we have advanced *one* ſtep towards the developement of the nature of the *Conjunction* itſelf,—I mean the

part

part of ſpeech ſo called,—which is ſtill a *Deſideratum* in grammar, the nature of it being, perhaps, leſs underſtood than that of any other of the parts of ſpeech *.

* THE author is fully ſenſible that, in ſeveral places of this eſſay, he has uſed expreſſions which, to an Engliſh reader, muſt appear extremely uncouth. Convinced as he is, that the word AD or AT, and ΔΕ, however variouſly applied, are always repreſentative of the *ſame idea*, he has attempted to *hold that circumſtance up to view*, by uſing always the ſame Engliſh word, TO, in tranſlating them. Now, in this attempt, ſuch uncouthneſs was unavoidable; for it happens that the Greek, Latin and Engliſh languages have not followed always the ſame range in the *application* of theſe words, although they are in *themſelves* ſtrictly ſynonymous. And whenever the uſage of our language does not correſpond with that of the Greek or Latin, a literal tranſlation cannot be attempted, without a manifeſt violation of the propriety of the Engliſh idiom:—In truth, it frequently happens that words of the *ſame generic meaning* are found in very *different ſpecial applications*, in different languages. For example, the Greek prepoſition ANTI, and the Latin ANTE, not only repreſent the *ſame idea*, *viz.* priority, but they are really the *ſame word*; and yet the ſpecial applications of them are by no means correſpondent with each other, ANTE, in Latin, never marking oppoſition, nor ANTI, in Greek, priority in reſpect of time.—On the other hand, words that are very different in their original import, frequently produce the ſame ultimate effect. Thus the words AD and EX are not only of different, but nearly of oppoſite meaning; and yet, of the two expreſſions, "AD ſuam "naturam fingere cæteros," and "EX ſua natura fingere cæteros," the effect is ultimately the ſame.

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

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 lamfalt, 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

* 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, tranſacted the affairs of the community, and yielded military ſervice, under their tithing men or decuriones, led by a common chief, called a *graff*, *burgraff*, or *count*, in the ſame way as the inhabitants of the country diſtricts.

THE converſion to Chriſtianity was, however, an event that, though it created no change in the general ſtructure of the legiſlature, muſt have naturally augmented the numbers of the deliberative body which preſided in it. As Chriſtianity incapacitated the leaders of tribes from officiating as chief prieſts at thoſe religious rites which were uſually celebrated at the opening of public aſſemblies, the biſhops and abbots came naturally to diſcharge this duty on ſuch occaſions. In this way, they muſt have ſhared in the rank, by ſharing in the functions of the chief; and the ſituation in which they thus appeared at the opening of all political conventions, would enable them to join, with much effect, in the deliberations which enſued; and their ſuperior knowledge, their ſacred character, and their influence with the people, would ſoon acquire them power equal to their rank. They muſt, therefore, have been well entitled to demand admiſſion into that council, which was formed by the king and the lay chiefs at the national aſſemblies; and, as they balanced the authority of thoſe chiefs, we cannot doubt, that the king would be diſpoſed to give the utmoſt effect to their claim. Accordingly, we every where find the dignified clergy preſiding along with the lay magiſtrates, in the provincial aſſemblies 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 muſt long have continued blended with the body of the freemen. It was by degrees only that eccleſiaſtics were at firſt exempted, and afterwards prohibited from yielding military ſervice; and we may be ſure, that, in a rude age, the clerical character muſt be unable to extinguiſh ſuddenly that of the warrior.

THE

THE leading propoſition in the foregoing hypotheſis is, that the diets of the European ſtates were originally national aſſemblies, containing, *de jure*, the whole warriors belonging to them, conducted by their local chiefs or magiſtrates, who, together with the king and dignified eccleſiaſtics, formed a ſenate or council that, in general, directed the common reſolves. I propoſe, in this part of the paper, to conſider the grounds of this propoſition, in the firſt place; and then, chiefly with a view to our own country, examine the evidence relative to the deliberative council which I have aſcribed to the diets, and to the ſituation of towns, in order to juſtify the hypotheſis, in ſtating that the former was an aſſembly of the magiſtracy, and that the latter reſorted to the diets, in the ſame manner as the country diſtricts.

CONSIDERING how certainly we know, that the warriors or *liberi homines* of every tithing and hundred were bound to attend perſonally, not only on the meetings of theſe diſtricts, but in the general meetings of the province or ſhire, where they not only were reviewed by the chief magiſtrate, but aſſiſted in the judicial and political deliberations which the buſineſs of their quarter required, it might have been imagined, that a natural analogy would have led authors to agree in the ſuppoſition, that the national diet was nothing more than an aggregate of the provincial diets, in the ſame manner as the provincial diets were aggregates of thoſe of leſſer diſtricts. The difficulty we feel in accommodating our reaſonings to a period, when both the buſineſs and the amuſement of a freeman conſiſted in making war, and when the habits of the migratory life of ſhepherd tribes were ſtill recent, and rendered the manners of ſociety extremely different from our own, is the only reaſon I can offer for this opinion having met with little attention or regard. Strong arguments in favour of it, from the hiſtory of the ancient German nations, I flatter myſelf, will be ſuggeſted from what has been ſtated in the former parts of this paper. Thoſe

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 diſ- " 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 aſſaſſinated 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 neceſſary prelude *. On theſe occaſions, the name of *placitum exercitale* is often aſcribed to them, while the term *placitum* ſimply is attributed to all diets without exception, where judicative and political authority was exerciſed. This circumſtance itſelf looks as if theſe aſſemblies had differed only in their object. The power and means of convoking them, and the perſons that they conſiſted of, muſt have been the ſame in both; and, without deliberative powers, we cannot conceive any thing more abſurd than to have beſtowed the name of *placitum* on an aſſembly of the national force.

BUT, though we have no particular deſcription of the Merovingian placita, or malla †, we find every where evidence, that all affairs of conſequence were tranſacted in them. The mayor of the palace was choſen in them ‡; differences among the royal family, and with foreign nations, were decided in them ‖; and the Salic law ſeems to have owed to them its ſanction §.

UNDER

* See PEPIN's Expediton to Italy. *Fredeg. Chron. Contin.*

† MAEL, in German, an aſſembly or convivium.

‡ Fredeg. Chron. cap. 43. et 89. And, I apprehend, the kings themſelves likewiſe. In a diſpute between CLOTAIRE II. and the children of THIERRI, CLOTAIRE makes this reply to an embaſſy from the latter: "*Judicio* Francorum *electo*, quicquid precedente do- "mino a Francis inter eoſdem judicabitur, pollicetur ſe implere." *Ibid.* § 40. In the ſame way, the conſtant expreſſion uſed in the Chronicles to record a ſucceſſion to the crown, is, "Et filium ejus Franci ſuper ſe regem ſtatuunt." *Geſt. Franc.* § 43. The very ceremony of the coronation of the French kings, as practiſed in modern times, is that of an election by the grandees, aſſembled within the church of Rheims, and an approbation of the people aſſembled without. In fact, however, the Chronicles often mention elections in expreſs terms.

‖ Thus AISTULFUS, king of the Lombards, engaged, "Ut omnia per judicium Fran- "corum emendaret;" and it was "per ſacerdotes et optimates Francorum," that he obtained peace. *Fredeg. Chron. Continuat.* In the ſame way, "GUNTRAN et CHILPERIC "pacem fecerunt, pollicentes alter alterutrum, ut quicquid ſacerdotes vel ſeniores popu- "li judicarent, pars parti componeret quæ terminum legis exceſſerat." 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 deſcribed: "Temporibus CLOTARII regis, una cum "principibus

UNDER the Carlovingians, we have much more particular accounts of theſe aſſemblies. The moſt unambiguous expreſſions of hiſtorians indicate that they were national *.

HINCMAR relates, that, at the placita, the " Epiſcopi abbates, " vel hujuſmodi honorificentiores clerici, ſibimet honorificabiliter " a cætera multitudine primo mane ſegregarentur ;" and that a ſimilar ſeparation took place, as to the comites, " vel hujuſmodi " principes." Theſe, he ſays, formed two councils, which met together in one, when the affairs under deliberation required it. Here, then, we have the magiſtracy, or governors of towns and counties, and the dignified clergy, forming a ſenate, and ſeparated from the multitude of which the reſt of the diet was compoſed. And it will be particularly obſerved, that this multitude were, by no means, as has often been pretended, a rabble of attendants and ſpectators ; for it is related, that no " inferiores perſonæ" were admitted among them ; and that their functions were to hear the reſolves of the lay and eccleſiaſtical magiſtracy ; and ſometimes (in caſes, I ſuppoſe, of very general intereſt) deliberate on them, and confirm them, not by their power in executing them, but by their ſuffrage in approving of them †.—There is alſo a leſſer diet mentioned by HINCMAR,

" principibus ſuis, id ſunt, 33 epiſcopis, 34 ducibus, et 79 comitibus, vel cætero populo " conſtituta eſt." And HINCMAR, archbiſhop of Rheims, under LOUIS LE DEBONNAIRE, a well informed author, and anxious to preſerve information of the conſtitution of his country, ſeems to hold it as a thing perfectly notorious, that, in all times, the national conſent had been given to the promulgation of laws. " Habent enim reges," ſays he, " et reipublicæ miniſtri, leges quibus, in quacunque provincia degentes regere debent " habent capitula Chriſtianorum regum, ac progenitorum ſuorum, quæ generali conſen- " ſu fidelium ſuorum tenere legaliter promulgaverunt." *Vol.* ii. *p.* 204. The capitularies are expreſs on this ſubject. One of them runs as follows : " Per capitula avi et pa- " tris noſtri, quæ Franci pro lege tenenda judicaverunt et fideles noſtri, in generali pla- " cito noſtro conſervanda decreverunt." *Capit. Carol. Cal. tit.* 39. *cap.* 8.

* IT is related under the year 767, " Ibi ſynodicum fecit (*ſcil.* PIPINUS) cum *omnibus* Francis in campo Bertini. *Annales Francor.*

† IT is thus I underſtand the following paſſage. It begins with mentioning, that there were two diets in the year, one of the general kind I am treating of, in which the whole

HINCMAR, which, he ſays, conſiſted only of the *ſeniores* and *præcipui conciliarii*, *i. e.* "the magiſtracy and principal officers of the crown," and was deſtined for the purpoſe of making preſents to the king, and conſulting on ſuch affairs reſpecting the buſineſs of the enſuing year, as required early deliberation.

OF this period, as well as the former, it is alſo to be remarked, that we find the term *placitum* applied indiſcriminately to the aſſembly ſummoned for immediate war, and to that where deliberation rather than action was its object *.

THE ancient German diet, under the houſes of Saxony and Franconia ſeems to have retained preciſely the form which HINCMAR aſcribes to it under CHARLEMAGNE. At the election of CONRAD II. *A. D.* 1024, we find the nation aſſembling in the plains between Worms and Mentz; the Franks on the weſt, the Saxons, Carinthians, and Bavarians, on the eaſt. The dignified clergy, and the dukes, counts, and marquiſſes, retired to an iſland on the Rhine, and agreed, that two perſons, named CONRAD, ſhould be the candidates. The archbiſhop of Mentz propoſed the eldeſt firſt. The dignified clergy gave him their ſuffrages, then the dignified laymen, and, in fine, the multitude of the nobility, diſtributed into national battalions, gave their conſent by cries and acclamations †. PFEFFEL, *vol.* 1. *p.* 180.

I NEED ſcarce obſerve, that this form of the diet under the houſe of MARTEL affords the ſtrongeſt indication of its form under that of CLOVIS; for it is clear from the Capitularies, that the feus had

t not

whole buſineſs of the year was arranged, ſo as not to be altered: "Niſi ſumma neceſ-
"ſitas quæ toto regno incumbebat;" and thus proceeds, "In quo placito generalitas
"univerſorum majorum, tam clericorum quam laicorum, conveniebat; ſeniores, propter
"concilium ordinandum; minores, propter idem concilium ſuſcipiendum et interdum pa-
"riter tractandum, et non ex poteſtate, ſed ex proprio mentis intellectu vel ſententia
"confirmandum." *Vol.* 2. *p.* 211.

* SEE paſſage in the preceding note, as an example of the latter; and for the former, ſee *Capit.* paſſim. Thus, *cap.* 2. *Car. Mag. cap.* 9. where the biſhops, counts and abbots are required to have people, "Qui, *&c.* ad diem denunciati placiti veniant, et ibi
"oſtendant quomodo ſint parati. Habeant loricas vel galeas et temporalem hoſtem."

† THE election of LOTHARIUS II. *A. D.* 1125, was decided againſt the inclination of the ſenate, by the will of the multitude, of which, as the accurate PFEFFEL obſerves,
"Les

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 coincides ſo exactly with that above deſcribed, while Poland, at the ſame time, was never feudalized, as greatly ſtrengthens the concluſion, that it preſerved much of the original ſtructure of the European 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, palatines, and caſtellans, *i. e.* governors of counties or fortreſſes, aſſemble 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 attend; 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 paludata, 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 belonged: " 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-

t 2 ſtance

* 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, becauſe 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.

ſtance which well explains why, on a vacancy of the throne, after a ſucceſſor was named by the palatines, it was always eſteemed neceſſary to aſſemble a ſolemn diet, in order to have their appointment confirmed, and the right of the new king recognized by the nation.

If we turn our reſearches more homeward, we ſhall find, that every thing, in the like manner, indicates, that the legiſlature was a national aſſembly.

The very places of meeting, in the open air, and in great plains afford reaſon to ſuppoſe, that the diets of the Angloſaxons were very popular aſſemblies; and all the expreſſions of hiſtorians, in mentioning them, likewiſe eſtabliſh that ſuch was the fact *. Even after the conqueſt, the Engliſh diets were ſtill at times very numerous. In an aſſembly under William Rufus, *A. D.* 1094, almoſt all the nobility of England are ſaid to have been preſent †; and it appears, that, beſides them and the dignified clergy, a great crowd of both clergy and laity attended; and that a miles, *unus de multitudine*, made a ſpeech, encouraging Archbiſhop Anselm in the conduct he was purſuing ‡. Accordingly, even the laws of the Conqueror bear to have been enacted, "Per commune concilium totius regni ‖." And the ancient

* The council, or diet, in which Edgar was to be abſolved from penance, in *A. D.* 973, is deſcribed thus: "Adunatis epiſcopis, abbatibus, et cæteris principibus, "cum tota regni ingenuitate, coram eis adſtante innumera populi multitudine." The council of *A. D.* 697, aſſembled at Berghamſted, enacted ſundry laws, or canons, which bear that they were decreed by the clergy; "Viris utique militaribus et communi omnium "conſenſu." Earl Godwin purged himſelf of the murder of the king's brother Alfred, "coram rege et univerſa gente." *Saxon Chron.* 1052. Matthew of Weſtminſter ſays, "Maxima pars regni, tam clericorum quam laicorum, in unum congregati "pari conſenſu Knutonem in regem elegerunt." The Saxon Chronicle relates, that, on Harold's death, "Populus univerſus elegit Edwardum in regem."

† Eadmerus calls it ſimply, "totius regni adunatio." *P.* 39.

‡ *Ibid.* p. 26.

§ The election of the dignified clergy was anciently in parliament; and I ſee a record in Madox, where Stephen, in veſting the biſhop of Bath with the temporalities of his

ancient entry in the journals of the Houſe of Lords ſuggeſts the idea of the nation having been aſſembled along with them: "Præſente etiam *toto* populo, et plebe de domo communi." The laſt words, *et plebe de domo communi*, muſt evidently have been added after the admiſſion of the repreſentatives of trading incorporations among the milites, or proper citizens of the nation.

We alſo find the ſame indiſcriminate application of the diet to civil and military purpoſes as in the continent. So low down as 23d Henry II. *A. D.* 1177, mention is made of an extraordinary parliament being aſſembled at Windſor, attended by all the earls, barons, and almoſt the whole military tenants of the king, with their horſes and arms, prepared to go wherever he ſhould command them *.

In Scotland, alſo, we have full evidence of the ancient diets being a national aſſembly. Benedictus Abbas, under the year 1188, mentions, That the biſhop of Durham, and others, were ſent by Henry II. to William, king of Scotland, to collect tithes: That William, being deſirous to get back certain caſtles that had been taken from him, agreed, provided the conſent of his ſubjects could be obtained: That the ambaſſadors came accordingly, "In Leoneis ad locum quæ dicitur "Brigeam; —et ipſe rex Scotorum, cum omnibus fere epiſcopis "et comitibus et baronibus terræ ſuæ, et cum infinita homi-"num ſuorum multitudine, ad locum præfixum venerunt; et "audita adventus nunciorum regis cauſa, et eorum petitione, "habito

his fee, addreſſes the grant, "Archiepiſcopis, epiſcopis, abbatibus, comitibus, baroni-"bus, *et omnibus fidelibus*, per totam Angliam, conſtitutis;" and adds, that the grant proceeded, "Canonica prius electione præcedente, et communi veſtro concilio, voto et "favore proſequente." This charter is teſted in a general council at Weſtminſter; "Audientibus et collaudantibus omnibus fidelibus," *&c.*

* Benedict. Abb. apud Littelton, Hen. II. vol. 3. p. 290. Even under Henry III. *an.* 1223, "Natali domini," ſays the Chronicle of Dunſtaple, "venit rex Northamp-"ton. et cum eo D. Cant. archiepiſcopus, et tot epiſcopi, et comites et barones, et "milites *armati*, quod nec in diebus patris ſui, nec poſtea, dignoſcitur tale feſtum in "Anglia celebratum." *Ap. Hody, p.* 300. See alſo note below, on p. 150.

" habito cum ſuis concilio, reſpondit, ſe non poſſe animos eo-
" rum inclinare ad decimam dandam. Et ipſi pro ſe reſponde-
" runt, ſe nunquam decimam daturos; nec etiam ſi rex An-
" gliæ, et dominus eorum, rex Scotiæ, juraſſent ſe illam habi-
" turos, unquam illam darent*." In the laws of WILLIAM, we find ſome introduced as follows: " Aſſiſa regis WILLIELMI
" facta apud Perth, quam epiſcopi, 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 ſatisfactory evidence of the ancient diet being an aſſembly 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 aſſembled the earls, barons, burgeſſes, and all the other freeholders of his kingdom, made a propoſal to them, which they approved of, and the perſons approving are enumerated in the following explicit manner: " Qui
" omnes et ſinguli comites, barones, burgenſes, et libere te-
" nentes, tam infra libertates quam extra, de domino rege, vel
" quibuſcunque aliis dominis infra regnum, mediatè vel imme-
" diatè tenentes, cujuſcunque fuerint conditionis ‖, conſide-
" rantes et fatentes præmiſſa eſſe vera, *&c.* habito ſuper præ-
" miſſis communi ac diligenti tractatu, *&c.* unanimiter conceſ-
" ſerunt," *&c.* §. This very curious record, the original of which

* Vol. 2. p. 515. † Cap. 7. See alſo general title. ‡ Cap. 32.

‖ THE eccleſiaſtics ſeem to have been omitted in this enumeration, becauſe the grant in agitation regarded only laymen. In the parliament, or aſſembly of the ſtates at Ayr, *A. D.* 1315, where the ſettlement of the crown was made on ROBERT I. the enumeration is as follows: " Epiſcopi, abbates, priores decani, archidiaconi, et cæteri eccle-
" ſiarum 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 ſummoned in 1115 or 1116, to recognize the ſucceſſion of his ſon WILLIAM, ſeems to have contained vaſſals of ſubjects. MALMSBURY ſays,

which is ſtill extant in the Advocates Library, proves, that, notwithſtanding the feudal ſubordination which was then taking deep root in Scotland, the loweſt military tenants in the kingdom 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 myſelf in this manner, becauſe, I imagine, every perſon acquainted with the hiſtory of the progreſs of ſociety, or with the genius 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 property 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 vicecomitis. 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 feebleneſs 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 poſſeſſion of a ſword and a lance was ſuch a characteriſtic of freedom, that the ceremony of emancipating a villein conſiſted in beſtowing them on him.

I DO not mean to contend, that every degree of emancipation, though creating an obligation to ſerve in war, conferred a right of entry into the courts of the hundred and ſhire. I rather incline to believe, that, in general, the emancipated remained ſubject to various burdens in favour of their patrons, and reſorted to that domeſtic juriſdiction which their patrons exerciſed 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 ſake of protection, to ſubmit to ſimilar burdens, and to a ſimilar degradation. But, on the other hand, we find the Saxon Ceorls entering into *ſodalitia* with the moſt conſiderable perſons in the ſtate: We find ſokemen, in the oldeſt times, members of the county-courts; and Doomſday proves, that even thoſe ſokemen, who probably had no entry there, and were transferable by their lords, retained ſo much of the characters of the ancient independence of freemen, that they exerciſed the functions of ſuitors of courts, and were capable of enjoying the emoluments of juriſdiction *.

* IN enumerating the lands of ROGERUS comes, it is ſaid in Doomſday-book; "Hanc terram tenuerunt 6 ſoccomanni, et dare et vendere terram ſuam potuerunt. "Unus eorum homo regis EDWARDI fuit, et Invuardam invenit vicecomiti. Tres iſtorum "Soccomannorum accommodavit PICOTUS (the vicecomes), ROGERIO comiti, *propter placita ſua tenenda.* Sed poſtea occupaverunt eos, homines comitis et retinuerunt cum terris "ſuis ſine liberatione, et rex inde ſervitium non habuit, nec habet. Sic ipſe vicecomes dicit." *P.* 193. 2. Again, when deſcribing Herſtingeſtan hundred; "Ibi eſt terra Soccomanorum 5 hid. ad geld. Terra 8 carruc. et 6 bov. Iſti ſoccomanni dicunt, ſe habuiſſe legrevitam, blodevitam, latrocinium ſuum, uſque ad 4 denar. et poſt 4 denar. habebat abbas forisfacturam latrocinii." In the remarks at the end of the ſurvey of the ſhire, it is ſaid, that a jury informed that, as to theſe 5 hides, "Terra ſoccomannorum fuit "tempore regis EDWARDI; ſed idem rex dedit *terram* et *ſocam* de eis ſancto Benedicto de RAMSEY, propter unum ſervitium quod abbas ALVINUS fecit ei in Saxonia, "et poſtea ſemper habuit." *Huntingtonſhire.*

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 reſtoration 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 leſſer freeholders were admitted into parliament, ſo that no cotemporary hiſtorians take any notice of the event; the numerous veſtiges of an ancient equality of ranks among thoſe who may juſtly be termed the warrior caſt of the nation *; the privileges of the nobleſſe on the continent, and the ſpirit of the common law in England, ſo favourable to the rights of the commons and adverſe to feudal uſurpation: Theſe are a few of the particulars which, I think, have never received any ſatisfactory explanation on the ſyſtem of thoſe authors who hold, that all our inſtitutions are to be conſidered as originating in feudal times.

PART II.

SECTION II. *Of the deliberative Body in the Anglo-Saxon and Scottiſh Diets; and whether or not they contained Repreſentatives of Towns.*

THERE are two points in the hypotheſis maintained in the preceding ſection that ſeem to demand ſeparate conſideration. Theſe are the members aſcribed to the deliberative body in the European diets in general, and in the wittenagemot in particular; and the denial of any repreſentation having belonged to the commons in the Gothic ages.

* THUS, in Scotland, where the greater and leſſer barons ſat together in one houſe of parliament, we find commoners holding the higheſt offices in the ſtate, and ſitting along with peers in juries and in trials in parliament.

As to the former of theſe circumſtances, it will not have eſcaped attention, that many of the facts already quoted ſtrongly confirm the general idea, that there was a preſiding body in the national diets, conſiſting chiefly of the eccleſiaſtical and lay magiſtracy. HINCMAR's deſcription of the placita under CHARLEMAGNE; what we know of the diets in Germany under his ſucceſſors, and of thoſe of the Viſigoths before the Saracen conqueſt, and the ſtructure of thoſe of Poland and Sweden, are all agreeable to this opinion. The queſtion, however, who the wites were, from which the Anglo-Saxon diet, or micelmot, derived ſometimes the name of *wittenagemot*, has been a matter of ſo much diſcuſſion, the opinion I offer is ſo adverſe to what the greateſt of our hiſtorians have entertained on the ſubject, and is itſelf ſo material in explaining the origin and functions of the peerage and titled nobility of modern Europe, that I flatter myſelf ſome obſervations, particularly directed to this ſubject, will not be unacceptable.

IN the *firſt* place, it is to be noticed, that many of the expreſſions of our ancient hiſtorians and records indicate, that the Saxon diet conſiſted of two bodies. This ſeems to be implied even in the common enumeration, which begins with the dignified clergy, and ends with ſome term denoting a great multitude of people, ſuch as *tota ingenuitas*, or *populus*; but there are not wanting more explicit expreſſions. Thus, WILLIAM of Malmſbury, who flouriſhed only ſixty-nine years after the conqueſt, makes HAROLD, when reproached for aſſuming the crown contrary to his oath, give the following anſwer to WILLIAM the Norman: "De regno preſumptuoſum fuiſſe, quod "abſque generali *ſenatus et populi* conventu et edicto, alienam "illi hæreditatem juraverit," *&c.* *.

Mr

* ANALOGOUS expreſſions are uſed with reſpect 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 ſenate and people, compoſing their ancient diets, admits of no diſpute.

Mr HUME, obſerving that vaſt numbers of members were always aſcribed to the Saxon diet, has thought it neceſſary to ſuppoſe, that the principal proprietors of land were entitled to ſeats in it; and he, at the ſame time, rejects the notion of the commons ſitting, or being repreſented in it, becauſe he finds no mention of repreſentatives in Saxon times; and becauſe, 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 reſolutions might be ſuppoſed to conſiſt of almoſt any given numbers without confuſion. The ſeparation of the diet into two bodies is, no doubt, irreconcileable with Mr HUME's ſyſtem; but it ſeems to obviate the difficulties that induced him to adopt it.

IN the *next* place, I apprehend the following paſſages clearly point out, that the eldeſt wites, or *ſapientes natu majores*, were the lay and eccleſiaſtical magiſtrates, and, by no means, merely conſiderable landholders. INA reigned in Weſſex in the end of the ſeventh and beginning of the eighth century. His laws are

diſpute. As to thoſe of Spain, there ſeems to be no room for ſuppoſing them different: "Tandem unus ex primatibus," ſays an ancient chronicle, "nomine CHINDASINTHUS, "collectis plurimis ſenatoribus Gothorum, cæteroque populo in regno Spaniæ ſublima-"tur. TOLOGANEM degradatum ad honos CLERICATI tonſorare fecit." FREDEG. § 82. The ſame conſtitution among the Lombards ſeems to be implied in the expreſſion of the chronicle: "Langobardi una cum concilio procerum ſuorum DESIDERIUM in ſedem reg-"ni inſtituunt." DU CHESNE, *tit.* 1. *p.* 775. As to France, again, under the firſt Race, we frequently meet with ſuch language as this: "CHILPERICUS rex, convocatis "melioribus Francis, reliquiſque fidelibus, nuptias celebravit filiæ ſuæ." GREG. *Tur. lib.* 6. § 45. "Ille vero congregatis ſenioribus ſecum, præparatis epulis," *&c. Lib.* 4. § 27. And FREDEGARIUS writes, "Conſilio ſapientum uſus pagos et civitates, "quod fratri ſuo CHARIBERTO ad tranſigendum ad inſtar privato habitu vivendum, "potuiſſet ſufficere noſcitur conceſſiſſe." *Cap.* 57. In the ſame way, the legiſlature of the Saxons, when conquered by CHARLEMAGNE, conſiſted of a ſenate and people: "Cum in Saxoniam CAROLUS perveniſſet totum perfidæ gentis *ſenatum ac populum*, "quem ad ſe venire juſſerat, morigeram ac fallaciter ſibi devotam invenit." EGINHARTUS *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

* Hiſt. of Gr. Brit. vol. 2. p. 246. † P. 21.

And the eccleſiaſtical wites, were, without doubt, the dignified clergy whom we find enumerated at the head of thoſe of whom the diets were compoſed. In the laws of ALFRED, it is ſaid; "Sancti epiſcopi et ſapientes laici ſtatuerunt." KINEWOLF, king of Weſſex, in writing about religious affairs, ſays; "Una cum "epiſcopis meis, nec non cum caterva ſatraparum;" or, more ſimply, "Cum conſenſu epiſcoporum, atque ſatraparum meorum." The term *ſatrap* here, and in other places, uſed by the Anglo-Saxon writers was certainly, of all others, the moſt proper to denote thoſe powerful provincial magiſtrates who were, in fact, petty kings, and united, like them, the civil and military powers. And it will, likewiſe, be noticed, that this term is uſed by KINEWOLF, as correſponding to that of ſapientes laici in the laws of ALFRED *.

IT may be tedious to add further authorities; but I will venture to ſay, that, if any perſon takes the trouble to look into the Saxon writers, he will, I believe, find, that the common expreſſions uſed by them are more juſt, if interpreted according to the ſyſtem I have offered, than in any other way. Thus, for inſtance, the current phraſe, "Conſidentibus totius Angliæ ſe-"natoribus," or, "Totius Angliæ majoribus natu," could, with no propriety, be uſed to expreſs, as is manifeſtly intended by it, that the ſenate was full and general, unleſs all the parts of England had ſenators peculiar to them; that is, that the ſenators were the provincial magiſtrates. If they had been either the judges of a royal court of juſtice, or had been conſiderable proprietors without functions, then the phraſe would naturally have run, "*Omnibus Angliæ ſenatoribus*," or, "*Omnibus Angliæ*

"*majoribus*

* IN the ſynod of *A. D.* 694, aſſembled chiefly on religious affairs, the enumeration of the members is more full; firſt, the archbiſhop of Britain and the biſhop of Rocheſter are mentioned, and then it proceeds as follows: "Cæteriſque abbatibus, abbatiſſis, preſby-"teris, diaconibus, ducibus, ſatrapis, in unum glomeratis." See alſo enumeration of the diet which abſolved EDGAR, quoted above in note p. 148.

"*majoribus natu conſidentibus.*" And many examples of a like nature might be quoted *.

It 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

* "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, Harolno "comiti, et omnibus ſuis *agri Dorſetenſis miniſtris.*" Hody, *p.* 64.

† Lib. 2. cap. 40.

‡ It 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 courſe, alone would attend the provincial and national diets *.

As to Scotland again, there ſeems to be every reaſon to believe, that its ancient diet was conſtituted in a manner very ſimilar to that of the Anglo-Saxons. We find the country divided, like England, into ſhires and wapontacks. We know, that the Saxons and Danes gave their language and cuſtoms to the ſouth-eaſtern parts of Scotland; and what is tranſmitted to us of the Iriſh and Welſh cuſtoms ſeems to differ from the arrangements of the Anglo-Saxons, only as having belonged to a more rude and uncultivated people. On theſe accounts, I think it reaſonable to ſuppoſe, that the great men, mentioned in the enumeration of the members of the ancient Scottiſh diets, were the magiſtracy of the nation. I know a learned author †, in a late work, ſeems inclined to diſpute that ever earls were official in Scotland. But, ſo late as the laws of DAVID II. ‡, earls are mentioned as provincial judges; and the ancient Scottiſh ſtatutes cannot be looked into without finding the term *judices* applied to earls, and others, with the ſame general impropriety as in the reſt of Europe, where it was conſtantly employed to denote magiſtrates rather than judges. When, therefore, in an aſſembly at Perth, fines for non-performance of military ſervice are ſaid to have been aſcertained, "Coram rege per omnes judices Scotiæ ‖," we ought to be at no loſs to diſcover, that it was the ſenators, or the magiſtracy of the nation, that formed the body here meant §.

* I SHALL afterwards, in conſidering the innovations in the ſtructure of the ancient legiſlatures, have occaſion 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 uſing a ſimilar mode of expreſſion, "Poſt "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

* 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 inſerted, 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 ſubject, belonging to liberties, or not belonging to them, are mentioned as aſſembled and deliberating in parliament.

ONE obſervation more is neceſſary on the preſiding body of the Britiſh diets, *viz.* that both in England and Scotland, it appears to have aſſembled in the ſame manner as the autumnal placita of the Franks, though no general diet of the nation had been convoked. The Saxon hiſtorians often mention aſſemblies where only ſenators in general, or, more particularly, biſhops, abbots, or ſeniores, are ſpecified as attending; and we find the Saxon monarchs trying great law ſuits in ſuch conventions. Thus, ſays the Hiſtory of Ely, " Edicitur generale placitum " apud Lundoniam," where the duces, principes, ſatrapæ, rhetores, and cauſidici, aſſembled; and there a queſtion of property was decided by them, in which the biſhop of Wincheſter was concerned *. In the ſame way, in Scotland, the remains of our

 ancient

were originally entitled to attend at the diets. The tenants *in capite* owed their attendance as the condition of their eſtates, and were compelled to give it accordingly, while other freemen were more apt to neglect a burdenſome and inconvenient duty, which was not, in their caſe, often enforced by immediate forfeitures. Accordingly, the bold inventor of the treatiſe Mod. Tenen. Parl. makes the tenants in chief attend parliament by neceſſity of their tenure, while others only might be aſked to attend. The real foundation, however, of this proviſion in Magna Charta was, I apprehend, no more than this, that the tenants in chief were, agreeably to the feudal arrangements, the leaders and magiſtrates of their vaſſals. Hence it was incumbent on the king to ſummon only his immediate vaſſals, each of whom was, in virtue of ſuch ſummons, obliged to attend, " cum hominibus ſuis." Accordingly we find, that, in Scotland, certain of the vaſſals owed only preſence, and not ſuit, at the king's courts; and that it was neceſſary to enforce the obligation of ſuit by various regulations. *Stat.* 1. ROB. I. *cap.* 2. &c. 4. et 5.

* Lib. 1. cap. 10. See for more ſuch aſſemblies, *cap.* 14. 45. 46. 60. This piece of hiſtory is the more remarkable, that it affords a ſtrong indication of the original independence

ancient laws take notice of ordinances and judgments decreed in ſimilar conventions. One GYLASPIC MACSCOLANE we find ordered to give ſureties, or ſurrender himſelf, by an aſſembly of all the judices Scotiæ and Galividiæ. A judgment reſpecting the widows third of lands, rendered by the king in his court, is marked by having been pronounced when many magnates were preſent, and, therefore, no doubt of the greater authority; and ALEXANDER II. iſſues ordinances, ſometimes "communi conſilio comitum ſuorum," and ſometimes along with the "comites barones et judices Scotiæ;" or, more generally, as in a caſe formerly quoted, "Recordatio facta coram do-"mino rege per omnes judices Scotiæ †."

* * * *

THE opinion, that the towns had repreſentatives, in the ancient European diets, deſerves particular examination, not ſo much on account of any argument or evidence produced in its favour, as becauſe men of ingenuity have maintained it, and that the diſcuſſion of the merits of it tends to throw light on the ſources from which this privilege was, in after ages, derived.

AND conſidering, that the ſupporters of this opinion generally hold, that the vaſſals of ſubjects, and even thoſe tenants *in capite*, whoſe property was leſs than a knight's fee, had no place

pendence of the counties. For, after relating the judgment of the generale placitum, it thus proceeds: "Poſt hæc, infra octavum diem convenerunt iterum ad Northampton, "et congregata ibi tota provincia ſive vicecomitatu, coram cunctis iterum cauſam ſu-"pradictam patefecerunt. Qua patefacta ac declarata, ut præjudicatum erat apud "Lundoniam, judicaverunt et iſti apud Northampton."

† IT is natural to conſider, as the remains of this ancient inſtitution, the known royal prerogative in England, of holding conventions of peers, though no parliament is in exiſtence; and the practice which appears from the Scots ſtatutes to have obtained in Scotland, of the peers iſſuing ordinances without the concurrence of the other eſtates of parliament.

place in the diet *; and that the repreſentation by knights of the ſhire in Britain, and deputies of nobleſſe on the continent, was a modern inſtitution, the æra of which is nearly aſcertained; it ſurely may be fairly urged, that a hypotheſis is, at leaſt, improbable which thus ſuppoſes, that, in rude and warlike times, the owners of ſmall eſtates, who formed ſo large a portion of the feudal militia, had no acceſs to the national council, while plebeian burgeſſes had, in all times, been admitted into it, and even, according to ſome, formed the wites, from which, among the Anglo-Saxons, it derived its name.

But though it were permitted us to ſuppoſe, that repreſentatives from counties, as well as from towns, had been delegated to the national diets, neither the diſorderly and calamitous ſtate of ſociety in the Gothic ages, nor the feudal uſurpations to which they gave birth, nor the feeble and disjointed condition in which they left the European nations, can ſuffer us to attribute to ſuch times an inſtitution which our own experience of it has proved to be the powerful guardian of civil liberty, the ſureſt ſource of equal and general laws, and the efficacious bond which unites a widely extended country into one great community, cemented by the ſame public intereſts, and

* The Abbé Mably, however, thinks, that the Commons, or Tiers Etat, formed a third chamber in the diet of the Carlovingians, becauſe the *Capit.* of *A. D.* 819, *art.* 2. requires *each* comes to bring with him to the diet, "12 ſcabinos, ſi tanti "fuerint, ſin autem de melioribus hominibus comitatus ſuppleat numerum;" and that the advocati of the dignified clergy ſhould alſo attend. But the ſcabini were always choſen "de nobilioribus;" and, at any rate, it is evident, the 12 beſt people of a county can, by no means, be reckoned as of the Tiers Etat. Beſides, Hincmar's deſcription of the aſſembly gives no countenance to the notion of a chamber of delegates. The regulation in queſtion, I apprehend, was deſtined to remedy, in part, that neglect of attendance on the diet, which, at laſt became ſo fatal to its authority; or, perhaps, for ſome particular purpoſe, like what we read in Hoveden, of William the Conqueror; "Willielmus rex, anno quarto regni ſui, conſilio baronum ſuorum, fecit "ſummonari per univerſos conſulatos Angliæ *Anglos nobiles* et ſapientes, et ſua lege "eruditos, ut eorum jura et conſuetudines ab ipſis audiret. Electis igitur de ſingulis "totius patriæ comitatibus viri duodecim," &c. And they are ſaid to have reported the laws upon oath.

and actuated by the ſame national ſpirit. It is ſtrange, that thoſe who profeſs to be the moſt zealous friends of the Houſe of Commons ſhould adopt a ſyſtem, according to which a legiſlature by repreſentatives, even when eſtabliſhed among a people uncorrupted by luxury, and trained to arms, proved inſufficient to anſwer the moſt eſſential purpoſes of government. The multiplied oppreſſion, the turbulency of powerful individuals, the national debility, the diverſity of local cuſtoms, which, it is not to be diſputed, were the reſult, as well as the attendants of the Gothic governments, are ſurely the ſtrongeſt evidence of a conſtitution intrinſically bad, or groſsly inadequate to the circumſtances of the people to whom it belonged.

BESIDES, if it be conſidered, that each diſtrict had conſtitutionally the election of its own chief magiſtrate *, who, it cannot be queſtioned, was a member of the diet, it will be difficult to conceive, how the meaſure of ſending any other repreſentative to ſuch aſſemblies ſhould have been adopted. A perſon with ſuch a character would have appeared to be another

* " AUDIENS autem CHILPERICUS omnia mala, quæ faciebat Leudaſtes eccleſiis Turo-
" nicis et omni populo, ANSUALDUM illuc dirigit. Qui veniens, ad feſtivitatem Sancti
" MARTINI, *data nobis et populo optione*, EUNOMIUS in comitatum erigitur. Denique Leu-
" daſtes cernens ſe *remotum*," &c. GREG. *Tur. lib.* 5. § 48. " Præcipientes jubemus,
" ut in ipſo pago Cenomanico accipere non debeant, ducem aut comitem, niſi per elec-
" tionem ipſius pagi, pontificis et pagenſium." BOUQUET, *tom.* 4. *ad ann.* 698. The emperor HENRY II. recognized, that it had been the right of the Bavarians, at all times, to chuſe their dukes. Again, "Ut judices, vicedomini, præpoſiti, advocati, centenarii
" boni et veraces, cum comite et populo, eligantur." *Capit. ad ann.* 809. See alſo L L. EDWARDI, cap. 35. and L L. BOIOR. tit. 2. cap. 1. The kings, as preſiding magiſtrates, had naturally the nomination of dukes and counts; and the people had the appointment or rejection. The kings ſeem to have interfered in prejudice of the people, by transferring the election into the general aſſembly of the magiſtracy, and then by aſſuming it altogether. Thus we have frequent mention of the " electiones
" de palatio" as to biſhops, and they are marked in the edict of CLOTAIRE II. ann. 615, as an alternative to elections " clero et populo." I have quoted a charter in MADOX, that proves a biſhop of Bath was elected in parliament in STEPHEN's time; and we find dukes and counts ſometimes ſent " e palatio," and ſometimes choſen, as in the above caſe of Tours. See alſo, lib. 8. § 42.

ther chief magiſtrate, and muſt have been conſidered as a rival and a foe to the natural head of the community.

VERY ſtrong arguments have been derived from the progreſs of the Houſe of Commons to its political conſequence; and, from its rank and functions, when firſt found acting in the legiſlature, to ſhow, that it was, by no means, a body coeval with the conſtitution. Theſe, however, are well known, and need not be inſiſted on.

BUT, independently of the foregoing obſervations, which, however they may produce conviction on people accuſtomed to eſtimate the force of political reaſonings, will poſſibly be little reliſhed by others; I apprehend we have evidence of a more direct nature againſt the antiquity of the repreſentation of towns. *If, previous to the æra of charters of incorporation, towns were governed preciſely in the ſame manner as the country*, it is manifeſt, that nothing can be more improbable, than that they reſorted to the diet in any other way than the reſt of the nation; and an examination of the ſtate of the Anglo-Saxon towns, compared with that of thoſe on the continent, both proves, that *they contained the ſame orders of perſons, and the ſame political arrangements as the country*; and even points out the circumſtances, in their ſituation, which led them to exchange their ancient ſtructure for their preſent conſtitutions.

IN the *firſt* place, it is evident from Doomſday, (which, it will be remembered, mentions the ſtate of things under EDWARD the Confeſſor, as well as their ſubſequent ſtate under the Conqueror, when the ſurvey was taken), that the towns were univerſally comprehended under the diviſions of the country, by counties, hundreds, and tithings, and were ſubjected to certain public burdens, in proportion to the diviſion at which they were rated *. And we accordingly find, that, when

* "BURGUM de Grentbrige pro uno hundret. ſe defend." *Grentebreſcire.* "Bede-"ford, tempore regis EDWARDI, pro dimidio hundret. ſe defendeb. et modo facit in "expeditione

when the towns, in the ſucceeding centuries, purchaſed charters, erecting them into little communities, it was neceſſary to ſeparate them from the ancient ſyſtem of ſubordination to which they belonged. Thus, thoſe charters contained, among other privileges, exemptions from owing ſuit to the county, and even hundred courts *; exemptions from the ancient authority of the ſheriff, as collector of the revenues of the ſhire; and proviſions, that burgeſſes ſhould not be tried by a jury of the county, unleſs one half of the jurymen were taken from their corporation. It is ſcarce neceſſary to add, that ſeveral of the towns which obtained charters were, at the conqueſt, nothing more than manors belonging to the king, or other great proprietors. ATKYNS, in his *Lex Parlamentaria*, has long ago mentioned ſeveral ancient vills of the domain that afterwards became royal boroughs.

2dly, DOOMSDAY exhibits the government of towns as the ſame with that of the country. Thus, it mentions the comes, vicecomes, and their ſubſtitutes, *viz.* præpoſiti, majores, *&c.* as the perſons who had authority in towns †: And thoſe that ranked as hundreds are deſcribed not only as ſubdivided into wards

" expeditione et in navibus." Of Exon,(Exeter) it is ſaid," Serviebat hæc civitas quantum " 5 hidæ terræ." *P.* 100. " Huntedun. Burg. defendeb. ſe ad geld. regis, pro quar- " ta parte Herſtingeſtan hundred." Of Clifford, it is remarked, " Iſtud caſtellum eſt " de regno Angliæ. Non ſubjacet alicui hundret. neque in conſuetudine. GISLIBET " vicecomes tenet illud ad firmam et burgum et carucat." (village and plowgate), *&c. &c.*

* IN the charter of Portſmouth, RICHARD I. grants; " Quod prædicta villa, et " omnes burgenſes in ea, et tenentes de ea, ſint quieti — de ſciris et hundredis, et " de ſectis ſcirarum et hundredorum, et de ſummis et auxiliis vicecomitum, et ſervien- " tibus et de placitis et querelis omnibus." BRADY *on Bor. App. p.* 14. In the charter of Dunwich, King JOHN grants; " Quod nullam ſectam faciant comitatum vel " hundredorum, niſi coram juſticiariis noſtris: et cum ſummoniti fuerunt eſſe coram " juſticiariis, mittant pro ſe, duodecim legales homines de burgo, qui ſint pro omni- " bus:" And, if they were to be amerced, " Amercientur per 6 probos homines " burgi, et 6 extra burgum." See others in MADOX Hiſt. Excheq.

* OF Huntedun, it is ſaid; " De toto hoc burgo exib. temp. Reg. EDW. de Landga- " ble 10 lib.; inde comes terciam partem habeb. rex duas, &c.; præter hæc habeb. " rex

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 they

" rex 20 lib. et comes 10 lib. de firma burgi." The cenſus of a mill of the burghlands, 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.* Lagmen 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 Herefordſcire. 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 diſtinguiſhed, performed the functions of magiſtrates over it, while the tenants or vaſſals of the manor compoſed the judges of the manor court, or hallmote, whoſe ſentences theſe magiſtrates carried into execution.

3*dly*, THE ranks and privileges of the inhabitants appear to have been the ſame in town and country. Beſides, lagmen, as already noticed, we find mention made of thanes in general, as reſiding in towns, and performing the ſame duties with thoſe of the country *. Next to the thanes, burgeſſes are enumerated, and theſe appear to have been in very different ſituations. Some of them are deſcribed as poſſeſſing lands and houſes in full property with juriſdiction, and ſubject to no rent or cenſus to any perſon; others of them as proprietors of manſes ſimply, and ſtill enjoying juriſdiction, even within this ſmall property †; and others, without this advantage, being ſubjected to the juriſdiction of particular perſons, and yielding to them, or to others, a cenſus or a conſuetudo. In fine, others are mentioned, whoſe manſes belonged in property to individuals, to whom they yielded rent and ſervices ‡: And, in ſome caſes, theſe different ſituations appear to be more or leſs blended together ‖. Beſides theſe

* SEE note, p. 160.; and the evidence abounds in Doomſday, and elſewhere. WILLIAM of Malmſbury ſpeaks of country barons admitted, long before his time, into the community of London. *Hiſt. Novor. lib.* 11. § 10. *f.* 106.

† IN Warwick, it is ſaid, there were 19 burgenſes, "qui habent 19 maſuras, cum ſa-"ca et ſocha, et omnibus conſuetudinibus, et ita habebant temp. Reg. ED." The burgenſes of Exon, it is ſaid, "Habent extra civitatem, 12 carucat. terræ, quæ nullam "conſuetud. reddunt, niſi ad ipſam civitatem." A manſe in France denoted not only a houſe, but 12 bonnés of land belonging to it. In Doomſday, however, maſura and domus ſeem to be ſynonymous. In Norwich, ſome burgeſſes enjoyed juriſdiction and patronage over other burgeſſes.

‡ IN Warwick, the king had, *in dominio*, 113 manſes, and the barones regis 112, which likewiſe paid geld to the king, and were appendages of their eſtates that lay *extra burgum*.

‖ IN Hereforde, "HERALDUS comes habeb. 27 burgenſes, eaſd. conſuet. hab. quas "alii burgenſes." The præpoſitus, however, "Habeb. in ſuo cenſu ſupra dictas om-"nes conſuetudines. REX vero habebat in ſuo dominio tres forisfacturas. Hoc erat "pacem

theſe burgeſſes, notice is taken of bordarii ſoccomanni, *&c.* as aſſiſting the burgeſſes to pay the cuſtoms or rents due by them *. The burgeſſes indiſcriminately are every where mentioned as yielding military ſervice, and ſubject to the burdens attending it, according to a certain modus, eſtabliſhed, as it ſhould ſeem, by cuſtom chiefly †. And citizens likewiſe partook of the ſports and amuſements of the nobleſſe of the country ‡.

In the country, the ſame ſtate of perſons appears. We do not, indeed, find the term *burgeſſes* applied to them. But there are numbers of people mentioned among the inhabitants of the country, that ſeem to differ in no reſpect from burgeſſes, except in wanting that name, which, it is evident, the nature of their place of reſidence could not admit of giving them. Thus, we

" pacem ſuam infractam, heinfaram et foreſtellum. Quicunque horum unum feciſſet, " emendab. 100 ſol. regi, cujuſcunque homo fuiſſet." Every maſura, likewiſe, was obliged to ſend a man to attend when the king hunted. In deſcribing the royal manor of Suchlie, it is ſaid, " In Wireceſtre unus burgenſis, ſed nil reddit."

* In Huntedone, it is ſaid, " T. R. E. fuerunt et ſunt modo 116 burgenſes, conſue- " tud. omnes et geld. regis reddentes; et ſub eis ſunt 100 bordarii, qui adjuvant eos ad " perſolutionem geldi. De his burgenſibus habuit ſanctus Benedictus de RAMSEY, 10 " cum ſac. et ſoc. et omni conſuet." *Borde* or *borderie* is an old French word, ſignifying a " domain aux champs, deſtiné pour le menage, labourage, et culture." Hence *bordelage* in the French law. ARGOU. *lib.* 2. *cap.* 4.

† OF the burgeſſes of Hereforde, it is ſaid, " Qui equum habebat ter in anno, per- " gebat cum vicecomite ad placita, et ad hundrez. ad Urmelavia." Again, " Burgen- " ſis cum caballo ſerviens cum moriebatur, habeb. rex equum et arma ejus. De eo qui " non habeb. equum, ſi moreretur, habeb. rex aut 10 ſolid. aut terram ejus cum do- " mibus. —— Si vicecomes iret in Wales cum exercitu, ibant hi homines cum eo. " Quod ſi ire juſſus, non iret, emendab. regi 40 ſolid." Exon tantum geldab. quando London, York, et Winton, geldab. " et hoc erat dimid. mark. argenti AD OPUS MILI- " TARE. Quando expeditio ibat per terram, ſerviebat hæc CIVITAS QUANTUM 5 HIDÆ " TERRÆ." Warwick ſent a contingent of 10 burgeſſes to aſſiſt in a war at land, and 4 boatſwains, or 4 lib. of pence in a war at ſea. " Qui monitus, non ibat," paid 100 ſolidi. Wilton ſent a man for every five hides, Ledeceſtre ſent 12 as a contingent, *&c. &c.*

‡ " ET cives Londoniæ habeant fugationes ſuas ad fugandum, ſicut melius et plenius " habuerunt anteceſſores eorum ſcilicet in Chiltre, et Middleſexe, et Surreie." *Charter by Inſpeximus of* HEN. I. *and* HEN. II. *and* RICH. I.

find there people poſſeſſing ſingle manſes, or ſingle roods or half roods of land, and ſometimes larger quantities, as ploughgates, and yielding military ſervice, and various cuſtoms, to the king or individuals. The rights of the owners of theſe lands likewiſe appear to have differed in the ſame way as thoſe of burgeſſes, and to have been ſubjected to a ſimilar diverſity of burdens *. I need not add, that we find the whole country abounding with ſoccomanni, bordarii, porcarii, bovarii, who appear to have been in ſome degree of ſervile condition, and diſtinguiſhed from each other chiefly by names derived from the particular ſpecies of rent or ſervice yielded by them, or other ſuch little circumſtances.

THE above particulars, and the authorities on which they are ſtated, appear to me, when maturely conſidered, to leave no reaſonable doubt, that the towns enjoyed no peculiar ſyſtem of adminiſtration, but were diſtinguiſhed merely as places of ſome ſtrength, where authority was better enforced, and where the ſmaller proprietors, and perſons of ſervile condition, who had preſerved or obtained a degree of liberty, reſorted in numbers, for the ſake of mutual protection. If the town belonged to an individual, it was governed in the ſame manner as the reſt of his eſtate. If the town belonged to different people, it formed, along with what was afterwards called its *liberty* (*i. e.* the banlieue or territory adjoining and belonging to it), a diviſion of the country, or a political community, and was ranked and governed accordingly.

AUTHORS ſeem, in general, to have ſteered very wide of this ſimple and natural concluſion. Some, ſtruck with the oppreſſive reſtraints

* IN the ſurvey of a manor, it is ſaid, "ANSGOT, homo comitis, tenet dimid. virg. "terræ. Et ULVIET unam hidam liberæ terræ." *P.* 180. In the manor of Arkenfelde, the king had 96 men, who, with their men, held 76 caruc. "et dant de con- "ſuetud. 4 ſextar. mellis, 20 ſol. pro ovibus, quas ſoleb. dare, et 10 ſol. pro fumagio; "nec dant geld. aut aliam conſuet. niſi quod pugnant in exercitu regis, ſi juſſum eis "fuerit." If a villein died in this manor, the king had an ox; if a freeman, his horſe and arms. But a page of Doomſday cannot be peruſed without perceiving abundant evidence of the aſſertion in the text.

reſtraints and burdens to which the more ancient charters of incorporation, 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 natural 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 coinage 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 preſerved 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 antiquity 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 belonging 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 anciently 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 reſorting in an aggregate body to the national diet, and there poſſeſſing much influence *.

Again, though we ſometimes find inhabitants of towns deſtitute of the right of alienating their property; that the crown was their heir inſtead of their children; and that ſervices of all ſorts, or compoſitions in lieu of ſervices, were exacted from them in the moſt oppreſſive manner; it neither follows, that all the inhabitants of towns were in this ſituation, nor that the inhabitants of the country were in happier circumſtances. Various cauſes tended to create a multiplicity of reſtraints and ſervices. The German kings ſubſiſted chiefly by gifts from the freemen of the nation, and, like the heads of all paſtoral tribes, received from them lodging, forage, and attendance when they journeyed. After the conqueſt of the Roman provinces, theſe voluntary aids degenerated into a variety of cuſtomary taxes, uncertain ſervices, and oppreſſive compoſitions. Fines alſo were preſcribed for all manner of delinquencies, and ſeem to have been employed as an inducement to the execution of the law, by rendering every proprietor a profiter from it. Perſonal protection, likewiſe, 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 reſtraints as to marriage, alienation, ſucceſſion, *&c.* over thoſe who received it. Beſides, the imperfections of agriculture, and the diſorders ariſing from the weakneſs of government, often reduced even freemen to the greateſt hardſhips; and it was lawful for them to ſell themſelves into ſlavery; and it was alſo lawful to purchaſe emancipation or relief, by ſubmitting to various burdens affecting their poſterity, as well as themſelves. In fine, the jealouſy and

* On the death of CANUT, the Saxon Chronicle relates, that HAROLD was choſen king by Earl LEOFRIC, *and the mariners of London*, and almoſt 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 uſe *baro* to denote thane; and the records for ſeveral reigns after the conqueſt employ both terms promiſcuouſly. MADOX. *Hiſt. Exch.* BOULAINVILIERS *Etat de la France, v.* 3. *p.* 56.

and excluſive ſpirit natural to rude communities, and the powers of proprietors to make particular regulations, and eſtabliſh tolls, and other cuſtoms, within their eſtates, produced reſtraints, from which again the crown ſold exemptions. Now, all theſe ſources of perſonal reſtraints reached equally to the country and to the towns, and appear accordingly from Doomſday, not to mention other evidence, to have overwhelmed both*. The towns, indeed, were early in condition to obtain freedom from them by actual purchaſe and by ſpecial grants; and, accordingly, their former ſtate under them has drawn more attention; while the country, obliged to wait for the gradual influence of political advancement, has derived its freedom ſlowly and inſenſibly, ſo that its ancient oppreſſions have attracted leſs obſervation.

Nor is there any reaſon for ſuppoſing, that towns were, in remote times, poſſeſſed of thoſe liberties, and of that conſtitution, which was conferred on them by the charters of incorporation. 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 reſpect;

* 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 ſhall, therefore, quote only two very curious paſſages from Doomſday. "Northamptonſcire 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 ſol. De Elemos, "20 ſol. De eq. venator, 20 ſol." See alſo Ledeceſtre and Warwick, *&c.* In deſcribing the cuſtoms of Arkenfelde in Hereforddeſcire, it is ſaid; "Si quis Wallenſium occid. ho-"minem regis, et facit heinfaram, dat regi 20 ſol. de ſolut. hominis, et de forisfac. "100 ſol. Si alicujus Taini hom. occiderit, dat 10 ſol. domino hominis mortui. Quod "ſi Wallenſis Wallenſem occiderit, congregantur parentes occiſi, et prædantur eum "qui occidit, ejuſque propinquos, et comburunt domos eorum, donec in craſtinum circa "meridiem corpus mortui ſepeliatur. 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 ſol. aut unum bovem re-"gi. Qui de hundret. remanet, tantumdem perſolvit. Similiter emendat qui, juſſus "a vicecomite ſecum ire in Wales, non pergit. Nam ſi vicecomes non vadit, nemo "eorum ibit. Cum exercitus in hoſtem pergit, ipſi faciunt avantwarde in reverſione "rerewarde. Hæ conſuetud. erant Wallenſium." *T. R. E. in Arkenfelde.*

ſpect; and it accordingly appears from the domeſtic regulations of CHARLEMAGNE, that the manufactures, conſumed by the royal houſehold, were ſtill prepared in the ancient manner, in his fiſcs or domains. It is, therefore, extremely improbable, that any merchants, or artiſans, that may have belonged to great towns, in the middle ages, were perſons of conſequence; and it is equally improbable, that, if they had been ſo, and been poſſeſſed of property and arms, and been formed into corporate bodies, they ſhould have become the ſlaves or dependants of a few owners of land in their neighbourhood. But, if the ancient towns were nothing elſe than fortified *pagi*, to which the great proprietors around them reſorted *; and, if the reſt of the inhabitants conſiſted either of clients, or dependants of theſe proprietors, ſubſiſting by cultivating little portions of land, and fighting under their banners, or of perſons of ſervile condition, who had obtained, or who ſought for ſome degree of liberty, and earned their living by exerciſing crafts, or aſſiſting the burgeſſes in their duties; the whole hiſtory of towns becomes perfectly natural, and the origin of that ſituation which led to incorporations is explained.

BEFORE incorporations were erected, there muſt have been ſocieties, reſulting from voluntary confederations, which found it deſirable to obtain the ſanction of law to their union. But it is in times of trouble and oppreſſion that people have recourſe to private aſſociations, and to the patronage of individuals, for that ſupport and protection which government is unable to afford them; and government, ſenſible of its debility, willingly gives its countenance to any meaſures that have the appearance

* LONG before charters of incorporation, WILLIAM the Conqueror conſidered them in this light: "Nullum mercatum vel forum ſit, nec fieri permittatur, niſi in civitati-"bus, et in burgis et muro vallatis, et in caſtellis, et in locis tutiſſimis, ubi conſue-"tudines regni noſtri — deperiri non poſſunt, nec defraudari nec violari. — Et ideo "caſtella, et burgi, et civitates ſitæ ſunt, et fundatæ, et ædificatæ, *ſciz.* ad tuitionem "gentium et populorum regni, et ad defenſionem regni, et idcirco obſervari debent, "cum omni libertate et integritate et ratione." *L. L.* GUL. I. *c.* 61. Saxon hiſtory juſtifies the aſſertion; and the laws of ATHELSTAN, c. 12. and 13. furniſh the regulation. The *burghbotam*, or expence of repairing the fortifications of towns, affected accordingly every land-eſtate in the kingdom.

of promoting a degree of public order, or affording ſhelter againſt private wrongs. We find accordingly, in the Saxon times, voluntary aſſociations entered into by men of different ranks, with a view to afford ſecurity to each other, and government approving of the regulations to which they had ſubjected themſelves *. National induſtry, however, was not then ſo far advanced as to permit us to ſuppoſe, that mere artiſans were of ſufficient conſequence to eſtabliſh ſuch ſocieties. The only embryo that can be diſcovered of a fraternity for a commercial purpoſe, is the gilda, which belonged to certain towns, and appears to have been an inſtitution ſomewhat reſembling the German muntzer †, and poſſibly, like thoſe fraternities, to have had ſome charge of the coinage, and of receiving the king's revenue in good money ‡.

In all probability, however, this inſtitution ſuggeſted to the reſt of the inhabitants the idea of forming ſimilar aſſociations. We know, that, in Germany, the ſimple burgeſſes aſſociated in this way, and, becoming wealthy and conſiderable, obtained a ſhare of the privileges of the muntzer; and the bordarii and cottagers, who originally inhabited only the ſuburbs of towns, (*extra murum*),

* In Canterbury, "Burgenſes habeb. de rege 33 acras prati in gildam ſuam."

† The mint of a diſtrict was, no doubt, originally under the care of the magiſtrate. The following grant of the year 955 ſhows that this was the caſe, and that towns in Germany were very ſimilar to what they were in England at the time of the ſurvey: "Concedentes, &c. omnem burgum, et univerſa quæ ibidem ad dominationem et pote-"ſtatem comitis pridem pertinuiſſe viſa ſunt, forum ſcilizet, teloneum, *monetam*, et "omnem diſtrictum, cum terra et manſionibus ipſius burgi." Bouquet, *tit.* 9. *p.* 618.

‡ The burgh of Huntedun, which was ranked as the fourth part of a hundred, "pro 50 hidis defendeb. ſe ad geld. reg. *Sed modo non geldab. in illo hund.* poſtquam "Rex Ws. gildum monete poſuit in burgo." The monetarii appear to have paid double the heriot, or relief, and ſometimes quadruple the cuſtom of the ſimple burgeſſes. It was probably the lucrative nature of the buſineſs that made it an object for the city nobleſſe in Germany to take charge of it. The monetarii in England had "ſaccam et "ſocham ſuam." L. L. Athelstani, c. 14. provide, That every burgh was to have at leaſt one; and when exemptions from the county juriſdictions were beſtowed on incorporations, there is very commonly a reſervation as to the monetarii: "Exceptis mo-"netariis et miniſtris noſtris." *Charter of* John *to London.* In Scotland, at this day, the guild brethren, as they are called, are diſtinguiſhed as ſuperior to the handycraftſmen, or trades.

rum), and came there to be called *cives opifices*, or *artifans*, ſoon 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 diſtinguiſhed by induſtry and wealth; for the muntzer found it neceſſary to have recourſe to commerce, and to join the free burgeſſes in trading adventures, if they did not chuſe to be eclipſed, in point of fortune, by their inferiors.

THERE is every reaſon to conclude, that ſimilar events in Spain, France, Britain, and other countries, were produced from ſimilar cauſes. The turbulence of the middle ages every where enabled the more wealthy, or the more fortunate, to reduce their neighbours under different degrees of ſubjection. Towns afforded an opportunity to the better ſort to form, for mutual ſecurity, leagues or ſocieties, which counteracted the progreſs of this calamity. Princes countenanced theſe aſſociations, and ſuch as were formed by the inferior inhabitants in imitation of them; and theſe bodies again, either by purchaſe, by force, or by growing cuſtoms, eſtabliſhed municipal governments, that maintained exemptions from the ancient ſyſtem of ſubordination, which was naturally deteſted by the induſtrious as burdenſome, tumultuary, and unſuitable to their habits. The towns accordingly ceaſed to reſort to the diets. Their warlike gentry, the companions of the ſovereign, either left them, or mingled in thoſe ſocieties of commerce or manufacture which governed them. Becoming, therefore, aſſemblages of manufacturers, rather than national bulwarks, they neceſſarily appeared degraded in the eyes of an age which was the ſource of chivalry and the offspring of the feus.

BUT that ſecurity which municipal governments afforded, ſoon 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

of delegates with their ſovereigns, and with each other; and, from little detached dependent plebeian republics, came to form a body which reſorted to the diets, as a third and an ignoble eſtate, formerly unknown in the European conſtitutions.

THESE obſervations, it is hoped, are ſufficient to juſtify the poſition, That the ſame ſimple arrangements of government pervaded the whole of a German nation, at its eſtabliſhment in a Roman province; and that it was only in conſequence of a revolution, the ſteps of which may, in general, be diſtinguiſhed, that we are entitled to ſuppoſe that the idea of aſſembling a nation by its repreſentatives was ſuggeſted or realized *.

* IT is ſcarce neceſſary to remark, that the claims of one or two Engliſh boroughs for the privilege of electing members of parliament, on the ground that they had reſorted to the Saxon diets, is rather explained by, than repugnant to the above hypotheſis. The evidence that was offered of the grounds of claim has not been preſerved; and the age in which it was offered is diſtinguiſhed by having been impoſed upon by the groſſeſt forgeries. The tradition, however, of anciently reſorting to the diets in the manner I have ſtated, may naturally, both have ſuggeſted the claim, and rendered it ſucceſsful.

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 ſound 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 materials 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 affectionate 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 completely 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 comprehends 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 præliis, diſcors ſeditionibus, ipſa etiam "pace ſævum *." 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 between 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 attention 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.

In

* 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 quis 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 peruſal of his works requires more than an ordinary exerciſe of attention. They are fitted to inſtruct rather than to amuſe. Their choiceſt beauties lie hid from vulgar obſervation; and the longer they are contemplated, even by the diſcerning, the higher is the pleaſure they afford. If ever any hiſtorian underſtood the ſprings of human action thoroughly, it was TACITUS. His penetrating eye never reſted upon the ſurface of objects, but ſearched their inmoſt receſs. His mind ſeems to have been formed for catching thoſe peculiarities in character, which, though not eaſily diſcerned, have no ſmall effect upon the conduct of men. Of this we have an inſtance in the caſe of CÆSONIUS PÆTUS, who had been improperly appointed by NERO for the defence of ARMENIA, and who rejected the advice of his experienced counſellors. "Verum ubi a viris militaribus adverſus urgentes caſus firmatus "erat, rurſus ne alienæ ſententiæ indigens videretur, in diverſa ac deteriora tranſibat*." An ordinary writer would have either told the fact ſimply, or have miſtaken its cauſe; but it became the ſubtilty of TACITUS to expoſe the falſe pride which made PÆTUS reject the counſel which he needed, and add obſtinacy to ignorance.

THE obſervations of TACITUS ſometimes illuſtrate not only the characters of the perſons to whom they are applied, but the nature of the times in which they lived. He is, indeed, as ſparing of his expreſſion as he is profuſe of his matter. This appears upon many occaſions; and particularly in the account given why POPPÆUS SABINUS had been raiſed from a very ordinary ſtation to offices of truſt and diſtinction. "Fine "anni POPPÆUS SABINUS conceſſit vita, modicus originis, "principum amicitia conſulatum ac triumphale decus adeptus: "Maximiſque provinciis per quatuor et viginti annos impoſitus; nullam ob eximiam artem, ſed quod par negotiis, neque "ſupra erat†." The elevation of this SABINUS (it ſhould ſeem)

* Ann. lib. 15. cap. 10. † Ibid. lib. 6. cap. 39.

ſeem) was owing, not to the preciſe extent of his abilities alone, but to the ſentiments which his jealous ſuperiors entertained of them. From the meaſure of talents which he poſſeſſed, they perceived, that the buſineſs of the public would not be neglected; and, from the mediocrity of thoſe talents, that its tranquillity would not be diſturbed.

OUR author's obſervation upon the fall of SALLUSTIUS CRISPUS is alſo worthy of himſelf. When this perſon was advanced in life, he loſt 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 ſituation is often aſcribed to the caprice of their patrons alone; but our author, with much ingenuity, and perhaps equal juſtice, aſcribes this to a capricious levity both in the patrons and in the objects of their beneficence. "Ætate provecta ſpeciem magis "in amicitia principis quam vim retinuit. Idque MÆCENATI "acciderat, fato potentiæ raro ſempiternæ: An ſatias capit, aut "illos cum omnia tribuerunt; aut hos, cum jam nihil reliquum "eſt quod cupiant *."

BUT almoſt the whole account of the reign of TIBERIUS contains the expoſition of a character not more odious than it was ſingular. An ordinary writer might have marked ſome of its general features, but ſuch a writer as TACITUS alone could unfold its intricacies. In almoſt every action, and every ſpeech, the tyrant had ſomething to conceal. Under the veil of moderation, he was ever anxious to undermine the liberties of his people. Flattery, however artfully adminiſtered, was, from the ſuſpiciouſneſs of his nature, apt to give him offence; and, though he was provoked with the ſervility of his ſubjects, yet he would not permit them to be free. This ſtruggle between contending humours, together with its effects upon thoſe around him, is beautifully inſinuated in the following words. "Acer-"beque increpuit eos, qui divinas occupationes, ipſumque do-

* Ann. lib. 3. cap. 30.

" minum dixerant. Unde anguſta et lubrica oratio ſub 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 leſs art is diſplayed than in unfolding that of the emperor himſelf. Along with many bad qualities, this SEJANUS had poſſeſſed the moſt wonderful addreſs. While the other ſubjects of TIBERIUS dreaded the violence and the caprice of his humours, he had art enough to render both the inſtruments of his elevation. He could make even the tyrant conceal his luſts, through a fear, or an attachment, of which he was the object. " Obtectis libidi-
" nibus, dum SEJANUM dilexit, timuitve †." By an unfortunate chaſm in the writings of TACITUS, the hiſtory of the fall, and the full expoſition of the character of SEJANUS are now loſt. His daring ambition, and almoſt unfathomable ſubtilty, preſent a ſubject that ſuits the hand of an able artiſt; and ſome of the great outlines ſtill remaining ſhew clearly the value of the picture when complete.

BUT, although TACITUS draws his characters in ſtrong colours, yet there is nothing in them bordering upon extravagance. The ſingularity of their conduct juſtifies that of the view held forth. Though many foul paſſions deformed the character of TIBERIUS; yet our author is candid enough to point out in it the ſmalleſt ſymptom of virtue. He repeatedly frees him from the imputation of avarice. He even ſeems happy in extolling the merit of his reply to ADGANDESTRIUS, who offered to deſtroy ARMINIUS, if the ſenate would ſend him poiſon for the purpoſe. " Reſponſum eſſe, non fraude neque occultis, ſed pa-
" lam et armatum populum Romanum hoſtes ſuos ulciſci.
" Qua gloria æquabat ſe TIBERIUS priſcis imperatoribus, qui
" venenum in PYRRHUM regem vetuerant, prodiderantque ‡."

As the character of TIBERIUS is not held forth as completely abandoned, ſo neither is that of GERMANICUS held forth as completely

* Ann. lib. 2. cap. 87. † Ibid. lib. 6. cap. 51. ‡ Ibid. lib. 2. cap. 88.

completely virtuous. TACITUS ſhows that partiality to virtue which becomes its friend; but his judgment was too ſtrong to be miſled, even by a venial bias. In ſpite of the amiableneſs of GERMANICUS, in almoſt every ſituation, he diſcovers, upon one occaſion, the frailties of a man. At the interview between him and PISO, they met "Firmato vultu, PISO adverſus me-"tum, GERMANICUS ne minari crederetur. Poſtremo paucis "familiarium adhibitis ſermo cœptus a CÆSARE, qualem ira "et diſſimulatio gignit *."

THOUGH the obſervations of TACITUS be profound, yet he rarely ſhows any anxiety, or employs any artifice to ſet them off to advantage. The current of his narration runs often ſo ſmooth, that the treaſures with which it is impregnated are apt to eſcape unnoticed. He wrote for thoſe only who had acuteneſs to catch his hints, and ability to apply them as they deſerve. A profound obſervation often preſents itſelf unexpectedly; and the reader's admiration is beſtowed the more willingly, becauſe the hiſtorian's ſenſe of dignity made him averſe from courting it. The cauſe of RUFUS's ſeverity is beautifully painted at the end of the following ſentence, by the uſe of four words. "Quippe RUFUS diu manipularis, dein centurio, mox "caſtris præfectus, antiquam duramque militiam revocabat, "vetus operis ac laboris, et eo immitior quia toleraverat †."

THE deſperate ſituation of the old emperor GALBA, who was employed in offering a ſacrifice, even after the ſchemes of OTHO his ſucceſſor had begun to take effect, is alſo delicately expreſſed in a few ſimple words. "Ignarus interim GALBA et "ſacris intentus, fatigabat alieni jam imperii deos ‡."

WITH much judgment, alſo, and, at the ſame time, with great ſimplicity of expreſſion, he aſſigns the reaſon why ANICETUS, who had been employed by NERO, firſt to attempt drowning his mother, and afterwards to ſlay her, incurred the emperor's diſpleaſure. "Levi poſt admiſſum ſcelus gratiâ, dein

* Ann. lib. 2. cap. 57. † Ibid. lib. 1. cap. 20. ‡ Hiſt. 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 balances 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

* Ann. lib. 14. cap. 62.

FROM all the obſervations made, and all the paſſages quoted, we may infer, that TACITUS was eminently endowed with that judgment, which, beſides giving the feeling and the fancy of the hiſtorian their due value, is itſelf the foundation of many capital qualities. This enabled him, we find, 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 ſecured the fairneſs of his deciſions, in ſpite of thoſe perſonal connections with which moſt men are blinded. It made him ſagacious in his opinions as to paſt things that are doubtful, and as to future things that are contingent. While it enabled him to ſee objects as they were, and inſured his reader againſt the impertinence of obſervations that are either trifling or miſplaced, it alſo repreſſed the weak vanity, which leſſens the merit that it means to exaggerate.

As the power of judgment comes late to maturity, both in the individual and in the ſtate, ſo hiſtory, in its moſt improved form, is never one of the earlieſt efforts of national genius. The perfection of the poet's art depends chiefly upon the acuteneſs of his feeling and the vivacity of his fancy. In the improvement of theſe powers, little or nothing is left to the poſſeſſor's induſtry, while judgment is fortified by the recollection of paſt errors, and ſtrengthens ſlowly by repeated trials. As the improvement of national wiſdom, too, is the fruit of national experience; ſo hiſtory cannot flouriſh but where intereſting facts preſent themſelves, and where their value is diſtinctly ſeen. Though thoſe powers which ſerve to embelliſh truth muſt not be extinguiſhed in the hiſtorian, yet judgment muſt preſcribe the laws by which they are to be controlled. Between the emotions of mind, and the reſpective impulſe that is the cauſe of each, a ſteady proportion is thus preſerved. As too much brilliancy in any object prevents it from being diſtinctly ſeen; ſo the brightneſs of the reader's fancy muſt illuminate

minate the ſubject of narration, without dazzling the reader's eye.

THE poſition now advanced, as to the period in ſociety at which hiſtorical narration appears in its moſt improved form, will be found to be juſtified by facts. In every literary æra, the poet has been the firſt to offer the fruits of his genius, and to court the diſpoſers of that approbation which is the reward of his excellence. Before even the remoteſt period to which any human record reaches, HOMER had diſplayed the wonderful powers of the Greek language; and, by his own practice, had fixed thoſe principles upon which future artiſts 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 proſe compoſition appeared. Upon the revival of letters, when thoſe arts were cheriſhed at Florence, which the Turks had baniſhed from Greece, the hiſtory of literature preſents the ſame appearances. The Genius of Italy, after ſlumbering for ages, was firſt awakened by DANTE and PETRARCH. In France, a taſte for the beauties of proſe was uſhered in by the poems of MALHERBE. In Britain, too, that elegance which has diſtinguiſhed the compoſitions of ſome of our countrymen, was firſt diſcernible in the works of our poets. The aſſertion, then, as to the period of hiſtorical genius, ſeems juſtified by facts. In every region in which literature has as yet flouriſhed, capital productions in hiſtory have announced the maturity, though they could not ſecure the continuance of claſſical taſte. Like a bird of paſſage, impatient of the rigours of every climate, this is ever ready to change its abode.

THOSE paſſages, produced now and formerly from TACITUS, though fraught with beauties of the firſt order, enable us to form but an imperfect judgment of his merits. We are, indeed, fairly entitled to infer, that the genius which gave exiſtence

iſtence to thoſe beauties is no ordinary one; but, before we decide 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 pardonable, as it ſprings from intention, and not from careleſſneſs. From wiſhing to ſhun that ſervile vanity, by which moſt writers court the admiration of their readers with exceſſive eagerneſs, TACITUS has fallen into a contrary extreme.

In vitium ducit culpæ fuga ſi caret arte.*

He ſometimes throws out his deepeſt reflections with an indifference that is ſuſpicious, ſo that the abſence of parade is not always an indication of his modeſty. The abruptneſs of his manner borders upon a ſtudied ſententiouſneſs; and, from being too conſcious 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 conſtruction, he may have copied SALLUST; but few hiſtorians are more nearly oppoſite in their manner. In the ſtyle of SALLUST, there is a ſtudied elegance, at which his ſuppoſed imitator

* HOR. de Arte Poet. v. 31.

tator never aimed; and, in the ſentiment of TACITUS, there is a depth which SALLUST could never rival.

TACITUS is accuſed of being vain of his erudition, and of ſeizing even the ſlighteſt opportunities of diſplaying it. He is ſaid to be at too much pains to give the origin of cuſtoms, both foreign and domeſtic, and to make too frequent references to the more remote events in the hiſtory of his country. This accuſation I hold to be groundleſs. A philoſophic mind, like that of TACITUS, muſt have ſeen a value in certain facts that eſcapes common obſervers. His benevolence, too, may have urged him to ſtimulate the remaining virtue of his contemporaries, by recalling to their remembrance the merits of their anceſtors. As the empire declined, he perceived, that the materials of hiſtory were the more likely to periſh; and, happily for ſociety, he poſſeſſed both that preciſion, by which the antiquary eſtabliſhes ſingle facts, and that power of arrangement, by which the hiſtorian ſtates a number in that order which is to form his detail.

THE energy of the ſtyle of TACITUS has been condemned as romantic. This may appear to be the caſe to thoſe who never felt that enthuſiaſm which warmed his breaſt. The glowing language of an elevated mind tallies ill with the cold propriety of vulgar criticiſm. The learned Biſhop of Worceſter, in his notes upon HORACE's art of poetry, tells us, that figurative expreſſion became the dignity of the hiſtoric character and genius of TACITUS; but that, had his contemporary SUETONIUS uſed the ſame language, he would have ſet his readers a-laughing *.

OUR hiſtorian's deſcriptions have been charged with inconſiſtency; but this is owing to the inconſiſtency of thoſe characters that are their ſubjects. A more ſuperficial obſerver would have preſented a picture leſs juſt, though more uniform in its parts; yet the merit of an hiſtorian is to be tried by the conſonancy of his relation with what exiſted, not with what may

* Vol. I. p. 75.

may be ſuppoſed. The ſingular duplicity of many of the characters in TACITUS furniſhes a full vindication of him in the reſpect mentioned. His ſagacity had eſcaped his critics, who, by charging him with the want of penetration, have unluckily diſcovered their own.

BUT the moſt partial admirers of TACITUS cannot deny, that his writings are ſometimes deformed with pieces of conceit and affectation. A certain quaintneſs and minute elegance in ſome parts of his works ſtands oppoſed to the manly beauties of others. Though this affectation in our author be real and highly culpable, yet it is ſometimes complained of when it does not exiſt. He is accuſed of exceſſive refinement in his views, and of aſſigning motives for conduct, of which even the agents were unconſcious. But it may be eaſier for a weak mind to deceive itſelf than an obſerver of ſuch deep penetration. In nice caſes, he generally ſuggeſts a variety of motives, and leaves it to his reader to ſelect the moſt probable. Where judgment alone is concerned, no writer, perhaps, was ever leſs apt to err. As ſoon as the diſcernment of his critics fails, their candour fails along with it; and they chuſe rather to attribute the obſcurity of the author to his weakneſs, than to their own want of penetration. The mind of the emperor CLAUDIUS, for example, feeble as it was, made a ſubject of obſervation that was fortunate both for the hiſtorian and his reader. A great anatomiſt only can mark minute deviations in nature from her ordinary proceſs; and, by ſtating ſlight deficiencies or exceſſes in certain parts, can explain irregularities that are glaring in the ſyſtem.

WHEN the judgment of TACITUS operates in the way of controlling his feeling and imagination, certain failures may be detected, which are not viſible when that power operates by itſelf. That vigour in each, which is the general cauſe of his excellence, renders the balance more delicate, and becomes, at times,

the neceſſary cauſe 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 redneſs of DOMITIAN's face was uſeful to him in ſuppreſſing the ſigns of ſhame. "Sævus "ille vultus et rubor, a quo ſe contra pudorem muniebat *." The character of DOMITIAN was ſo completely abandoned, that we muſt ſuppoſe him deſtitute of every ſentiment like modeſty; and, at any rate, it is abſurd to talk of a perſon thus ſtifling the ſigns of emotions of which he was actually conſcious.

OUR author alſo ſpeaks of the Germans as ſeparated from the Dacians, "Mutuo metu *aut* montibus †." When two ſubjects ſo completely different as fear and mountains, are ſtated as operating in the production of one common effect, we are apt to imagine, that the hiſtorian had forgot his dignity, and aimed at a ſpecies of wit.

THE ſame unmeaning quaintneſs appears when TACITUS tells us of the confirmed jealouſy that ſubſiſted between the Lugdunenſes and Viennenſes. "Unde æmulatio, et invidia, "et uno amne diſcretis connexum odium ‡." That the vicinity ſhould inſure the diſagreement of theſe two nations is highly probable; but, in order to announce this ſentiment, there was no need to go in queſt of the pointed antitheſis involved in the two terms *diſcretis* and *connexum*.

THE fact is, that the writings of PLINY, QUINCTILIAN, and the other contemporaries of TACITUS, do all carry the ſymptoms of declining taſte. That period had arrived, at which, as the ingenious critic || before quoted obſerves, the writer muſt find means to ſtrike and to ſurpriſe. Antitheſis, remote alluſions, and the double ſenſe of words, are the tools by which he does ſo. In theſe artifices, ſuited to pleaſe the falſe taſte of his countrymen,

* Vit. AGRIC. cap. 45.

† De Mor. Germ. cap. 1.

‡ Hiſt. lib. 1. cap. 65.

|| Biſhop of Worceſter.

countrymen, TACITUS was often eminently ſucceſsful. Thus, in telling us, that AGRIPPINA was able to give the empire to her ſon CLAUDIUS, but was unable to ſubmit to his ſovereignty, he makes one word denote both the power and the abſence of it. " Truci contra ac minaci AGRIPPINA, quæ filio dare im- " perium, tolerare imperitantem nequibat *." The verb *nequibat* is equally connected with the two infinitives *dare* and *tolerare*; but it muſt be decompounded, before it is applied to the firſt of them, ſo as to bring forth the hiſtorian's meaning.

FROM the charge of affectation and conceit, in certain inſtances, then, our author cannot be freed. It is the prerogative of criticiſm to cenſure without fear, to deſpiſe the authority of names, and to decide upon principle. TACITUS, perhaps, expected, that the luſtre of his uncommon accompliſhments would deſtroy the ridicule that is aimed at common defects; that even the luxuriant play of his genius would extort that reſpect which is due to its moſt correct productions.

MANY of the impurities that occur in the ſtyle of TACITUS are to be imputed to the times in which he lived, and not to any careleſſneſs, or to any ignorance of his. The contemporaries of CICERO himſelf ſometimes attacked that orator's ſtyle. From jealouſy of his reputation, perhaps, they were diſpoſed to reject even terms, " græco fonte cadentia et parce detorta." In judging of the legitimacy of expreſſion in a dead language, the moſt ignorant are often the moſt preſumptuous. The influence of analogy is held to be more extenſive than it is; and a high degree of uniformity is ſuppoſed to exiſt in a ſubject of all others the moſt eccentric. TACITUS, then, may have had authorities for thoſe expreſſions which we hold to be the moſt irregular. From the boldneſs and originality of his views, at the ſame time, we may ſuppoſe, that he would be apt to bend the language of his country to his own conceptions, and to ſpurn at the fetters of ſtrict grammatical authority.

* Ann. lib. 12. cap. 64.

TACITUS, doubtleſs, ſeems attached to expreſſions more commonly to be met with in writers of poetry than of proſe. Expreſſions more ſimple, at the ſame time, might have produced an equal, if not a ſuperior effect. By means of thoſe Greciſms, in which he abounds, he ſeldom preſents an idea with more energy than CÆSAR and LIVY could have done without them. Though high poetical authority often ſcreens his ſtyle from the imputation of being impure, yet its general character becomes artificial and too much his own. When the barrenneſs of language, beſides, does not call for innovations, the writer is blamable who makes them.

UPON examining the ſtyle of TACITUS, we ſhall find, that he employs ſome terms that are either peculiar to himſelf, or ſupported by authority not ſtrictly claſſical. The term *diffugium* *, though expreſſive of the idea it preſents, is ſupported by no other authority. By being compounded, it heightens the original notion of a rapid departure from an object ſuppoſed dangerous. The term *ſuſtentaculum* † is alſo ſingular. It clearly ſuggeſts the idea of a neceſſary ſupport. As a derivative from *ſuſtento*, the frequentative from *ſuſtineo*, it denotes the conſtant preſſure of one body upon another immediately under it. *Auctito*, alſo, is a verb that is to be found in no other claſſic, though, at the ſame time, it is highly expreſſive of the conception which the hiſtorian means to preſent by it. "Qui pecunias fœnore "*auctitabant* ‡." As a double frequentative from *augeo*, it expreſſes ſtrongly the eagerneſs of uſurers to enrich themſelves. The verb *reſtaurare*, though not peculiar to TACITUS, reſts upon authority that is not to be truſted. JUSTIN and ULPIAN uſe it; but the purer writers employ *inſtaurare* in its ſtead.

WE may, beſides, diſcover in TACITUS ſingular uſes of terms that are to be ſeen in the works of the beſt claſſics. He takes the adjective *avarus*, and the abſtract noun *avaritia*, in a ſenſe very different

* Hiſt. 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 praiſe in AGRICOLA as a judge. " Ubi officio ſatisfactum, nulla ultra poteſtatis perſona. Tri- " ſtitiam et arrogantiam et *avaritiam* exuerat *." CICERO's definition of the vice fixes the preciſe force of the term. " Ava- " ritia (ſays he) eſt injurioſa appetitio alienorum." But no affection that is injurious can be meritorious in any perſon, far leſs in a judge; and the moſt rigid aſſertor of public rights cannot, in juſtice, invade thoſe of individuals. Both the character and the object, then, of this *appetitio*, employed by CICERO in the definition of *avaritia*, are reverſed by TACITUS. That deſire which he applauds muſt have been more than innocent; and its objects muſt have been the property of that community in behalf of which AGRICOLA acted as a judge.

THE uſe made by our author of the adjective *avarus* correſponds entirely with the uſe now ſtated of the abſtract noun *avaritia*. He tells us of GALBA, that he was, " Pecuniæ ali- " enæ non appetens, ſuæ parcus, publicæ *avarus* †." The term *avarus*, in this acceptation, expreſſes all that inſatiable thirſt for poſſeſſion, in behalf of the public, which the avaritious have for themſelves. It denotes an inflexible keenneſs in GALBA to ſupport every claim of the ſtate he governed, in ſpite of thoſe temptations to which the virtue of other emperors had yielded.

THE word *gnarus*, which is properly applicable to the perſon 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 ſays, " Nihil tam *ignarum* barbaris " quam machinamenta et aſtus oppugnationum; at nobis ea " pars militiæ maxime *gnara* eſt." SALLUST had applied the term *ignarus* to the thing unknown, as well as to the perſon ignorant; as, when he ſays, " Mare magnum et *ignara* lingua " commercia

* De vita AGRIC. cap. 9.

† Hiſt. 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 compounded, 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 inveſting a fortified place ; but, inſtead of this act, there is here ſubſtituted the manner in which a perſon is delivered up as a ſecurity, 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 announced, is comprehended by that in which the fact affirmed takes place. Thus, " Mutantur ſæpe hominum mores, *alias* " adverſis rebus, *alias* ætate ingraveſcente ‖." The future exiſtence 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 appear 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 applying 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 interrogation 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 ſilent.

* PLINY, lib. 24. cap. 14.
† JUSTIN, lib. 4. cap. 1. 8.
‡ Ann. lib. 3. cap. 73.
‖ EUN. lib. 4. cap. 5. 7.

ſilent. Thus, " *An* neſcis longas regibus eſſe manus *?" CICERO, too, employs *An* in the ſame way, when he perſonifies his country, and makes it reaſon with him as to the propriety of perſecuting CATILINE; " Quid tandem impedit te? *An* in- " vidiam times?"

AN ſometimes does not operate as an interrogative particle at all, but only expreſſes doubt, or ignorance, upon the part of the ſpeaker. Thus SALLUST ſays of SYLLA, " Multique du- " bitavere fortior *an* felicior eſſet †." So alſo, " Haud ſcio *an* " nemini magis quam tibi faciendum ‡"

UPON the beſt authority, then, (it ſhould ſeem) *An* deviates from its original power, which is purely interrogative. It, in the firſt place, ſtates a queſtion to which no anſwer is expected; and, in the next, it preſents the mind of the ſpeaker as unable to ſatisfy itſelf, but, at the ſame time, as requiring no information from others.

TACITUS uſes *An*, in the ſenſe laſt mentioned, in a way that is peculiar to himſelf. In uſing it, he profeſſes his ignorance as to the manner in which certain facts took place, but he ſuppreſſes the term that announces the uncertainty. Thus, " AR- " CHELAUS finem vitæ ſponte *an* fato implevit ‖." He records the fact, that this king did die; and the particle *An*, beſides ſuggeſting two ways, in one of which he might have died, is, without the aid of an *incertum eſt*, a *dubito*, or *haud ſcio*, made to intimate alſo his ignorance, whether he periſhed by a voluntary or by a natural death. There is clearly heſitation upon the part of the hiſtorian, otherwiſe he would have been abſurdly reducing all the modes of death to two, and uſing *An* as equivalent to *Vel*. In the ſame way, he talks of the ſeeming moderation of GERMANICUS after the defeat of the Germans, " De ſe " nihil addidit, metu invidiæ, *an* ratus conſcientiam facti ſatis " eſſe §."

SOME

* 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 ‖."

* 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 ſuggeſting ignorance in the ſpeaker in reſpect to the ſuitableneſs of an affirmation, applicable to one of two or more alternatives, to the excluſion of the reſt. But *An* ſuppoſes, that ſomething, though not enough, is known with regard to each of the whole. Thus, they who doubted whether SYLLA owed moſt to his valour or his good fortune, poſſeſſed facts that tended to eſtabliſh both opinions, though neither preponderated. The mind is thus exhibited as balancing circumſtances, and terminating in doubt from the ſcantineſs of that information which *An*, as an interrogative, ſerves originally to furniſh. *Sive*, again, ſuppoſes complete ignorance as to all the alternatives ſtated, ſo as to preclude that doubt, of which the act of balancing probabilities is the ſign. In the caſe of *An*, (we have found), ſomething is known with reſpect to all of them; in the caſe of *Sive*, nothing is known in reſpect to any one; and the whole ſubject is held forth as either, in its nature, inſcrutable, or as induſtriouſly and effectually concealed. Thus TIBULLUS ſays;

Vivite felices, memores et vivite noſtri
Sive *erimus*, ſeu *nos fata fuiſſe velint* *.

TERENCE alſo ſays;

—— *Hæc* ANDRIA
Sive *iſta uxor*, ſeu *amica eſt*, *gravida e* PAMPHILO *eſt* †.

In the firſt of theſe inſtances (it is clear) that heaven only could know which of the alternatives was to take place; and, of courſe, the matter was inſcrutable. In the ſecond, DAVUS virtually acknowledges, that he was not ſo much in the young man's confidence as to know whether he was married or not; and, of courſe, that matter, though perhaps known to others, was effectually concealed from him.

IF the account given of *An* and *Sive* be juſt, TACITUS is ſingular, either in taking them as ſynonymous particles, or in employing

* Lib. 3. el. 5. 31. † AND. act. 1. ſc. 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

* Hiſt. lib. 1. cap. 39. † Ibid. lib. 2. cap. 95.

the ſhortneſs of the former. Such uſes of *And* in Engliſh, and Και in Greek, are frequent; but an inſtance preciſely ſimilar to that mentioned will hardly be found in Latin.

THE uſe which TACITUS makes of the prepoſition *Penes* is not to be juſtified by any good authority. He tells us, that TIBERIUS was offended becauſe the practice of marrying by the *Confarreatio* had fallen into diſuſe. "Pluresque ejus rei "cauſas adferebat; potiſſimam *penes* incuriam virorum femi-"narumque *."

THE prepoſition *Penes* denotes the relation which an object bears to a perſon, as being in his power and under his direction †. Thus,

Me penes *eſt unum vaſti cuſtodia mundi* ‡.

A CERTAIN vicinity is ſuppoſed to exiſt between the maſter and that which is ſubject to his dominion. Within a limited ſphere, accordingly, he is underſtood to have the merit of what is laudable, and the demerit of what is the contrary. So, "*Pe*-"*nes* aliquem laudem eſſe ‖;" and, "Illorum eſſe hanc culpam "credidi quæ te eſt *penes* §." The term *illorum*, in the laſt inſtance, 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 whoſe door it actually lay, as being in a ſphere within which that perſon had an excluſive right to exerciſe authority.

IN the expreſſion, "potiſſimam *penes* incuriam virorum fe-"minarumque," the prepoſition is evidently employed, as in the paſſage quoted from TERENCE, to ſtate the relation between

* ANN. lib. 4. cap. 16.

† I MIGHT here ſtate the preciſe meaning of *Penes* at greater length, by ſhewing the difference between it and *Apud*, with which it is ſometimes confounded; but I reſerve an analyſis of the Latin prepoſitions as the ſubject of future conſideration.

‡ OVID, Faſt. 1. 119. ‖ CIC. de Cl. Or. 142.

§ TER. HEC. act. 4. ſc. 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 denoting 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, perhaps, 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, alſo, often imitates SALLUST, in adopting uſes of terms, and modes of conſtruction, that are properly Greek. Thus, " Memoriæ Druſi eadem quæ in Germanicum decernuntur, pleriſque additis ut ferme *amat* poſterior adulatio *." As the Greek verb φιλεω often denotes ordinary and natural occurrence in certain caſes, ſo does the Latin verb *amo* here.

—— Φιλεει δε τε κερτομα βαζειν †.

—— *Amatque convicia loqui.*

So alſo, " Οπερ εν τοις τοιουτοις φιλει." The attachment to a ſpecified action, ſuggeſted by the two verbs in the different languages, is made to denote its frequency even among inanimate objects. TACITUS alſo ſuppreſſes the governing prepoſition, after the manner of the Greeks. Thus, as they ſaid, " Ρωμαιος πατριδα," for " Ρωμαιος κατα την πατριδα;" ſo he frequently adopts ſuch poetical expreſſions as, " Clari genus ‡," " Animum vultumque " converſi ‖."

FROM the view now taken of the ſtyle of TACITUS, it ſhould ſeem, that it will not bear a compariſon with that of the writers during the reign of AUGUSTUS. The age of high claſſical purity was, in his days, paſt; and, of courſe, the grammatical ſtandard eſtabliſhed by practice had altered. As the firſt wiſh of our author muſt have been to pleaſe his contemporaries, ſo he would naturally adopt thoſe modes of expreſſion that were moſt agreeable to them; and we cannot ſuppoſe him able, though he had been diſpoſed, to reſiſt that progreſs towards corruption which had already commenced. The impurities of his ſtyle, at the ſame time, can never cancel the dignity of his ſentiment. In the one, we ſee the Roman language, in ſome degree, corrupted; but, in the other, we ſee human reaſon proportionably improved.

THE

* Ann. lib. 4. cap. 9.
† HESIOD. Ep. 5. 788.
‡ Ann. lib. 6. cap. 9.
‖ Hiſt. lib. 1. cap. 85.

THE character of TACITUS as an hiſtorian, though, upon the whole, deſervedly high; yet cannot, in every reſpect, eſcape our cenſure. He poſſeſſed powers perfectly adequate to the taſk of ſpeculating upon the affairs of men, as becomes a philoſopher. His ſenſibility catched thoſe delicate ſhades in the human character, of which ordinary obſervers loſe ſight amidſt its great outlines. His fancy ſuggeſted the preciſe emotions moſt likely to ariſe in a trying ſituation; led him to adopt that language by which ſuch emotions ſeek vent; and to ſeize the circumſtances, in every object deſcribed, which ſtrike the obſerver firſt, and bring the reſt along with them. His judgment diſcriminated the genuine from the ſpurious, however artfully embelliſhed; and, in the action even of complicated cauſes, could aſſign the exact influence of each in the production of their common effects. But the ardour of his feeling, and the quickneſs of his fancy, ſometimes betrayed him into errors. Strong as his judgment was, it did not always watch and controul their exceſſes. The elegance of his ſtyle and ſentiments, accordingly, degenerates, at times, into affectation, and their animation into extravagance. From the general vigour of his powers, he has thrown beauties into many paſſages which few writers, in any age, have rivaled, and which none have ſurpaſſed; but, from an undue balance, occaſionally exiſting among theſe powers, certain paſſages are overwrought, and deformed by thoſe attentions that were meant to improve them.

SHAKESPEARE and TACITUS are, perhaps, the two writers who leave upon the minds of their readers the ſtrongeſt impreſſion of the force of their genius. Splendid beauties in each are but eclipſed by faults which would have cancelled the merit of ordinary performers. We ſhould, indeed, have no ſtandard for meaſuring their excellence, did not the poet ſometimes ſhock us with his extravagancies, and the hiſtorian 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 perſonal 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

* 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.



PRINTED BY NEILL & CO.

1 — 28
Sutherland
July '81.

ERRATA.

Phyſ. Cl. page 98. *line* 12. *for* and *x read* and *z*.

——— 213. *line* 5. for *vis incita* read *vis inſita*.

——— 314. *line* 4. *from the bottom, for* greater *read* leſs.

——— 324. *The Author finds, on reſuming the computations, that the error in latitude is but half a minute. Since this article was printed off, he has ſeen, in the Memoirs of the Academy of Berlin, Elements of this Orbit, by* P. Fixlmilner, *and a compariſon of them with a great number of Obſervations. There is ſome miſtake in this article of the Memoirs; for the mean diſtance and diurnal motion ſet down in thoſe Elements, are inconſiſtent with each other, and both of them are incompatible with the Obſervations. The Author will juſt obſerve, that the* form *of the Ellipſe is preciſely the ſame with that deduced by him from the ſecond ſuppoſition reſpecting the ſecond 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* 10. 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 firſt lines of the note ſhould be a ſeparate note on* page 123. *taken off at the end of the* 2d paragraph, *at the word* preſuppoſes.

——— 127. *line* 25. *for* prepoſition *read* propoſition.

——— 206. *Note* †, *for* Ep. *read* Εχγ. καὶ ἡμιϛ.

DIRECTIONS FOR THE BINDER.

The Binder is deſired to obſerve that the Vol. conſiſts 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 Phyſical Claſs, and the other Plates (which fold out) according to the references marked upon them.