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TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. IV.

EDINBURGH:

PRINTED FOR T. CADELL JUN. AND W. DAVIES
(SUCCESSORS TO MR CADELL) IN THE STRAND, LONDON,
AND
J. DICKSON, AND E. BALFOUR, EDINBURGH.

MDCCXCVIII.

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VI.

* Now Joint Professor of Chemistry in the University of Edinburgh.

† By mistake No. V. is repeated.

II.

PAPERS OF THE LITERARY CLASS.

ADVER-

ADVERTISEMENT.

Edinburgh, February 15. 1798.

At a Meeting of the Council of the Royal Society it was, this day, *Refolved*, That a Publication of Papers, communicated to the Society, fhall hereafter be made annually, whether fuch Papers be fufficient to form an entire Volume, or only a Part of a Volume.

TRANS-

HISTORY

OF

THE SOCIETY.

THE Third Volume of these *Transactions* brings down the History of the Society no farther than the end of the year 1792, though it contains several Papers that are of a later date.

Phys. Cl. Dr MONRO read a paper, entitled, Observations on the Muscles, and particularly on the Effects of the Oblique Fibres. This paper is inserted in the Third Volume of the Transactions, Part II. No. XIII. p. 250. 1793. Jan. 7. Dr Monro on the muscles, and on the effects of the oblique fibres.

Lit. Cl. Mr STEWART read the first part of his Biographical Account of the late ADAM SMITH, LL. D. [See Vol. III. Hist. p. 55.] Jan. 21. Biographical account of Dr. Smith.

1793. Mar. 18. Biographical account of Dr Smith.

Lit. Cl. Mr STEWART read the remainder of the Biographical Account of the late ADAM SMITH, LL. D.

April 3. Mr Playfair on poriſms.

Phyſ. Cl. Mr PLAYFAIR read ſome Obſervations on Poriſms, additional to thoſe formerly communicated. Theſe were intended to prove, that the propoſitions called Poriſms do not, as ſome mathematicians have alleged, involve in them any violation of the *law of continuity*. This ſubject belongs to the ſecond part of the paper, No. VII. of the preceding volume; which ſecond part has not yet been fully communicated to the Society.

Mr Fiſher on trigonometry.

AT this meeting was alſo read a paper on Trigonometry, entitled, An Eaſy and General Method for ſolving all the Caſes of Plane and Spherical Triangles, by the Reverend WALTER FISHER, miniſter at Cranſtoun.

IT has long been an object with mathematicians to reduce the rules of trigonometry to the ſmalleſt number poſſible, and to give them the form moſt eaſily retained in the memory. Lord NAPIER, whoſe diſcoveries have ſo much facilitated and abridged the labour of numerical calculation, applied himſelf to ſimplify the rules of trigonometry with great ſucceſs. He invented the rule of the *Circular Parts*, which gives an apparent unity to theorems, where a real unity is wanting, and is perhaps the moſt fortunate attempt toward an *artificial memory* that has been made by any of the moderns.

VARIOUS improvements of this rule have ſince been propoſed. That of M. PINGRÉ is one of the beſt: He retains Lord NAPIER's arrangement of the circular parts, and reduces the rules of ſpherical trigonometry to four; the two firſt of which are NAPIER's, and the other two a generalization of the common theorems reſpecting the ſegments, into which the perpendicular, drawn to any ſide of a ſpherical triangle, divides that ſide, and alſo the angle from which it is drawn. See *Mem.*

Mem. Acad. Sciences, 1756, p. 301. There is a fifth rule, it muſt be obſerved, neceſſary for the caſe, when the three ſides, or three angles of the triangle, are given, as this caſe refuſes to ſubmit to NAPIER's rule in any form of it.

THE author of the paper, now communicated to the Society, has alſo been ſucceſsful in his attempt to render the rules of trigonometry eaſily retained in the memory. He employs the circular parts, and makes uſe of fewer rules than M. PINGRÉ, as he has only four, including one for the caſe juſt mentioned.

THE theorems Mr FISHER employs are not new, but they are judiciouſly ſelected, and are leſs embarraſſing in the application than either thoſe of NAPIER or PINGRÉ. They are as little as poſſible ſubject to ambiguity; they do not require the letting fall a perpendicular, and they apply both to plane and ſpherical triangles.

1. M denotes the *middle part* of the triangle, and muſt always be aſſumed betwixt two given parts. It is either a ſide or the ſupplement of an angle.

2. A and a are the two parts adjacent to the middle, and of a different denomination from it.

3. O and o denote the two parts oppoſite to the adjacent parts, and of the ſame denomination with the middle part.

4. l is the laſt or moſt diſtant part, and of a different denomination from the middle part.

THEOR.

THEOR. I.

$$\text{Sin A} : \text{ſin a} :: \text{ſin O} : \text{ſin o}.$$

THEOR. II.

$$\text{Sin}\,\frac{A-a}{2} : \text{ſin}\,\frac{A+a}{2} :: \tan\frac{O-o}{2} : \tan\frac{O+o}{2}.$$

THEOR. III.

$$\text{Tan}\,\frac{A-a}{2} : \tan\frac{A+a}{2} :: \tan\frac{O-o}{2} : \tan\frac{O+o}{2}.$$

THEOR. IV.

$$\text{Sin A} \times \text{ſin a} : 1 :: \text{ſin}\,\frac{A+a+l}{2} \times \text{ſin}\,\frac{A+a-l}{2} : \overline{\text{ſin}\,\frac{M}{2}}^{2}.$$

Mr Fisher recommends, for the purpoſe of remembering theſe rules, to commit to memory the words *Sao, Satom, Tao, Sarſalm,* formed from the abreviation of the terms of the above proportions. It is obvious that theſe four theorems apply to plane triangles, providing that, inſtead of the ſine or tangent of a ſide, you take the ſide itſelf.

1793. Nov. 4. Dr Hope on a mineral from Strontian.

Phyſ. Cl. Dr Hope read a paper, giving an account of a Mineral from Strontian in Argyleſhire, and of a Peculiar Species of Earth contained in it. A ſhort abſtract of this paper was inſerted

ſerted in the laſt volume of the Tranſactions. The paper itſelf is the firſt of the Phyſical Claſs in this volume. [See Part II. p. 1.]

Phyſ. Cl. Dr MONRO read a paper, being Experiments on the Nervous Syſtem with Opium and Metalline Subſtances, with a view of determining the Nature and Effects of Animal Electricity. This paper is publiſhed ſeparately. 1793. Dec. 2. Dr Monro on the nervous ſyſtem.

AT this meeting a paper was alſo communicated from ANDREW MACKAY, LL. D. containing an Account of a Series of Obſervations, made by him in the Obſervatory at Aberdeen, for determining the Latitude of that place. Dr Mackay on the latitude of Aberdeen.

DR MACKAY alſo promiſed to ſend his Obſervations for determining the Longitude of the Obſervatory. Theſe were not received till September 1796. Both papers are inſerted in this volume, Part II. No. VI. p. 135.

DR JAMES ANDERSON read a paper, entitled, Obſervations on Peat Moſs. This paper has been publiſhed ſeparately. 1794. Jan. 6. Dr Anderſon on peat moſs.

Phyſ. Cl. A paper was read from Mr LOCHEAD, F. R. S. Edin. on the Natural Hiſtory of Guiana. It is inſerted in this volume, Part II. No. II. p. 41. March 3. Mr Lochead on the natural hiſtory of Guiana.

Phyſ. Cl. Dr HUTTON read the firſt part of a paper, being a Diſſertation on the Philoſophy of Light, Heat, and Fire. This paper, which conſiſted of ſeveral parts, was read at the different Meetings of the Society in May, June, July, Auguſt, and December, of this year. It has been ſince publiſhed ſeparately in one volume 8vo. The following abſtract contains an account of April 7. Dr Hutton on the philoſophy of light, heat, and fire.

of the object of the Differtation, and of fome of the reafonings employed in it.

Dr Hutton was led into the fpeculations contained in the Differtation, by an account of two experiments made by M M. de Saussure and Pictet of Geneva. In the firft of thefe experiments, two concave fpecula were placed oppofite and parallel to one another, about twelve feet diftant; and in the focus of one of them was a ball of iron, which had been heated to incandefcence, but allowed to cool till it was no longer luminous, even in the dark. In the focus of the other fpeculum a thermometer was placed, which prefently rofe 8° (of Reaumur's fcale) above another that ftood near it, but without the focus. *Voyages dans les Alpes, tom. II.* § 926.

To account for this phenomenon, M. de Saussure fuppofes, that there exifts what M. Lambert and fome other philofophers have called *radiant heat*, and that this heat may be obfcure, and not accompanied with light. This radiant heat he conceives to be reflected in the fame manner that light is, and by that means to have produced the effect on the thermometer that has juft been defcribed.

To this folution Dr Hutton objects, alleging, that it afcribes properties or capacities to heat which are inconfiftent altogether with our notions of it. We know heat only as a quality of bodies, and as acting either in expanding them, when it is called fenfible heat, or in giving them fluidity, when it is termed latent heat. We never perceive it as exifting in any other fhape, and therefore, to fuppofe it capable of moving through fpace, independently of body, and of being reflected from a polifhed furface, is to afcribe to heat properties not predicable of it, and quite inconfiftent with its nature, fo far as we have information concerning it.

Dr Hutton therefore propofes another explanation. From experiments which he had made, long fince, he had found that the

the different ſpecies of light, when of equal intenſity, as eſtimated by the eye, are of unequal intenſity when their effect is meaſured by the thermometer. In theſe experiments he rendered light of different colours equally intenſe to the eye, by increaſing or diminiſhing the diſtance from the luminous body, till he could juſt read by the light of it. In this way he compared the red light from a fire of coals, with the white light of flame, and found, that while they were equally powerful in affording viſion, the red was incomparably the moſt powerful in producing heat.

When a body, therefore, is heated to incandeſcence, like the iron ball in M. de Saussure's experiment, it emits at firſt the white or compound light, but as it cools, the light which it emits becomes of the red ſpecies, and this is the laſt that diſappears. As the body cools, therefore, the power of its light, to produce heat, increaſes in proportion to its power to afford viſion, and, therefore, when this laſt vaniſhes, or ceaſes entirely, the other may ſtill remain in a certain degree. Thus, in the experiment juſt deſcribed, the iron ball, after it had loſt all light to the eye, continued to emit rays of light, which, though they made no impreſſion on the organ of viſion, had power to produce heat, and expand the mercury in the thermometer. To the principle, therefore, of the irradiation of obſcure heat, by which M. de Saussure explains the above phenomenon, Dr Hutton ſubſtitutes that of *obſcure, or inviſible light*, which, though it be in appearance more paradoxical, is in reality free from the very ſtrong objections which preſs againſt the other hypotheſis.

We muſt not omit to obſerve, that M. Pictet varied the experiment, by placing a matraſs full of boiling water, inſtead of the iron ball, in the focus of one of the ſpecula. The thermometer in the other was ſtill affected, and raiſed a little more than a degree. The irradiation of inviſible light explains this alſo; for it is natural to ſuppoſe, that ſuch an irradiation takes place from all bodies, when above a certain temperature, whether they be in the act of cooling down from incandefcence or not.

THE fame ingenious and accurate obferver, made another change in the circumftances of the experiment, by fmoking the bulb of the thermometer; in confequence of which it was heated fooner, and rofe higher than before. This appearance is perfectly conformable to Dr HUTTON's theory, and feems quite inconfiftent with the other. The black coating of the bulb, by its well known property of abforbing light, tended to accelerate and increafe the effect of the light in heating the thermometer; but the fame coating being of fmoke, and a very bad conductor of heat, muft have oppofed the tranfmiffion of heat through the glafs, and have both retarded and diminifhed its effect.

NOTHING, indeed, can be more unlike than the laws which ufually regulate the propagation of light and heat. To move with extreme velocity through the tranfparent fubftance of fome bodies, without heating them in any fenfible degree; to be reflected from the furfaces of others, without entering them at all; and, laftly, to be abforbed by certain bodies, neither paffing through them, nor being reflected from them, thefe are the properties of light. Heat, on the other hand, is lowly propagated through all bodies, combines with them intimately in its paffage, and often remains at reft without any motion whatever.

THE converfion of thefe experiments, which was very ingenioufly imagined by M. PICTET, led to a fact ftill more fingular and unexpected. Inftead of the heated body, he placed a matrafs, with ice in the focus of one of the fpecula; the confequence was, that the thermometer in the focus of the other was fenfibly depreffed. When the cold was increafed, by pouring nitrous acid on the ice, the depreffion of the thermometer was alfo increafed.

To

To account for this phenomenon, M. Pictet considers the thermometer as the body irradiating heat, and the matrafs with the ice as the body which receives it, fo that the experiment is the fame with the former, only that the obfcure heat moves in the contrary direction.

This explanation, however, is not only liable to the objections that have been made, in general, to the fuppofition of radiant and obfcure heat, but it involves in it new difficulties. It implies, for inftance, that the irradiation from the heated body is affected by the ftate of the body which receives that irradiation, a principle furely contrary to all analogy. In the irradiation of light from a luminous body, nothing fimilar to this is obferved: Whether the light of a candle fall on a white wall, by which it is reflected, or on a black wall, by which it is abforbed, no difference is produced in the quantity of light emitted, but it remains in both cafes the fame. In no cafe, it fhould feem, can the quantity of the radiating matter depend on the condition of the recipient bodies; yet, according to the preceding explanation, a body muft be fuppofed to irradiate heat more copioufly when the body on which the irradiation falls is cold than when it is hot; a fuppofition which, being, as has been faid, contrary to analogy, cannot be admitted.

The Doctor next proceeds to offer his own explanation, but with the diffidence that ought to accompany every attempt to account for a phenomenon fo fingular as this, and having fo little analogy with any other fact that relates to the communication of heat. He fuppofes that all bodies irradiate invifible light, when they are of an ordinary temperature, and that this irradiation diminifhes as their heat diminifhes. The temperature of the thermometer, therefore, in the above experiment, is to be confidered, like that of all other bodies, as being maintained by the action of two caufes, viz. the irradiation of invifible light from the furrrounding bodies, and the communication of heat from them by contact. The thermometer, therefore, that is placed in the focus of one of the mirrors, in the above experiment, will be affected by any body whatſoever that is placed in the focus of the other. If that body be cooled below the temperature of the ſurrounding bodies, leſs light will be irradiated from it, and reflected on the thermometer; the thermometer, therefore, will be depreſſed, till the influx of heat from the air, or other bodies with which it is in contact, ſupply the deficiency. This, however, is thrown out rather as a queſtion to be reſolved by future obſervations, than as a theory already eſtabliſhed. The experiments by which it muſt ſtand or fall are not indeed difficult to be imagined. They are however of extreme delicacy in the performance; and Dr HUTTON, who, in differing from the philoſophers of Geneva, does juſtice to the accuracy and judgment with which they have conducted their inquiries, expreſſes a wiſh, that the ſkill and ingenuity of M. PICTET were again directed toward this object.

BY the preceding inquiry, Dr HUTTON was led to conſider the connection between light and fire, as well as between light and heat; a ſubject which he had formerly treated of in ſeveral papers read before the Royal Society, and afterwards publiſhed in his chemical diſſertations.

IN theſe he objected to the theory of fire as laid down by M. LAVOISIER, and the French chemiſts; acknowledging, at the ſame time, that the oxygenating of bodies, by vital air, is to be ranked among the greateſt diſcoveries in phyſics. It is a diſcovery, however, in his opinion, that will by no means explain all the phenomena of burning, by which the exiſtence of ſome other cauſe is clearly pointed out, beſide the decompoſition of the vital air, and the extrication of the *calorique* or *latent heat*, which maintained the air in a ſtate of fluidity. The arguments in ſupport of this aſſertion, which Dr HUTTON employs here, are founded on the appearances exhibited by bodies burning without

without flame, and burning with flame; that is, on the phenomena of combuftion and inflammation.

In the combuftion of a piece of charcoal, two diftinct effects may be traced, viz. 1. The oxygenating of the carbonic fubftance, by which fixed air is produced, or carbonic acid in an elaftic ftate; 2. The production of a great quantity of light and heat, while the charcoal is undergoing this change. It is with refpect to this laft part of the procefs only that different opinions are entertained. The phlogiftic theory maintains, that in the oxygenation of the carbonic fubftance by the vital air, the phlogiftic matter of that fubftance is fet free from combination with it, and in making its efcape exhibits the phenomena of light and heat.

The antiphlogiftic theory, on the other hand, fuppofes, that, by the decompofition or the condenfation which the vital air undergoes, while it oxygenates the carbonic fubftance, the latent heat is transferred to that fubftance, and produces light and fire.

Now, if it can be fhewn that a burning coal, though placed in circumftances the moft favourable for its oxygenation, may neverthelefs lofe its heat, and ceafe to burn entirely, it is certain, that it is not alone by the *calorique* of the vital air that the fire is fupported. Let then a confolidated piece of charcoal, fuch as the mineral kingdom, in many places, affords in great perfection, be heated to the higheft degree of incandefcence, and expofed, infulated, to the atmofpheric air. Here every condition is united favourable to the oxygenation of the coal, a fufficient quantity of heat, and free accefs of air. If the heat, fupplied from the decompofition of the vital air, were able to maintain the heat of the coal, it would continue to burn; but the fact is, that, in fuch a fituation as is here defcribed, the coal lofes its heat, and it is at laft extinguifhed. It is plain, therefore,

fore, that more heat is loſt by communication with the atmoſphere than is acquired from the decompoſition of the vital air.

Now, let the experiment be ſo far varied, that the incandeſcent coal, inſtead of being ſuſpended ſingly in the atmoſphere, is ſurrounded with other burning coals, that are likewiſe ſuſpended, and at ſuch a diſtance from it as to leave room for the free paſſage of a current of air: We know, with certainty, that the central coal will now continue to burn as long as thoſe that ſurround it are incandeſcent, or emit a certain degree of light. But the circumſtances of the coal, in this experiment, are in nothing more favourable to the receiving of heat from the decompoſition of the vital air than they were in the former; for if it be ſaid, that the air aſcends through the greater maſs of burning matter, with more rapidity than before, and ſo depoſits more of the *calorique*, it muſt be remembered, that it alſo abſtracts more heat from the coals, juſt in the ſame proportion, or in proportion to its rapidity. If then the antiphlogiſtic theory be true, the heat acquired by the coal, in the one of theſe experiments, ſhould be to the heat abſtracted from it, in the ſame ratio that the heat, acquired in the other experiment, is to the heat abſtracted. But this does not hold; for the heat acquired, in the firſt experiment, is leſs than the heat abſtracted, and in the ſecond it is not leſs, but is either equal, or greater. Therefore the antiphlogiſtic theory is not true; that is to ſay, the theory which derives the ſupply of heat, in burning bodies, entirely from the *calorique* of the vital air.

We muſt therefore admit another cauſe, before we can fully explain combuſtion; and this can be no other than the extrication of the phlogiſtic matter of the body which is oxygenated, the converſion of that matter into light, and then the production of heat.

In the phenomena of inflammation, Dr Hutton thinks that the proofs of his theory of fire are no leſs concluſive than in thoſe

thoſe of combuſtion. The inconceivable rapidity with which fire is propagated through an inflammable and tranſparent vapour, is among the moſt remarkable of thoſe phenomena, and is certainly inconſiſtent with the new theory of burning, and indeed with every other that makes fire to be produced by heat alone. Let an inflammable fluid be heated till it boil, and to the top of the column of vapour emitted from it let the ſmalleſt ſpark of flame be applied. The vapour is kindled, and, however high the column, the flame deſcends in an inſtant to the ſurface of the inflammable ſubſtance, and ſets fire to it. Now, it is impoſſible that mere heat could deſcend in this manner, againſt the ſtream of vapour that is continually riſing from the boiling fluid. This is quite contrary to the laws by which it is uſually propagated; and it ſhould ſeem, that the fact can only be accounted for by the celerity with which light moves through tranſparent bodies, and by ſuppoſing that the extrication of light is the immediate cauſe of burning.

THE above inſtance is conformable to the experience of every day: Another example, which Dr HUTTON gives of the celerity with which fire is propagated through an inflammable and tranſparent vapour, is more ſingular, and may perhaps be thought hypothetical, but it is at leaſt a very happy application of his theory. This example is the meteor, which was ſeen in 1783, over all Great Britain, and as far ſouth as Paris. There can be no doubt, ſays he, that this was a ſtream of inflammable vapour which had iſſued from the mineral regions of Iceland, at that time laid waſte by ſubterraneous eruptions. This train of inflammable vapour, about 60 miles high in the atmoſphere, had been kindled at the north end, probably by an electrical ſpark, and the inflammation ran the ſpace of ſeveral hundred miles, (at leaſt 1000), in a minute of time, or little more.

THUS the inflammation of a body of pure vapour, in contact with the atmoſpheric air, is made with a rapidity quite inconſiſtent

ſiſtent with the propagation of heat. Inſtances, ſtill more remarkable, of the rapid progreſs of fire, are found in the inflammation of ſuch vapours, when mixed with that proportion of vital air which is neceſſary for decompoſing the phlogiſtic ſubſtance.

On the whole, Dr Hutton concludes, that in no caſe is the light which appears in burning, an effect of the heat obtained from the decompoſition of vital air, but that it is the extrication of phlogiſton, of fixed light, or a certain modification of the ſolar ſubſtance, which had exiſted in the inflammable bodies, and had been chemically combined with their elements. It appears alſo, that it is light which is immediately produced in burning, and that it is only mediately that heat is excited: This is true both of combuſtible bodies which burn in an aſſociated ſtate, and of thoſe inflammable ſubſtances where the emerging light heats both the inflammable body, and the contiguous atmoſpheric fluid.

The Doctor proceeds to explain, more at large, his notions of the ſolar ſubſtance, of which he conceives light, heat, phlogiſton, and electricity, to be ſo many different modifications. His notions on this ſubject are very peculiar, as he conceives the ſolar matter to be without gravitation, without inertia, and, it may be added, without extenſion. The nature of this abſtract does not admit of entering further on the argument: It is ſufficient to remark, that the theory of *heat* ſeems to be arrived at a point where it muſt almoſt unavoidably ſtand ſtill, till ſome experiments ſhall determine how far the gravitation of bodies is affected by the heat, whether ſenſible or latent, that is contained in them. The experiments already made, though ingeniouſly contrived, and ably executed, are not ſufficient to decide a queſtion of ſuch extreme delicacy; nor does it ſeem probable, that, without having recourſe to the pendulum, a ſatisfactory ſolution of the difficulty will ever be obtained.

Phyſ. Cl. Dr MONRO read a paper, concerning the Communication of the Ventricles of the Brain with one another, in Man and Quadrupeds. This paper is publiſhed in Dr MONRO's book, entitled, Three Treatiſes, &c.

1794. Aug. 18. Dr Monro on the communication of the ventricles of the brain.

MR KEITH alſo communicated an Improvement of the Mercurial Level, deſcribed in the Second Volume of the Tranſactions of the Society.

Mr Keith on an improvement of the mercurial level.

THIS improvement conſiſts in a contrivance for avoiding the trouble of pouring the mercury out and into the level, every time it is uſed. Beſide the canal of communication at the bottom, between the two upright columns of mercury, on which the *flots* ſwim, (ſee Vol. II. Part II. No. III.), there is, in the new conſtruction of the inſtrument, another canal, parallel to the former, cut in the upper part of the wood, which allows the air to circulate freely, according as the mercury below riſes or falls. The whole is made perfectly cloſe, ſo that no air can get admittance.

THE inſtrument may be carried about in this manner, with the mercury remaining in it; and though by agitation that fluid calcines, and is converted into a grey powder, this only happens when it has free acceſs to vital air; and as all ſuch acceſs is here prevented, the mercury will not loſe its metallic luſtre.

THE level, in this form of it, as it requires no previous adjuſtment, is very commodious, and, when much accuracy is not required, may be uſed with advantage.

Phyſ. Cl. Dr ANDERSON read a paper, entitled, Obſervations on Wool-bearing Animals.

1795. Jan. 5. Dr Anderſon on wool-bearing animals.

Phyſ. Cl. Mr PLAYFAIR communicated an Abſtract of a Journal of the Weather, kept at his Houſe in Windmill Street, for

Feb. 2. Mr Playfair on the weather of 1794.

for the year 1794. This abſtract, with thoſe for 1795 and 1796, make the laſt of the Phyſical papers in this volume.

1795. Feb. 2. Dr Anderſon on the making of indigo.

AT this meeting Dr ANDERSON alſo read a paper on the Making of Indigo at Tranquebar, by Dr ANDERSON of Madras.

Extract of a letter from W. Hall, Eſq;

AN extract of a letter from W. HALL, Eſq; of Whitehall, Berwickſhire, was read, giving an Account of a Great Degree of Cold which he had obſerved on the Evening of the 22d of January, when the Thermometer ſtood between 5 and 6 degrees below 0 of FAHRENHEIT's ſcale.

March 2. Dr Wilſon on the effects of opium on the living animal.

Phyſ. Cl. Dr ALEXANDER WILSON read the firſt part of a paper, concerning the Effects of Opium on the Living Animal. This paper has been publiſhed ſeparately: An abſtract of it follows.

THE difference in the reſults of the experiments that have been made to aſcertain the effects of opium, and the inconſiſtency of the concluſions deduced from them, led Dr WILSON to enter on the experimental inveſtigation contained in this paper. The firſt point which he endeavours to aſcertain is, whether opium, applied to the internal ſurface of the heart, is capable of ſo affecting its nerves, as to act on thoſe of every part of the body, producing the general convulſions obſerved on injecting a ſolution of this drug into the heart or blood-veſſels. It appears from his experiments, that the only effects of the application of opium to the internal ſurface of the heart, are thoſe of interrupting its motion, and deſtroying its irritability; and that when convulſions ſucceed, they are owing to the opium being conveyed along the aorta, and immediately applied to the brain. It has alſo been aſſerted, that opium, applied to diſtant parts of the body, is capable of affecting the motion of the heart, through the medium of the nervous ſyſtem. Injected into the cavity of the

the abdomen, for inſtance, it almoſt immediately impairs the action of the heart. It is only, however, when applied to an extenſive ſurface that it has this effect; and if Dr WILSON's obſervations be juſt, this effect is not produced through the medium of the nervous ſyſtem; but is the conſequence of the opium deſtroying the muſcular power, and, conſequently, the circulation in thoſe veſſels to which it is applied; thus ſuddenly diminiſhing the ſupply of blood to the heart, and at the ſame time oppoſing an additional obſtacle to its perfect evacuation. The experiments, next related, demonſtrate that opium, immediately applied to the brain itſelf, although it excites violent and univerſal convulſions in all the muſcles of voluntary motion, is incapable of affecting at all the contractions of the heart. It even appears, from theſe experiments, that although opium be applied at the ſame time to the brain and ſpinal marrow of a frog, in conſequence of which, (if the ſolution employed be ſtrong), the animal inſtantly expires, as if thunderſtruck, the motion of the heart is not in the leaſt affected by it. It continues to beat with the ſame frequency and force after, as it did before, the application of the opium. We arrive, then, at this concluſion, that opium, applied to a diſtant part of the body, does not affect the motion of the heart, through the medium of the nervous ſyſtem; nor, on the other hand, does opium, applied to the heart, affect any other part of the body, through the ſame medium. But the heart is not the only muſcle, which opium, applied to a diſtant part, ſeems incapable of affecting through this medium. Many conſiderations render it highly probable, that the ſame is true of all the muſcles of involuntary motion, without exception. That it is ſo of the muſcular coat of the alimentary canal, which, next to the heart, may be conſidered the chief of this claſs of muſcles, appears from the experiments next related. On comparing the experiments above alluded to, with thoſe in which opium thrown into the ſtomach and inteſtines, the cavity of the abdomen, &c. is found to produce convulſions, it appears probable, that in the latter caſes, as in the former, the convulſions do not proceed from any action of the opium on the nerves of the part to which we apply it, but from its being received into the ſanguiferous ſyſtem, and immediately applied to the brain. The experiments which follow, in the treatiſe, confirm this conjecture. On comparing together all the experiments there related, and thoſe alluded to in the introduction, it appears, that the various effects of opium on living animals may be divided into three claſſes. The firſt comprehending its action on the nerves of the part to which it is applied, not differing eſſentially from that of any other local irritation. The ſecond comprehending its effects on the heart and blood-veſſels; that of increaſing their action, when applied in a ſmall quantity; and that of impairing, or altogether deſtroying their power of action, when applied to them more freely. The third comprehending its effects, when immediately applied to the brain; which, when the doſe is moderate, are impaired ſenſibility, languor, ſleep; when applied more fully, convulſions and death. In all its effects on the living animal body, opium has much, in common with other ſubſtances, but at the ſame time ſomething in each peculiar to itſelf. It may appear an omiſſion, Dr WILSON obſerves, that he has not ranked among the effects of opium, received into the ſyſtem, thoſe which it ſeems to produce on the muſcles of voluntary motion. In ſome of the foregoing experiments, the irritability of theſe muſcles was found much impaired after death, although the opium was not applied directly to the muſcles themſelves. But it appears, both from an experiment related in the Treatiſe, and others alluded to, that the impaired irritability of theſe muſcles is owing, not to any direct action of the opium on them, but to the violent convulſions excited in them, in conſequence of the opium being applied to the brain.

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The doctrine of the ſympathy of the nerves has been ſo much employed in accounting for the effects of opium, that Dr Wilson judged it proper to make ſome obſervations upon it; in which he endeavours to prove, that no ſuch law of the animal œconomy exiſts; and that all the phenomena, which have been referred to this ſuppoſed law, depend on certain changes taking place in the *ſenſorium commune*.

In an appendix, he relates ſome experiments, made with a view to determine the manner in which tobacco acts on living animals. From theſe experiments it appears, that the ſymptoms which tobacco produces, when thrown into the heart, are the ſame with thoſe excited by its immediate application to the brain. That theſe ſymptoms, when the tobacco is exhibited in the former way, proceed from no action of the tobacco on the nerves of the heart, but from its being conveyed along the aorta, and immediately applied to the brain; ſince they do not follow its injection into the heart, when the aorta is previouſly ſecured by ligature; although it was found, that interrupting the circulation does not unfit the nervous ſyſtem from undergoing the change neceſſary for the production of ſuch ſymptoms. It alſo appears from theſe experiments, that tobacco produces the ſame effects, though more ſlowly, when thrown into the ſtomach and inteſtines as when thrown into the heart: That in the former caſe, as in the latter, they are ſtill to be aſcribed to the tobacco being received into the ſanguiferous ſyſtem, and immediately applied to the brain; and that the effects of this drug, when it acts merely on the nerves of the part to which it is applied, do not eſſentially differ from thoſe of any ſtrong topical irritation. It may alſo be collected from theſe experiments, that the preſence of tobacco in the ſyſtem, like that of opium, only affects the irritability of the muſcles of voluntary motion, when it produces convulſions in them; *i. e.* when it is applied in conſider-

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able quantity to the brain. It appears, therefore, that the *modus operandi* of tobacco, on the living animal body, is in every inſtance analogous to that of opium.

1795. April 6. Mr Playfair on the trigonometry of the Brahmins.

Phyſ. Cl. Mr PLAYFAIR read a paper on the Trigonometry of the Brahmins. The paper is inſerted in this volume, Part II. No. IV. p. 83.

May 5. Mr Wilſon on motions of wicks in a baſon of oil.

Phyſ. Cl. Mr PLAYFAIR communicated a letter from Mr Profeſſor WILSON of Glaſgow, giving an Account of certain Motions obſerved in ſmall lighted Wicks, when made to ſwim on a Baſon of Oil, or any other Fluid which can maintain Flame. [See this volume, Part II. No. VI. p. 163.]

June 1. Dr Wilſon on the effects of opium on the living animal.

Phyſ. Cl. Dr ALEXANDER WILSON read the remaining part of his paper on the Effects of Opium on the Living Animal.

Dr Anderſon on making chinam.

DR JAMES ANDERSON alſo read an Account of the Method of making Chinam at Madras, communicated by Dr ANDERSON of Madras.

June 15. Mr Marſhall on the Argonautic expedition.

Lit. Cl. Mr DALZEL read an Eſſay on the Argonautic Expedition, by the Reverend Mr EBENEZER MARSHALL, Miniſter at Cockpen.

Aug. 3. Mr Keith on different thermometers.

Phyſ. Cl. Mr KEITH read a Deſcription of different Thermometers, accompanied with figures, by which the Degree of Heat may be recorded for every hour and minute throughout the year.

Nov. 2. Dr Monro on the internal hydrocephalus.

Phyſ. Cl. Dr MONRO read a paper on the Internal Hydrocephalus. This, with ſome other papers, already mentioned, by the ſame Author, have been publiſhed ſeparately; and as an account of the

the diſcoveries, which Dr MONRO has made in the Structure of the Brain, the Ear, &c. could not be ſufficiently underſtood without the numerous plates by which they are illuſtrated, it is unneceſſary to attempt any detail of their contents.

Phyſ. Cl. A paper, by Dr BALFOUR of Calcutta, was communicated, on the Diurnal Variations of the Barometer. 1796. Jan. 4. Dr Balfour on the diurnal variations of the barometer.

DR BALFOUR's Obſervations, on the Diurnal Variations of the Barometer, were made at Calcutta, and communicated to the Aſiatic Society in 1794. A copy of them, which he ſent to a friend in Edinburgh, was the paper now read in the Royal Society.

THE ſituation in which theſe obſervations were made, entitles them to peculiar attention; for it is well known, that, between and near the tropics, the barometer is very ſteady, and free from thoſe great and ſudden changes that take place in higher latitudes. It is in ſuch ſituations, therefore, that the ſmaller periodical variations of the barometer, if they exiſt at all, are likely to be diſcovered, as being ſeparate from thoſe accidental irregularities with which they muſt be complicated in our northern climates.

DR BALFOUR's diligence, in obſerving the barometer, has alſo been ſingularly great. He impoſed on himſelf the taſk of obſerving the ſtate of that inſtrument every half hour, for an entire lunation, from the new moon on the 31ſt of March, to that of the 29th of April 1794.

THE reſult was, the diſcovery of a periodical variation in the barometer, conſiſting of two oſcillations, which it performs regularly every twenty-four hours.

1. ON every day, that Dr BALFOUR obſerved, with ſcarce any exception, the barometer conſtantly fell between ten at

night

night and ſix in the morning; and this it did progreſſively, without any intermediate riſing but in one inſtance.

2. Between ſix and ten in the morning the barometer conſtantly roſe; it alſo did ſo progreſſively, and rarely with any intermediate falling.

3. Between ten in the morning and ſix at night the barometer fell progreſſively, without a ſingle exception.

4. Lastly, between ſix and ten at night the barometer roſe progreſſively, without any intermediate falling, except in one inſtance.

These are Dr Balfour's general concluſions; and, accordingly, on caſting an eye over the table into which he has reduced his obſervations, one is immediately ſtruck with the appearance of two *maxima*, viz. at ten at night and ten in the morning; and, again, two *minima*, alſo diametrically oppoſite to one another, at ſix in the morning and ſix at night.

The quantity of theſe diurnal variations is not very conſiderable, but ſufficient, at the ſame time, to leave no doubt of their reality. The difference between the contiguous *maximum* and *minimum* is ſometimes $\frac{1}{10}$ of an inch, though in general it is leſs than half that quantity.

It does not appear that the above variations have any relation to the heat and cold of the atmoſphere, or to the changes of the temperature of the mercury in the barometer, though, with reſpect to this laſt, we are not furniſhed with ſufficient information.

Till theſe obſervations are further multiplied and extended, it will be in vain to attempt any explanation of the facts to which they relate. It ſeems not improbable, however, that they are connected with the reciprocations of the ſea and land winds, during the day and night, or with the heating and cooling of the ſuperincumbent atmoſphere. It would be of great uſe to have

have the obſervations repeated at different ſeaſons of the year. An obſerver equally aſſiduous with Dr BALFOUR will not be eaſily found; but it will perhaps be ſufficient to obſerve the barometer every three hours, and particularly at the ſtationary points.

IT is proper to remark here, that ſome obſervations of a ſimilar ſort have been made in Europe; where, though the ſituation is far leſs favourable, than in India, for diſcovering the true law of ſuch minute variations, reſults have been obtained tolerably conſiſtent with one another, yet differing conſiderably from thoſe that are ſtated above.

A SERIES of ſuch obſervations was inſtituted by M. PLANER of Erfort in Germany, and is deſcribed in the *Ephemerides* of the Meteorological Society at Manheim for 1783. Before theſe obſervations, it had been remarked, that when the barometer is riſing, it ſtands lower at noon than at any other time of the day, and higher at the ſame hour when it is deſcending. M. PLANER's obſervations ſeem to extend and modify this concluſion; for they make it appear, that between ten and two, both of the day and night, that is, for two hours before, and two hours after the ſun is on the meridian, the elevations and depreſſions of the mercury are leſs than at any other time of the day; and that between ſix and ten in the morning, and, again, between ſix and ten at night, theſe elevations and depreſſions are the greateſt. The ſame rule ſeems to be confirmed by the obſervations of M. COTTE in France, of which he has given an account in the *Journal de Phyſique* for 1792 and 1794.

THESE laſt concluſions ſeem to indicate ſome periodical retardation of the movement of the mercury in the barometer, whether aſcending or deſcending; but it is difficult to form any notion of the force by which ſuch an effect can be produced. Perhaps the only general inference that is yet deducible, from comparing all the circumſtances, is, that certain diurnal variations of the barometer do actually exist; that more information on the subject is necessary before any explanation of them can be attempted; and that it is in the countries lying near to the equator that we are to look for these periodical variations least interrupted and obscured by accidental irregularities.

1796. Feb. 1. Mr Playfair on the weather of 1795.

Phys. Cl. Mr Playfair read an Account of the Weather for 1795, extracted from his Journal kept for the Society.

Feb. 15. Biographical account of Lord Abercromby.

Lit. Cl. Mr Mackenzie read his Biographical Account of Lord Abercromby. [See History of the Society, Appendix, p. (1)].

March 7. Mr Wallace on geometrical porisms.

Phys. Cl. A paper was communicated, containing Certain Geometrical Porisms, with their Application to the Solution of Problems, by Mr William Wallace, Assistant-teacher of the Mathematics in the Academy of Perth. [See this volume, Part II. No. V. p. 107.]

March 21. Biographical account of Dr Robertson.

Lit. Cl. Mr Stewart read the first part of his Biographical Account of the late Dr Robertson.

April 4. Biographical account of Dr Roebuck.

Phys. Cl. A Biographical Account of the late Dr Roebuck was read, communicated by Mr Professor Jardine of the University of Glasgow. [See Hist. Appen. No. IV. p. (65)].

May 2. Extract of a letter from W. Hall, Esq;

Phys. Cl. An Extract of a Letter from Mr Hall to Sir James Hall, Bart. was read, giving an Account of an Extraordinary Halo of the Moon, observed on the 18th of February last. [See this Volume, Part II. No. VII. p. 173.]

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1796. May 9. Dr Hutton on the fulphurating of metals.

Phyf. Cl. Mr STEWART read a paper by Dr HUTTON, viz. An Examination of a New Phenomenon which occurs in the fulphurating of Metals, with an Attempt to explain that Phenomenon.

AN account that was given, fome time ago, in the Literary Journals, of certain experiments made in Holland on the fulphurating of metals, gave rife to this communication. According to that account, when metallic filings are mixed with fulphur, and expofed in a clofe veffel to a certain degree of heat, the mafs kindles, and burns not only without vital air, but in any air whatfoever, or even in a vacuum. In the experiment, as thus reprefented, Dr HUTTON readily faw a ftrong argument againft the theory which explains the phenomena of fire by the extrication of the *calorique* of vital air; and in this light he confidered it in the end of the Differtation on the Philofophy of Light, &c. of which an abftract has been already given. Dr HOPE having however fuggefted to him, that, in making the experiment, he had feen reafon to doubt the reality of the inflammation, they agreed to repeat the experiments together. Dr HUTTON was then convinced that this fact had been mifreprefented, or rather mifunderftood; and therefore thought it neceffary, in this paper, to correct the error into which he had been led by that mifreprefentation, defcribing the real appearances, and endeavouring to explain them on known principles. "In doing this," fays he, "I fhall deftroy the argument which the experiment feemed to afford againft the doctrine of *calorique,* but I fhall have no reafon to change the conclufion that I formed againft that doctrine, founded on facts that are univerfally acknowledged."

THE fact, as thefe gentleman obferved it, is this: The metal and fulphur being mixed in due proportions, and expofed to heat in a clofe glafs veffel, the fulphur firft melts, then undergoes a kind of ebullition, emitting vapours which condenfe in the upper part of the veffel, and are a fublimation of the fulphur. In this ſtate, and while the heat communicated was ſtill under that of incandeſcence, there appeared in the bottom, or hotteſt part of the maſs, an incandeſcent ſpot, which increaſed in ſize. The glaſs veſſel was now removed from the fire, and carried into a dark room, that the light emitted from it might be the more accurately obſerved. There the incandeſcence was plainly perceived, ſpreading from the place where it firſt began, and gaining ground continually, till the whole became very luminous. The heat, when thus diffuſed through the maſs, begins inſtantly to diminiſh, and the body quickly cools, as a ſimilar maſs of any other ſubſtance would do. Theſe are the appearances obſerved in the experiment; and are what Dr Hutton proceeds to explain.

It is evident that the incandeſcence, which has juſt been deſcribed, is an operation proceeding from the maſs itſelf, and not from the intenſity of the heat communicated to it, for that heat is not ſenſibly incandeſcent; whereas the heat which the maſs acquires, after the veſſel is removed from the fire, is conſiderably luminous. We have here, therefore, a ſpecies of kindling like that of burning bodies; but, at the ſame time, diſtinctly different from it. In burning, a phlogiſtic ſubſtance is decompoſed, by means of the oxygenating principle; and the matter of light, which was contained in that ſubſtance, being ſet at liberty, is emitted in the form of light, and heats thoſe bodies by which it happens to be extinguiſhed or abſorbed. But, in this experiment, though the maſs is a phlogiſtic ſubſtance, there is no decompoſition of the phlogiſton, no appearance of inflammation; ſo that its incandeſcence proceeds from another cauſe than that which operates in burning. On attending to the circumſtances, however, we ſhall perhaps diſcover that the phenomena of this experiment are not anomalous, but follow a rule, exemplified in many inſtances, though not preciſely with the ſame appearances.

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THIS rule ſeems to be no other than that which regulates the extrication of latent heat, when bodies paſs from a fluid to a ſolid ſtate, though this caſe is ſomewhat more complicated than uſual, and attended with circumſtances that are yet but imperfectly underſtood. It muſt therefore be conſidered, whether the ſources of latent heat in the bodies, here combined, be ſuch as we can reaſonably ſuppoſe adequate to the effect produced.

FIRST, then, we have the latent heat of the ſulphur, when it is ſimply in its melted ſtate; it has then an aqueous or perfect fluidity, to which the quantity of its latent heat neceſſarily correſponds. But this is not preciſely the ſtate in which the ſulphur combines with the metal; for before that happens, and while the ſenſible heat increaſes, the ſulphur becomes viſcid, and loſes its perfect fluidity. We have nothing with which we can compare this phenomenon, or by which we can eſtimate the latent heat now contained in the ſulphur. There is however reaſon to think, that this heat is of the ſpecies which Dr HUTTON, in his Diſſertations on ſubjects in Natural Philoſophy, diſtinguiſhes by the name of the *latent heat of ductility*. The reaſon for this ſuppoſition is, that when the ſulphur, in its viſcid ſtate, is plunged into cold water, it does not concrete into its uſual, hard, friable, and cryſtallized ſtructure, but is changed into a tranſparent ductile maſs. This ſtate it ſeems to owe to the latent heat contained in it; for after ſome hours expoſure to cold, it gradually loſes its ductility, and undergoes another change of ſtructure, ſo as to reſume its ordinary appearance, as if it had been concreted and cryſtallized from the ſtate of ſimple fluidity.

BUT the ſulphur alſo emits another ſpecies of heat, on its combination with the metallic ſubſtance. This is what may be called the conſtitutional heat of a body, or that by which its volume is preſerved in oppoſition to any force endeavouring to diminiſh

diminiſh it. The volume of the ſulphur is obviouſly much diminiſhed on its combination with the metal; and therefore a quantity of its *conſtitutional heat* muſt be expelled, correſponding to the condenſation or diminution of bulk which it has undergone. This quantity may be very great; but it is what at preſent our ſcience has not the proper means of eſtimating.

Such are the ſources of heat contained in the ſulphur. The metal alſo, by loſing its ductility, may emit a certain quantity of latent heat, and may thus contribute to increaſe the ſenſible heat of the compound maſs. The quantity of this effect, like the former, it is difficult to eſtimate.

These, then, are the different ſpecies of latent heat, which may be ſuppoſed to emerge, and become ſenſible, on the combination of the ſulphur and the metal in the preceding experiment, and on the inſtantaneous concretion of the compound maſs. The conſequence of this muſt be, that the maſs already heated, from without, nearly to a red heat, having this additional heat communicated, muſt become incandeſcent, and emit light. This muſt happen, even if the latent heat emerging ſhould be but in a very ſmall quantity; and thus the leading fact of the incandeſcence ſeems to be ſufficiently accounted for.

It may alſo be uſeful to remark, that there are other caſes in which incandeſcence ſeems to be produced, on the principle here aſſigned, though not perhaps in a degree equally remarkable.

In the aſſaying of ſilver on the teſt, when the lead is ſufficiently ſeparated, ſo as to leave the ſilver ſtill fluid, but in a degree of heat inferior to what is required to melt it, or to preſerve its fluidity, the button of ſilver inſtantly concretes, and appears at the ſame time much more luminous. Here there is evidently no cauſe that operates, but the latent heat of fluidity, emitted, as on all occaſions, when concretion takes place;

place; and had the ſilver been here, in the loweſt degree of incandeſcence, or the higheſt degree of obſcure heat, the phenomenon would have been as remarkable as in the ſulphurating of metals.

On the ſame principle it ſeems to be, that, in a very common, but very inſtructive experiment, a bar of cold iron is made incandeſcent, by hammering it with a certain degree of rapidity and force, ſo that the condenſation may be ſufficiently quick to expel the heat all at the ſame time, or nearly ſo. In this caſe, it is the latent heat of ductility that is made to appear, as in the congelation of water it is the latent heat of fluidity.

Iron alſo furniſhes another example of the ſame kind, where the incandeſcence is very conſpicuous, but where the proceſs is not ſo ſimple as in the former inſtances, becauſe a part of the light is probably produced from another cauſe. This example is found in the converſion of pig iron into malleable iron by Mr Corte's proceſs, viz. by keeping the iron melted in a reverbatory furnace, and expoſed, by being agitated, to the influence of the atmoſphere. When the caſt iron comes in this manner to its malleable ſtate, it quickly diſplays the brighteſt incandeſcence poſſible, coagulating, at the ſame time, from its melted ſtate. Now, there can be no doubt that this extreme incandeſcence ariſes from the commutation of latent into ſenſible heat, and the commutation of that heat again into light, in which ſtate it is emitted by the incandeſcent body. In this caſe, however, it is probable, that there is alſo light emitted immediately on the principle of burning, and that the iron is in part ſcorified, by being oxygenated and loſing its phlogiſton. But this alſo is in a great meaſure owing to the extreme heat produced by the congelation of the iron; for the heat of melted iron is not alone ſufficient for that effect.

The theory above laid down will enable us to explain all the different ſteps in the complicated proceſs of the ſulphurating of of metals. When the mixture of the metal and ſulphur is expoſed to heat, and the ſulphur melted, it is not immediately combined with the metal; for it requires a greater degree of heat, and one which is perhaps nearly that of incipient incandeſcence, to produce the compound ſubſtance of the ſulphurated metal. The moment, however, that this combination is formed, that part of the maſs, in which it began, loſes its fluidity, and is made to concrete, and at the ſame time becomes ſtrongly incandeſcent. In this ſtate, if the glaſs veſſel be removed from the fire, the proceſs of the combination of the ſulphur with the metal will be carried on, as has been deſcribed above. For the firſt incandeſcent part is that which had been moſt immediately expoſed to the heat of the burning coals, and had, by that means, acquired the temperature neceſſary for the combination of the two ſubſtances; but at this time the part immediately contiguous to the concreted portion of the maſs is in the next degree of heat; conſequently, upon the emerging of the latent heat of the firſt portion, this ſecond portion, having its heat increaſed, is made to combine, and, by its inſtant conſolidation, produces incandeſcence. This incandeſcence of the ſecond portion produces a like effect upon the third; and thus the heat, combination, concretion, and incandeſcence, ſpread quickly through the whole maſs, without any further aſſiſtance from external fire.

In all this there is ſo great a reſemblance to the phenomena of burning, that ſome attention is neceſſary to enable an obſerver to diſtinguiſh the one proceſs from the other.

When a maſs of charcoal, properly prepared for combuſtion, is kindled in one part by the heat of incandeſcence, the oxygenation begins, attended with the decompoſition of phlogiſton, and the emiſſion of the fixed light. The neighbouring parts being then heated, by the light emitted from the firſt kindled part, are alſo kindled themſelves, and ſerve to augment both the

the intenſity of the heat and the extent of the burning. In this manner the parts of the maſs are kindled in ſucceſſion, until the whole is incandeſcent; it is at the ſame time gradually conſumed, the vital air uniting with the carbonic principle, and this laſt being deſerted by the fixed light of the phlogiſton.

In the ſulphurated maſs, though there be the ſame appearance of ignition propagated ſucceſſively from a central point to the adjacent parts, yet it is not real ignition, but ſimple incandeſcence, produced from the extrication of latent heat, in the manner already explained. It is diſtinguiſhed from ignition by this circumſtance: that, as ſoon as the incandeſcence has ſpread over the whole maſs, there is an end of the generation of heat, and the ſulphurated metal cools from its incandeſcent ſtate, like any other incombuſtible body heated to the ſame degree. In the whole proceſs there is no oxygenation; no production of fixed or carbonic air; no apparent waſte; nor any thing emitted from the maſs, except the light of incandeſcence.

Thus, Dr Hutton concludes, that, in the proceſs of the ſulphurating of metals, we perceive the action of the ſame laws as in the converſion of water into ice, and muſt explain both on the great principle, by the diſcovery of which his friend Dr Black rendered ſo important a ſervice, not to chemiſtry alone, but to many other branches of natural philoſophy.

He is aware, however, that an explanation of it will alſo be attempted by ſome chemiſts, on the principle of the change of the capacity for heat; an explanation which he conſiders as extremely fallacious and unphiloſophical. When he applies theſe epithets to the doctrine of the capacities for heat, he does not mean to object to the phraſe, *capacity for heat*, or to the application of that phraſe to expreſs a mere matter of fact, viz. the difference of the ſpecific heat of bodies, or the unequal quantities of heat contained in different ſubſtances, when their maſſes and temperatures are equal. But what Dr HUTTON calls fallacious and unphiloſophical is, the aſſigning the change in the capacity of a body for heat, as the cauſe of the abſorption or emiſſion of heat, at the moment when that change takes place. This ſuppoſition is grounded, as he contends, on a falſe view of the facts concerning the tranſition of water from a hard to a fluid ſtate, or the contrary. The chemiſts, for example, who maintain this doctrine, hold, that when water is cooled down to a certain temperature, it neceſſarily freezes and becomes ice, a ſubſtance that has a much leſs capacity for heat than water has; on which account a certain quantity of the heat contained in the water is expelled, and enters into the ſurrounding bodies. Now in all this it is ſuppoſed, that water, at a certain temperature, is neceſſarily changed into ice, which is by no means true; becauſe it is well-known, that water may be cooled ſeveral degrees below what is called the point of congelation without loſing its fluidity. Dr HUTTON tells us, that he has found means to cool it no leſs than 30° below that temperature, without its being changed into ice. Though it be true, therefore, that water muſt be cooled to a certain temperature before it can freeze, it is not true, converſely, that it does freeze whenever it is cooled to that temperature. It follows, as a neceſſary conſequence, that ſomething elſe beſide a change of temperature is eſſential to congelation, and is the cauſe of that wonderful change which water undergoes in paſſing from a fluid to a ſolid ſtate. The ſeparation of the latent heat ſeems a cauſe more adequate to the effect, and ſerves to explain the cooling of the water below the point of congelation, without the loſs of its fluidity, becauſe this only happens when the eſcape of the latent heat is prevented.

THAT the heat, abſorbed by the water, is the true cauſe of its fluidity, appears from the facility with which this hypotheſis explains

explains all the other phenomena of congelation. There is, as has juſt been ſaid, a certain fixed temperature, at which water and ice are convertible into one another. At this temperature, however, a mixed body of ice and water may remain for ever without any of the water being congealed, or any of the ice melted; but let there be added to this compound maſs a quantity of heat, by communication from a warm body, and there is a certain quantity of the ice melted, while the maſs remains in its former temperature. Now, if we meaſure the quantity of the heat, communicated to this compound maſs, without changing its temperature, and alſo the quantity of ice melted, that is, the quantity of fluidity produced, it will be found that they are in all caſes proportional to one another, and have therefore the relation of cauſe and effect. This certainly amounts to no leſs than a full demonſtration, that the heat abſorbed, or rendered inſenſible to the thermometer, is the cauſe of fluidity. To ſay, that the change of the capacity for heat is the cauſe of the abſorption of the heat, is, in fact, to affirm, that the fluidity of the water is the cauſe of that abſorption, and, of conſequence, leaves the fluidity as a phenomenon without a cauſe: for it has been ſhown that mere change of temperature is not the cauſe of it.

Dr Hutton has been remarkably happy in his explanation of the manner in which heat produces fluidity. Heat, ſays he, has two diſtinct effects on body: The one of theſe conſiſts in its power of diſtending the ſubſtance of the body, or increaſing its volume, and this is the effect that is meaſured directly by the thermometer: The other effect of heat is to move the particles of hard bodies on their *axes*, and by this rotatory motion to ſeparate their poles of attraction, which were united in their ſtate of hardneſs and ſolidity. The particles of the body, in conſequence of this rotatory motion, are in a ſtate of equilibrium; they have no diſpoſition to cohere together, and are ready to obey the impreſſion of the ſmalleſt force.

SUCH are the ideas which Dr HUTTON had formed on the ſulphuration of metals, and the theory by which it muſt be explained; and they are rendered more intereſting, by being the laſt communication made by that ingenious and profound philoſopher.

1796. June 20. Biographical account of W. Tytler, Eſq;

Lit. Cl. Mr MACKENZIE read a Biographical Account of the late WILLIAM TYTLER, Eſq; of Woodhouſelee. [Hiſtory, No. II. p. (17)].

July 4. Dr Walker's ſtatiſtical account of Collington.

Phyſ. Cl. Some Paſſages from Dr WALKER's Statiſtical Account of the pariſh of Collington were read.

Nov. 7. Mr Ivory on the rectification of the ellipſis.

Phyſ. Cl. Mr PLAYFAIR communicated an Extract of a Letter from JAMES IVORY, A. M. containing a New Series for the Rectification of the Ellipſis. [See Part II. of this volume, No. VIII. p. 177.]

Dr Mackay's determination of the longitude of the Obſervatory at Aberdeen.

AT this Meeting Dr MACKAY's Determination of the Longitude of the Obſervatory at Aberdeen was alſo communicated. [Part II. of this volume, No. V. p. 140.]

THE eſtabliſhment of a New Obſervatory, where there are ſo few as in Scotland, is an event of too much importance, in the literary hiſtory of the country, to be paſſed over without notice. The eſtabliſhment of that at Aberdeen ought the more to be recorded, that it does great honour to the public ſpirit and ſcientific zeal of the Principal and Profeſſors of the Mariſhall College, and of the other gentlemen by whoſe voluntary ſubſcription it was brought about. From the funds which their ſubſcription afforded, an Obſervatory was built in 1781, on a part of the Caſtle Hill, which was given in a preſent to the College

College by the Magiſtrates and Town-Council of Aberdeen. The building conſiſted of three rooms, two of which, forming the wings, were circular, about 12 feet in diameter, with conical roofs. The eaſtermoſt of theſe was for the quadrant, and had its roof moveable, and furniſhed with ſlits; the weſtern was the tranſit room; its roof had ſlits, but was not moveable; the room in the middle ſerved for the accommodation of the aſtronomer.

THE inſtruments, with which the Obſervatory was furniſhniſhed, were a tranſit inſtrument by RAMSDEN; a moveable aſtronomical quadrant, of 2 foot radius, by MACULLOCH; an equatorial inſtrument by SISSON and RAMSDEN; an achromatic teleſcope and a divided object glaſs micrometer by DOLLOND; an aſtronomical clock, with a gridiron pendulum, by MARIOTTE. To theſe were added an aſſiſtant clock by GADBY, Aberdeen; an alarm clock; a barometer and thermometer, the two laſt by MILLER, Edinburgh.

THE tranſit inſtrument, and the equatorial, were preſents from the late Earl of BUTE, at that time Chancellor of the Univerſity. They are both inſtruments of great value; the tranſit, in particular, is ſaid to be of ſingular excellence, and altogether worthy of the great artiſt by whom it was conſtructed.

THE Obſervatory, however, ſuch as it is here deſcribed, has been but of ſhort continuance. About three years ago barracks were built on the Caſtle Hill, immediately to the north of the Obſervatory; and as it appeared to be of conſequence, that the ground occupied by the latter ſhould belong to the barracks, it was purchaſed by Government, and the Obſervatory demoliſhed. It is to be rebuilt, however, on an improved plan, and in a ſituation where it will be leſs incommoded by the vicinity of the town than formerly, and where, it is hoped, the ſeries

ſeries of obſervations may be continued, which Dr MACKAY has begun with ſo much diligence and accuracy.

ACCORDING to Dr MACKAY, the latitude, from a mean of 64 obſervations of the ſun's meridian altitude, is 57°. 9′. 1″, or becauſe the ſun's ſemidiameter, taken from the *Nautical Almanac*, is about $1\frac{1}{2}''$ too great, it is more exactly 57°. 8′. $59\frac{1}{2}''$, and this agrees to $\frac{1}{4}$ of a ſecond with the mean of 8 obſervations of the meridian altitudes of fixed ſtars.

THE longitude, determined alſo by a mean of ſeveral obſervations, is 0^h. 8′. 32″ of time, or 2°. 8′ weſt of Greenwich.

HENCE it appears, that the beſt maps and charts require ſome correction in the poſition they aſſign to Aberdeen, and probably to a great part of the eaſt coaſt of Scotland. AINSLEY's map places Aberdeen in latitude 57°. 5′. 9″, which is 3′. 50″ too far ſouth: It is however very exact in the longitude, which it makes 1°. 6′ eaſt of Edinburgh; ſo that, reckoning the longitude of Edinburgh 3°. 14′. 45″ weſt of Greenwich, as it is nearly, there remains 2° 8′. 45″ W. for the longitude of Aberdeen.

M. DE LA ROCHETTE, in a chart of the north ſea, conſtructed with great ſkill and accuracy, lays down Aberdeen in latitude 57°. 5′, and in longitude 2°. 21′. 31″ weſt from Greenwich; ſo that there is an error of nearly 4′ in the latitude, and 13′ in the longitude. It is likely that the latter affects the poſition of the coaſt for a conſiderable extent.

1797. Feb. 6. Mr Playfair on the weather of 1796.

Phyſ. Cl. A Report concerning the Weather in 1796 was communicated by Mr PLAYFAIR. [See this volume, the laſt Article of Part II.

APPEN-

APPENDIX.

OFFICE-BEARERS of the SOCIETY.

OFFICE-BEARERS elected for the enfuing Year, at the General Meeting held for that Purpofe, 25th November 1793. Office-bearers of the Society.

President.

His Grace the Duke of BUCCLEUGH.

Vice-Prefidents.

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

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

Counfellors.

Phyf. Cl.	*Lit. Cl.*
Mr *Benjamin Bell.*	Lord *Craig.*
Mr *Greenfield.*	General *Fletcher Campbell.*
Mr *George Fergufon.*	Mr *Mackenzie.*
Dr *Gregory.*	Lord *Dreghorn.*
Dr *Rutherford.*	Commiffioner *Edgar.*
Profeffor *Stewart.*	Mr *David Hume.*

OFFICE-

Office-bearers of the Society.

Office-Bearers of the Society.

Physical Class.

Prefidents.

Dr *Black*.	Dr *Home*.
Dr *Hutton*.	Dr *Monro*.

Secretaries.

Profeffor *Playfair*.	Dr *Walker*.

Literary Class.

Prefidents.

Mr Baron *Gordon*.	Dr *Hugh Blair*.
Sir *William Miller*.	Dr *Adam Ferguffon*.

Secretaries.

Mr *Frafer Tytler*.	Profeffor *Dalzel*.

At the General Meetings in 1794, 1795, and 1796, the fame office-bearers were elected.

LIST

LIST of MEMBERS *or* FELLOWS *of the* ROYAL SOCIETY *of* EDINBURGH, *continued from the third Volume.* [Hiſtory of the Society, Appendix.]

THE following Members were elected at the General Meeting, Jan. 27. 1794. Members choſen, Jan. 27. 1794.

NON-RESIDENT.

The Reverend *John Brougham* of Brookhill, county of Cavan, Ireland. *L.*
The Reverend *Dacre Carlyle*, A. M. *L.*
James Glenie, Eſq; F. R. S. Lond. *P.*

THE following were elected at the General Meeting, Jan. 26. 1795. Members choſen, Jan. 26. 1795.

RESIDENT.

The Reverend *George Baird*, D. D. Principal of the Univerſity of Edinburgh.
Robert Hamilton, Eſq; Advocate.
The Reverend *Thomas Hardy*, D. D. Profeſſor of Church Hiſtory in the Univerſity of Edinburgh.
Francis Humberſton Mackenzie, Eſq; of Seaforth.
Alexander Phillip Wilſon, M. D. Phyſician in Edinburgh.

NON-RESIDENT.

John Cooper, M. D. Phyſician at Fochabers.
William Garſhore, Eſq; of London.
John Gillies, LL. D. F. R. S. London, and Hiſtoriographer to his Majeſty for Scotland.

FOREIGN.

John Godfrey Smeiſſer, A. M. & F. R. S. London.
Gaſper Voght, Eſq; of Hamburgh.

Members choſen, June 27. 1796.

THE following were elected at the General Meeting, June 27. 1796.

RESIDENT.

Lieutenant-Colonel *Alexander Dirom*, F. R. S. London. *P.*
The Right Honourable Lord *Fincaſtle*. *P.*
The Reverend Sir *Henry Moncrieff-Wellwood*, Bart. D. D. *L.*
Patrick Murray, Eſq; of Ochtertyre, Advocate. *P.*

NON-RESIDENT.

Andrew Berry, M. D. Madras. *P.*
Sir *Henry Englefield*, Bart. F. R. S. London. *P.*
Dr *Freer*, Profeſſor of Medicine in the Univerſity of Glaſgow. *P.*
Dr *James Gaſcoigne*, Phyſician at Plymouth. *P.*
Richard Kirwan, Eſq; F. R. S. London. *P.*

FOREIGN.

Mark Auguſtus Pictet, Profeſſor of Philoſophy in the Academy of Geneva. *P.*
M. P. Prevoſt, Honorary Profeſſor in the Academy of Geneva. *P.*

THE

THE following were elected at the General Meeting, June 26. 1797. Members chosen, June 26. 1797.

RESIDENT.

Robert Beatſon, Eſq; of Kilrie. *P.*
Dr *Andrew Duncan junior*. *P.*

NON-RESIDENT.

The Reverend *Walter Fiſher*, Miniſter at Cranſtoun. *P.*
The Rev. *George Gleig*, L L. D. Epiſcopal Miniſter at Stirling. *L.*
Charles Hatchett, Eſq; F. R. S. London. *P.*
Major *James Rennel*, F. R. S. Lond. *P.*

FOREIGN.

John Jeffcot, M. D. F. R. Coll. of Phyſicians at Stockholm, and Profeſſor of the Practice of Medicine at Upſal. *P.*

Members deceafed.

LIST of MEMBERS *who have died ſince the Publication of the laſt Volume.*

Colonel *Edmonſtone* of Newton. June 24. 1793.

Honourable *James Veitch* of Elliock, (Lord *Elliock*), one of the Senators of the College of Juſtice. July 1. 1793.

Honourable *Francis Garden*, (Lord *Gardenſtone*), one of the Senators of the College of Juſtice. July 22. 1793.

Abraham Guyot of Neuchatel. May 22. 1794.

John Roebuck, M. D. July 16. 1794.

Reverend Dr *Bell*, Miniſter at Coldſtream. Auguſt 9. 1794.

Right Honourable Lord *Daer*. Nov. 5. 1794.

Charles Scott, M. D. Phyſician in London.

Sir *William Jones*, one of the Judges of the Supreme Court at Bengal, and Preſident of the Aſiatic Society.

Alexander Gerard, D. D. Profeſſor of Divinity, King's College, Aberdeen. Jan. 22. 1795.

Sir *Francis Kinloch* of Gilmerton. April 16. 1795.

Rev. *John Main*, D. D. Miniſter at Newton. May 13. 1795.

William Smellie, Printer in Edinburgh. June 24. 1795.

Adair Crawford, M. D. Phyſician to St Thomas's Hoſpital, London, and Profeſſor of Chemiſtry in the Academy at Woolwich. Auguſt 5. 1795.

Honourable *Alexander Abercromby*, (Lord *Abercromby*), one of the Senators of the College of Juſtice. Nov. 17. 1795.

James Robertſon, D. D. Profeſſor of Oriental Languages in the Univerſity of Edinburgh. Nov. 25. 1795.

John

John Anderfon, L L. D. Profeffor of Natural Philofophy in the Univerfity of Glafgow. Jan. 13. 1796.

George Campbell, D. D. Principal of the Marifhall College, Aberdeen. April 6. 1796.

Thomas Reid, D. D. Emeritus Profeffor of Moral Philofophy in the Univerfity of Glafgow. Nov. 7. 1796.

Honourable *John Maclaurin*, (Lord *Dreghorn*), one of the Senators of the College of Juftice. Dec. 24. 1796.

Thomas Gordon, Profeffor of Philofophy, King's College, Aberdeen. March 11. 1797.

James Hutton, M. D. March 26. 1797.

Archibald Arthur, A. M. Profeffor of Moral Philofophy in the Univerfity of Glafgow. June 1797.

DONA-

Lift of Donations.

DONATIONS presented to the ROYAL SOCIETY OF EDINBURGH, *continued from the preceding Volume.*

From the Author.

Charts of the China Navigation, fol. by *George Robertson*, Efq; F. R. S. Edin. and now Commander of the Berrington, Eaft Indiaman.

From the Author.

Hiftorical and Biographical Sketches of the Progrefs of Botany in England, 2 vol. 8vo, 1790, by *Richard Pulteney*, M. D. and F. R. S.

General View of the Writings of LINNÆUS, 8vo, 1781, by the fame.

From the Reverend *Andrew Brown.*

A Model of an Indian Canoe, with the Belt and Pouch of an Indian Hunter. 1794.

From the Author.

Syftem of Mineralogy, 2 vol. 8vo, 1795, by *J. G. Smeiffer*, F. R. S. Lond. & Edin.

From the Author.

Report of a Survey of the Thames, 8vo. 1794, by Mr *John Rennie*, Engineer, F. R. S. Edin.

From the Literary and Philofophical Society at Manchefter.

Manchefter Memoirs, vol. iv. Part 2. 1794.

From

From the American Academy of Arts and Sciences.

Memoirs of the Academy, vol. ii. part 1. Boſton, 1793.

From the Author.

Ueber die Bleyglaſur unſerer Topferwaare, vom Hofrath, G. A. Ebell. Hannover, 1794.

From the Editor, *Francis Maſeres*, Eſq; Curſitor Baron of Exchequer.

Scriptores Logarithmici, or a Collection of Curious Tracts on the Nature and Conſtruction of Logarithms, 3 vol. 4to. 1791, 1796.

From *John Thomas Stanley*, Eſq;

Three Views of Geyſer, a hot Spring in Iceland, from Drawings taken on the Spot.

From the Royal Society of London.

Tranſactions of the Royal Society of London from 1790 to 1794.

From the Author.

Remarks on the Antiquities of Rome and its Environs, 4to, 1797, by *Andrew Lumiſden*, Eſq; F. R. S. Edin.

From M. *Chevalier*, F. R. S. Edin.

On the pretended Tomb of HOMER, 4to. 1797.

I. Account *of the* Life *of Lord Abercromby*. By *Henry Mackenzie*, *Esq;* F. R. S. Edin.

[*Read by the Author*, *Feb*. 15. 1796.]

THE life of which I am about to give ſome account to this Society cannot be called a literary one; of literary lives only it is perhaps the proper buſineſs of the *Royal Society* to record the particulars; but it has been in the practice of allowing a wider range to this cuſtomary notice of its deceaſed Members. Of the lives of ſuch as were eminent in ſtation or in uſefulneſs, in abilities or in virtue, it has been accuſtomed to hear a narrative, which, though not important to learning, is intereſting to humanity. Under this title, it will indulge me with a ſhort account of the life of Lord Abercromby.

He was the youngeſt ſon of George Abercromby of Tullibody, a gentleman of a reſpectable family and conſiderable fortune in Stirlingſhire, and of Anne Dundas, daughter of Mr Dundas of Manor. He was born on the 15th day of October 1745. His father ſtill lives at the very advanced age of 91, and has had the ſingular good fortune to ſee two of his elder ſons, who were both bred ſoldiers, appointed Commanders in Chief of the Britiſh forces, one in the Weſt and the other in the Eaſt Indies, the moſt important ſtations with which their country could entruſt them. His age indeed has, within

Account of Lord Abercromby.

these few months, been clouded by the death of him who is the subject of this paper; but it is something for a father, it is something for his friends, to mix their sorrows with the general regret of his country.

His youngest son Alexander was early destined for the profession of the law, to which his father had himself been bred, at a time when the *Faculty of Advocates* comprehended one half of the gentlemen of Scotland. At that period, commerce and manufactures had not attained, in this part of the kingdom, that extension and improvement which renders them objects of pursuit to men of birth or fortune. The sword and the gown were here the only professions suited for such men; for our church did not, like those of England and France, offer endowments considerable enough to attract the interested or to excite the ambitious. In Scotland, however, the profession of the law was adopted by the eldest sons of the gentry, rather as conferring a sort of fashionable distinction, than as one from which they looked for business or emolument. It led to a learned, or at least a polite education, and gave a sort of dignity beyond the mere idleness of a man of pleasure. Hence perhaps there was in those times an elegance of manners, joined with a degree of knowledge and information, among the *Faculty of Advocates* in Scotland, not to be met with among any similar body of men in any other country. I mention this historically, because it does not perhaps exactly subsist at present, from causes which may be held not to improve the manners so much as, in a political and commercial view, they may be supposed to meliorate the situation of a country.

Mr Abercromby, with a view to the law, which his prospects made it necessary for him to follow as a profession, received the customary education at the University of Edinburgh. There the writer of this memoir first knew him. He had abilities which qualified him for being more a scholar, than the

 vivacity

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vivacity of his diſpoſition then allowed him to become. With uncommon beauty of countenance and pleaſantneſs of manner, the favourite of every relation and acquaintance, he did not then (as is common with young men ſo circumſtanced) apply to his ſtudies with the conſtant and unremitting aſſiduity which is calculated to attain deep learning. But he had a readineſs and acuteneſs that could eaſily perform his exerciſes when he wiſhed to perform them. After going through the ordinary courſe of claſſes at the Univerſity, conſiſting of the Latin and Greek languages, of Logic, Philoſophy, the Civil and Scots Law, he was admitted Advocate in the year 1766.

For ſome time after his coming to the bar, he retained ſomewhat of that gaiety of deportment and of conduct, which are not exactly ſuited to the dry and uninviting paths that conduct men to legal eminence. His manners and diſpoſition were better fitted for the leſs ſerious and more engaging ſociety of men of faſhion and pleaſure. During ſeveral years he lived a good deal in ſuch ſociety, and gave but little promiſe of that attention and application to buſineſs for which he was afterwards diſtinguiſhed. Though not unremittingly attentive, however, to his profeſſion, he was never neglectful of its duties; and when any particular caſe was put into his hands, he gave very convincing proofs, both of his general talents, and of his power of application to buſineſs in detail.

But it was not long before he felt the propriety of ſecluding himſelf more than he had hitherto done from the ſcenes of conviviality and amuſement, which had interfered with a more ſerious and determined application to his profeſſion. He had lent to lighter ſociety a certain gaiety and ſportfulneſs of mind, which, in a character of leſs native vigour and ability, might have been fatal to the future proſpects of his life. But he poſſeſſed an intrinſic character, which it was not difficult for him to reſume; and from that pride and dignity of ſoul which he

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always maintained in an uncommon degree, he felt it unworthy of him not to make every effort for riſing into eminence in the profeſſion which he had choſen, from which, being a younger ſon, and not likely to be poſſeſſed of a large patrimony, he was to derive ſupport and independence.

An opportunity ſoon occurred of drawing the attention of the Court in which he practiſed, and indeed of the country at large, to the talents which he poſſeſſed, and to that exertion of them which he could command. He was counſel in a cauſe, which, from its peculiar circumſtances, had attracted much public curioſity, and divided for ſome time the public opinion. This was the caſe of *Wilſon and Maclean*, in which a particular fact (the period of the death of a ſhipmaſter, from whom a receipt was produced in bar of the plaintiff's claim, but which receipt was alleged to be a forgery) was involved in ſo much uncertainty, and that uncertainty ſtrengthened by the oppoſite depoſitions of ſuch a number of witneſſes, that it became a queſtion of uncommon notoriety and expectation, not only from the extraordinary circumſtances of that individual cauſe, but as involving a general legal conſequence of the incertitude of oral teſtimony in fixing the date of not very diſtant events. In this cauſe Mr Abercromby was employed for the purſuer or plaintiff, and made a ſpeech, in oppoſition to one of equal ability from Mr Blair, now Solicitor-General, ſo conſpicuous for the cloſeneſs of its deduction, the force and clearneſs of its argument, the eloquence and impreſſive ſenſibility of its declamation, as to excite a very ſtrong ſenſation at the bar and in the public, and to mark him as an Advocate from whom the moſt ſtrenuous and ſucceſsful exertions were to be expected. It is ſeldom that at the bar of *Scotland*, any appearance, however brilliant, has much effect in bringing a counſel into profeſſional celebrity or employment. From the conſtitution of the Supreme civil Court in this country, where trial by jury does not take place, and

and from the nature of its proceedings, which are chiefly carried on by *written* arguments, a ſpeech, however remarkable, is rarely followed by thoſe important conſequences to a barriſter's future buſineſs, of which there are daily inſtances in *Weſtminſter Hall.* But in this caſe Mr ABERCROMBY's appearance made ſuch an impreſſion in his favour as very ſoon to place him among the moſt riſing young men of the profeſſion. He took advantage of this circumſtance by a ſtep, of which the expediency was doubted by many of his friends at the time, but was afterwards allowed by them all. Soon after his being called to the bar, he had been appointed Sheriff-depute of *Stirlingſhire*, which he now (in 1780) reſigned for the leſs lucrative and more precarious ſituation of *Depute-Advocate*, on the idea of the latter office being more beneficial in its conſequences, as not precluding him from buſineſs ariſing within the county of *Stirling*, where he had many connections both from relationſhip and acquaintance, but rather tending to advance his employment, from the opportunities it afforded him of appearing in public and criminal caſes. This appointment of *Depute-Advocate* he held under Mr HENRY DUNDAS, then Lord Advocate for Scotland, in conjunction with Mr BLAIR, ſince his Majeſty's Solicitor, and Mr CRAIG, now a Judge in the Courts of Seſſion and Juſticiary. Thoſe two gentlemen and Mr ABERCROMBY were as much connected in private friendſhip as in public buſineſs; a friendſhip to which one who has known them long and intimately, may be pardoned for aſcribing a conſiderable advantage towards the attainment of that profeſſional eminence, as well as of that general eſtimation and reſpectability which they have all enjoyed.

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Mr ABERCROMBY now roſe with great rapidity in his profeſſion, and was among the beſt employed barriſters of his ſtanding in Scotland. To this ſucceſs he was not more entitled by his talents than by his aſſiduity; and it was a peculiar merit in him, who

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who had once indulged ſo much in gaiety and amuſement, and who was ſo much fitted by nature to ſhine among the gay and the amuſing, to devote himſelf now to buſineſs with a rigid attention and punctuality not always met with even among men of the moſt grave and ſerious diſpoſitions. His ſpeeches and his papers were held in equal eſtimation. His general method in both was, to ſtate the *fact* which gave origin to the cauſe ſimply and perſpicuouſly, and then to apply thoſe principles and arguments in *law* which bore upon the caſe, from which he drew the concluſion in favour of his client. When the caſe admitted of it, he was fond of illuſtrating his argument by ſome appoſite claſſical alluſion, or ſome anecdote of ancient or modern times, with which his memory was abundantly ſtored. His expreſſion was always elegant, and when the ſubject called for it, roſe to a degree of animation and eloquence much beyond what buſineſs-men might think neceſſary in a mere legal pleading. He excelled particularly in that indignant tone in which a good man rebukes injuſtice or oppreſſion, and that pathetic in which he pleads the cauſe of the unfortunate; a ſtyle which his own mind, nice as it was in honour, and open to compaſſion, naturally prompted.

The laborious employments of his profeſſion did not ſo entirely engroſs him as to preclude his indulging in the elegant amuſements of polite literature. He was one of that ſociety of gentlemen, who, in 1779, ſet on foot the periodical paper, publiſhed at Edinburgh, during that and the ſucceeding year, under the title of the MIRROR, and who afterwards gave to the world another work of a ſimilar kind, the LOUNGER, publiſhed at Edinburgh in 1785 and 1786. To theſe publications he was a very valuable contributor, being the author of ten papers in the *Mirror* and nine in the *Lounger*. His papers are diſtinguiſhed by an eaſe and gentlemanlike turn of expreſſion, by a delicate and poliſhed irony, by a ſtrain of manly, honourable

nourable and virtuous ſentiment. In ſome of them we find that unaffected tenderneſs, of which I took notice above as frequently diſtinguiſhing his profeſſional labours. One of thoſe papers I have often read ſince his death, with feelings which I believe to be ſo much in uniſon with thoſe of my preſent audience, that I hope I ſhall not be thought to treſpaſs on their time or patience, if I quote the concluſion now. In N° 90. of the *Mirror*, he mentions as one of the calamities of extremely lengthened life, the loſs of friends, and gives a very natural and affecting account of his own feelings on an occaſion of that ſort. The picture contained in that paper is no *fancy-drawing*; it is a portrait of one of the earlieſt and moſt excellent friends of Mr ABERCROMBY, and of the writer of this memoir, Mr GORDON of *Newhall*, whoſe accompliſhments and whoſe virtues will not be ſoon forgotten by ſome members of this Society. Alas! I did not imagine, when I heard Mr ABERCROMBY read that paper of the Mirror, that, in a few years, it ſhould be applicable to the loſs of its Author! If any of thoſe who now participate in this reflection, ſhould one day have occaſion to recal in this place the remembrance of him who reads the preſent account, may his memory be as dear to his friends, and as valuable to ſociety, as thoſe to whom his feeble words now endeavour to do juſtice! Account of Lord Abercromby.

"THERE is one circumſtance (ſays Mr ABERCROMBY, in the paper I allude to) which with me is alone ſufficient to decide the queſtion (whether long life be an object much to be deſired). If there be any thing that can compenſate the unavoidable evils with which this life is attended, and the numberleſs calamities to which mankind are ſubject, it is the pleaſure ariſing from the ſociety of thoſe we love and eſteem. Friendſhip is the cordial of life. Without it, who would wiſh to exiſt an hour? But every one who arrives at extreme old age, muſt

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muſt make his account with ſurviving the greater part, perhaps the whole, of his friends. He muſt ſee them fall from him by degrees, while he is left alone, ſingle and unſupported, like a leafleſs trunk, expoſed to every ſtorm, and ſhrinking from every blaſt.

" I HAVE been led to theſe reflections by a loſs I lately ſuſtained in the ſudden and unlooked-for death of a friend, to whom, from my earlieſt youth, I had been attached by every tie of the moſt tender affection. Such was the confidence that ſubſiſted between us, that, in his boſom, I was wont to repoſe every thought of my mind, and every weakneſs of my heart. In framing him, nature ſeemed to have thrown together a variety of oppoſite qualities, which, happily tempering each other, formed one of the moſt engaging characters I have ever known. An elevation of mind, a manly firmneſs, a *Caſtilian* ſenſe of honour, accompanied with a bewitching ſweetneſs, proceeding from the moſt delicate attention to the ſituation and the feelings of others. In his manners ſimple and unaſſuming; in the company of ſtrangers modeſt to a degree of baſhfulneſs; yet poſſeſſing a fund of knowledge, and an extent of ability, which might have adorned the moſt exalted ſtation. But it was in the ſocial circle of his friends that he appeared to the higheſt advantage; there the native benignity of his ſoul diffuſed, as it were, a kindly influence on all around him, while his converſation never failed at once to amuſe and to inſtruct.

" NOT many months ago I paid him a viſit at his ſeat in a remote part of the kingdom. I found him engaged in embelliſhing a place, of which I had often heard him talk with rapture, and the beauties of which I found his partiality had not exaggerated. He ſhewed me all the improvements he had made, and pointed out thoſe he meant to make. He told me all his ſchemes, and all his projects. And while I live, I muſt ever retain a warm remembrance of the pleaſure I then enjoyed in his ſociety. Account of Lord Abercromby.

" The day I meant to ſet out on my return, he was ſeized with a ſlight indiſpoſition, which he ſeemed to think ſomewhat ſerious; and, indeed, if he had a weakneſs, it conſiſted in rather too great anxiety with regard to his health. I remained with him till he thought himſelf almoſt perfectly recovered; and, in order to avoid the unpleaſant ceremony of taking leave, I reſolved to ſteal away early in the morning, before any of the family ſhould be aſtir. About daybreak I got up, and let myſelf out. At the door I found an old and favourite dog of my friend's, who immediately came and fawned upon me. He walked with me through the park. At the gate he ſtopped, and looked up wiſhfully in my face; and, though I do not well know how to account for it, I felt, at that moment when I parted with the faithful animal, a degree of tenderneſs, joined with a melancholy ſo pleaſing, that I had no inclination to check it. In that frame of mind I walked on (for I had ordered my horſes to wait me at the firſt ſtage) till I reached the ſummit of a hill, which I knew commanded the laſt view I ſhould have of the habitation of my friend. I turned to look back on the delighful ſcene. As I looked, the idea of the owner came full into my mind; and, while I contemplated his many virtues and numberleſs amiable qualities, a ſuggeſtion aroſe, if he ſhould be cut off, what an irreparable loſs it would be to his family, to his friends, and to ſociety. In vain I endeavoured to combat this melancholy foreboding, by reflecting on the uncommon vigour of his conſtitution, and the fair proſpect it afforded of his enjoying many days. The impreſſion ſtill recurred, and it was ſome conſiderable time before I had ſtrength of mind ſufficient to conquer it.

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"I HAD not been long at home when I received accounts of his being attacked by a violent diſtemper, and in a few days after I learned that it had put an end to his life.

"THIS blow, for a time, unmanned me quite. Even now, the chief conſolation I find is in the ſociety of a few choſen friends. Should they alſo be torn from me, the world would to me be as a deſert; and, though I ſhould ſtill endeavour to diſcharge my duty in that ſtation which Providence has aſſigned me in life, I ſhould never ceaſe to look forward, not without impatience, to thoſe peaceful manſions where the weary are at reſt, and where only we can hope to meet again with thoſe from whom we have been parted by the inexorable hand of death."

IN 1792, when in this high and advancing ſituation at the bar, an offer was made to him of the appointment of Judge of the Court of *Seſſion*, in the room of Lord ROCKVILLE, deceaſed. This appointment he heſitated for a conſiderable time to accept, from an idea he had formed of the difficulty of executing the office in that manner in which he conceived it ought to be executed, and of the laborious and fatiguing application and exertions of mind which its various duties required. He was at length prevailed on to accept of it, principally from the very handſome manner in which it was offered to his acceptance, and in compliance with the wiſhes of his friend Mr Secretary DUNDAS, who knew, from early and continued acquaintance, the value of that acquiſition which he wiſhed the Bench to make, in the appointment of Mr ABERCROMBY to a Judge's ſeat. That appointment accordingly took place on the 30th of May 1792; and on the 14th of December following, he was called to a ſeat in the Court of *Juſticiary*, on the vacancy occaſioned by the death of Lord HAILES.

THE manner in which he executed thoſe very important offices, is freſh in the memory of every one. To the moſt aſſiduous and unremitting attention to his duty, and the moſt accurate conſideration of the legal principles which were to determine his deciſion, he joined a talent for announcing that deciſion, and the grounds on which it reſted, in ſuch a manner as to give ſingular weight and dignity to his opinion, and to make the ſtrongeſt impreſſion on his audience. He did not ſpeak often, but when he did, he never failed to throw light on the caſe before the Court. He never forgot, (what is liable to be forgotten in a Court which, from the number of its Judges, partakes ſomewhat of the nature of a popular aſſembly), that he was delivering the opinion of a Judge, not arguing the cauſe of a barriſter. He never replied to any of his brethren, remembering that a Judge does not ſpeak for victory; that it is his buſineſs to pronounce his own opinion, not to combat the opinions of others. He ſpoke ſhortly, ſeldom on the circumſtances of the caſe in detail, but on ſome leading and prominent point on which the opinion he was to deliver was founded. His expreſſion was clear and perſpicuous, correct, at the ſame time, and elegant. His ſpeaking was ſlow and deliberate, and in that cool and ſolemn manner which becomes a judicial opinion; yet, like his appearances at the bar, it did not fail in animation when it was directed to the cenſure of unfairneſs, to the detection of diſhoneſty, or to the rebuke of oppreſſion. He was of particular uſe in the civil Court, by an attention to the proceedings, and to the checking of any impropriety in the conduct of the buſineſs. On this ground, his own ſtrict obſervance of propriety gave him great advantage. When he did cenſure, even when there was occaſion for ſeverity, it was with ſo much gravity and dignity of manner, and ſo much temperance of expreſſion, as to enſure the approbation

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of the impartial, as to impreſs conviction, as well as to impoſe ſilence, on the cenſured. Lord ABERCROMBY poſſeſſed thoſe virtues and accompliſhments which inveſt the ſtation of a Judge with an authority the moſt venerable and the moſt perſuaſive. Purity of mind and of character, a nice ſenſe of honour and decorum, a delicacy of private and a dignity of public deportment; theſe are at all times moſt important qualities in a Judge; at no time perhaps ſo much as at the preſent, when they are ſo eſſential to conciliate the eſteem and to command the reverence of the people for the magiſtracy and conſtitution of their country.

To the *criminal Court* thoſe qualities are peculiarly appropriate. In that Court, the Judge is the organ of the offended majeſty of the law; his deportment ought to be ſuited to that function, grave, deliberate, decided. Above the atmoſphere of the paſſions, he may ſpeak with ſeverity, but never with reſentment; and his duty is too ſolemn and too majeſtic, to admit of the light or the frivolous, either in manner or expreſſion. Yet, amidſt the unbending declaration of the law, and the ſteady deciſion of its miniſter, he may, and in ſome caſes ought to feel that dignified compaſſion for human frailty, that tempers the rigour, but does not detract from the awfulneſs of juſtice. Such was the deportment of Lord ABERCROMBY. The firmneſs of his mind, and the dignity of his demeanour, were particularly called forth at that momentous juncture, when the deciſions of the criminal Court of Scotland vindicated the laws, and upheld the conſtitution, againſt the daring attacks of turbulence and ſedition.

THE laſt piece of duty which Lord ABERCROMBY performed as a Judge of the Court of Juſticiary, (immediately after the admiſſion of his friend Lord CRAIG as a colleague), was the northern circuit in the ſpring of the year 1795. On that jour-

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ney he felt himſelf a good deal indiſpoſed, but returned to Edinburgh, reſtored, as he ſaid, to his uſual health, though his altered looks and appearance ſtrongly excited the apprehenſions of his friends. Thoſe apprehenſions were but too ſoon verified. He was attacked in ſummer 1795 with a breaſt-complaint, attended with dangerous ſymptoms, for which, after ſome palliative means, to which his diſorder never at all yielded, he was adviſed to try the milder climate of *Exmouth* in Devonſhire, a voyage to the Continent being, in the preſent ſituation of public affairs, difficult to accompliſh, and particularly diſagreeable to his inclinations. He was accompanied in this journey by his nephew, the eldeſt ſon of his brother Sir RALPH ABERCROMBY, who watched the laſt days of his uncle with that tender aſſiduity which, though the world can neither ſee its merit nor feel its ſufferings, is one of the moſt important and moſt diſintereſted of all the domeſtic duties. On the road to Exmouth, he was ſeized with ſtill more violent ſymptoms than any his diſorder had hitherto exhibited; and though he experienced, during the ſpace of about two months, ſome temporary relief, he never gained any material advantage, and the diſeaſe made progreſſive advances, till at laſt it carried him off on the 17th day of November 1795. He bore its ſufferings with the greateſt patience and fortitude; and though for ſome time he entertained hopes which his phyſicians and friends ſaw to be but too ill founded, he met its concluſion with perfect compoſure and reſignation.

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THE diſorder which terminated ſo fatally was perhaps only the effect of a gradually debilitated conſtitution, not of any determinate and immediate cauſe. Yet ſome of his friends, with an anxiety natural in ſuch a circumſtance, have traced it to various ſources. An accidental fall into the uninclosed foundation of a houſe in the New Town of Edinburgh, was by

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ſome, I believe not on any medical authority, ſuppoſed to have produced the complaint to his breaſt. The anxiety and application he beſtowed on the duties of a very laborious profeſſion, might contribute to exhauſt the ſtrength of his conſtitution; and, if mental affections are to be allowed ſuch force, the uneaſineſs which for ſome years he experienced on the ſubject of public affairs and the political ſtate of his country, might impair and weaken his health and ſpirits. Deeply impreſſed himſelf with the excellence of the Britiſh conſtitution, and of the happineſs derived from it, he ſaw with horror and indignation (at a period conſiderably earlier than that which excited the apprehenſions of moſt other people) the efforts of deſperate and deſigning men to overturn it; he lamented the deluſion of thoſe who were miſled to join them; and he trembled for the effects of that deluſion in eſtimable and benevolent but viſionary minds, who might indulge the pride of political theory and ſpeculation, to the danger, as he conceived, of all good order and regular government, of all ſocial happineſs and ſocial virtue.

Of the public virtues of Lord Abercromby, I have given a pretty full detail, becauſe thoſe ſpeak loudeſt in example, and are moſt generally uſeful to mankind. Of his private virtues and accompliſhments I might ſpeak in this Society on the teſtimony of many of its Members, who will long remember the excellence of his diſpoſition, the worth and honour of his heart, the amiable and engaging manners which he exhibited. From birth, from education, from native ſentiment, and improved ſociety, he cultivated, and was never a moment unimpreſſed with the feelings of a *gentleman*, with that delicacy of mind, " above the fixed and ſettled rules," which poliſhes the manners, which refines morality, which dignifies virtue; of which ſuch an example is the more valuable in theſe days, when

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I am afraid a ſtyle of life and manners has become in ſome degree faſhionable, which deſtroys this honourable diſtinction; which degrades the higher ranks by vices and follies that uſed to be a reproach to the leaſt worthy among the lower; in which name and ſtation ſanctify groſſneſs in pleaſure and coarſneſs in demeanour, and wealth ſhoots out into caprice and abſurdity, inſtead of expanding into generoſity and uſefulneſs.

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THE Society will pardon this digreſſion, which I confeſs to be unneceſſary, and to ſome may appear ungracious; they will forgive it to him who, looking from the tomb of his friend on the world he has left, with that gentler miſanthropy (if it ſhall be thought to merit that term) which is made up rather of regrets than of reſentments, naturally enough indulges in an aggravation of what he has loſt, and, it may be, in an unfavourable eſtimate of what remains for him to enjoy.

INDEPENDENTLY, however, of the eſtimation of friendſhip, it may certainly be affirmed, that in the death of Lord ABERCROMBY ſociety has ſuſtained a loſs of no light nor common kind; a loſs which his friends and acquaintance will long and deeply lament; and which, without diſparagement to the virtues or the abilities of his ſurvivers, will not be eaſily repaired to the public.

II.

II. *A ſhort* ACCOUNT *of the* LIFE *and* WRITINGS *of WILLIAM TYTLER*, *Eſq; of Woodhouſelee*, F. R. S. EDIN. *By HENRY MACKENZIE*, *Eſq;* F. R. S. EDIN.

[*Read by the Author*, *June* 20. 1796.]

THE cuſtom which this Society has eſtabliſhed, of giving ſome account of the lives of its deceaſed members, is in every caſe gratifying to friendſhip, in many intereſting to curioſity, but in thoſe which ſerve to record the purſuits and occupations of men of letters, it is more ſtrictly and properly an object coming within the views of a literary inſtitution. The hiſtory of the authors is always in a great degree the hiſtory of the literature of a country; and even excluſive of an immediate relation to their works, the narrative of their private and domeſtic habits is often, in a moral point of view, uſeful and intereſting to the ſcholar and the author. In both theſe reſpects, I may claim the attention of the Society to the following ſhort account of the life and writings of our late worthy colleague, Mr WILLIAM TYTLER.

Mr TYTLER was the ſon of Mr ALEXANDER TYTLER, writer in Edinburgh, by JANE, daughter of Mr WILLIAM LESLIE, merchant in Aberdeen, and grand-daughter of Sir PATRICK LESLIE of Iden, Provoſt of Aberdeen. He was born at Edinburgh, October 12. 1711. He received his education at the High School and Univerſity of his native city, and diſtin-

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guished himself by an early proficiency in those classical studies, which, to the latest period of his life, were the occupation of his leisure hours, and a principal source of his mental enjoyments.

In the year 1731, he attended the academical lectures of Mr Alexander Bayne, Professor of Municipal Law in the University of Edinburgh, a gentleman distinguished alike for his professional knowledge, his literary accomplishments, and the elegance of his taste. The Professor found in his pupil a congenial spirit, and their connection, notwithstanding the disparity of their years, was soon ripened into all the intimacy of the strictest friendship. So strong indeed became at length that tie of affection, that the worthy Professor, in his latter years, not only made him the companion of his studies, but when at length the victim of a lingering disease, chose him as the comforter of those many painful and melancholy hours which preceded his death.

At the age of thirty-one, Mr Tytler was admitted into the Society of *Writers to his Majesty's Signet*, and continued the practice of that profession with very good success, and with equal respect from his clients and the public, till his death, which happened on the 12th of September 1792. He married, in September 1745, Anne Craig, daughter of Mr James Craig of Dalnair, writer to the Signet, by whom he has left two sons, Alexander Fraser Tytler, his Majesty's Judge-Advocate for Scotland, and Professor of Civil History in the University of Edinburgh, and Major Patrick Tytler, Fort-Major of the Castle of Stirling; and one daughter, Miss Christina Tytler. His wife died about nine years before him, and previously to that period, he had lost a son and a daughter, both grown to maturity.

It is perhaps only in smaller communities, like that of *Edinburgh*, that the union of business and literary studies can easily take place. In larger societies, such as that of *London*, here the

the professional objects are greater and more extensive, and the different classes of men are more decidedly separated from one another, there is a sort of division of mind as well as of labour, that makes the lawyer or the merchant a perfect lawyer or merchant, whose mind and time are wholly engrossed by the objects of his profession, and whom it might considerably discredit among his brethren of that profession, were he to devote any portion of either to classical study or literary composition. In Edinburgh it is otherwise; the professional duties are not in general so extensive as to engross the whole man, and his connections in society extending through many different classes of his fellow-citizens, he has opportunities of conversing, of reading, and of thinking on other objects than merely those immediately relating to the business which he follows. This is perhaps the most agreeable state of society of any, which, if it may sometimes prevent the highest degree of professional eminence and skill, (though even on that ground many arguments might be offered in its favour), certainly tends to enlarge the mind, and to polish the manners; to give a charm and a dignity to ordinary life, that may be thought ill exchanged for the inordinate accumulation of wealth, or the selfish enjoyment of professional importance. Account of W. Tytler, Esq;

AMONG that Society of which Mr TYTLER, at the period I have mentioned, was admitted a member, the *Writers to the Signet*, there were always many individuals possessed of much general learning and knowledge; and the classical education which was generally bestowed on young men destined for that Society, frequently led them to indulge in historical and literary disquisitions, little connected with the ordinary course of their professional employments. Mr TYTLER was one of those who, from his earliest years, had applied himself to letters and classical study; and amidst an accurate knowledge and unremitting attention to his business, he never ceased to cultivate and to enjoy them.

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THE moſt remarkable feature of Mr TYTLER's character was an ardour and activity of mind, prompted always by a ſtrong ſenſe of rectitude and honour. He felt with equal warmth the love of virtue and the hatred of vice; he was not apt to diſguiſe either feeling, nor to compromiſe, as ſome men more complying with the world might have done, with the faſhion of the time, or the diſpoſition of thoſe around him. He ſeldom waved an argument on any topic of hiſtory, of politics or literature; he never retreated from one on any ſubject that touched thoſe more important points on which he had formed a decided opinion. Decided opinions it was his turn to form; and he expreſſed them with a warmth equal to that with which he felt them. He took ſtrong common-ſenſe views of objects, not from want of acuteneſs to perceive leſs palpable relations, but from that warm and ardent caſt of mind to which ſuch views are more congenial than the ſubtleties of abſtract or metaphyſical diſquiſition.

NOR was it in opinion or argument only that this warmth and ardour of mind were conſpicuous. They prompted him equally in action and conduct. His affection to his family, his attachment to his friends and companions, his compaſſion for the unfortunate, were alike warm and active. He was in ſentiment alſo what JOHNSON (who felt it ſtrongly in himſelf, and mentions it as the encomium of one of his friends) calls a *good hater;* but his hatred or reſentment went no further than opinion or words, his better affections only roſe into action. In his opinions, or in his expreſſion of them, there was ſometimes a vehemence, an appearance of acrimony, which his friends might regret, which ſtrangers might cenſure; but he had no aſperity in his mind to influence his actual conduct in life. He indulged oppoſition, not enmity; and the world was juſt to him in return; he had opponents, but I ſincerely believe not a ſingle enemy. His conteſts were on opinions, not on things; his diſputes were hiſtorical and literary. In converſation, he carried

carried on these with uncommon interest and vivacity; and the same kind of impulse which prompted his conversation (as is justly observed by an author, who published some notices of his life and character in the periodical work entitled *The Bee*) induced him to become an author. He wrote not from vanity or vain-glory, which ROUSSEAU holds to be the only inducement to writing; he wrote to open his mind upon paper; to speak to the public those opinions which he had often spoken in private; opinions on the truth of which he had firmly made up his own conviction, and was sometimes surprised when he could not convince others; it was fair to try, if, by a fuller exposition of his arguments, he could convince the world. Account of W. Tytler, Esq.

WITH this view, he published, in 1759, his "Enquiry, historical and critical, into the Evidence against MARY *Queen of Scots*, and an Examination of the Histories of Dr ROBERTSON and Mr HUME with respect to that Evidence;" in which he warmly espoused the cause of that unfortunate Princess, attacked with severity the conduct of her enemies, and exposed the fallacy, in many parts the fabrication, of those proofs on which the charges against her had been founded. This work was the first on that side of this celebrated question which interested the public in general, and appealed in behalf of the Queen to the judgment and feelings of the people. The learned and industrious Mr WALTER GOODALL had several years before published his examination of the *Letters* of MARY, on which her accusers had so much rested as evidence of her guilt; but that examination, however elaborate and acute, was not well calculated, either in form or style, for general perusal. Mr TYTLER's work gave to the arguments of GOODALL the conciseness and compression necessary to command the attention of the reader, supported them by a variety of new proofs and illustrations, and drew from the general history of the period in question, and from the characters of the leading actors of the scene, arguments more impressive and interesting than any which

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which mere verbal criticiſm of the letters, or an examination of cotemporary documents, could ſupply. The firſt editions of the *Enquiry* were in one volume 8vo; but the author afterwards conſiderably enlarged it, particularly in the hiſtorical part, and publiſhed, in 1790, an edition (being the fourth) in two volumes of the ſame ſize.

THE problem of MARY's guilt or innocence, (to uſe the language of a near relation of Mr TYTLER's, expreſſive indeed of Mr TYTLER's own ſentiments on the ſubject), if conſidered merely as a detached hiſtorical fact, would appear an object which, at this diſtance of time, ſeems hardly to merit that laborious and earneſt inveſtigation to which it has given riſe; though, even in this point of view, the mind is naturally ſtimulated to ſearch out the truth of a dark myſterious event, diſgraceful to human nature; and our feelings of juſtice and moral rectitude are intereſted to fix the guilt upon its true authors. But when we conſider that this queſtion involves a diſcuſſion of the politics of both England and Scotland during one of the moſt intereſting periods of their hiſtory, and touches the characters, not only of the two ſovereigns, but of their miniſters and ſtateſmen, it muſt then be regarded in the light of a moſt important hiſtorical enquiry, without which our knowledge of the hiſtory of our own country, and of that political connection with England which from that time influenced all State-affairs in Scotland, muſt be obſcure, confuſed, and unſatisfactory. In addition to theſe motives of enquiry, this queſtion has exerciſed ſome of the ableſt heads both of the former and of latter times; and it is no mean pleaſure to engage in a conteſt of genius and of talents, and to try our ſtrength in the deciſion of a controverſy, which has been maintained on both ſides with conſummate ability.

IF to perſons, however, of cooler and leſs ſanguine tempers, it ſhould ſtill appear ſingular, that any ancient hiſtorical diſquiſition ſhould ſo keenly engage the minds and the paſſions of literary

terary men, it may perhaps be obſerved, that it is on objects of this ſort that theſe are frequently more occupied and excited than on others which might at firſt ſight appear better calculated to occupy and excite them. On objects of preſent and immediate concern, the mind and the affections have certain limits to which the actual and known intereſt neceſſarily confines them. The others have a ſort of ideal range which no ſuch fixed and certain boundary reſtrains. The intereſt is created, not found, and the fancy foſters and nouriſhes the ſubject of its own creation, till it engroſſes the attention and excites the paſſions to a degree that muſt appear very extraordinary to thoſe who conſider it in its natural and unexaggerated colours. Diſputes of literary as well as political enthuſiaſm, have therefore been generally the moſt obſtinate and warm of any; and this, which is quaintly termed the *Marian* controverſy, of all ſuch diſputes the keeneſt. Even Mr HUME, placid as he was from nature, and accuſtomed, from his earlieſt literary life, to contradiction and attack, loſt ſomewhat of his uſual temper on the occaſion, and ſubjoined an angry note to the latter editions of his Hiſtory, which I ſhall not quote, becauſe, from my reſpect for his memory, I am rather inclined to wiſh that it had not been written.

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WITHOUT venturing any opinion on the queſtion itſelf, it may be ſufficient in this place to ſay, that Mr TYTLER acquired high reputation by his diſcuſſion of it. The *Enquiry* was univerſally read in Britain, and very well tranſlated into French, under the title of "Recherches Hiſtoriques et Critiques ſur les "principales Preuves de l'Accuſation intentée contre MARIE "Reine d'Ecoſſe." The intereſt it excited among literary men, may be judged of from the character of thoſe by whom it was reviewed on its publication, in the periodical works of the time. Dr DOUGLAS, now Biſhop of Saliſbury, Dr SAMUEL JOHNSON, Dr JOHN CAMPBELL, and Dr SMOLLET, all wrote reviews of Mr TYTLER's book, containing very particular accounts of its

merits,

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merits, and elaborate analyſes of the chain of its arguments. As an argument on *evidence*, no ſuffrage could perhaps be more deciſive of its merit than that of one of the greateſt lawyers, and indeed one of the ableſt men that ever ſat on the woolſack of England, the late Lord Chancellor HARDWICKE, who declared Mr TYTLER's Enquiry to be the beſt concatenation of circumſtantiate proofs brought to bear upon one point, that he had ever peruſed. What effect that body of evidence, or the arguments deduced from it, ought to have upon the minds of thoſe to whom the ſubject becomes matter of inveſtigation, I do not preſume to determine. The opinion of the late Dr HENRY, author of *The Hiſtory of Great Britain on a new Plan*, may perhaps be thought neither partial nor confident; who ſays, in a letter to Mr TYTLER, publiſhed in the volume of *Tranſactions of the Antiquarian Society of Scotland*, That he would be a bold man who ſhould now publiſh an hiſtory of Queen MARY, in the ſame ſtrain with the two hiſtorians, (Mr HUME and Dr ROBERTSON), whoſe opinions on the ſubject the Enquiry had examined and controverted.

I CANNOT help obſerving, in juſtice to Mr HUME's impartiality, that no poſſible motive could be aſſigned for the prejudice which the favourers of Queen MARY have ſuppoſed him to entertain againſt her. As a party queſtion, in which view Mr TYTLER has placed it in his *Introduction* to the latter editions of his work *, Mr HUME had ſurely no bias to miſlead him

* "THE character, accompliſhments and misfortunes of this Princeſs, (ſays the Introduction), have been the ſubject of much writing and controverſy among the Britiſh hiſtorians. Republican writers, equally averſe to monarchy and to the Houſe of Stuart, have drawn her picture in the blackeſt colours, by traducing her as an accomplice with the Earl of BOTHWELL in the murder of the Lord DARNLEY her huſband. On the other hand, the writers attached to the ancient conſtitution of their country, and to the Family of STUART, have regarded that unfortunate Princeſs as one of the moſt virtuous and accompliſhed characters of that age, and as a victim to the ſecret conſpiracies carried on by ſome of the heads of the reformed party in her kingdom for her deſtruction."

him in the consideration of it; and it is a circumstance rather singular, that while he has generally been charged with *Toryism* by one party, he should, on the other hand, be accused by implication of *Republicanism* in this question on the history of the unfortunate Queen of Scots.

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THE other illustrious historian, whose opinions Mr TYTLER controverted in his Enquiry, though of opposite sentiments from Mr TYTLER as an author, lived with him in habits of private friendship and familiar intercourse. The last time Mr TYTLER dined at Dr ROBERTSON's, he saw with peculiar satisfaction HAMILTON's historical picture of Queen MARY, with the portrait of the Doctor on one side, and his own upon the other. Dr ROBERTSON, talking accidentally with the writer of this account on the subject of the *Marian controversy*, said, "I have told Mr TYTLER, that nothing but a regard for what I conceive to be historical truth, could have given my history that complexion which is so different from what he thinks it should have worn. MARY was the natural heroine of my history, if truth had allowed me to make her so."

SUCH would have been the natural vanity of an author; nor was the national vanity of a Scotsman less interested in the fate of this beautiful and unfortunate Queen, whom her evil destiny transplanted from the sunshine of a gay and gallant court to a barbarous and unfriendly clime; to a clime, shaken by the storms of faction, and desolated by the furious contentions of a tyrannical and savage aristocracy. It has been matter of regret with some who feel for the Princess in this view of her history, that her advocates have not left her cause to those feelings, but have pushed very far her pretensions to unimpeachable conduct and princely virtues, instead of pleading an apology for error or weakness, from the circumstances of the times and the intricacies of her situation. Even in the pages of ROBERTSON, after all that he has allowed of presumptive evidence for her impru-

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dence or her crimes, the sentiment of the reader, let his historical opinion be ever so adverse to the Queen, prevails over his justice, and the dramatic effect of the story is uniformly, compassion for the Princess, and resentment against her enemies.

To him who looks on that portion of history rather with the eye of a moralist than of an antiquarian, her marriage with BOTHWELL is the most unfavourable passage of her life, both as affecting the propriety of her conduct in that particular, and as tending to corroborate the evidence produced by her enemies on the great charge of privacy in the murder of her husband. Of that marriage, Dr HENRY thus expresses himself, in the letter I mentioned above, written to Mr TYTLER on the 20th of July 1790, a few months before his (Dr HENRY's) death. " Her last marriage (says the Doctor) was the most unhappy, and there seems still to be some difficulty in vindicating her conduct in contracting that marriage. Was she seized by BOTHWELL in her passage from Linlithgow, in consequence of a pre-concert, and with her own consent; or was it by mere violence, and without her having any intimation, that such an attempt was made? If I could answer that question, I should know what to think of several other things."

IN consequence of this letter from Dr. HENRY, Mr TYTLER wrote a *Dissertation on the Marriage of Queen* MARY *with the Earl of* BOTHWELL; which, with the letter that occasioned it, was published, in 1792, in the Transactions of the Antiquarian Society of Scotland, of which Mr TYTLER was one of the Vice-presidents. In this dissertation, he maintains, in conjunction with WHITAKER and STEUART, that the Queen's marriage with BOTHWELL was an object which the treacherous MURRAY and his associates had all along wished to accomplish, and that it was at last brought about by the daring ambition (encouraged by them) of BOTHWELL himself, who, having seized the Queen on her return from visiting her son at Linlithgow, carried her prisoner to Dunbar, where, by the most flagitious and violent

violent means, he firſt obtained the privilege, and then the legal character of a huſband. Account of W. Tytler, Eſq;

I HAVE placed this *Diſſertation* next in order to the *Enquiry*, becauſe both relate to the ſame hiſtorical fact, though in point of time it was the laſt of Mr TYTLER's compoſitions. Before that Diſſertation, he had produced ſeveral other works on hiſtorical and literary ſubjects, namely,

I. *The Poetical Remains of* JAMES *the Firſt, King of Scotland,*

In one volume 8vo, publiſhed at Edinburgh in 1783. The volume, of which the above is the general title, contains a Diſſertation on the Life and Writings of King JAMES the Firſt, one of thoſe Princes, in whoſe lives, diſaſtrous rather than unfortunate, adverſity was the parent of wiſdom and of virtue, and was cheared by religion, philoſophy, and the muſes. This Diſſertation introduces two well known ancient poems, which Mr TYTLER, on very ſtrong grounds, aſcribes to the King, *viz. The King's Quair*, and *Chriſt's Kirk on the Green.* The poem of *The King's Quair*, or in modern Engliſh the King's book, is a very ſtriking proof, not only of the poetical genius and imagination of its author, but of a taſte cultivated and refined by an acquaintance with the claſſical poetry of the ancients, and the works of thoſe eminent bards who were his cotemporaries, CHAUCER, GOWER and LYDGATE. The ſubject of the poem is the paſſion of JAMES for his lovely miſtreſs JANE, daughter of the Earl of Somerſet, who afterwards became his Queen; and the chief circumſtances of the poet's life, the misfortunes of his youth, his long captivity, the incident which gave riſe to his love, its purity, conſtancy, and ſucceſs, are well deſcribed under the quaint, but at that time faſhionable figure of poetry, allegorical viſion. This work, which is mentioned by JOHN MAJOR as the compoſition of JAMES, and which in later times had been ſeen by Biſhop TANNER in an ancient MS. among

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the Seldenian archieves in the Bodleian library at Oxford, was, in confequence of a diligent fearch made at Mr TYTLER's inftigation, happily recovered, and by him now for the firft time given to the public, with explanatory, critical and hiftorical notes. The poem of *Chrift's Kirk on the Green* was well known to the public, and had long been admired for its wit and humour; but it had been afcribed, even by antiquarian writers, to JAMES *the Fifth* of Scotland, the author of *The Gaberlunzie Man*, and other ludicrous compofitions. It occured to Mr TYTLER, that the public was in a twofold error refpecting this favourite poem; firft, in confidering it merely as a *jeu d'efprit*, or fanciful difplay of the author's imagination and powers in the ludicrous; and fecondly, in attributing the compofition to JAMES the Fifth. In the Differtation on the Life of JAMES the Firft, he has argued, with much ingenuity, that the fcope and view of the work was political and patriotic; its end, the beft purpofe of a Sovereign's writings, the improvement of his people. The Englifh at that time excelled all other nations in the ufe of the *bow*. JAMES, on his return to his kingdom, was mortified by the ftriking inferiority of his own fubjects in that particular to their warlike neighbours. The practice of archery, and of *weapon-fchawing*, a military exercife, had gone into fhameful neglect during the weak adminiftration of the Regents of the kingdom. To remedy this defect, a more regular difcipline was enforced by the young Monarch, by ftatutory regulations; who tried at the fame time the efficacy of ridicule in compofing this ironical fatire (for fuch, according to the ingenious fuppofition of Mr TYTLER, is *Chrift's Kirk on the Green*) on the awkward management of the bow, and the neglect of archery among the Scots. In the age of JAMES the Fifth, the vulgarly reputed author of the poem, the ufe of fire-arms had completely fuperfeded the bow as an engine of war. The laws of JAMES the Fifth required, that every man fhould arm himfelf with a hackbut or mufquet. In that era, therefore, the fatire on the want

want of ſkill in archery would have been loſt or miſapplied, its irony no longer felt, its ſalutary end no more perceived. Beſides this argument from the general tenor of the poem, Mr TYTLER has adduced the intrinſic evidence ariſing from the *language* of the piece, as clearly aſcertaining its date to belong to that period to which he has aſſigned it. Account of W. Tytler, Eſq;

AT the end of the poem of *Chriſt's Kirk on the Green*, is a note by Mr TYTLER, in which he pays a juſt tribute to the worth as well as genius of our celebrated paſtoral poet ALLAN RAMSAY, and contradicts, from his own perſonal knowledge, the abſurd ſtory of RAMSAY's not being the author of the well known paſtoral drama, *The Gentle Shepherd*.

SUBJOINED to the Diſſertation and Poems, is an Eſſay by Mr TYTLER (firſt annexed to ARNOT's Hiſtory of Edinburgh, publiſhed in 1788) on the *Scottiſh muſic*. This laſt was very properly included in the volume above mentioned, from its connection with the hiſtory of the Prince, whoſe poems it was the chief purpoſe of that volume to record and illuſtrate; the ſyſtem maintained by Mr TYTLER in this eſſay on the Scottiſh muſic, being, that the ſtyle of the ancient melodies of this country was firſt introduced by King JAMES the Firſt. This was chiefly founded on a paſſage in the *penſieri diverſi* of TASSONI, better known as the author of the celebrated mock-heroic *la ſecchia rapita*, who, mentioning the muſical talents of this Monarch, aſcribes to him the "invention of a new kind of muſic, plaintive and melancholy," which Mr TYTLER, in this eſſay, ſuppoſes was the original of thoſe beautiful and pathetic airs which are known and diſtinguiſhed as the national muſic of Scotland.

II. *Obſer-*

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II. *Obfervations on the VISION, a Poem firft publifhed in* RAMSAY'S *Evergreen.*

Thefe obfervations, which vindicate ALLAN RAMSAY'S title to the poems in queftion, were publifhed in the before-mentioned volume of the Antiquarian Tranfactions in 1792.

III. *An Account of the fafhionable Amufements and Entertainments of Edinburgh in the laft Century, with the Plan of a grand Concert of Mufic [performed there] on St Cecilia's Day* 1695.

Mr TYTLER was likewife the author of a paper in the *Lounger*, No. 16. "*Defects of modern Female Education in teaching the Duties of a Wife.*"

ON all Mr TYTLER'S compofitions the character of the *Man* is ftrongly impreffed, which never, as in fome other inftances, is in the fmalleft degree contradicted by or at variance with the character of the *Author*. He wrote what he felt, on fubjects which he felt, on fubjects relating to his native country, to the arts which he loved, to the times which he revered. A zealous Scotfman, a keen mufician, an old man with his youthful remembrances warm in his mind, he wrote on the hiftory of Scotland, on mufic, and on the amufements of former times in Edinburgh; and I confefs, that from a knowledge of this circumftance, I read his works with an intereft which I fhould not feel, if I confidered them as flowing from a pen which was the inftrument of the author's ingenuity rather than of his heart.

HIS heart indeed was in every thing he wrote, or faid, or did. He had, as his family and friends could warmly atteft, all the kindnefs of benevolence: he had its anger too; for benevolence is often the parent of anger. There was nothing neutral

neutral or indifferent about Mr TYTLER. In philoſophy and in hiſtory, he could not bear the coldneſs, or what ſome might call the temperance of ſcepticiſm; and what he firmly believed, it was his diſpoſition keenly to urge. Account of W. Tytler, Eſq;

HIS mind was ſtrongly impreſſed by ſentiments of religion. His piety was fervent and habitual. He believed in the doctrine of a particular providence, ſuperintending all the actions of individuals, as well as the great operations of nature; and he had a conſtant impreſſion of the power, the wiſdom, and the benevolence of the Supreme Being.

HIS reading was various and extenſive. There was ſcarcely a ſubject of literature or taſte, and few even of ſcience, that had not at times engaged his attention. In hiſtory he was deeply verſed; and what he had read his ſtrong retentive memory enabled him eaſily to recal. Ancient as well as modern ſtory was familiar to him, and in particular the Britiſh hiſtory, which he had read with the moſt minute and critical attention. Of this, beſides what he has given to the public, a great number of notes which he left in MS. touching many controverted points in Engliſh and Scottiſh hiſtory, afford the moſt ample proof.

IN muſic as a ſcience he was uncommonly ſkilled. It was his favourite amuſement; and with that natural partiality which all entertain for their favourite objects, he was apt to aſſign to it a degree of moral importance which ſome might deem a little whimſical. He has often been heard to ſay, that he never knew a good taſte in muſic aſſociated with a malevolent heart; and being aſked, what preſcription he would recommend for attaining an old age as healthful and happy as his own? "My preſcription, ſaid he, is ſimple: ſhort but cheerful meals, muſic, and a good conſcience." In his younger days, he had been a good performer on the harpſichord; but his chief inſtrument was the German-flute, which he thought peculiarly adapted to the expreſſion of thoſe natural and ſimple melodies in

which

Account of W. Tytler, Esq;

which he moſt delighted, the Scottiſh airs. He was one of the original members of the *Muſical Society of Edinburgh*, in which he continued, during a period of near ſixty years, till his death; during the greateſt part of which time, he was a Director of that Society, and felt for its permanence and proſperity that warm and lively intereſt, which animated him alike in buſineſs, in ſtudy, and in amuſement.

IN perſon, Mr TYTLER was rather thin, and ſomewhat below the middle ſize. His walk, even at the lateſt period of his life, was of that quick and ſpringy ſort which accorded with the activity of his mind. In his youth, he was fond of manly exerciſes, and often talked with regret of thoſe which the gentlemen of Scotland had loſt in the refinement or effeminacy of modern times.

ENDOWED with ſo many qualities adapted for friendſhip, Mr TYTLER had many friends, and among theſe were ſome of the moſt diſtinguiſhed literary characters of the age. In that number were the late Dr JOHN GREGORY, Principal CAMPBELL and Dr GERARD of Aberdeen, Dr REID, Dr BEATTIE, Lord KAMES, and Lord MONBODDO. A man who lives ſo long muſt neceſſarily loſe much of his cotemporary ſociety; but the loſs was compenſated to him more than it generally is to perſons of his age, by that intereſt which he took in the converſation and in the amuſements of the younger people who were the acquaintance or companions of his children.

HE was indeed of a temper remarkably ſocial, and found, from the congenial ardour of his own mind, particular delight in the company of young people; to whom, from the ſtore of anecdotes he poſſeſſed regarding the incidents, the manners, and the habits of former times, his converſation was equally inſtructive and entertaining. He was, however, one of thoſe fortunate praiſers of times paſt who are perfectly alive to the enjoyment of the preſent; whoſe partial recollection of former times and former joys reſults from the ſame warm and active

temperament,

temperament that ſtill preſerves cordiality for preſent friends and ſpirit for preſent amuſements. He retained this ardour and activity to the cloſe of life; and at fourſcore, was as ready as ever to join in the converſation, to participate the mirth, even to enter into the innocent convivial frolic of his young friends and relations. At his country-ſeat of *Woodhouſelee*, diſtant about ſix miles from Edinburgh, where he ſaw them with peculiar ſatisfaction, he had erected in a private and ſombre walk, an urn, with this inſcription: Account of W. Tytler, Eſq;

Hunc lucum
Caris mortuis amicis
Sacrum dicat
W. T.

Yet from this walk, from the indulgence of the remembrance and regrets which it inſpired, he would return to the ſocial circle within, with unbroken ſpirits and unabated cheerfulneſs.

In domeſtic life, Mr Tytler's character was particularly amiable and praiſe-worthy. He was one of the kindeſt huſbands and moſt affectionate fathers. At the beginning of this account, I mentioned his having loſt, at an advanced period of life, an excellent wife, and a ſon and daughter both grown to maturity, who merited and poſſeſſed his warmeſt affections. The temper of mind with which he bore thoſe loſſes, he has himſelf expreſſed in a MS. note, written not long before his death; with which, as it conveys a ſentiment equally important in the conſideration of this life, and in the contemplation of that which is to come, I ſhall conclude the preſent Memoir: "The lenient hand of time, (ſays Mr Tytler, after mentioning the death of his wife and children), the lenient hand of time, the affectionate care of my remaining children, and the duty which calls on my exertions for them, have by degrees reſtored me to

 myſelf.

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myfelf. The memory of thofe dear objects gone before me, and the foothing hope that we fhall foon meet again, is now the fource of extreme pleafure to me. In my retired walks in the country I am never alone; thofe dear fhades are my conftant companions! Thus, what I looked upon as a bitter calamity, is now become to me the chief pleafure in life."

III.

III. *A* BIOGRAPHICAL ACCOUNT *of Mr* WILLIAM HAMILTON, *late Professor of Anatomy and Botany in the University of Glasgow. By* ROBERT CLEGHORN, M. D. F. R. S. EDIN. *Lecturer in Chemistry in the University of Glasgow.*

[*Read 6th Nov.* 1792.]

IN writing the life of a person who himself published nothing, it is extremely difficult to satisfy the expectation of his particular friends, without incurring the charge of adulation from the rest of the public. How far I have succeeded in doing justice to Mr HAMILTON's merit, without insensibility or exaggeration, must be determined by those who knew him, and by those who can appreciate the worth of such professional remarks as I shall lay before them in the sequel. Mr WILLIAM HAMILTON was born in Glasgow July 31. 1758 *. Having finished the usual course at the Grammar School, he went to Glasgow College in 1770, and continued there studying with great diligence till 1775, when he became Master of Arts at the age of seventeen.

 HAVING

* HIS father was Mr THOMAS HAMILTON, an eminent surgeon, and professor of anatomy and botany in Glasgow; his mother Mrs ISABEL ANDERSON, daughter of Mr ANDERSON, formerly professor of church-history in the University of Glasgow.

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HAVING ſhewn an early and ſtrong predilection for the ſtudy of phyſic, he went to Edinburgh, which was then, as it is ſtill, the moſt celebrated ſchool of medicine in Europe. During the ſummer of 1775, he ſtudied botany under the late worthy Dr HOPE; and during the two enſuing winters he ſtudied with great ardour under all the medical profeſſors, and enjoyed the friendſhip of Dr CULLEN and Dr BLACK, who having been formerly members of the College of Glaſgow, were the companions and friends of his father.

Mr HAMILTON intended to have remained a third ſeaſon in Edinburgh, but the ſtate of his father's health rendered it neceſſary for him to give up this plan. Accordingly, in ſummer 1777, he accompanied his father to BATH, and from thence to London, where he was recommended to the particular notice of the late Dr WILLIAM HUNTER, and of his brother Mr JOHN HUNTER. Each of theſe gentleman was connected with Mr T. HAMILTON by early friendſhip, and a conſtant intercourſe of good offices. Under their direction Mr HAMILTON quickly diſtinguiſhed himſelf by that ardent purſuit of anatomical and profeſſional knowledge, which marked every part of his ſubſequent life. Though left at an early age to his own conduct, in a city abounding above all others with objects of pleaſure and amuſement, he reſiſted the blandiſhments of both, devoting his time to the acquiſition of knowledge, applying not only to thoſe parts of ſtudy which were entertaining, but to thoſe alſo which the young are apt to neglect as unintereſting, or to deſpiſe as uſeleſs, and manifeſting, on every occaſion, a diligence diſcouraged by no difficulty, and interrupted by few avocations.

SUCH conduct did not eſcape the eye of Dr HUNTER. Indefatigable himſelf, he was delighted with appearances of profeſſional zeal among his ſtudents; and he was ſo particularly pleaſed with them in the ſon of his old friend, that, after the firſt ſeaſon, he invited Mr HAMILTON to live in his houſe, and committed the diſ-

ſectingfecting-room to his care. In this ſituation, the beſt that a ſtudent of anatomy could wiſh for, Mr Hamilton continued two years hearing the lectures, and enjoying the converſation, of the firſt anatomiſt in London. How far, in Dr Hunter's opinion, he improved this opportunity, appears from the following letter addreſſed to Mr T. Hamilton, December 31. 1778: "Your ſon makes me very happy on your account, and for his own ſake. I ſee and hear much of him; and every body regards him as ſenſible, diligent, ſober, and of amiable diſpoſitions. He is now in the direct road for acquiring knowledge, as director in the diſſecting-room. It obliges him to apply, becauſe he is to anſwer any queſtion, and ſolve any difficulty that may occur; and which is beſt of all, he is to demonſtrate all parts of the body again and again to ſtudents. This is a moſt inſtructive province, and a fine introduction to giving lectures, as it gives facility in public ſpeaking, and a habit of demonſtrating diſtinctly and clearly, both of which are eaſily acquired while we are young; and yet, for want of that very opportunity, are poſſeſſed by few. In this way he will acquire not only knowledge, but a character for knowledge with the public, which a young man cannot procure but by being in ſome public ſtation."

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In another letter to the ſame gentleman, dated May 18. 1780, Dr Hunter ſays: "Your ſon has been doing every thing you could wiſh, and from his own behaviour, has profited more for the time than any young man I ever knew. From being a favourite with every body, he has commanded every opportunity for improvement which this great town afforded during his ſtay here; for every body has been eager to oblige and encourage him. I can depend ſo much on him, in every way, that if any opportunity ſhould offer for ſerving him, whatever may be in my power I ſhall conſider as doing a real pleaſure to myſelf."

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The opportunity hinted at ſoon occurred. Mr HAMILTON came to Glaſgow in 1780, and taught for his father during the enſuing winter. Having given moſt ſatisfying proofs of knowledge in anatomy, and of talents as a lecturer, he was appointed in 1781 ſucceſſor to his father, who had reſigned ſome time before. When conſulted about this appointment, Dr HUNTER ſaid to the Marquis of GRAHAM, now Duke of MONTROSE, "That from an intimate knowledge of Mr HAMILTON, as a man, and as an anatomiſt, he thought him every thing that could be wiſhed for in a ſucceſſor to his father, and that it was the intereſt of Glaſgow to *give him*, rather than his to ſolicit the appointment."

HIS father lived till January 1782; but the whole burden of lecturing, and the greateſt part of the buſineſs, devolved on the ſon. The buſineſs was very extenſive, as old Mr HAMILTON was connected with many of the moſt reſpectable families in Glaſgow and its neighbourhood. His profeſſional character, too, was high as a ſucceſsful practitioner, and a ſkilful operator; and being withal a man of great hilarity, and genuine humour, his company was courted by all who reliſhed wit and good fellowſhip. From the co-operation of ſo many favourable circumſtances, Mr HAMILTON's progreſs was extremely rapid, his outſet being encumbered with few of thoſe difficulties, which have often obſtructed the courſe of other young practitioners. His father lived long enough to introduce him fully. His youth did not diminiſh the confidence of his patients; becauſe, beſides knowing that he had ſtudied with uncommon care, in ſituations the moſt favourable for acquiring knowledge, they believed that he had ready acceſs at all times to the experience of his father. By gentleneſs of manners, by unaffected benevolence, by the moſt prudent circumſpection in all his conduct, and by unremitting attention to his patients, he not only retained moſt of thoſe who had employed his father, but added many

many to the number. While he practifed extenfively as a furgeon, his fkill in anatomy made him be confulted by many furgeons, older than himfelf, before they performed operations; and, in a few years, thofe who had been his pupils, practifing in diftant parts of the country, confulted him on fimilar occafions. Befides anatomy, he taught botany and midwifery; which laft he practifed with fuch fuccefs, that he was called to almoft every difficult cafe near Glafgow. In October 1783, he married Mifs ELIZABETH STIRLING, an accomplifhed lady, connected with feveral opulent families in Glafgow and its neighbourhood. From thefe connections, his practice, already extenfive, was very confiderably increafed.

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ANXIOUS to excel, not only as a fkilful phyfician, and an expert furgeon, but as a public teacher, he was led to confider every cafe that he treated more accurately than is ufually done by thofe who confine their attention to practice merely. Though naturally convivial, and endowed with a confiderable degree of his father's humour, he avoided company as much as he could with prudence, and devoted every vacant hour to ftudy, and efpecially to writing. He kept a regular account of all uncommon cafes, accompanying the conclufion of each with remarks fuggefted at the moment, and forming, at the end of each year, a general table of the difeafes which had prevailed during the different feafons. This plan facilitated his practice, and was highly gratifying to his patients, by convincing them, that their former complaints were diftinctly remembered: But he had a higher object in view than the affifting of his own memory, or the gratifying of particular patients. His object was to have publifhed a Syftem of Surgery, illuftrated with cafes, of which feveral are fully and accurately drawn up. As a fpecimen of what might have been expected from this work, had he lived to finifh it, I fhall mention a few particulars, which, on account of

their

Account of W. Hamilton.

their novelty or importance, ſeem moſt worthy of being recorded.

UPON performing lithotomy for the firſt time, he was ſtruck with the difficulty of introducing the gorget, and, on examination, he found it blunt at the point, where ſharpneſs was moſt needed, ſo that inſtead of cutting, it tore the urethra. The cuttler finding it difficult to ſharpen the gorget, as commonly made, up to the button which goes into the ſtaff, Mr HAMILTON directed him to make it in two ſeparate pieces, which, locking together, had all the firmneſs of the old inſtrument, with the advantage of being eaſily ſharpened when taken aſunder. This inſtrument he always employed afterwards in operating, which he did often, and with great ſucceſs.

IN midwifery he met with ſeveral uncommon caſes, of which the moſt remarkable are inſtances of two women who ſurvived a complete inverſion of the womb*. He detailed thoſe caſes to his pupils, along with others that ended fatally; and took occaſion from them all to enforce the neceſſity of avoiding force, or even haſte, in delivering women. The following extract, nearly in his own words, proves with what caution he treated his patients, and with what care he conſidered their caſes afterwards: "I have ſeen four caſes of inverted uterus, of which two patients died, and two recovered. This recovery is ſo ſingular, that I know only one caſe by THOMAS BARTHOLINUS ſimilar to it.

"THE great object in all caſes of ſuch danger, is to underſtand fully how the accident happens, that ſo we may be able to prevent is occurrence. It is evident, that the uterus can never be inverted when it is contracted, or even beginning to contract itſelf; it therefore muſt happen when the fibres of it are relaxed,

* BOTH theſe patients are ſtill alive; and the hiſtory of one is given in the Medical Communications of London, vol. 2.

relaxed, allowing themſelves to be bent in any direction, and when the uterus is ſtill large. This is the condition of the uterus; when the child has been forced away, either by the action merely of the abdominal muſcles and diaphragm, or by the aſſiſtance, as it is called, of the midwife, ſhould the placenta adhere to the very fundus or near it, a ſmall degree of force, applied to the cord, may invert the uterus while large, flaccid, and empty. Account of W. Hamilton.

"The ſureſt method of preventing ſuch an accident, then, is to produce a complete and regular contraction of the uterus, which may be accompliſhed more eaſily than ſome have imagined. For we know, that as long as any ſtimulus is applied to the cavity, and eſpecially to the mouth, which is the moſt irritable part of the womb, a contraction will take place, in order to expel the ſtimulating cauſe. Therefore, by allowing the child to be born ſolely by the pains of labour, by giving no aſſiſtance in the extraction, (except where the ſize of the child, or the malconformation of the pelvis, render aſſiſtance abſolutely neceſſary), and by preventing the delivery of the body from being accompliſhed by the abdominal muſcles ſolely, we force the uterus to contract itſelf, and to expel its contents. After the delivery of the body, by allowing the legs to lie for a ſhort time in the vagina, and to preſs on the mouth of the womb, we enſure its contraction.

"By ſuch management, the uterus having been made to contract itſelf properly, we have the placenta ſeparated, and ready for extraction. Thus, together with the danger of inverſion, we are freed from two more common accidents, *viz.* a retained placenta and a flooding. Beſides, the child is leſs hurt, when the ſlow delivery allows time for the dilatation of the paſſage; and it runs no riſk of thoſe ſprains and bruiſes which often happen in attempting to pull away the child without the aſſiſtance of a labour-pain.

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"I HAVE paid particular attention to this ſubject, and I have always found, that where the womb was inverted, where the placenta was retained, or where much flooding followed the birth, the child had been born, head and body at once, by a ſingle pain. An attention to this point, procured Dr HUNTER part of the fame which he ſo juſtly poſſeſſed, on account of his ſkill and caution in midwifery. He has often told me, that many women had been under his care, who, with other practitioners, had loſt much blood, and been expoſed to much danger, from the ſpeedy extraction of the after birth. By allowing it to ſeparate ſlowly from the uterus, and after ſeparation to lie for half an hour in the vagina, he completely avoided the flooding, and the danger that attends it."

MR HAMILTON was called to many caſes of luxation, both of the ſhoulder and thigh joint; in reducing which, he ſucceeded by very ſimple means, after other ſurgeons, who employed the force of machinery, had failed. On this ſubject he wrote an accurate paper; in which, after deſcribing the joints, with the ligaments and muſcles that ſurround them in a natural ſtate, he conſiders fully the change brought on every part by luxation, deducing partly from the ſtructure of the parts, chiefly from his own extenſive experience, the following directions concerning the beſt mode of reducing the joint to its natural poſition.

"THE ſituation of the muſcles round the joint differs much according to the kind of diſlocation.

"IN all caſes the deltoid is ſtretched, but particularly when the bone is thrown directly downwards. The long head of the biceps muſt be ſometimes torn, but, where it is not, it will be extended, and the ligament through which it paſſes, and which binds it to the humerus, will be always lacerated in a greater or leſs degree. The muſcles that are moſt deranged, are the ſupraſpinatus, ſubſcapularis, and infraſpinatus. Theſe two laſt we ſhall call the lateral muſcles of the joint.

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" In the diflocation downwards the fupraſpinatus will be on the ſtretch, the ſubſcapularis and infraſpinatus will have their fibres lengthened, and their direction altered, in conſequence of the head of the humerus being thrown below the glenoid cavity.

" When the bone is diſlocated outwards, and reſts on the dorſum ſcapulæ, the ſituation of the muſcles will be nearly the following: The ſubſcapularis and ſupraſpinatus will be both very much ſtretched, while the infraſpinatus, having the humerus thrown under it, will be relaxed, and a number of its fibres will be torn from the ſcapula, to make room for the head of the bone.

" In the third ſituation, when the bone is luxated inwards, the ſupraſpinatus and infraſpinatus will be on the ſtretch, while the ſubſcapularis will be relaxed, and in the ſame ſituation as its oppoſite muſcle has been deſcribed in the preceding ſpecies of diſlocation.

" This account is drawn from the natural ſituation of the parts, and the few caſes of diſlocation where there has been an opportunity of diſſecting the arm. It may be obſerved, that in all the three ſpecies of luxation, the ſupraſpinatus and deltoid are put much upon the ſtretch, the laſt in a leſs degree. From this we may infer the propriety of relaxing theſe muſcles completely during the time of reduction; and this is another reaſon for raiſing the arm when we attempt to replace the bone.

" Mr Thomson * ſpeaks of the head of the humerus being caught between the tendons of the infraſpinatus and teres minor, as in a nooſe; this can happen only in the luxation outwards, and is one reaſon for relaxing them completely in attempting reduction, by throwing the arm towards the ſide of the ſcapula, oppoſite to that where the head of the bone is lying. Having mentioned the ſituation of the muſcles, I ſhall now

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* London Medical Obſervations, vol. 2. p. 354.

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point out the changes that take place on the joint, when left unreduced, as being our proper guide in judging what line of practice is to be followed in ſuch caſes. An unreduced luxation may be deſcribed in three ſituations: The firſt, when the parts are little changed from the ſtate they are in, immediately after diſlocation happens. The ſecond, where motion is beginning to take place, and when the ſoft parts become adapted to the diſlocated ſtate of the bones. And the laſt, when a new joint is formed. After the head of the bone is lodged on ſome part of the ſcapula, it is found to conſolidate the cellular membrane and muſcular fibres under it, ſo as to form a kind of ſoft ſocket for itſelf, which, by the preſſure of the cartilage on the end of the humerus, and by the motion the arm admits of, gets a ſmooth ſurface. The burſal ligament torn on that ſide next the humerus, is pulled acroſs the glenoid cavity, and the muſcles will be found in the ſtate I have already deſcribed.

"After the inflammation and ſwelling, conſequent upon the injury, have gone off, the patient will be plagued with pains in the ſtretched muſcles, and will be incapable of moving the joint with eaſe. The inflammation will however make the lacerated parts grow together, ſo as to obliterate the paſſage through which the head of the bone eſcaped from the joint. This may be reckoned a luxation in a recent ſtate. After ſome time the muſcles begin to adapt themſelves to the ſtate of the bones, thoſe that were overſtretched are lengthened, and the relaxed ones contract, ſo that the perſon is capable of moving his arm, and by degrees the motion becomes more conſiderable. The burſal ligament now gets adheſions to the edges of the glenoid cavity, over which it lies, and the opening in it, through which the bone paſſed, is filled up, ſo that it embraces the humerus cloſely. The torn paſſage in the ſoft parts has become as firm as if no laceration had ever take place. The ſocket, formed in the cellular ſubſtance, between the head of the humerus and the ſcapula,

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ſcapula, begins now to be removed, from the conſtant preſſure made upon it; and before this, which we would call the ſecond ſtate of the diſlocation, is completed, that bone is reſting on the ſurface of the ſcapula itſelf. It is much to be wiſhed, that it were aſcertained, by accurate obſervations, when theſe changes take place, and particularly when the third ſtate, which we are next to deſcribe, begins. This laſt ſtate of a diſlocation is, when nature is beginning to form a new joint to ſupply the place of the old one.

" The ſoft ſocket having been completely removed, the humerus is reſting on the ſurface of the ſcapula. By preſſure, and frequent motion, a cavity is formed for the head of the bone; the ſurface of this new cavity becomes ſmooth, and is covered with a cartilaginous cruſt; the attachment of the humerus to the parts around anſwers the purpoſe, and at laſt aſſumes the appearance of a ligament, ſo that a new joint may be ſaid to be formed completely in all its parts. That this can happen, has been proved by diſſection; and particularly in a man, after whoſe death my father had an opportunity of examining his arm, which had been diſlocated for upwards of thirty years. This perſon was a fencing-maſter, and, as it was his right arm, he was obliged to perform with it a great variety of motions. He had acquired ſo completely the uſe of it, that he could perform all the different motions neceſſary in the ſmall ſword, except puſhing a high carte *.

" Monſieur Moreau † gives two caſes ſimilar to this, of old luxations of the thigh, where the head of the femur had formed a new acetabulum for itſelf in the os innominatum. Another caſe, though not of a diſlocated ſhoulder, I ſhall likewiſe deſcribe,

* Mr Thomson diſſected a man with a new ſocket, formed in the inſide of the ſcapula, Med. Obſ. vol. 2.

† Memoires de l'Academie de Chirurgerie, tome v. p. 45. ſmall edition.

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ſcribe, as illuſtrating the efforts of nature, to ſupply the motion between bones after diſlocation, and where a proceſs for forming a new joint, that, ſo far as I know, has never been deſcribed, is taking place. The bones are from a woman, who was diſſected in the theatre here, about four years ago; the thigh had been long diſlocated, and the woman had been able to walk about. The neck of the os femoris lay on the edge of the acetabulum, while the head, which is changed in its ſhape from the preſſure of the ſurrounding parts, was on the dorſum ilii beyond this cavity. The edge of the acetabulum filled up the hollow at the neck of the femur, which is made deeper by its preſſure. There are two proceſſes of bone growing into the acetabulum from the os femoris, and which at laſt would have formed a kind of head to play in this the cavity of the old joint, and thus have made a new one conſiderably different from that in the caſes already mentioned. By one or other of theſe different ways, nature attempts to remedy the injury done to a limb after luxation. At the time the head of the humerus is forming a new ſocket for itſelf, the glenoid cavity is deſtroyed, its ſides approach each other, and the hollowed part is filled up by granulations of bone. The burſal ligament adheres to the ſurface of this cavity, and is thus to all appearance loſt.

"The patient continues in this ſtate, with a joint either more or leſs perfect, and, when proper attention has been paid, the new joint may be made a very uſeful one; and to this point alone our treatment of old diſlocations ought to be directed. The treatment of luxations muſt differ according to the ſtate of the diſeaſe. When they are recent, reduction in the eaſieſt and ſafeſt manner is the ſurgeon's object: And here we ſhall make a few obſervations, drawn partly from what we have already ſhown to be the ſtate of the joint and muſcles, and partly from experience.

"The head of the humerus being in all caſes pulled beyond the glenoid cavity, and lodged on the ſcapula, the firſt ſtep towards

wards replacing it, muſt be to draw it out, ſo as to bring it over that cavity out of which it was thrown. Account of W. Hamilton.

"THIS is to be done by making the extenſion of the arm, with ſuch a degree of force as to ſeparate the bones from each other, and ſo applied that it may act only upon the parts round the diſlocated joint. When extenſion is omitted, as was the caſe among the old ſurgeons, the attempts made by the lever to force the humerus into its place, ſo far from having ſalutary, were attended with very bad, conſequences. Extenſion, however, in the modern practice, is our firſt view. The reſiſtance to the extenſion is owing to the contraction of the ſurrounding muſcles, which is partly voluntary, and partly the effect of their being much ſtretched, from the new ſituation of the bone. The firſt it is ſeldom in our power to prevent, as the terror of reduction, and the uneaſineſs conſequent upon moving the arm, makes the patient exert his muſcles to reſiſt what gives him pain; and ſo far as no reſolution in him can prevent this action, it may be ſaid to be involuntary. Were it poſſible to deceive him, and make him ſuppoſe we were only examining the ſtate of his arm, when we were really making the proper extenſion, this cauſe of difficulty might be overcome in ſome degree. The reſiſtance from the overſtretched muſcles is of more importance, as it is in our power to prevent it, and, when not attended to, muſt increaſe the ſurgeon's difficulty, and by extending the muſcles, already too much on the ſtretch, may produce greater laceration than from the diſeaſe intended to be remedied.

"THE obſervations we have already made on the ſtate of the muſcle after diſlocation, muſt now appear neceſſary, being on a ſubject little attended to, though of great importance, and particularly as they lead us to place our patient in ſuch a manner as to remove this cauſe of difficulty and danger.

"ANOTHER cauſe preventing reduction, is the bone being pulled in ſuch a direction by the ſurgeon, as not to paſs through the

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the cavity it formed for itſelf in diſlocation, but is made to preſs on the ſurrounding parts, ſo that if the force is continued to be exerted in the ſame direction, a new paſſage muſt be torn for it. This, like the laſt, may be avoided, by attending to the moſt probable poſition of the limb when the accident happened. We have attempted to prove, that, in general, diſlocation is moſt apt to happen when the arm is raiſed; and therefore that this poſition is the preferable one for reduction. I ſuſpect in many caſes, where improper attempts to reduce the bone have been made, that the difficulty is increaſed by the bone tearing a paſſage for itſelf in a new direction, and thus, by twiſting the muſcles, preventing reduction from being accompliſhed.

" THE laſt obſtacle is from the burſal ligament. As in no caſe of diſlocation the head of the bone can paſs out without lacerating it, ſo, in reduction, it cannot be replaced, unleſs it is brought through the ſame opening by which it went out; for if we attempt to bring the humerus over the glenoid cavity in a wrong direction, the ligament will get between it and the ſcapula, and thus, when apparently reduced, the bone will return to its old ſituation, as ſoon as the arm is let looſe. This can be avoided only by the poſture of the limb; and here alſo, in the raiſed ſtate of the arm, the bone will return moſt readily through the opening in the ligament, as being put into the ſame poſition in which it was luxated.

" THESE three great difficulties in reduction, then, are to be remedied by a proper poſition of the patient and of his arm; and this, I think, there can be no doubt, is by placing him ſo, that the extenſion may be made when his arm is raiſed. In order to this, I make him ſit on the ground, the ſcapula, with the glenoid cavity upwards, being kept fixed by two aſſiſtants who are placed behind him. I put a towel round the humerus, immediately above the elbow, both to give me a firmer hold of the part, and likewiſe, that, if neceſſary, I may have a place for an aſſiſtant

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or two in the extenſion to lay hold by. The fore arm is bent up, ſo as to relax the biceps completely; and this I prefer to the ſtate of half flexion, as the extenſor triceps is not one of the muſcles that gives any difficulty in reduction. When the bone is luxated directly downwards, I make the extenſion ſtanding oppoſite to the patient's ſide; but, when it is either outwards or inwards, I place myſelf towards that ſide, oppoſite to where the head of the bone is lying, and I carry the arm in the ſame direction. If, for example, the head of the humerus is under the pectoral muſcle, I carry the arm outwards towards the patient's back, and *vice verſa*.

" I THEN begin to make the extenſion with a ſlow and ſteady force, but of ſuch a kind as I find is capable of overcoming the reſiſtance of the muſcles, and of bringing the bone out of its place. After it is completely diſengaged, it is pulled into the glenoid cavity by the action of the ſurrounding muſcles, ſo as not to require any preſſure in the axilla to raiſe it up. In this manner I have reduced ſeveral diſlocations of the ſhoulder; and in none have I failed, or been obliged to uſe the force I have ſeen applied in other modes of reduction, and without effect. Among the caſes I have ſucceeded in, there were ſeven where all the other methods had been tried in vain; and in three of theſe the arm had been out for three weeks. Mr WHITE of Mancheſter * has employed a mode of reduction ſimilar to this, as to the poſition of the arm; but I think the other parts of his plan are not equal to that here deſcribed. The raiſed ſtate of the arm is likewiſe adviſed by Mr THOMSON, from the ſituation he found the muſcles in the diſſection of two men with diſlocated humeri, who had died before reduction had been effected.

" IN this manner of reduction, all the extended muſcles are relaxed by the arm being raiſed; the ſupraſpinatus and deltoid

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* Medical Obſervations, vol. 2. p. 373.

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in the diſlocation downwards; and in that to the ſide, by turning the humerus towards the ſide of the ſcapula oppoſite to that on which its head is lodged, the lateral muſcle is taken off the ſtretch it was put into by the diſlocation. When theſe over-ſtretched muſcles are thus attended to, the reduction becomes more eaſy to the ſurgeon, and much leſs hazardous to the patient, as laceration is guarded againſt.

" AFTER long and violent attempts to reduce the ſhoulder, particularly with the muſcles on the ſtretch, I have heard of the bone becoming ſo looſe, that when it had been at laſt got into its ſocket, it fell out again very readily. This I imagine muſt have been owing to the muſcles round the joint, and the ligament, having been very completely torn, ſo that the humerus had loſt its natural ſupport. In the two modes of reduction moſt commonly made uſe of, the ſtate of the muſcles is not enough attended to. When the arm is at an acute angle with the ſide, as when we attempt to force in the bone with the heel in the axilla, the ſuperior muſcles are very much on the ſtretch; and when the patient is placed on a chair, and the arm forms a right angle with the body, they are ſtill not ſufficiently relaxed to prevent additional difficulty and danger; and I muſt agree with Mr THOMSON in thinking attempts in theſe directions often the cauſe of ſucceeding bad conſequences. Another advantage of reduction with the raiſed arm is, that as ſoon as the humerus is diſengaged from the ſcapula, the muſcles, that from the nature of the diſlocation were moſt extended, contracting, pull it into its ſocket. In other modes of reduction, a conſiderable force is required to preſs the bone into its place, after the arm is fully extended. When this force is great, the parts that lie over the bone muſt be bruiſed, particularly if a hard body is uſed to effect this purpoſe. On this account the *Ambe*, both of FREACK and PETIT, appears to me a bad inſtrument. It pulls out the arm at right angles, and therefore it requires conſiderable action

tion of the end of the inftrument as a lever to force the humerus into its place, while the preffure on the patient's fide is equal to the force of the extenfion. It can likewife be properly ufed only in the diflocation downwards. Account of W. Hamilton

"In all diflocations of the humerus, the extenfion, I think, fhould be made with the hands, in place of pulleys, as by the firft, the direction of the bone can be better adapted to the refiftance and fituation of the furrounding parts.

"In what we called the fecond ftate of an unreduced diflocation, the obftacles are more numerous than in the recent. The mufcles have now adapted themfelves to the fituation of the bones, the hole in the ligament is in part grown up, and the lacerated paffage in the foft parts is obliterated, the fides of it having, by inflammation, adhered to each other. Thefe being added to the difficulties in recent luxations, render the reduction here both more difficult, and more apt to be attended with laceration, than in the other. Thefe obftacles are to be got over, however, by the fame means. The patient ought to be put into the fame pofition, and the extenfion made in the fame manner, only it will require the force to be greater, and to be longer continued, before it accomplifhes the end in view. I do not think, however, it will be neceffary to employ any other method, (as that of Mr White), as every thing may be done by the hand, that can be expected from pulleys.

"In the laft ftate, and even in the latter part of the fecond, inftead of reduction, we fhould attempt to render the new joint that is forming as perfect as poffible. This is to be done principally by making the patient ufe his arm as often, and for as long a time as he can, without pain or fatigue, and to perform with it a variety of motions.

"In this way we will haften the formation of the new joint, and render him fooner capable of ufing his arm. That this is poffible is evident from the cafe of the fencing-mafter already

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mentioned, who followed his profeſſion for upwards of five and twenty years before his death, and who, by being obliged to uſe his arm, acquired the motion of the new joint ſooner than if he had been under no ſuch neceſſity.

"It is a matter of importance to aſcertain when the changes, we have deſcribed, take place. I imagine the recent ſtate may continue for a fortnight or three weeks: But ſtill we want obſervations to point out when the muſcles become completely adapted to the new ſituation of the bones; when the glenoid cavity begins to loſe its ſhape, and the ligament to adhere to it; and, particularly, when the ſurface of the ſcapula begins to become hollowed and ſmooth, ſo as to receive the head of the humerus. Theſe, however, may be gueſſed at, by the quality and degree of motion enjoyed in the diſlocated joint. Were theſe points fully aſcertained, they would guide us in our practice, and prevent attempts being made to reduce old diſlocations, where the ſurgeon, from want of knowledge of the proceſs carrying on by nature to form a new joint, and the obliteration of the old cavity, racks the patient's limbs to no purpoſe; and even ſhould he be ſucceſsful, he might be ſaid not to reduce, but really to diſlocate, as he deſtroys a new joint beginning to enjoy motion, and throws the end of the bone on a ſurface which has now loſt every thing neceſſary to make it a part of a joint."

Mr Hamilton had occaſion once to open the cheſt of a *Lady*, who had water in her breaſt. The quantity at firſt drawn off amounted to ſixteen ounces; a great deal oozed out afterwards, and ſome of the ſymptions were for a little relieved, but the patient died in a few weeks. On the beſt manner of performing this operation, he makes the following remarks:

"In Mr Bell's mode of operating, which I here followed, ſimply drawing off the water, and avoiding every thing that may bring on inflammation on the cavity, is not ſufficiently kept in view. An extraneous body, a canula, is introduced and kept in

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for two or three days. The effect of this practice is evident; inflammation may be brought on over the cavity; ſuppuration will ſucceed, and the caſe will be converted into one of empyema, with an opening in the cheſt. The effects of keeping in a canula in the abdomen were found, by the old ſurgeons, to be ſo bad, that the practice was given up, even before the faintneſs, from drawing off the water at once, was ſo well underſtood as to be capable of being prevented. In our patient, ſymptoms of inflammation from the canula were beginning when it was withdrawn, and had it been kept in another day, the inflammation would probably have become ſo conſiderable, that it might have been expected to produce the worſt conſequences.

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"The view with which a canula is introduced and kept in, is, to allow the water to run off only when we chooſe it, and to prevent air from getting into the cavity. The firſt intention it does not anſwer; as in our patient, though it was introduced through the pleura when only a ſmall perforation had been made in it, ſo that it might be cloſely embraced, the water oozed out by its ſides, and more was diſcharged in this way than by the canula itſelf.

"Air is likewiſe more apt to get into the cavity by the canula, than if the water was diſcharged without it. It is impoſſible to ſtop it ſo accurately and quickly with the finger or cork, as to prevent the acceſs of air, when there is little water left, or when the lungs are not in a ſituation to fill the cavity, and eſpecially when the patient is inſpiring. This I found to be the caſe, when I drew off the laſt water by it. But before I left the patient, I evacuated the air as completely as poſſible, by depreſſing that ſide of the cheſt during expiration.

"From the ſtructure of the thorax, air is apt to be drawn in by the external wound, and is again not eaſily expelled. The moſt ready method of evacuating it, is by compreſſing that ſide of

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of the cheſt during expiration, at the ſame time preſſing up the viſcera of the abdomen, ſo as to make the diaphragm aſcend; and thus, by leſſening the cavity, while the patient, by ſhutting the glottis, prevents the air from eſcaping, but forces it into the collapſed lung, we force out as much of it as poſſible. Other ways of evacuating it hath been ſuggeſted by different writers. Sucking it out by a ſyringe, or an elaſtic bottle, are common propoſals, but I am afraid can never be put in practice. The bottom of the wound between the ribs is ſo irregular, that they can never be applied when the canula is out; and when it is in, more air would be admitted during the time the ſyringe, or bottle, was fitting on, than could be extracted by them. But after all the water is evacuated, the wound muſt be healed up, for if not, ſuppuration will come on the wound, and when the canula is then withdrawn, the ſkin, that was intended to act as a valve, will have become fixed by the inflammation, and will not come down over the hole in the pleura, ſo that air muſt be admitted, though it was excluded before.

" WHETHER common air does hurt to any cavity, I doubt much. Water, with a penetrating wound, would be as bad. The inflammation of the wound is what is moſt to be dreaded, as it ſpreads from that over the whole cavity. The canula, therefore, as inducing inflammation, muſt, in my opinion, be very hurtful.

" IN place of the operation deſcribed by Mr BELL, I would propoſe doing it in the following manner: I would place my patient in the common poſture, and, after the ſkin was well pulled up, make my inciſion in the uſual place and manner, till I came down to the pleura. I would then make an opening through it, about half an inch in length, merely dividing the membrane. In cutting into the cavity, great care ſhould be taken not to do it raſhly, leſt an adheſion of the lungs to the pleura be over the inciſion. At the ſame time we muſt expect to find the

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the pleura much thicker than it naturally is, owing to the effects of inflammation, and the preſſure of the water, ſo that a timid operator, not aware of this circumſtance, (which is not taken notice of), might deſiſt, from an idea of having met with an adheſion, when he was really only half way through the membrane. In a caſe of hydrothorax I opened, I found the *pleura coſtalis* a fifth of an inch thick. I would then allow as much water to run off as I thought proper, two aſſiſtants making ſuch a degree of preſſure on the ribs of that ſide as to prevent their being raiſed in breathing, during the time the fluid was diſcharged. After I had drawn off ſuch a quantity as flowed readily, and the patient could bear without faintneſs, I would bring the looſe ſkin over the hole in the pleura, and fix it there with ſlips of emplaſt. adheſiv.; I would then lay the patient on the diſeaſed ſide, ſo as to allow the water to ooze off by the wound, while air would be prevented from getting in, by the ſkin acting as a valve. If the patient grew faint, from the evacuation being too quick, it could eaſily be leſſened, or ſtopped, by making him turn more and more towards his back, or oppoſite ſide, ſo as to make the hole in the pleura leſs a depending opening; or, by making preſſure upon the ſkin over the opening, the diſcharge might be completely ſtopped. If the lung was not diſeaſed, as the water flowed off, it would be more and more filled with air, and expanded. If it was ſo much diſeaſed as to be incapable of expanſion, by no mode of operation can more water be drawn off than what diſtended the cavity; a quantity muſt be left equal to the want of enlargement of the lung; if we draw off more than this, air muſt ſupply its place; for we are not to imagine we can take away all the water, and leave a vacuum. The wound will admit of the water oozing long enough to evacuate all that ſhould be taken away; and it will not be prevented from healing, ſo as to endanger the patient, from the riſk of internal inflammation. If we find a

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large quantity thus evacuated, it will prove the lung of that ſide to be ſound; as, air being entirely excluded, the cavity muſt be filled up by that alone, after the water is diſcharged. If little runs off, it is probably one of theſe caſes where the lung is ſo much indurated as to be for ever incapable of performing its function. In the firſt caſe, the patient may derive benefit from the operation; the diſeaſe may be prevented from recurring. In the other we have done him no hurt; he will breathe more eaſily as long as the oozing continues, by taking away the redundant water, but, as this cannot be kept up long, he muſt at laſt be left to his fate.

" LAYING the patient on the diſeaſed ſide after the operation muſt be of ſervice, as it both allows the water to run off, and it prevents him from enlarging that ſide of the cheſt, and thus running a riſk of drawing in air by the wound. When a canula is kept in, this is impracticable; the patient cannot be laid much towards that ſide without the canula preſſing on the bed-clothes. In the manner I have propoſed, the operation will, I think, be more ſafely performed, and might therefore be oftener tried.

" WHAT I have ſaid applies only to hydrothorax. In empyema an opening muſt be kept in the cheſt, to diſcharge the matter as it forms. The two diſeaſes certainly require different ſurgical treatment. In the firſt, inflammation has not come on, and is to be guarded againſt In the other, the collection of matter is the effect of it, and its being regularly diſcharged will, if any thing can, abate it. I ſhould therefore follow Mr BELL's plan* in this, though I would differ from it in the other; and as the ſteps of the operation in theſe two caſes would be the ſame, except leaving in the canula in empyema, we may attempt it

* THE canula recommended by Mr BELL has no lip or margin round the opening. By ſuch an addition it has a hold of the parts round the opening, and can be kept much ſteadier.

it when proper, though we may not be certain of the nature of the fluid contained. In moſt caſes we may aſcertain this before from the ſymptoms; but, at all events, the puncture in the pleura will put it beyond a doubt." Account of W. Hamilton.

Mr Hamilton had an opportunity of ſeeing ſeveral herniæ in women, upon ſome of whom he operated ſucceſsfully; and, from conſidering all the caſes he had ſeen, he was led to make the following remarks, ſome of which he thought new.

"When I began the practice of ſurgery, as I had never met with a caſe of hernia in women, I believed implicitly in the doctrines we find in every writer on the ſubject, *viz.* that women have ſeldom bubonocele, but are more ſubject to femoral hernia. Soon after I had begun to practiſe, I was called to a conſultation about a woman with a hernia, which had been ſtrangulated for two days. As it was placed in the groin, I at firſt ſight thought it a femoral hernia; but, upon examining it attentively, I found it was a bubonocele that had gone towards the thigh, in place of towards the labium. The operation which was performed put the matter beyond a doubt, and ſhowed that it came through the ring of the muſcle. In a few months I was called to another patient in the ſame ſituation, and I found, to my ſurpriſe, the ſame appearances which in the firſt I took to be a *luſus naturæ;* the hernia in the groin, at the top of the thigh, and yet evidently coming through the ring; having all the appearances at firſt ſight of femoral hernia, but in reality a bubonocele. The operation here, likewiſe, which I performed, made me certain of the fact. In a third, under ſtrangulation, I found the ſame appearances, and operated.

"Finding the hernia bubonocele in theſe three caſes, yet with all the appearance of that ſpecies where the gut is puſhed out under Paupart's ligament, I began to ſuſpect that the common account given by authors was erroneous, and that bu-

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bonocele had, from inaccurate obſervation, been often deſcribed for femoral hernia. From the time I began to have theſe ſuſpicions, I have miſſed no opportunity of determining my point; and I have been lucky enough to have the diſſection of two women, with the apparent femoral hernia, which turned out bubonocele. I have likewiſe had five or ſix living patients with hernia, where I had an opportunity of a careful examination, and have again operated in a ſimilar caſe. As the reſult of theſe ten or twelve caſes is againſt the common opinion, I ſhall ſtate my obſervations at full length.

"The idea that a bubonocele in women was to take the ſame road with a ſimilar hernia in men, has, I fancy, miſled; for we find, that this is the account commonly given of the diſeaſe, that the gut paſſes down into the labium. Now, if we compare the two caſes, we will find there is no ſimilarity. In men, the gut and ſack are ſurrounded by the cremaſter, and are therefore conducted towards the teſticle. The cellular membrane of the ſcrotum is free of fat, and therefore yields more eaſily to the preſſure of the gut than that of the parts around; and thus the hernia paſſes more eaſily in this direction than in any other. In women, when the hernia has paſt the ring, it has no cremaſter to conduct it to the labium, it may therefore puſh in any other direction; but as the cellular membrane of the labium, and from it to the ring, is very much loaded with fat in moſt women, it will find more obſtruction in this direction, and will therefore be puſhed where the parts yield more readily. The parts on the groin are leſs loaded with fat, the gut therefore will be preſſed here. This I found corroborated by all the three caſes, where I either operated or was aſſiſtant; and in the two diſſections the hernia was puſhed outwards from the ring, and in one it had gone up along the belly above the ring. This only takes place when the hernia is ſmall. If the ring is much opened, and a great quantity of gut forced out, the motion of the

the thigh preſſes it inwards and downwards, and it then goes towards the labium. This I have inſtances of in ſome women I have lately examined with herniæ. Account of W. Hamilton

" The appearances of the bubonocele, when ſmall, will deceive a practitioner if he is not on his guard, and make him imagine it a femoral rupture. The marks by which the one may be diſtinguiſhed from the other, though ſituated in the ſame place, are few and ſimple.

" As the faſcia of the thigh joins Paupart's ligament, the femoral hernia is always under this faſcia; it is therefore more compreſſed; it is not looſe, and we cannot ſo well graſp it with the hand; and, inſtead of being rounded on the top, it is more or leſs flattened. The bubonocele again is only under the ſkin and cellular membrane, is therefore looſer, can be graſped, and is rounded on the top.

" In femoral hernia the ſwelling begins at the edge of Paupart's ligament, and goes down, and we feel the ring and the parts above the ligament uncovered by the hernia. In the bubonocele of women it goes over Paupart's ligament, and ſometimes up upon the muſcles over the ring, and extends more to each ſide along the bending of the thigh than the other.

" From theſe marks not having been attended to, I ſuſpect much that the place where the hernia lay was alone taken into view, and caſes ſimilar to mine had been called femoral ruptures. Indeed I have every reaſon to ſuppoſe ſo, as ſome of the caſes where I was moſt certain of their being bubonocele, had been looked on as of the other kind.

" I would therefore recommend to practitioner's attention to theſe marks, ſo as to determine how far the obſervations I have been led to make are juſt.

" The bubonocele in this ſituation in women, from its often lying in parts over the ring, makes the reduction much more uncertain, as we cannot graſp the part of the hernia juſt coming

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through the ring, ſo as to force it back, which is eſſentially neceſſary to ready reduction, and which we can always do in men, from the looſeneſs of the ſkin at the top of the ſcrotum.

" Upon examining the ſtate of the parietes of the belly in women, and comparing them with thoſe of men, I ſee no reaſon for their being more ſubject to femoral hernia than bubonocele, though in general I think them leſs liable to the diſeaſe altogether than men. The figure of the pelvis makes Paupart's ligament a little longer in them, but the ſpace under it is in proportion as well filled up by muſcles, veſſels, and fat, *&c.* ſo that no more room is allowed for the viſcera to be forced out in the one than in the other. The rings of the muſcle in women, though leſs apt to yield, as being more contracted than in men, are in proportion the weaker part, and therefore the paſſage through which a viſcus will be more readily puſhed. In operating upon this ſpecies of bubonocele, I varied a little from the common method. As the tumor extended along the bending of the thigh, my inciſion being made in this direction, was parallel in ſome meaſure to the ring. This made the introduction of the biſtory, to cut the tendon, a little more difficult, but it gave me advantages to counterbalance this inconvenience. I had after the reduction a piece of integuments above the inciſion, which when preſſed down covered the ring. This ſoon formed adheſion with the parts below, and effectually excluded the expoſure of the cavity of the abdomen, which adds much to the danger of the operation. In the common operation, where the ring is laid in view, and is at the bottom of the wound, the integuments over it having been divided, I ſuſpect the inflammation on the edges and bottom of the wound, which is kept open, extends through the ring to the peritonæum, altogether independent of the expoſure, and produces very fatal effects. Now, in my method, this was prevented; the integuments being found immediately over the ring. In dreſſing the wound

wound I uſed ſtitches to keep the lips together, which was likewiſe aſſiſted by bending up the thigh. This I look on as of conſequence in every operation for hernia, as the healing the parts by the firſt intention over the ring muſt be of eſſential ſervice in preventing inflammation in the abdomen; and the only objection that has been made to it, the riſk of the gut ſlipping out, may be eaſily prevented by a compreſs over the opening in the tendon for a few days: And after this, as adheſions will have taken place, unleſs great force is uſed, no protruſion can happen." Account of W. Hamilton.

To theſe ſpecimens others might be added, were not this memoir already too long, and were not theſe ſufficient to juſtify what has been ſaid of the unremitting attention and ſound judgment of a gentleman, whoſe premature death was regarded by all his friends as a loſs to ſcience and to ſociety. His conſtitution, ſomewhat enfeebled by early and intenſe application to ſtudy, was worn out with the toil of buſineſs and thought, in which he was continually engaged; and, after a tedious illneſs, he expired, March 13. 1790, in the thirty-ſecond year of his age, leaving a widow and two ſons.

Having lived according to the laws of religion and virtue, and being naturally of a placid, cheerful temper, he bore much ſuffering without complaint, looking forward to death, which for ſome time he knew to be unavoidable, with thoſe ſenſibilities indeed which every good man feels on the proſpect of leaving his deareſt friends, and entering into an untried exiſtence, but without unmanly dejection or timidity. Beſides the approbation of his own mind, he was ſoothed with the affectionate attentions of all his family, and with the regrets of his brethren and the public, who from day to day teſtified the utmoſt ſolicitude concerning his health; uttering not the unmeaning language of ceremony, or the intereſted one of flattery, but that of ſincere

Account of W. Hamilton.

ſincere eſteem and gratitude. Even when his funeral paſſed along, many among the crowd were obſerved to ſhed tears for one whoſe kindneſs had ſoothed their minds, and whoſe ſkill had relieved them in the hour of diſtreſs; nature prompting them to pay this grateful tribute to him who could no longer obſerve or reward them.

THE ſoftneſs and tenderneſs with which he ſpoke to his patients; the attention with which he liſtened to all their complaints, however frivolous; the readineſs with which he ſympathized with their feelings; to a byeſtander in health might ſometimes appear exceſſive, but, to the ſame perſon in diſeaſe, the whole appeared but a reaſonable exertion of humanity. Delighted with the kindneſs of his manner, his patients vied with each other in their commendations, of which he proved himſelf worthy, by the utmoſt delicacy of converſation, and the ſtricteſt purity of conduct, no leſs than by exertions of ſuperior ſkill, and by a punctual laborious attendance. His prudence, which was uncommon for his years, led him to avoid all oſtentatious diſplay of the extent to which he was employed; by which means, together with the moſt modeſt demeanour, he, in part, ſtifled that envy which is apt to riſe in the old, when they ſee themſelves overtaken or outſtripped by the young.

As a lecturer, his manner was remarkably free from pomp and affectation. His language was ſimple and perſpicuous, but ſo artleſs, that it appeared flat to thoſe who place the beauty of language in the intricacy of arrangement, or the abundance of figures. His manner of ſpeaking correſponded with his ſtyle, and was ſuch as might appear unintereſting to thoſe who think it impoſſible to be eloquent without violent geſtures, and frequent variations of tone. He uſed nearly the tone of ordinary converſation, as his preceptor Dr HUNTER did before him, aiming at perſpicuity only, and truſting for attention to the importance of the ſubjects he treated. Theſe he ſelected with great judgment.

judgment. Holding in contempt all hypothefes unfupported by fact, and inapplicable to the improvement of practice; omitting or paffing flightly over parts remarkable for curiofity more than utility; he demonftrated with great diftinctnefs and precifion thofe parts which it is neceffary to know accurately; accompanying his demonftrations with fpecimens of morbid parts, and with every remark, phyfiological or practical, which he was able to collect from extenfive reading, and careful reflection on his own practice. To excite emulation among his ftudents, and to honour the memory of his friend, he gave a gold medal, bearing the figure of Dr WILLIAM HUNTER, as a prize to the beft differtation on a furgical fubject. By thefe means, he had the fatisfaction of contributing to increafe the number of medical ftudents in Glafgow; and while his ftudents became from year to year more numerous, they began to difcover alfo that ardour, which it is impoffible either to excite or maintain where the ftudents are few.

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IV.

figment. Holding in contempt a hypothesis unsupported by fact, and inapplicable to the purposes [illegible] appearing [illegible] their [illegible] and practical [illegible] accomp- [illegible] practical. When he was [illegible] reading, and careful reflection on his [illegible]. [illegible] emulation among his students, and to honour the memory of his friend, the [illegible] be- [illegible] of Dr. William Hunter [illegible] the best dissertation on a [illegible] subject. By these means he had the satisfaction of [illegible] increase the number of medical students in Glasgow; and when his students became [illegible] more numerous, they began to discover [illegible] that [illegible] impossible [illegible] to maintain where the stu- dents are few.

IV. ACCOUNT *of JOHN ROEBUCK*, M. D. F. R. S. EDIN. *Communicated by Mr JARDINE*, F. R. S. EDIN. *and Professor of Logick in the University of Glasgow.*

[*Read April* 4. 1796.]

DOCTOR JOHN ROEBUCK was born at Sheffield in Yorkshire, in the year 1718. His father was a considerable manufacturer and exporter of Sheffield goods, who, by his abilities and industry, had acquired a competent fortune. JOHN, his eldest son, the subject of this memoir, was intended, by his father, for carrying on his own lucrative business at Sheffield; but was, from his early youth, irresistably attached to other pursuits, more calculated to gratify his ambition, and give fuller play to his powers. Notwithstanding this disappointment in his favourite object, his father had liberality enough to encourage his rising genius, and to give him all the advantages of a regular education.

AFTER he had gone through the usual course of the Grammar-school at Sheffield, both his father and mother being strict dissenters, they placed their son, for some years, under the tuition of the late Dr DODDRIDGE, who was, at that time, master of an Academy at Northampton, and had justly acquired high reputation among the dissenters, both as a divine and as an instructor of youth. Under the Doctor's care Mr ROEBUCK made great proficiency, and laid the foundation of that classical taste and knowledge for which he was afterwards eminently distinguished.

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guiſhed. It would appear that Dr DODDRIDGE had been much pleaſed with the ardour and enthuſiaſm, in the purſuit of knowledge, diſcovered by his pupil; for, Mr ROEBUCK, in an after period of his life, uſed frequently to mention the ſubjects of converſations and inquiries of various kinds, in which the Doctor had engaged him. It was during his reſidence at this Academy, that he contracted an intimate acquaintance with his fellow-ſtudents, Mr JEREMIAH DYSON, afterwards much known in the political world, and Mr MARK AKENSIDE, afterwards Dr AKENSIDE, which terminated only with their lives.

FROM the Academy at Northampton, he was ſent to the Univerſity of Edinburgh, where he applied to the ſtudy of medicine, and particularly to that of chemiſtry, which, about that time, began to attract ſome attention in Scotland. While he reſided there he diſtinguiſhed himſelf much, among his fellow-ſtudents, in their literary ſocieties and converſations, by great logical and metaphyſical acuteneſs, and by great ingenuity and reſource in argumentation. The late ſagacious Dr PORTERFIELD, to whom he had been introduced, obſerved and encouraged his riſing genius, and was greatly inſtrumental in promoting his improvement. There, too, he formed an intimate acquaintance with Mr HUME, Mr ROBERTSON, afterwards Dr ROBERTSON, Mr PRINGLE, afterwards Lord ALEMOOR, and ſeveral other perſons of literary eminence; a circumſtance which produced, in his mind, a partiality ever afterwards in favour of Scotland, and contributed not a little to his making choice of it for the chief field of his future exertions and induſtry.

AFTER Mr ROEBUCK had gone through a regular courſe of medical education at Edinburgh, being now determined to follow the practice of phyſic, he next ſpent ſome time at the Univerſity of Leyden, then in high reputation as the firſt ſchool of medicine in Europe: There, after the uſual reſidence and courſe of trials, he obtained a degree in medicine; and his diploma,

dated

dated 21ſt February 1743, has affixed to it the reſpectable names of MUSCHENBROEK, OSTERDYK, VAN ROYEN, ALBINUS, GAUBIUS, &c. He left Leyden, after having viſited ſome part of the north of Germany, about the end of the year 1744. Account of Dr Roebuck.

SOON after his return from the Continent, ſome circumſtances induced Dr ROEBUCK to ſettle, as a phyſician, at Birmingham. Before that time, Birmingham had begun to make a rapid progreſs in arts, manufactures, and population, and, by the death of an aged phyſician, an opening was preſented to him, which afforded an immediate proſpect of encouragement in that line. His education, talents, and intereſting manners, were well calculated to promote his ſucceſs as a phyſician. He accordingly met there, at a period more early than he expected, with great encouragement, and was ſoon diſtinguiſhed, in that town, and the country adjacent, for his ſkill, integrity, and charitable compaſſion, in the diſcharge of the duties of his profeſſion.

IT appeared, however, ſoon after his reſidence was fixed at Birmingham, that his ſtudies and induſtry were turned to other objects beſides thoſe of his profeſſion. Strongly attached to the riſing ſcience of chemiſtry, he conceived high views of extending its uſefulneſs, and of rendering it ſubſervient to the improvement of arts and manufactures. With this view, he fitted up a ſmall laboratory in his own houſe, in which he ſpent every moment of his time, which he could ſpare from the duties of his profeſſion. There, in the true ſpirit of his great maſter, Lord BACON, of whoſe philoſophy he was a great admirer, he carried on various chemical proceſſes of great importance, and laid the foundation of his future projects, on well tried and well digeſted experiments*.

* Verus experientiæ ordo, primo lumen accendit, deinde per lumen iter demonſtrat, incipiendo ab experientia ordinata et digeſta, atque ex ea, et educendo axiomata, et axiomatibus conſtitutis, rurſus experimenta nova.

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THE firſt efforts of his genius and induſtry, thus directed, led him to the diſcovery of certain improved methods of refining gold and ſilver, and particularly to an ingenious method of collecting the ſmaller particles of theſe precious metals, which had been formerly loſt in the practical operations of many of the manufacturers. By other chemical proceſſes, carried on about the ſame time in his little laboratory, he diſcovered alſo improved methods of making ſublimate, hartſhorn, and ſundry other articles of equal importance. After having received full ſatisfaction from the experiments upon which ſuch diſcoveries and improvements were founded, he next digeſted a plan for rendering them beneficial to himſelf, and uſeful to the public. A great part of his time being ſtill employed in the duties of his profeſſion, he found it neceſſary to connect himſelf with ſome perſon in whom he could repoſe confidence, and who might be, in other reſpects, qualified to give him ſupport and aſſiſtance in carrying on his intended eſtabliſhments. With this view, he choſe as his aſſociate Mr SAMUEL GARBET of Birmingham, a gentlemen well qualified by his abilities, activity, and enterpriſing ſpirit, for bearing his part in their future undertakings. Their firſt project was the eſtabliſhment of an extenſive laboratory at Birmingham, for the purpoſes above mentioned, which, conducted by Dr ROEBUCK's chemical knowledge, and Mr GARBET's able and judicious management, was productive of many advantages to the manufacturers of that place, and of ſuch emolument to themſelves, as contributed greatly to the boldneſs of their future projects. That laboratory has, ever ſince that time, continued at Birmingham, and is ſtill conducted by Mr GARBET. Dr ROEBUCK, long before his death, had given up his intereſt in it.

ABOUT this time, in 1747, the Doctor married Miſs ANN ROE of Sheffield, a lady of a great and generous ſpirit, whoſe temper and diſpoſition equally fitted her for enjoying the proſperous

ſperous circumſtances of their early life, and for bearing her equal ſhare of thoſe anxieties and diſappointments in buſineſs which ſhaded, but did not obſcure, the later period of their lives. Account of Dr Roebuck.

Dr Roebuck's unremitted perſeverance in his chemical ſtudies, together with the ſucceſs that attended them, led him, ſtep by ſtep, to other reſearches of great public and private benefit.

The extenſive uſe of the vitriolic acid in chemiſtry, and the proſpect of its application to ſome of the mechanic arts, had produced a great demand for that article, and turned the attention of chemiſts to various methods of obtaining it. The late Dr Ward had obtained a patent for making it; and, though the ſubſtances from which it might be obtained, as well as certain methods of obtaining it, had been known to others, and particularly pointed out by Lemery the elder, and by Glauber, yet Dr Ward was the firſt, it is believed, who eſtabliſhed a profitable manufacture upon the diſcovery. Much, however, was wanting to render the acid of univerſal uſe in chemiſtry, and of extenſive utility in the arts, where great quantities of it were required. The price of it was high, ariſing from the great expence of the glaſs veſſels, which were made uſe of by Dr Ward in procuring it, and the frequent accidents to which they were liable in the proceſs.

Dr Roebuck had been, for ſome time, engaged in making experiments with a view to reduce the price, and at length diſcovered a method of preparing it, by ſubſtituting, in place of the glaſs veſſels formerly uſed, lead ones of a great ſize; which ſubſtitution, together with ſundry other improvements in different parts of the proceſs, completely effected his end.

After the neceſſary preparations had been made, Meſſrs Roebuck and Garbet eſtabliſhed a manufacture of the oil of vitriol at Preſtonpans, in Scotland, in the year 1749. This eſtabliſhment not a little alarmed Dr Ward, who attempted to defeat

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feat their plan, by taking out a patent for Scotland, in addition to the one he had formerly obtained. In this attempt he failed. Dr ROEBUCK's discovery was found not to come within the specification of Dr WARD's patent.

THE Prestonpans Company, convinced that patents are of little avail in preserving the property of new inventions or discoveries, in conducting their vitriol works resolved to have recourse to the more effectual methods of concealment and secrecy. By that method they were enabled to preserve the advantages of their ingenuity and industry for a long period of years, and not only served the public at a much cheaper rate than had ever been done formerly, but, it is believed, they realized, in that manufacture, a greater annual profit from a smaller capital than had been done in any similar undertakng. The vitriol work is still carried on at Prestonpans; but, long before Dr ROEBUCK's death, he was obliged to withdraw his capital from it.

ABOUT this time Dr ROEBUCK was urged, by some of his friends, to leave Birmingham, and to settle as a physician in London, where his abilities might have had a more extensive field of exertion. He had been early honoured with the acquaintance of the late Marquis of ROCKINGHAM, who, as a lover of arts, had frequently engaged him in chemical experiments at Rockingham-house. It was there, also, he became acquainted with the late Sir GEORGE SAVILLE, and with several other persons of rank and influence. His old friend and school-fellow, Mr DYSON, too, by this time, had acquired considerable name and influence, and pressed him much to take that step. Under such patronage, and with the energy of such talents as Dr ROEBUCK possessed, there could be little doubt of his soon arriving at an eminent rank, as a physician in London. But the chemical concerns, with which he was at that time deeply occupied, held out to him a prospect of a richer harvest, determined him to give up the practice of medicine altogether,

and

and to fix his reſidence, for the greateſt part of the year, in Scotland.

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THE ſucceſs of the eſtabliſhment at Preſtonpans, which had far exceeded their expectation, enabled the Doctor and his partner Mr GARBET, to plan and execute other works of ſtill greater benefit and public utility. In the proſecution of his chemical ſtudies and experiments, Dr ROEBUCK had been led to beſtow great attention on the proceſſes of ſmelting ironſtone, and had made ſome diſcoveries, by which that operation might be greatly facilitated, particularly by uſing pitcoal in place of charcoal. Mr WILLIAM CADDELL of Cockenzie, in the neighbourhood of Preſtonpans, a gentleman earneſtly intent upon promoting manufactures in Scotland, had, for ſeveral years, laboured, without much ſucceſs, in eſtabliſhing a manufacture of iron; a circumſtance which may have probably contributed to turn Dr ROEBUCK's attention more particularly to that ſubject. As the capital which he and his partner Mr GARBET could appropriate for carrying on the iron manufacture was not equal to ſuch an undertaking, and chiefly depended upon the profits of their other works, their firſt intention was to attempt a ſmall eſtabliſhment of that kind, in the vicinity of their vitriol works at Preſtonpans. But the flattering proſpects of ſucceſs, ariſing from a courſe of experiments which Dr ROEBUCK had lately made, encouraged them to extend their plan, and to project a very extenſive manufactory of iron. A ſufficient capital was ſoon procured, through the confidence which many of their friends repoſed in their abilities and integrity. In fact, the eſtabliſhment which they made, or rather the capital which gave it exiſtence, was the united capital of a band of relations and friends, who truſted to Dr ROEBUCK and Mr GARBET the management of a great part of their fortune. When all previous matters had been concerted, reſpecting their intended eſtabliſhment, the chief exertions of chemical and mechanical

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chanical ſkill, neceſſary in the execution, were expected from Dr ROEBUCK. It fell to his ſhare alſo to fix upon the beſt and moſt favourite ſituation for erecting their intended works. With that view, Dr ROEBUCK examined many different places in Scotland, particularly thoſe on both ſides of the Frith of Forth; and, after a careful and minute compariſon of their advantages and diſadvantages, he at length made choice of a ſpot, on the banks of the river *Carron*, as the moſt advantageous ſituation for the eſtabliſhment of the iron manufacture. There, he found, they could eaſily command abundance of water for the neceſſary machinery; and in the neighbourhood of it, as well as every where both along the north and ſouth coaſts of the Frith, were to be found inexhauſtible quarries of ironſtone, limeſtone, and coal. From Carron, alſo, they could eaſily tranſport their manufactures to different countries by ſea. The communication with Glaſgow, at that time, by land-carriage, which opened up to them a ready way to the American market, was ſhort and eaſy.

MANY other things, which need not be here enumerated, fell to Dr ROEBUCK's ſhare in preparing and providing for the introduction of this new manufacture into Scotland, particularly with reſpect to the planning and erection of the furnaces and machinery. To inſure ſucceſs, in that department, nothing was omitted which ability, induſtry, and experience could ſuggeſt. With this view, he called to his aſſiſtance Mr SMEATON, then by far the firſt engineer in England. It was from him he received plans and drawings of the water-wheels and blowing apparatus, which, notwithſtanding all the mechanical improvements which have been made ſince, remain unrivalled in any of the other ironworks erected in Britain. This was the firſt introduction of Mr SMEATON into Scotland, and was the occaſion of various other diſplays of the ſkill and experience of that celebrated engineer in that part of the iſland.

With

With the ſame view, and to the ſame effect, in a future period of his operations, he employed Mr JAMES WATT, then of Glaſgow, and had the merit of rendering that inventive genius, in the mechanical arts, better known both in this country and in England. Account of Dr Roebuck.

THE neceſſary preparations, for the eſtabliſhment of the iron-works at Carron, were finiſhed in the end of the year 1759; and on the 1ſt January 1760 the firſt furnace was blown: and in a ſhort time afterwards a ſecond was erected.

No period of Dr ROEBUCK's life required from him more vigorous and laborious exertions than that of the eſtabliſhment of the Carron works, and the firſt trials of the furnaces and machinery. His family and friends remember well the ardour and intereſt which he diſcovered; the inceſſant labour and watchfulneſs which he exerted on that occaſion. Every thing was untried, the furnaces, the machinery, the materials, the workmen; the novelty of the undertaking in that country, its extent and difficulty, and the great ſtake at iſſue, were circumſtances that muſt have occaſioned much ſerious thought and anxiety to the partner, upon the credit of whoſe knowledge and experience the work had been undertaken. But the Doctor had great powers and great reſources: and the firſt trial gave ſufficient indications of future ſucceſs.

FOR ſome time after the eſtabliſhment of the Carron works, Dr ROEBUCK continued to give his attention and aſſiſtance in the general management and ſuperintendance of them, and with him all meaſures of future operations were concerted. During this period, ſome alterations of great importance were ſuggeſted by him, and carried into effect. By carefully obſerving the progreſs of ſmelting in the furnaces, at firſt worked by bellows, beſides their being ſubject to various accidents, the Doctor diſcovered the neceſſity of rendering the blaſt both ſtronger and more equable; and propoſing, as a problem to Mr

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SMEATON, the beſt method of effecting that end, that celebrated engineer ſoon gave the plan of a blaſt by three or four cylinders, which was afterwards tried, and ſucceeded even beyond expectation.

WHEN the buſineſs at Carron ſunk by degrees into a matter of ordinary detail, and afforded leſs ſcope for the Doctor's peculiar talents, he was unfortunately tempted to engage in a new and different undertaking; from the failure of which he ſuffered a reverſe of fortune, was deprived of the advantages reſulting from his other works, and, during the remainder of his life, became ſubjected to much anxiety and diſappointment.

THE eſtabliſhment of the Carron works, and the intereſt Dr ROEBUCK had in their ſucceſs, had naturally turned his attention to the ſtate of coal in the neighbourhood of that place, and to the means of procuring the extraordinary ſupplies of it which the ironworks might in future require. With the view, therefore, of increaſing the quantity of coal worked in that neighbourhood, by an adventure which he thought would alſo turn out to his own emolument, he was induced to become leſſee of the Duke of HAMILTON's extenſive coal and ſalt works at Borrowſtounneſs. The coal there was repreſented to exiſt in great abundance, and underſtood to be of ſuperior quality; and as Dr ROEBUCK had made himſelf acquainted with the moſt improved methods of working coal in England, and then not practiſed in Scotland, he had little doubt of this adventure turning out beneficial and highly lucrative. In this, however, he was cruelly diſappointed. The opening of the principal *ſtratum* of coal required much longer time, and much greater expence, than had been calculated; and, after it was opened, the perpetual ſucceſſion of difficulties and obſtacles which occurred in the working and raiſing of the coal, was ſuch as has been ſeldom experienced in any work of that kind. The reſult was, that after many years

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of labour and induſtry, there were ſunk in the coal and ſalt works at Borrowſtounneſs, not only his own, and the conſiderable fortune brought him by his wife, but the regular profits of his more ſuccesſful works; and, along therewith, what diſtreſſed him above every thing, great ſums of money borrowed from his relations and friends, which he was never able to repay: not to mention, that, from the ſame cauſe, he was, during the laſt twenty years of his life, ſubjected to a conſtant ſucceſſion of hopes and diſappointments, to a courſe of labour and drudgery ill ſuited to his taſte and turn of mind, to the irkſome and teaſing buſineſs of managing and ſtudying the humours of working colliers. But all theſe difficulties his unconquerable and perſevering ſpirit would have overcome, if the never ceaſing demands of his coal-works, after having exhauſted the profits, had not alſo compelled him to withdraw his capital from all his different works in ſucceſſion; from the refining work at Birmingham, the vitriol work at Preſtonpans, the ironworks at Carron, as well as to part with his intereſt in the project of improving the ſteam engine, in which he had become a partner with Mr WATT, the original inventor, and from which he had reaſon to hope for future emolument. It would be painful to mention the unhappy conſequences of this ruinous adventure to his family and to himſelf. It cut off for ever the flattering proſpect which they had of an independent fortune, ſuited to their education and rank in life. It made many cruel encroachments upon the time and occupations of a man, whoſe mind was equally fitted to enjoy the high attainments of ſcience, and the elegant amuſements of taſte. As the price of ſo many ſacrifices, he was only enabled to draw from his colliery, and that by the indulgence of his creditors, a moderate annual maintenance for himſelf and family during his life. At his death, his widow was left without any proviſion whatever for her immediate or future ſupport,

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and without the ſmalleſt advantage from the extraordinary exertions and meritorious induſtry of her huſband.

Dr Roebuck had, ſome years before his death, been attacked by a complaint that required a dangerous chirurgical operation. That operation he ſupported with his uſual ſpirit and reſolution. In a ſhort time he was reſtored to a conſiderable ſhare of his former health and activity. But the effects of it never entirely left him, and ſeveral ſlighter returns of the complaint gradually impaired his conſtitution. He ſtill, however, continued, till within a few weeks of his death, to viſit his works, and to give direction to his clerks and overſeers. He was confined to his bed only a few days, and died on the 17th July 1794, retaining to the laſt all his faculties, his ſpirit and good humour, as well as the great intereſt which he took, as a man of ſcience and reflexion, in the uncommon events which the preſent age has exhibited.

From a man ſo deeply and ſo conſtantly engaged in the detail of active buſineſs, many literary compoſitions were not to be expected. Dr Roebuck left behind him many *works*, but few *writings*. The great object which he kept invariably in view was to promote arts and manufactures, rather than to eſtabliſh theories or hypotheſes. The few eſſays which he left, enable us to judge of what might have been expected from his tale ts, knowledge, and boldneſs of invention, had not the active undertakings in which, from an early period of life, he was engaged, and the fatiguing details of buſineſs, occupied the time for ſtudy and inveſtigation. A compariſon of the heat of London and Edinburgh, read in the Royal Society of London June 29. 1775, Experiments on ignited bodies, read there 16th February 1776, Obſervations on the ripening and filling of corn, read in the Royal Society of Edinburgh 5th June 1784, are all the writings of his, two political pamphlets excepted, which have been publiſhed. The publication of the eſſay on ignited bodies was occaſioned

occaſioned by a report of ſome experiments made by the Comte DE BUFFON, from which the Comte had inferred, that *matter* is heavier when hot than when cold. Dr ROEBUCK's experiments, made with great accuracy before a committee of the Royal Society at London, ſeem to refute that notion. Account of Dr Roebuck.

IT is the works and eſtabliſhments projected and executed by Dr ROEBUCK, with the immediate and more remote effects of them upon the induſtry, arts, and manufactures of Scotland, which urge a juſt claim to the reſpect and gratitude of his country. This tribute is more due from the diſcerning part of mankind, as this ſpecies of merit is apt to be overlooked by the buſy or the ſuperficial, and to fail in obtaining its due reward. The circumſtances of Dr ROEBUCK have, in this reſpect, been peculiarly hard: For though, moſt certainly, the projector and author of new eſtabliſhments highly uſeful to his country, and every day becoming more ſo, he was, by a train of unfortunate events, obliged to break off his connexion with them, at an unſeaſonable time, when much was yet wanting to their complete ſucceſs: and thus he left others in the poſſeſſion, not only of the lucrative advantages now derived from them, but even, in ſome meaſure, of the general merit of the undertaking, to a conſiderable part of which he had the moſt undoubted claim.

THE eſtabliſhment of the laboratory at Birmingham, in the year 1747, the firſt public exhibition of his chemical talents, was, at that particular period, and in the ſtate of the arts and manufactures at that time, highly beneficial, and ſubſervient to their future progreſs: and the continuance and ſucceſs of it, in that place, is a proof of the advantages which many of the manufacturers receive from it. Much had already been done, and many improvements made in arts and manufactures, chiefly by the ſuggeſtions of that ingenioufneſs and experience, which, in the detail of buſineſs, might be expected from the practical artiſt. Dr ROEBUCK was qualified to proceed a ſtep farther; to direct

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direct experience by principles, and to regulate the mechanical operation of the artist by the lights of science. The effects of that establishment extended, in a particular manner, to all that variety of manufactures in which gold and silver were required, to the preparing of materials, the simplifying of the first steps, to the saving of expence and labour, and to the turning to some account what had been formerly lost to the manufacturer. It is well known, that, while Dr ROEBUCK resided at Birmingham, such was the opinion formed of his chemical knowledge and experience by the principal manufacturers, that they usually consulted him on any new trial or effort to improve their several manufactures; and, when he left that place, they sincerely regreted the loss of that easy and unreserved communication they had with him, on the subjects of their several departments.

ON account of similar circumstances, the benefit to the public, from the establishment of the vitriol works at Prestonpans, in the extension and improvement of many of the arts, cannot now be exactly ascertained. The vitriolic acid is one of the most active agents in chemistry, and every discovery which renders it cheap, and accessible to the chemist, must be greatly subservient to the progress of that science. By the establishment at Prestonpans, the price of that valuable acid was reduced from sixteen to four pence *per* pound. It is to Dr ROEBUCK, therefore, that chemists are indebted for being in possession of a cheap acid, to which they can have recourse in so many processes.

BUT Dr ROEBUCK's object, in the prosecution of that scheme, was not so much to facilitate the chemist's labour, as to render that acid, in a much higher degree than it had formerly been, subservient to many of the practical arts. By rendering the vitriolic acid cheap, great use came to be made of it in preparing the muriatic acid, and GLAUBER's salts from common salts. Its use has been farther extended to many metallic processes; and it has lately been employed in separating silver from the

the clippings of plated copper, the ufe of which is very extenfive. Account of Dr Roebuck.

The application of the vitriolic acid in bleaching linen, or a fubftitution of it for four milk, was firft publifhed by Dr Francis Home. But it is well known to feveral of Dr Roebuck's chemical friends, that he had tried it, found it effectual, and had frequently recommended it to bleachers before the date of that publication. The quantity of it now confumed in that art is very great. Of late it has been ufed in decompofing common falt, with the addition of manganefe, in order to obtain the oxygenated muriatic acid, by which the procefs of bleaching fine linen is amazingly fhortened. Much of it too is ufed in preparing the beft kind of aquafortis, or nitrous acid, from faltpetre, which was decompofed formerly, and ftill is, in many cafes, by vitriol, inftead of the vitriolic acid; but the vitriol gives an aquafortis of inferior ftrength and purity. The dyers alfo employ great quantities of it in different proceffes, particularly in diffolving indigo, in one of their methods of dying with that drug.

At firft, the manufactories of the vitriolic acid in Britain fupplied foreign nations as well as our own, though foreigners, having fince difcovered or learned the art, now make it themfelves. But it would be tedious to mention all the applications of it which have been already made, and it is impoffible to fay how far the ufe of this powerful agent in chemiftry, and the arts, may be carried. Enough has been faid to fhow, that Dr Roebuck's difcoveries, in that department, have been of the greateft advantage to fcience and the practical arts, in facilitating the procefs for procuring this acid, and in rendering it of general ufe; and it is but fair that the name of that perfon fhould ftand on record, to whom chemifts and artifts are fo much indebted for their fubfequent fuccefsful labours.

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THE project and eſtabliſhment, however, of the ironworks at Carron, the moſt extenſive eſtabliſhment of that kind hitherto in Britain, muſt be conſidered as Dr ROEBUCK's principal work. The great and increaſing demand for iron in the progreſſive ſtate of arts, manufactures and commerce in Britain, and the great ſums of money ſent every year to the north of Europe for that article, turned the attention of chemiſts and artiſts to the means of promoting the manufacture of iron, with the view of reducing the importation of it. No perſon has a better founded claim to merit, in this particular, than Dr ROEBUCK. The ſmelting of iron by pitcoal, it is indeed believed, had been attempted in Britain in the beginning of the laſt century. In the reign of JAMES I. ſeveral patents ſeem to have been granted for making hammered iron by pitcoal, particularly to the Honourable DUD DUDLEY and SIMON STARLEVANT. It does not appear, however, that any progreſs had been made in the manufacture in conſequence of theſe patents. In later times trials have been made by ſo many different perſons, and in ſo many different places in England, nearly about the ſame time, that it may be difficult to ſay where and by whom the firſt attempt was made, particularly as the diſcoverers of ſuch proceſſes wiſhed to conceal the knowledge they had gained as long as they could. But Dr ROEBUCK was certainly among the firſt, who, by means of pitcoal, attempted to refine crude or pig iron, and to make bar iron of it, inſtead of doing it by charcoal, according to the former practice: And he was, without all queſtion, the perſon who introduced that method into Scotland, and firſt eſtabliſhed an extenſive manufacture of it. It is not meant to aſcribe to him the ſole merit of the eſtabliſhment at Carron. No man was ever more ready than he was, to do juſtice to the abilities and ſpirit of his friends and partners, Meſſrs GARBET, CADDELL, &c. who firſt embarked with him in that great undertaking. But ſtill it may be ſaid with truth, that

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the original project of the ironworks at Carron, the chemical knowledge and experience on which they were founded, the complicated calculations which were previoufly required, the choice of the fituation, the general conduct and direction of the buildings and machinery, the fuggeftion of many occafional improvements, together with the removal of many unforefeen obftacles and difficulties, which occurred in the infant ftate of that eftablifhment, were, in a great meafure, the work and labour of Dr ROEBUCK. Nor can it, with the leaft fhadow of juftice, detract from his merit, that a larger capital, and greater expence than was at firft calculated, have been found neceffary to bring the works at Carron to their prefent ftate of perfection; or, that great alterations and improvements have taken place, during the courfe of forty years, in a great and progreffive eftablifhment. In all works of that kind, the expence exceeds the calculation. The undertakers even of the lateft ironworks which have been erected, notwithftanding all the advantages obtained from recent experience, will be ready to acknowledge, that, in thefe refpects, there is little room to blame the original projector of the firft eftablifhment of that kind in Scotland. But the beft, and moft infallible proof of Dr ROEBUCK's merit, and of the found principles on which thefe works were eftablifhed, is the prefent profperous ftate of that eftablifhment, the great perfection of many branches of their manufactures, and, particularly, the many extenfive and flourifhing ironworks, which have been fince erected upon the model of Carron, in different parts of Scotland, at Cleugh, Clyde, Muirkirk, and Devon. It cannot be denied that all thefe works have fprung from the eftablifhment at Carron, and are ultimately founded upon the knowledge and experience which have been obtained from them; for fome of the partners, or overfeers of thefe new works, and many of the workmen, have been, at one time or another, connected with that of Carron. Hence, then, it is ow-

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ing to the projector and promoter of the eſtabliſhment at Carron, that Scotland is, at this moment, benefited to the amount of many hundred thouſand pounds, in working up the raw materials of that manufacture found in the country itſelf, and which, previous to that eſtabliſhment, was of no value whatever. Such are the *preſent*, but ſcarcely any idea can be formed of the *future* advantages to this country, which may be derived from the extenſion of the iron manufacture. About 60,000 tons of iron have been annually imported into Great Britain for more than twenty years paſt, and though there has been, for ſome time, about 20,000 tons of bar iron made in Britain by pitcoal, yet the foreign imported iron has ſuffered little or no diminution in quantity. This great conſumption of iron, no doubt, is owing to the various improvements of late years, and the general extenſion throughout all Europe of commerce and the arts. The manufacture of iron muſt therefore continue to increaſe, and Scotland, abounding every where in ironſtone, pitcoal, and in command of water for machinery, has the proſpect of obtaining the largeſt ſhare of it.

To the eſtabliſhment of the Carron works, and to the conſequences of that eſtabliſhment, may be aſcribed alſo the exiſtence of other public works in Scotland of great importance and utility. The opening of a communication by water betwixt the Forth and the Clyde had long been projected, and frequently the ſubject of converſation in Scotland, but nothing in fact had been attempted. The eſtabliſhment of the ironworks at Carron ſoon called forth ſufficient intereſt and enterpriſe to bring about the execution of this grand deſign. Some of the partners of the Carron Company, foreſeeing the advantages they would derive from ſuch a communication, propoſed, at their own expence, to execute a ſmall canal; and, after taking the preparatory ſteps, actually applied to Parliament to obtain authority for that purpoſe. But the project of the ſmall canal

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not meeting with the approbation of ſome noblemen and gentlemen in that part of Scotland, they oppoſed the bill, and obliged themſelves to execute a greater canal, which has now been many years finiſhed, and is found to be of the greateſt advantage to the trade and commerce of Scotland. The merit of this undertaking is not meant to be aſcribed to Dr ROEBUCK, excepting in ſo far as it neceſſarily aroſe from the eſtabliſhment of the Carron Company, of which he was the original projector; and it may reaſonably be doubted, whether, without that eſtabliſhment, it would have yet taken place. Several other canals have, ſince that time, been executed in different parts of Scotland, and other very important ones are at preſent projected.

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The different eſtabliſhments which Dr ROEBUCK made at Borrowſtounneſs in carrying on the coal and ſalt works there, though ultimately of no advantage to himſelf, were attended, during the courſe of thirty years, with the moſt beneficial effects upon the trade, population, and induſtry of that part of Scotland. They were the means alſo of adding very conſiderably to the public revenue. Previous to the time theſe works fell under Dr ROEBUCK's management, they produced no advantage either to the proprietor, or the adventurers, or to the public. But by his mode of conducting them upon a more extenſive plan, by opening up new ſeams of coal, and of better quality, he was enabled to export a very conſiderable quantity, to increaſe the quantity of ſalt, and, of courſe, the revenue ariſing from theſe articles. In theſe works, and in the management of a large farm, Dr ROEBUCK gave employment to near a thouſand perſons at Borrowſtounneſs, and in the neighbourhood.

NOR was it ſolely by the different eſtabliſhments which he projected and executed, but by many other things neceſſarily connected with them, that Dr ROEBUCK's labours were beneficial to Scotland. Along with them he may be ſaid to have introdu-

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ced a ſpirit of enterpriſe and induſtry, before that time little known in Scotland, which ſoon pervaded many other departments of labour, and gave birth to many other uſeful projects. He brought from England, then much farther advanced in arts and induſtry, many ingenious and induſtrious workmen, at great expence, who, by their inſtructions and example, communicated and diffuſed ſkill and knowledge to others. At all times Dr Roebuck held out liberal encouragement to riſing genius, and induſtrious merit; and ſpared no expence in making trials of improvements and diſcoveries, which were connected with the different projects and works which he was carrying on.

Such was the active and uſeful life of Dr Roebuck, a man of no common caſt, who united, in a very high degree, a great number of ſolid and brilliant talents, which, even ſeparately, fall to the lot of but few individuals. Diſtinguiſhed by an ardent and inventive mind, delighting in purſuit and inveſtigation, always aſpiring at ſomething beyond the preſent ſtate of ſcience and art, and eagerly preſſing forward to ſomething better or more perfect, he thus united energies the moſt powerful, with the moſt unwearied and perſevering induſtry. To that peculiarity of imagination, ſo fitted for ſcientific purſuit, which readily combines and unites, which ſteadily preſerves its combinations before the eye of the mind, and quickly diſcovers relations, reſults and conſequences, was added, in his character, great promptitude and firmneſs in deciſion. Strongly and early impreſſed with the great importance of applying chemical and phyſical knowledge to the uſeful arts, to the melioration of civil life, he never loſt ſight of that favourite view, and diſcovered great boldneſs and reſource in the means and expedients which he adopted to promote it. He was certainly maſter of the beſt philoſophy of chemiſtry known in the earlier parts of his life, and though, in every ſtage of that ſcience, he marked and underſtood the progreſs of the diſcoveries, yet his

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numerous avocations did not permit him to follow them out by experimental proceſſes of his own. Upon that, and indeed almoſt upon every ſubject, his mind readily graſped the moſt uſeful and ſubſtantial points, and enabled him to throw out ſuch hints, and hypotheſes, as marked him the man of genius. Account of Dr Roebuck.

DURING the courſe of a regular education, both at Edinburgh and at Leyden, Dr ROEBUCK ſtudied the claſſic authors with great attention, particularly the hiſtorical and political parts of their works. Upon theſe ſubjects he had read much, ſelected with judgment, and was well acquainted with the facts and philoſophy of ancient governments. This taſte he carried with him, and improved in every period of his life, and in every ſituation. It abundantly rewarded him for the earneſtneſs and diligence with which it had been acquired. It became his favourite reſource, and indeed one of the chief enjoyments of his life. Poſſeſſing the happy talent of turning his mind from ſerious and fatiguing, to elegant and recreating purſuits, it was no uncommon thing with him to return from the laboratory or the coalpit, and draw relaxation or relief from ſome one or other of the various ſtores of claſſical learning.

No man was better acquainted with the hiſtory of his country than Dr ROEBUCK, or more admired and revered the conſtitution of its Government. By temper and education he was a Whig, and at all times entered, with great warmth, into the political diſputes and controverſies which agitated parties, in the different periods of his life. If the natural warmth of his temper, and his enthuſiaſm on theſe ſubjects, led him, on ſome occaſions, beyond the bounds of candid argumentation, his quick ſenſe of decorum, and his perfect habits of good manners, produced an immediate atonement, and reſtored the rights of elegant and poliſhed converſation.

THE general acquaintance which Dr ROEBUCK had acquired with natural and experimental philoſophy, together with his claſſical

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claſſical and political knowledge, rendered him an agreeable companion to the learned, almoſt of every department, and procured him the attachment and friendſhip of many of the firſt literary characters in Britain. With his friend Dr BLACK he lived, till his death, in cloſe habits of intimacy; and he often acknowledged, with much frankneſs, the advantages which he derived, in his various purſuits, from a free and unreſerved communication with that eminent chemiſt.

THE amiable diſpoſitions of ſenſibility, humanity, and generoſity, which ſtrongly marked his character, in the general intercourſe of ſociety, were peculiarly preſerved and exerciſed in the boſom of his family, and in the circle of his friends. In the various relations of huſband, father, friend, or maſter, and in the diſcharge of the reſpective duties ariſing from them, it would not be eaſy to do juſtice to his character, or to determine in which of them he moſt excelled; nor muſt it be forgot, for it reflected much honour on his benovelent heart, that his workmen not only found him at all times a kind and indulgent maſter, but many of them, when their circumſtances required it, a ſkilful and compaſſionate phyſician, who cheerfully viſited the humbleſt receſſes of poverty, and who attached them to his ſervice by multiplied acts of generoſity and kindneſs.

WE cannot conclude this narrative, without expreſſing our regret, that talents ſo great, and ſervices ſo uſeful to his country, as were thoſe of Dr ROEBUCK, ſhould have turned out of ſo little account to himſelf and his family. But this is, in fact, no uncommon caſe. The great benefactors of ſociety have never been men actuated by gain or intereſt, but thoſe whoſe ambition was fixed on promoting the convenience and happineſs of men. The Doctor had in fact too little regard for money, and was generous in the extreme. It muſt be confeſſed, too, that his confidence and ardour prevented him from foreſeeing ſome of the difficulties and obſtacles he met with, and frequently tempted him

him to lay out large ſums, in the proſecution of ſome of his projects, without ſufficient œconomy, and, of courſe, without proper returns. His open, unſuſpicious temper, alſo, led him frequently to put too much truſt and confidence in ſome of thoſe who had the charge of his works, which proved to him the cauſe of many cruel diſappointments. But even from his errors and failure the public have derived advantage; and it is ſurely indiſputable, that a man, who paſſed ſixty years in acquiring knowledge, and enlightening his countrymen, is well entitled to the gratitude of his country. During his life, his public ſervices were not altogether overlooked. He often met with flattering marks of approbation from many liberal and public ſpirited noblemen and gentlemen in this country; and the City of Edinburgh, then under the auſpices of Provoſt DRUMMOND, when they honoured him with the freedom of their City, was pleaſed to add in his diploma, "That it was given for eminent ſervices done to his country." But enough has not yet been done. Some farther tribute is due to his memory: For there is a juſt debt of gratitude conſtituted againſt the public, which cannot be conſidered as diſcharged, as long as the Widow of Dr ROEBUCK, whoſe fortune was ſunk in theſe great undertakings, is left without any proviſion for her immediate or future ſupport.

Account of Dr Roebuck.

END OF THE HISTORY.

The Biographical Account of Dr Robertson, *read before the Society March* 21. *and May* 9. 1796, *will appear in the next Volume of the Transactions.*

I.

PAPERS OF THE PHYSICAL CLASS.

I. ACCOUNT *of a* MINERAL *from* STRONTIAN, *and of a peculiar Species of* EARTH *which it contains. By* THOMAS CHARLES HOPE, M. D. F. R. S. EDIN. *Professor of Medicine in the University of Glasgow, and Physician to the Glasgow Royal Infirmary.*

[*Read Nov.* 4. 1793.]

THE mineral, of which I have the honour to lay an account before the Society, was brought to Edinburgh in considerable quantity about six years ago by a dealer in fossils, though indeed it had found its way, long before this period, into one or two collections.

BY some it was mistaken for fluor. Its great specific gravity, its fibrous appearance, and its quality of forming an insoluble substance with sulphuric acid, made it generally be received as the native carbonate of barytes. From a few experiments, I was led at that time to entertain some doubt of its being any form of barytes; and for several years, when I filled the chemical chair in the University of Glasgow, I used, when I exhibited the mineral itself, to mention in my lectures such of its properties as I had discovered, and which indicated that it did not belong to the barytic genus. Towards the end of the year 1791, 1791, I commenced and executed a ſeries of experiments, the detail of which I laid before the College Literary Society of this place in March 1792. Theſe not only ſatisfied me that I had been right in my conjecture, which was, that this mineral differs from aërated barytes, but alſo gave reaſon to imagine, that it contains a peculiar and hitherto unknown kind of earth. Other experiments, more lately performed, ſtrongly confirm, and perhaps I may add, eſtabliſh this notion.

Dr CRAWFORD, having remarked the conſpicuous difference in the form of the cryſtals of the muriate of this foſſil and of the muriate of barytes, and in their ſolubilities in water, has thrown out a conjecture to the ſame purpoſe, at the end of his paper on the Muriated Barytes, in the ſecond volume of the London Medical Communications.

2. THE mineral of which I have been ſpeaking, I am informed, is found in the lead-mine of Strontian in Argyleſhire. It lies imbedded in the metalliferous vein, ſcattered among the ore and the different ſpecies of ſpar that are moſt commonly met with in ſuch ſituations. I have ſpecimens in which portions of lead-ore are attached to this mineral, and others in which it, calcareous and ponderous ſpars, are intermingled in large and conſiderable maſſes.

More obvious Qualities.

3. THE appearance of this foſſil varies in different ſamples. It univerſally poſſeſſes the ſparry ſtructure, and ſometimes bears a ſtrong reſemblance to ſome ſorts of calcareous or fluor ſpars. Its texture is commonly fibrous. The fibres ſometimes are ſlender, and in cloſe contact with each other, ſo as to give the maſs a conſiderable degree of compactneſs. At other times the fibres are much more groſs, and aſſume a kind of columnar appearance. The fibres or columns have, in the greater number of ſpecimens, a degree of divergency, iſſuing as radii from

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a centre. The uniformity of this radiation is frequently interrupted by the fibres proceeding from different points of convergence, croſſing and interſecting each other. Occaſionally on the ſurface, but more frequently in vacuities within the maſs, the mineral is diſcovered ſhooting into ſlender priſmatic or columnar cryſtals of various lengths. Some of theſe end obtuſely, others of them in a ſharp point; they are generally ſtriated, and have ſix ſides. I have ſeen theſe cryſtals traverſing the cavities in the form of the fineſt and moſt delicate ſpiculæ, and when diſpoſed in a radiated form, equalling in delicacy, and reſembling in appearance, the moſt exquiſite zeolites. In other portions, the ſtriated fibrous contexture is ſcarcely diſcernible. Sometimes the Strontian ſpar is tranſparent and colourleſs, more commonly it has a tinge of yellow or green, and ſome diverſity is obſervable in the depth of the tint.

4. It is not ſo hard as to ſcintillate; it may be ſcratched by a knife; it readily yields to the ſtroke of the hammer; it has no particular fracture, though it commonly breaks along the direction of the fibres.

5. It is a heavy ſpecies of ſpar, having a ſpecific gravity, going between 3.650 and 3.726.

Chemical Qualities.

6. This mineral to the taſte is inſipid, and is only in a ſmall degree ſoluble in water. I boiled ten grains of it, reduced to a very fine powder, in four ounces of diſtilled water for ſome time; about two grains and a half were diſſolved.

7. It is powerfully attacked by ſeveral of the acids, and a ſolution takes place in ſome of them. This is accompanied by a lively and briſk effervescence, which in this as in every other inſtance, proceeds from the diſengagement of an aerial fluid.

8. The gas that ariſes during a ſolution of this mineral in muriatic acid, extinguiſhes the flame of a candle, and is abſorbed

ſorbed by water. The water thereby acquires the taſte of water impregnated with fixed air or carbonic acid, and the property of precipitating lime-water and of rediſſolving the precipitate when added to exceſs; from which circumſtances I infer, that the elaſtic fluid that is diſengaged is carbonic acid gas.

9. To diſcover how much of this acid it contains, I diſſolved in diluted muriatic acid 960 grains, uſing every precaution to prevent any thing but elaſtic fluid from eſcaping during the efferveſcence. The diminution of weight that took place amounted to 290 grains. This correſponds with the reſult of ſeveral other experiments made with the ſame intention. This ſpar conſequently contains 30.2 *per cent.* of carbonic acid.

10. Having premiſed thus much with regard to the action of acids in general on the foſſil, and concerning its compoſition, I ſhall delay mentioning its habitudes with each till I have detailed the effects of heat upon it.

11. When heat is applied to the Strontian ſpar, it crackles a little, and as the temperature increaſes it loſes its tranſparency, becomes white, opaque, and in ſome meaſure friable. It requires, however, a very ſtrong fire to produce any further change.

12. I put two pieces, weighing together 320 grains, into a ſmall crucible, and inverting another over it, I placed it in an open fire. In this ſituation it remained for three hours, the fire being good, and at different times animated by means of bellows. Theſe pieces retained their form; they were white, opaque and brittle, and had loſt only two grains of their weight. Their chemical properties were unaltered.

13. A very vehement heat occaſions remarkable changes. A ſmall maſs was incloſed in a crucible, made of pure Stourbridge clay, already prepared for forming glaſs-houſe pots, having a lid fitted to it of the ſame materials. The crucible, gradually heated, was kept for forty-five minutes in the intenſe heat excited by the well managed fire of a ſmith's forge. At

the expiration of this time, the crucible itſelf became ſoft and from being turned in the fire was diſtorted in its ſhape. On examination after cooling, part of the ſpar was found to have undergone fuſion, and was converted into a glaſs of a bottle-green colour. The vitrified portion occupied the ſurface; the internal part was to appearance ſimilar to the reſult of the laſt experiment, but it felt much lighter. It now had an acrimonious taſte; it attracted water with great avidity, and imbibed it with a hiſſing noiſe; it was rendered ſoluble in this fluid. The loſs of weight which the ſpar ſuſtains when the action of the fire has produced its fulleſt effect, amounts to 38.79 *per cent.* When a little water is poured on the calcined mineral, it ſwells, burſts with a hiſſing noiſe, and becomes hot with more rapidity and in a greater degree than lime; like it, it falls into a dry powder, but the particles are not ſo fine.

The powder unites with acids into the ſame ſort of compounds as before, but no effervеſcence attends the combination. When the glaſs is dropped into muriatic acid, it is ſlowly acted upon; at length a jelly is formed, which becomes perfectly fluid on the addition of water, a minute portion of powdery matter, which probably comes from the crucible, remaining undiſſolved. If the calcined ſpar be left expoſed to the atmoſpheric air, in the courſe of twenty-four hours, it ſwells, cracks and crumbles into powder, at the ſame time attracting carbonic acid, and becoming effervеſcent.

14. Under the blowpipe the ſpar becomes white and opaque, and loſes a part of its carbonic acid. I have not been able to vitrify it *per ſe*. With borax, mineral alkali and microſmic ſalt, it melts readily into a white vitreous matter. An effervеſcence attends the fuſion, particularly when borax is employed.

15. It appears from the experiments already recited, that the Strontian mineral loſes a greater weight when ſubjected to heat than during ſolution in acids. This muſt be aſcribed to the expulſion of moiſture in the one caſe, and the retention of it in the

the other. The difference marks the quantity of water which enters into the compoſition of the ſpar. By heat 38.79 *per cent.* is expelled, while there is a loſs by ſolution of 30.20.

HENCE 100 parts contain of	earthy baſis,	61.21
	carbonic acid, -	30.20
	water, -	8.59
		100

16. As I hope to be able to render it probable, that this earthy baſis differs from any of the hitherto known ſpecies of earth, I ſhall, to ſave circumlocution hereafter, take the liberty of calling it by the name of *Strontites*; by which I wiſh to be underſtood to mean the earthy matter in a ſtate of purity, in the ſame way as lime and barytes denote the pure earthy baſes of calcareous ſpar and of aërated barytes.

17. OF the qualities of the Strontites it will be proper to add ſome more particulars.

STRONTITES has a pungent acrid taſte. When brayed in a mortar, the ſubtle powder that ariſes is penetrating and offenſive to the noſtrils and lungs. It is ſoluble in water in the proportion nearly of 2.7 grains to the ounce, at temperature 60. The ſolution is clear and tranſparent, poſſeſſing a ſtrong taſte, not unlike that of lime water; it changes to a green, papers ſtained with the juice of violets or radiſhes. On expoſure to the air, ſtrontitic water quickly acquires a cruſt on the ſurface, in conſequence of the earth attracting carbonic acid and becoming inſoluble.

18. HOT water diſſolves a much larger quantity than cold, and depoſits the Strontites as it cools in the form of colourleſs and tranſparent cryſtals. The moſt ready way of obtaining theſe is to pour a quantity of boiling water into a Florence flaſk, and then to throw in the recently calcined ſpar in ſmall pieces. After the ebullition that enſues has ceaſed, ſhake the flaſk well,

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and place it ſo that it ſhall cool ſlowly and without diſturbance. The cryſtals will be found attached to the inſide of the veſſel, ſhooting beautifully through the water to the length of an inch or more. The form of the cryſtal is abundantly diſtinct; it is a thin quadrangular plate, which is ſometimes ſquare, though more frequently a parallelogram; the largeſt of them ſeldom exceed a quarter of an inch in length, and that is uſually ſomewhat more than their breadth. Sometimes the edges of the plates are plain, oftener they preſent two facets meeting like the roof of a houſe. They, for the moſt part, adhere to each other in ſuch a manner as to form a thin plate an inch or more in length, and half an inch in breadth, the margin being irregular from projecting rectangles, the whole terminated by a regular cryſtal. Sometimes the plates are thicker, and form ſolid parallelopepids, and occaſionally are ſeen perfect cubes.

19. In the courſe of expoſure to the air for a few hours, theſe cryſtals ceaſe to be tranſparent; they become white, powdery and effervescent. The gain of carbonic acid does not compenſate the loſs of humidity; for they ſuffer a diminution of weight which amounts to nearly 10 *per cent.* To preſerve them, we muſt have recourſe to phials very cloſely corked. When ſubjected to heat, they loſe the ſuperficial moiſture with a hiſſing noiſe; as the heat approaches to near a dull red, they undergo fuſion, which ſeems to be of the watery kind; for as ſoon as all the humidity is diſſipated, there remains a white powder that reſiſts an extreme degree of heat. Water enters largely into their compoſition; 100 grains of them loſt by the expulſion of the moiſture, 68 grains. Water diſſolves them but ſlowly, particularly when they have not been bruiſed, in the proportion of 8.5 grains to the ounce at temperature 60. An ounce of water, in a heat ſufficient to keep the ſolution boiling, diſſolved no leſs than 218 grains. This is an aſtoniſhing degree of ſolubility in an earthy matter, and affords a diſtinguiſhing feature of Strontites. Theſe ſolutions are poſſeſſed of all the

properties of Strontitic water above recounted. In acids the cryſtals are diſſolved without effervescence, and there reſult the ſame products as when the native mineral is employed.

20. When I firſt obſerved the Strontites in a ſtate of cryſtallization, I imagined it was the only earth that could, in conſequence of its greater ſolubility in warm than in cold water, be obtained in this form, and I noted this property as characteriſtic of it. I have however been ſo fortunate as likewiſe to procure cryſtals of barytes.

Habitudes of Strontian Mineral with Acids.

With Sulphuric Acid.

21. When a ſolid piece of ſpar is dropped into ſulphuric acid, a few air bubbles ariſe, but theſe ſoon ceaſe, and the maſs remains undiſſolved. If, however, the ſpar be firſt reduced into fine powder, and then added to the acid in ſmall portions, an effervescence takes place, a combination is formed, and the compound falls to the bottom. The acid, in very minute quantity, renders Strontitic water turbid, which ariſes from the formation of the ſulphate.

22. The ſulphate of Strontites is in the form of a white powder. It has no taſte, and very little ſolubility in water. I boiled one grain for ſome minutes in four ounces of diſtilled water, half a grain was diſſolved. The ſolution became turbid on the addition of the carbonate of potaſs, of barytic water, and of muriate of barytes. Sulphuric acid, when aided by heat, readily diſſolves it. An effuſion of water cauſes the acid to part with the earthy ſalt.

With

With Nitrous Acid.

23. When the nitrous acid in its ſtrongeſt ſtate is poured on a maſs of native carbonate of Strontites, no action enſues; but if ſome water be added, the acid commences to act with energy, and a ſolution, attended with a briſk effervefcence, is the conſequence. Very little will be diſſolved, though the ſpar be finely powdered, if the acid be highly concentrated. A ſmall increaſe of temperature, it may be remarked, enables the ſtrong acid to attack the ſolid ſpar, and to accompliſh the ſolution. If you employ an acid previouſly diluted, the ebullition inſtantly begins; for this purpoſe, an equal quantity of water at leaſt muſt be mixed with the acid. If much leſs be added, the effervefcence and ſolution will commence, but they will both ſoon ceaſe. When the quantity of water is ſufficient, the acid free from adulteration, and the ſpar pure, no reſiduum is left, and a clear and tranſparent ſolution is obtained; but if ſomewhat leſs of the water be employed, the ſalt that is formed by the union of the acid and earth immediately aſſumes a ſolid cryſtalline form. It was by a ſolution carried on in this manner that I procured the moſt regular, though by no means the largeſt cryſtals of this nitrate.

24. The ſolution has a ſtrong pungent taſte. It is perfectly neutral, and readily by evaporation yields cryſtals. Theſe are rarely produced in ſo regular a manner that their form can be eaſily aſcertained. By a ſlow and ſpontaneous evaporation, cryſtals were formed that were hexagonal truncated pyramids. The moſt perfect cryſtals, obtained in the way a little ago deſcribed, were octohedral, conſiſting of two four ſided pyramids united by their baſes. Sometimes the apex is truncated, and the cryſtals terminate like a wedge; often likewiſe the angles are truncated in different degrees, which gives a conſiderable variety to the ſhape of the cryſtals.

25. THIS ſalt is very ſoluble in water. One ounce of diſtilled water at temperature 60 diſſolved an equal weight. With the aid of a boiling heat, the ſame quantity diſſolved one ounce, ſeven drachms and fourteen grains. The ſolution, ſaturated in a boiling heat, parts not with the ſalt immediately on cooling, but depoſits it ſlowly in the form of a confuſed maſs of cryſtals. The nitrate of Strontites in a dry air loſes its water of cryſtallization and effloreſces; in a moiſt, it attracts humidity, and runs *per deliquium*.

26. THIS, as all other nitrates, deflagrates on hot coals. Subjected to heat in a crucible, it decrepitates gently, and then melts. When the heat riſes to redneſs, it begins to boil, and the acid is diſſipated. If a combuſtible ſubſtance be at this time brought into contact with it, a deflagration, with a very beautiful vivid red flame, is produced. By the operation of the heat, the ſalt ſuffers a complete decompoſition, the acid is expelled, and the earth remains in a ſtate of purity, unleſs inflammable matter has gotten acceſs to it, in which caſe it will prove a carbonate.

With Muriatic Acid.

27. VERY ſimilar phenomena to thoſe already deſcribed, as attending the action of nitrous acid on the Strontian ſpar, are exhibited on pouring muriatic acid on this ſubſtance. When the acid is concentrated, and the ſpar is in ſolid pieces, no action whatever, or very little, takes place. The efferveſcence is briſk, and the ſolution rapid, when the acid is diluted with about an equal weight of water. A gentle heat, applied to the ſtrong acid. has the ſame effect as dilution.

28. THE ſolution in the weak acid is tranſparent and free from colour, and affords cryſtals moſt readily. On diſſipating part of the fluid by heat, and permitting the reſt to cool, the muriatic ſalt cryſtallizes in a beautiful manner. The cryſtals

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are delicate ſlender priſms, ſometimes two inches long, having a ſoft ſilky appearance. If the refrigeration has been very gradual, the priſms will be formed leſs delicate, and of a more diſtinguiſhable ſhape. All of them are hexagonal, ſome having all their ſides equal, others having two broad ſides, with two intervening narrow ones, while another ſort is ſeen with three broad alternating with three narrow ſides. At one time they end abruptly, at another an obtuſe trihedral pyramid terminates them, and now and then they are ſeen pointed like a needle.

29. By the facility of cryſtallization, and by the peculiar form of the cryſtals, this earthy ſalt may be eaſily detected wherever it exiſts in ſolution. For this purpoſe, put a few drops on a plate of glaſs, and the muriate will ſoon diſcover itſelf by ſhooting into its long ſlender needles, which are often diſpoſed in a radiated form.

30. These cryſtals, after they are thoroughly dried, ſuffer little change from expoſure to air, yet when the atmoſphere is greatly loaded with moiſture, they are apt to deliqueſce. Their ſolubility in water is great. At temperature 60, one ounce of diſtilled water is capable of diſſolving one ounce, four drachms and one ſcruple. To the ſame quantity of diſtilled water, kept boiling on a ſand bath, I added in ſucceſſive portions four ounces of the ſalt, which became fluid, and I imagine I might have added any quantity more with the ſame event, as the temperature of the ſolution, when boiling, ſeems ſufficient to enable the water of cryſtallization itſelf to diſſolve the ſaline matter.

31. If into a ſaturated ſolution, ſome ſtrong muriatic acid be thrown, a precipitation inſtantly happens. The matter that falls down is the ſalt in ſmall needle form cryſtals, and the ſeparation of them from the water ariſes from the force with which the acid attracts the fluid, being greater than that exerted by the ſalt to retain its ſolvent.

32. THE tafte of the falt is peculiar, fharp and penetrating. When urged quickly by heat, the muriate of Strontites undergoes the aqueous fufion, and by lofing the water of cryftallization, and with it 42 *per cent.* of its weight, becomes a white powder, which, as foon as the crucible is heated to rednefs, melts. A quantity of this falt was kept in the red heat of a ftrong open fire, occafionally enlivened by bellows, for above an hour. It had been in perfect fufion, yet its acid was not expelled. It could not, however, when contained in a fmall fpoon of platina placed upon charcoal, endure, without decompofition, the ftronger heat excited by the blowpipe.

With Acetous Acid.

33. ORDINARY diftilled vinegar diffolves the Strontian foffil, after being reduced to a very fine powder, but with no great energy. An effervefcence, as ufual, accompanies the diffolution. The liquid acetite is tranfparent, and without colour. It changes, though flowly, the colour of violet teft papers to a green. By fpontaneous evaporation, it dries up into a friable falt, compofed of minute cryftals.

THESE are perfiftent, though expofed to the atmofphere. They render green the vegetable colours. They feem to be nearly equally foluble in hot and cold water; for a quantity of water, kept in a ftate of ebullition, which diffolved them at the rate of 196 grains *per* ounce, depofited no cryftals on cooling.

With Oxalic Acid.

34. THE Strontian mineral muft be in fine powder, elfe it will remain untouched by this acid. When finely pulverized fpar is thrown into oxalic acid, an oxalate of little folubility is generated, which falls to the bottom of the veffel, under the form

form of a white powder. This acid, poured into Strontitic water, unites with the earth, and precipitates with it.

35. This is one of the moſt inſipid, and one of the moſt inſoluble of the combinations into which Strontites enters. Ten grains were boiled in four ounces of diſtilled water for ſome minutes, there remained undiſſolved fully nine grains. The clear liquor had the ſlighteſt poſſible degree of milkineſs produced in it, on the addition of ſulphuric acid, or of carbonate of potaſs. By heat the oxalic acid is deſtroyed, and the earth remains partly pure and partly united to carbonic acid.

With Tartarous Acid.

36. With this acid the mineral exhibits appearances nearly ſimilar to thoſe now deſcribed. There is however, for a ſhort period, an extremely feeble efferveſcence. Here I may remark, that for the ſake of promoting the union of Strontites with the weaker acids, I frequently employ what I call the artificial carbonate of Strontites, by which I mean this earth precipitated from an acid by an efferveſcent alkali. On this powder the acid of tartar acts with vigour. When dropped into Strontitic water, it carries down the Strontites in union with it.

37. The tartrite is nearly inſipid. I boiled ten grains of it in four ounces of diſtilled water; ſix grains were diſſolved. This ſolution, after it had ſtood ſome weeks in a cloſe phial, depoſited during froſty weather ſeveral ſmall but very regular cryſtals, the form of which is a triangular table, having the edges and angles ſharp and well defined. Theſe cryſtals undergo no alteration from expoſure to the air. When acted upon by heat, they at firſt ſwell and are puffed up after the manner of borax, and at length with ignition loſe their acid, which is the firſt change that the powdery tartrite ſuffers under ſimilar treatment.

With Fluoric Acid.

38. Scarcely any perceivable effervefcence happens when Strontian fpar is thrown into acid of fluor. It is brifk if the artificial carbonate be ufed, but little is diffolved, as the fluate falls to the bottom. Fluor acid occafions a milkinefs in Strontitic water by the formation of a fluate, which is poffeffed of nearly the fame folubility as the preceding.

With Phofphoric Acid.

39. This acid attacks the fpar, though in a folid form, but the progrefs of the effervefcence and folution is exceffively flow. A bit, weighing two or three grains, was not completely diffolved in twenty-four hours, though the difengagement of carbonic acid went on without interruption. The folution continues clear as long as the acid is confiderably in excefs; but as foon as the point of faturation approaches, it becomes thick, from the depofition of a white powdery phofphate. When the acid of phofphorus is dropped into Strontitic water, a precipitate appears, which is rediffolved when the acid comes to be redundant. The phofphate, if perfectly neutral, has little folubility in water. Ten grains of it, treated with four ounces of boiling diftilled water, left a refiduum of nine grains.

With Succinic Acid.

40. The acid of amber, diffolved in water, affaults, but with no remarkable activity, the artificial carbonate of Strontites. A clear folution refults, which, by fpontaneous evaporation, yields a cryftalline fuccinate, which is perfiftent in the air.

With Acid of Arſenic.

41. The arſenic acid diſſolves with tardineſs ſmall but ſolid pieces of the foſſil. With the artificial carbonate the effervefcence is lively. In either caſe, the compound continues diſſolved till the acid is almoſt ſaturated, when the liquor grows thick, from the depoſition of a white powder, which is the arſenicate. A precipitate is formed by pouring Strontitic water on acid of arſenic; but agitation makes it diſappear. This happens till the acid is nearly ſaturated; after which the precipitate will not be taken up, unleſs upon the addition of ſuch a quantity of acid as ſhall make it predominate. The arſenic acid being dropped into Strontitic water, a copious precipitate deſcends to the bottom, which vaniſhes when the acid comes to prevail.

42. Having diluted a quantity of this acid with about twice its volume of water, I threw into it the artificial carbonate to nearly perfect ſaturation. A clear ſolution reſulted, which evaporated on a plate of glaſs, gave a gelatinous ſubſtance, that by longer expoſure to the air dried into a white powder. Cryſtalline forms ſhowed themſelves on the inſide of a glaſs, which contained ſome of the ſolution after it had ſtood for ſome time. It is ſomewhat curious, and deſerving of notice, that this ſolution lets fall the greater part of the arſenicate it contains as ſoon as it is made to boil by the application of heat.

The arſenicate fully neutralized is only in a ſmall degree ſoluble in water; an ounce of which, when boiling, takes up rather more than a grain.

With Boracic Acid.

43. To the acid of borax diſſolved in hot water, I added a minute portion of artificial carbonate of Strontites; a ſlight

effervefcence and folution took place ; and this happened when fimilar fparing quantities were thrown in for two or three times, after which the powder united with gentle effervefcence, and fell to the bottom. I poured Strontitic water into a fimilar folution of the acid ; at firft no difturbance of tranfparency was obfervable, but when the point of faturation was not far diftant, a copious precipitate appeared. This I wafhed with cold water, that feems to act little upon it, and diffolved it in boiling, of which it requires about an hundred and thirty times its own weight. The folution changes to a green, the colour of paper ftained with the juice of violets.

With Carbonic Acid.

44. The combination of Strontites with carbonic acid we have in the Strontian mineral, the properties of which I have been detailing. The earth, foluble in water, becomes fcarcely fo by uniting with this acid. With an excefs of acid its folubility increafes confiderably, as is the cafe with barytes and lime. The folution of Strontites is precipitated by water impregnated with carbonic acid, and the precipitate is rediffolved by the addition of more of the fame fluid.

45. Strontites, and all its combinations, poffefs a remarkable property, and one which I long confidered as peculiar to them : I allude to the quality of tinging the flame of combuftible bodies of a red colour. The muriate has this power in the moft eminent degree. Its effects are well exhibited by putting a portion of the falt on the wick of a candle ; it caufes the flame to affume a beautiful deep blood-red colour. All the other compounds, and Strontites itfelf, occafion more or lefs of the fame appearance. The nitrate approaches the neareft to the muriate ; and it is in confequence of this property that the deflagration of this falt with an inflammable fubftance exhibits fo brilliant and vivid a red flame. It is a pretty experiment to ex-

tinguifh

tinguiſh a candle by means of carbonic acid gas, as it iſſues from a briſkly effervefcing ſolution of the ſpar in muriatic acid. After the nitrate, comes Strontites in cryſtals; the acetite holds the next place. Thoſe that follow give but a faint tinge of red. I ſhall enumerate them in the order of their power: Tartrite, ſulphate, oxalate, fluate, arſenicate, carbonate, phoſphate and borate; the effect of the two laſt is extremely feeble *.

46. It is worthy of remark, that a certain portion of humidity is abſolutely requiſite to enable theſe ſubſtances to alter the hue of the flame. By way of illuſtration, dry by a gentle heat the moſt powerful of them all, the muriate, and by that bring it to the ſtate of a dry white powder. In this condition it will not affect the flame; moiſten it, and inſtantly you reſtore its former power. This holds true with regard to all the reſt; ſo much ſo indeed, that thoſe which have not much moiſture in their compoſition will not affect the flame without an addition of humidity. This is the caſe with the ſulphate, tartrite, oxalate, phoſphate, arſenicate, borate, fluate, carbonate and calcined ſpar. Nay, it is even true with reſpect to the acetite, though in a cryſtalline form.

47. All the combinations of Strontites with different acids, excepting the carbonate, are decompoſed by the three alkalis in their ordinary effervefcent ſtate, by virtue, in part, of a double elective attraction. When a ſolution of carbonate of potaſs, for example, is dropped into the muriate, at firſt a tranſparent gelatinous precipitate is formed, which, upon agitation, after further additions of alkali, acquires a white curdy appearance. Similar phenomena accompany the precipitations by the carbonates of ſoda and ammoniac; no effervefcence attends any of them. The precipitate, when dried, proves to be a white

 ſubtle

* The beautiful experiment with the muriate was firſt mentioned to me in the 1787, by an ingenious gentleman, Mr Ash, who was then ſtudying phyſic at Edinburgh.

ſubtle powder, and is what I have hitherto denominated the artificial carbonate. In diluted muriatic acid, I diſſolved 200 grains of Strontian mineral, and then added ſalt of tartar, which had run *per deliquium* as long as it occaſioned any precipitate. By the teſt of ſulphuric acid, I diſcovered that the alkali had ſeparated the whole of the earth, which was well waſhed, and afterwards dried before a fire, being towards the concluſion of the exſiccation brought very near the bars; it weighed 198 grains. This *deficit* of two grains I aſcribe to accidental loſs, as during waſhing, by adhering to the filter, *&c.* The artificial carbonate poſſeſſes all the chemical qualities of the native, with this difference, that it parts with its acid more readily when urged by heat.

48. THE pruſſiate of potaſs and of lime did not diſturb the tranſparency of a ſolution of a pure colourleſs maſs of Strontian mineral in nitric acid. Sometimes, however, theſe ſubſtances threw down from ſolutions in the muriatic acid a ſparing precipitate of a blue colour, which denotes the exiſtence of a minute portion of iron in ſome ſpecimens. The precipitate is moſt abundant when a coloured ſpar has been employed; whence I conclude, that the colour which the ſpar occaſionally exhibits is adventitious, and is owing to the iron it contains.

49. WITH ſulphur, Strontites combines into an hepar. Equal weights of calcined Strontian mineral and flowers of ſulphur were triturated together, and expoſed to heat in a covered crucible. The heat was continued till a few minutes after the blue flame had ceaſed to appear at the chinks of the cover. The maſs had been in fuſion. Being pulveriſed, part was thrown into muriatic acid; an effervеſcence enſued, and the hepatic odour became offenſive. Boiling water was poured on the remaining portion; a yellow-coloured fluid reſulted, which was decompoſed by acids, and gave with acetite of lead a very abundant black precipitate. In the humid way likewiſe a hepar may be formed. On a mixture of equal parts of flowers of

of ſulphur and cryſtals of Strontites, I poured ſome hot water, which I cauſed to boil for ſome time. A liquid hepar, of a dark yellowiſh brown colour, was the product, and ſhowed the ſame qualities as the preceding.

50. CRYSTALS of Strontites were diſſolved, but ſparingly by alcohol. The tincture was of a yellow colour, and burned with a reddiſh flame.

51. HAVING detailed all the properties of the Strontian mineral, and of its earthy baſe, with which I have made myſelf acquainted, my next object ſhall be to conſider, and, if poſſible, to determine, whether this earth be really different and diſtinct from all thoſe that are already known. There are two kinds to which the Strontitic baſis bears in its properties no inconſiderable reſemblance, I mean barytes and lime; yet it ſeems to me to differ as much from both of them as they differ the one from the other. In external appearance, it muſt be acknowledged, ſome ſimilarity is obſervable among the native carbonates of theſe earths. The Strontian foſſil reſembles moſt the barytic ſpar. Indeed this is ſo much the caſe, that many perſons admitted it into their collections as the aërated barytes. Nay, a French chemiſt of ſome note, M. PELLETIER, informs us, that having analyzed a maſs, which he received from the Honourable Mr GREVILLE, he did not publiſh the reſult, for the reaſon, " qu'elle ne m'avoit fourni rien de particulier *."

52. THESE two productions of nature agree in exceeding other earthy ſpars in ſpecific gravity; in retaining their carbonic acid, unleſs when urged by a very intenſe heat; in diſſolving when cauſtic in water; in affording the pure earth in cryſtals; in diſſolving in acids with nearly ſimilar phenomena; in forming ſalts of difficult ſolubility with ſeveral of the acids, and cryſtallizable ones with the nitric and muriatic. In theſe reſpects a ſtrong analogy prevails between them, yet it is but an analogy; for in the points now

enumerated,

* Ann. de Chem. t. 10. p. 188.

enumerated, as well as in others, a confiderable difference actually prevails.

53. THEIR fpecific gravities differ, that of native carbonate of barytes being 4.338, while that of Strontitic fpar goes from 3.650 to 3.726. The laft mentioned parts with its acid fomewhat more readily, and without being fufed itfelf, or acting fo powerfully on the clay of the crucible; and when calcined, it imbibes moifture with much greater avidity, fplitting with more heat and noife. There fubfifts a greater difference between the folubility of pure Strontites in hot and cold water than of barytes *; moreover, the forms of their cryftals difagree widely. Strontites generates with fulphuric acid a lefs ponderous and more foluble earthy falt than barytes. It is true that both barytes and Strontites form cryftallizable falts when combined with nitric or muriatic acids, but the cryftals have no fimilarity either in property or afpect. Thofe, into the compofition of which Strontites enters, fuffer changes from expofure to the air, which do not happen to the nitrate or muriate of barytes, and they are vaftly more foluble in water. In the figure of the cryftals alfo the difference is very remarkable. A ftrong and weighty argument in favour of the diftinct nature of thefe earths is furnifhed by the circumftance, that folutions of Strontites in acids fuffer no decompofition from pruffiate of lime or potafs; for here I put out of confideration the change that is occafionally produced when the minute portion of iron is prefent; while, as every body knows, a prominent and difcriminating feature of barytes is its precipitation by either of thefe fubftances. A mark of diftinction not lefs decided is the quality that Strontites and its compounds poffefs of tinging the flame of combuftible bodies of a red colour; a property that does

* I have, fince this paper was read, difcovered that the difference of folubility of barytes in hot and in cold water is fully as remarkable as that of Strontites. This mark of diftinction confequently muft be rejected.

does not belong to barytes, the muriate of which gives a very faint greenish hue. To these add, what assuredly carries great weight with it, that these substances do by no means agree in the order of their attractions. On the whole, I think it abundantly manifest, that the fossil from Strontian is not aërated barytes, and that it has not this earth for its basis.

54. It has been above remarked, that this mineral occasionally assumes the appearance of some sorts of calcareous spar; and it has likewise been noticed, that some analogy prevails between the properties of their component earths. In no circumstance does this appear so strongly as in the quality of tinging flame, which I have discovered to belong also to the compounds of lime, though in a much smaller degree. The muriate of lime gives the flame of a candle, when applied in the manner formerly described, a red colour, which is considerably less vivid and brilliant than that produced by muriate of Strontites, and short of that occasioned by the nitrate of this substance. It is easy, however, to show, that Strontites and lime materially differ. The specific gravity of the Strontian far exceeds that of calcareous spar, which is commonly about 2.700. The former retains its carbonic acid much more obstinately in the fire. But the incomparably greater solubility of the pure earth in hot water, and its crystallizing, are characters of themselves sufficient to discriminate Strontites from lime, and I shall only further observe, that Strontites forms a less soluble compound with sulphuric acid, yields a crystallizable nitrate and muriate, and displays a power of attraction different from lime; whence I reckon it certain, that the earth of Strontian mineral is not lime.

55. I need not draw a parallel between the appearance and properties of this fossil and any of the other earthy bodies, as it is not in the most distant degree like any of them.

56. It perhaps deserves notice, that the mineral I have been treating of, though different from the native carbonates of barytes

rytes and lime, holds a ſort of intermediate ſpace, and forms a kind of link between them. To illuſtrate what I mean, I may obſerve, that in ſpecific gravity, fuſibility, capability of decompoſition by heat, and in the ſolubility of the compounds it forms, it ſtands in the middle. Thus, heavier than calcareous and lighter than barytic ſpar, it is more eaſily melted than the one, leſs ſo than the other. When ſubjected to heat, it parts with its carbonic acid more readily than barytes, leſs ſo than lime. The ſulphate, nitrate and muriate of it are all more ſoluble than the ſame ſalts of barytes, and leſs ſoluble than thoſe of lime. In one reſpect indeed it exceeds both, and that is, ſolubility in hot water, which perhaps is ſo great as may make ſome perſons, over fond of nice diſtinctions, deny it a place among the earths altogether *.

57. This kind of intermediate ſituation ſhall perchance induce ſome to imagine, that this earth is a peculiar combination of the other two. At firſt, I confeſs, when this idea ſuggeſted itſelf to me, I did not deem it improbable; but now, after full inveſtigation, I muſt reject the notion. This, I hope, I do with good reaſon, ſince I have found that, like the acknowledged ſimple earths, this ſubſtance bears repeated ſolutions, cryſtallizations and precipitations, without ſhowing the ſmalleſt diſpoſition to a ſeparation of principles; and ſince the means that diſunite an artificial mixture of the two earths, ſuch as diſſolving in muriatic acid and cryſtallizing, or precipitating by pruſſiate of potaſs or lime, have no effect in occaſioning a disjunction of its parts.

58. As the earthy baſis of the Strontian ſpar poſſeſſes remarkable qualities that are peculiar to it, and forms with acids combinations unlike thoſe generated by the known earths, and differs from all of them in the order of its attractions, I cannot heſitate to conclude, that it is an earth *ſui generis*, a new

2 and

* *Vide* note to 53.

and diſtinct genus. It belongs decidedly to the ancient order of them called alkaline or abſorbent, of which the moſt abundant ſpecies, the calcareous earth, has been long known. To my illuſtrious maſter in chemiſtry, Dr BLACK, we are indebted for eſtabliſhing the diſtinct nature of magneſia. Dr GAHN and Mr SCHEELE have the merit of diſcovering barytes.

59. CONSIDERING it as a peculiar earth, I thought it neceſſary to give it a name: I have called it *Strontites*, from the place where it was found; a mode of derivation, in my opinion, fully as proper as from any quality it may poſſeſs, which is the preſent faſhion. My reaſon is, that I think there is leſs chance of diſcovering two new earths in the ſame ſpot, than of finding two poſſeſſed of the ſame property any where. The denomination, however, is of little moment, provided it be well underſtood what it is intended to denote, and there be no room for miſtake.

60. To complete the hiſtory of Strontites, it remains for me to ſtate what I have diſcovered reſpecting the order of its attractions. I ſhall begin with pointing out the order in which the principal acids attract it, and then I ſhall ſhow the place due to its attraction among thoſe of other ſubſtances for acids.

61. SULPHURIC acid attracts Strontites with the greateſt force; for when added to a ſolution of the nitrate, muriate, tartrite, arſenicate, ſuccinate, fluate, acetite and borate, it inſtantly cauſes a diſturbance of tranſparency, and a white precipitate falls to the bottom. When poured upon the oxalate, which is ſcarcely ſoluble in water, and permitted to remain for ſome hours upon it, this acid expels the oxalic, and takes its place. I may here remark, that the precipitates formed by the ſulphuric acid do not deſcend ſo rapidly as the ponderous ſulphate of barytes; they have oftentimes in their fall more the appearance of ſulphate of lime. On this account, Strontites, though a good one, is by no means ſo delicate a teſt of the preſence of this acid as barytes, nor can it be employed altogether

with the fame advantage in the purification of nitric and muriatic acids from the fulphuric.

62. The acid of fugar, or oxalic acid, follows the fulphuric. This acid takes the new earth from all the folutions above mentioned, and with it falls in a powdery form, excepting from the fluate. It is a curious fact, that the oxalate is foluble in muriatic acid with partial decompofition. I obtained an oxalate by dropping the acid of fugar into muriate of Strontites, which I wafhed well with cold water, and dried. I then introduced it into muriatic acid, that did not diffolve it till a very little diftilled water was added. The folution, in a few hours, had depofited a fmall quantity of cryftals, which I dried on blotting paper. They were perfiftent in the air, they diffolved in water, and imparted to it the tafte of oxalic acid. This fluid was not difturbed in its tranfparency by fulphuric acid, and it occafioned in lime water a copious precipitate of very little folubility; whence I inferred thefe cryftals were oxalic acid, and their form did not contradict the conclufion. On evaporating the liquor from which they had been depofited, I procured a powdery oxalate and cryftallized muriate. The reafon of this partial decompofition I cannot at prefent affign; it cannot be explained in the fame way that the partial decompofition of fulphate of potafs or foda by nitric or muriatic acid is accounted for.

63. The third place belongs to the tartarous acid, which decompofes and caufes a milkinefs in the folutions of the earth in nitric, muriatic, fuccinic, arfenic, boracic and acetous acids.

64. Then comes the acid of fluor, which precipitates the earth from its folution in all the acids I have tried, excepting the three already mentioned as exceeding it in force. It is remarkable, that a folution of fluate is not rendered turbid by oxalic acid, though it be certain, that the oxalic has the ftronger attraction; perhaps a triple compound is formed.

65. Nitric

65. Nitric acid holds the next place. When this acid, in a ſtate of concentration, is poured into a ſaturated ſolution of the muriate, a precipitate immediately deſcends. This conſiſts of minute cryſtals of the nitrate. An affuſion of water reſtores fluidity. The liquor on evaporation affords the nitrate in cryſtals.

66. Muriatic acid, as uſual, ſucceeds the nitric. As it forms a very ſoluble compound with Strontites, the decompoſitions accompliſhed by it are made apparent by evaporation. The phoſphate of Strontites is diſſolved readily by this acid. The liquor, when the moiſture is diſſipated by a very gentle heat, yields cryſtals of the muriate and phoſphoric acid in a concrete ſtate. The arſenicate is taken up ſtill more readily; and from the ſolution, by an evaporation not puſhed ſo far as to deprive the arſenic acid of its humidity, are obtained cryſtals of the muriate. The borate diſſolved in this acid exhibits phenomena ſimilar to the phoſphate. By adding this acid to the acetite, and evaporating, we get the muriate.

Succinic acid, if it do not rank before the two laſt mentioned acids, without doubt, holds the place immediately following.

67. Phosphoric acid comes next in order. It makes no change in the combinations containing any of the acids already noticed, but inſtantly throws down a precipitate from the acetite, arſenicate and borate. With regard to the two laſt of theſe, care muſt be taken not to add more phoſphoric acid than is ſufficient, elſe the precipitate will be inſtantly rediſſolved, and will elude obſervation.

68. After phoſphoric ſtands acetous acid, which unqueſtionably has a feebler attraction than any of the preceding, and I think a greater than the acid of arſenic, becauſe this acid, dropped into the acetite, diſturbs not the tranſparency. Boracic acid follows the arſenic, and laſt of all comes carbo-

nic acid, which is expelled by all the others, as appears from the narration already given.

Order of Attractions among the Principal Acids for Strontites.

STRONTITES.
Sulphuric acid.
Oxalic.
Tartarous.
Fluoric.
Nitric.
Muriatic.
Succinic.
Phoſphoric.
Acetous.
Arſenic.
Boracic.
Carbonic.

69. THE attraction of the new earth for acids ranks high. For ſulphuric acid, barytes has unqueſtionably a ſtronger attraction than Strontites. I added barytic water to a ſolution of ſulphate of Strontites; and though only an extremely minute portion of this earthy ſalt be contained in the fluid, yet an immediate milkineſs end precipitation was the conſequence. This earth however comes next; for I find that, when I pour Strontitic water into ſolutions of ſulphate of potaſs, of ſoda, or of lime, the liquor becomes turbid, and the Strontitic ſulphate falls to the bottom.

70. I HAVE not aſcertained how the attraction of Strontites ſtands with oxalic acid further than that the force of its attraction for this acid is ſuperior to that of potaſs, and conſequently of all thoſe ſubſtances that are inferior to it.

71. The earth attracts tartarous acid more forcibly than alkalis do. Add Strontitic water to tartrite of potaſs, and tartrite of Strontites will deſcend; but its attraction is weaker than that of barytes or lime, for the ſolutions of either of theſe earths renders tartrite of Strontites turbid. The ſame place is due to this earth in its attraction for fluoric acid as with acid of tartar; barytes and lime exceed it, potaſs is feebler.

72. With reſpect to nitric and muriatic acids, the order ſeems ſomewhat different. Here fixed alkalis appear to predominate. Yet of this, after ſeveral trials, I was ſomewhat uncertain, in conſequence of peculiar phenomena that occur. When abſolutely cauſtic potaſs is dropped into a diluted ſolution of muriate of Strontites, tranſparent cryſtalline flakes appear; but long before all the earth is diſengaged, the alkali ceaſes to occaſion more precipitation, and it may be afterwards added in quantity, without producing any viſible effect. If, however, an effervescent alkali be now poured in, a copious curdy precipitate will be formed. Two hundred grains of Strontian ſpar were diſſolved in muriatic acid. To the ſolution, diluted with more than an equal quantity of diſtilled water, I added potaſs, till it no longer occaſioned depoſition. I permitted the precipitate to ſubſide, and then poured in ſome potaſs, which cauſed no viſible change. The clear liquor was decanted off, and the remaining portion filtered. The precipitate, when collected and weighed, amounted only to 24 grains. With the clear liquor, I mixed carbonate of potaſs, and I obtained an abundant white precipitate This I waſhed, and dried by a gentle heat; it weighed 170 grains. On another occaſion, I diſſolved a ſimilar quantity of the mineral in the ſame acid, and after dilution I added the alkali very ſlowly. The matter ſeparated aſſumed the form of quadrilateral lamellar cryſtals, ſome of which, unattached to any others, ſhowed the wedge ſhaped margin like an ordinary cryſtal of Strontites; frequently they adhered to each other, ſometimes appearing in arboreſcent figures.

figures. I continued to pour in potaſs as long as any precipitation followed, and I certainly conſumed more alkali than would have been ſufficient to ſaturate the whole of the acid. The cryſtalline depoſite, when dried quickly, efferveſced very feebly with muriatic acid; it was much more abundant than the former; it weighed 74 grains. From the ſupernatant liquor, carbonate of potaſs ſeparated efferveſcent Strontites to the amount, when dry, of 132 grains. The matter thrown down by potaſs, when diſſolved in muriatic acid, cryſtallizes in every reſpect like ordinary muriated Strontites. It is alſo ſoluble in water, and generates Strontitic water. From theſe experiments it appears, that potaſs precipitates only a portion of the Strontites, which is in the ſtate of cryſtals, and that this portion is variable in quantity, which I imagine in ſome meaſure depends upon the ſtate of dilution. How this comes to paſs it is not eaſy to ſay. I am diſpoſed to aſcribe it either to the production of a triple compound, or to the ſolubility of Strontites in pure alkali. The weight of the two precipitates, in neither experiment, exactly amounted to that of the ſpar employed; nor was this to be expected. In the former it was deficient by ſix grains, in the latter it exceeded by as much. The deficit of the one may ariſe in part from the loſs of matter adhering to the filter, but principally from the heat employed in drying, expelling too much moiſture from the firſt precipitate. *A priori*, it might be imagined, that there ſhould always be a deficiency, ſince part of the earth is diſengaged in its pure ſtate, as invariably happens with lime. Inſtead of this, however, in the latter experiment there was rather an increaſe of weight. This I impute to the cryſtalline form in which the Strontites is ſeparated; for in this ſtate it is united to a greater weight of water than it contains of both carbonic acid and water when it is efferveſcent.

73. The impracticability of precipitating all the Strontites from muriatic acid, ſuggeſted ſome doubts whether the alkali

really poſſeſſed a ſtronger attraction or not. Theſe were removed by the reſult of the following experiments: I diſſolved a quantity of nitrate of potaſs in boiling water, and threw in ſome maſſes of recently calcined Strontites. The heat generated commenced an ebullition, which I prolonged by the heat of a ſand bath, the mouth of the flaſk being ſtopped by a perforated cork. During the cooling, cryſtals of Strontites were depoſited. I next diſſipated by boiling much of the water of the clear fluid, managing the operation ſo that the atmoſpherical air ſhould have as little acceſs as poſſible. By this proceſs I obtained cryſtals of nitre, intermixed with a ſmall quantity of cryſtallized Strontites. I performed a ſimilar experiment with a ſolution of muriate of ſoda, and the reſult only differed in this, that the cryſtals of common ſalt were depoſited during the evaporation of the liquor, and thoſe of Strontites, for the ſecond time, during the ſubſequent refrigeration; whence the inference is deducible, that Strontites cannot detach the nitric or muriatic acid from the alkalis with which they are united in ſaltpetre and ſea ſalt.

74. THE attraction of barytes for muriatic acid exceeds that of the new earth. To a ſolution of Strontitic muriate I added ſome native carbonate of barytes lately calcined and reduced to fine powder. Soon marks of decompoſition were apparent, and the liquor conſiſted of muriate of barytes. Muriated barytes, on the other hand, ſuffers no change from the earth I have been deſcribing. The attraction of lime for this acid is feebler than that of Strontites. Muriate of lime became muriate of Strontites, ſome time after I had introduced the powder of calcined Strontian ſpar into it. Ammoniac was inſtantly diſengaged from the muriatic acid by Strontites.

75. POTASS attracts acetous acid more forcibly than Strontites, and diſlodges it.

76. PHOSPHORIC acid is one of thoſe that prefer Strontites to alkalis. Strontitic water immediately cauſes a precipitation

in

in phoſphate of potaſs or ſoda. Strontites in its turn gives place to lime and barytes.

77. THE ſame order as in the preceding is obſerved with regard to the acid of arſenic.

78. BORATE of Strontites ſuffers no viſible change from lime-water or potaſs, but is turned muddy inſtantly by barytic water. A ſolution of borax is decompoſed by diſſolved Strontites.

79. THE attraction of Strontites for carbonic acid is powerful. It renders mild alkalis cauſtic, and becomes thereby itſelf a carbonate. I was deſirous of determining the relative attractions of barytes, lime and Strontites for this acid, but found it not an eaſy matter. The difficulty proceeds from all the three being entirely or nearly equal in power. BERGMAN was not able to decide between the two firſt of them. In hopes of aſcertaining this point, with artificial carbonate of Strontites in ſubtle powder, I mixed a quantity of barytic and of lime water, and kept them in phials accurately cloſed. I had the bottles ſkaken very often during a week. At the expiration of this time, I decanted carefully from both the ſupernatant fluid, and ſaturated it with marine acid. The liquor of the one, treated in this manner, gave, on evaporation, muriate of barytes; from the other I obtained muriate of lime. Theſe experiments ſeem to ſhow, that Strontites will not yield carbonic acid to either of theſe earths. Again, when Strontitic water, poured upon the carbonates of barytes and of lime, is managed in the ſame manner as the former, the clear liquors, ſaturated with the ſame acid, afford, both of them, muriate of Strontites. This earth conſequently had not taken the fixed air from either. Since then neither lime nor barytes can attract carbonic acid from Strontites, and ſince this acid will not deſert either of theſe to combine with Strontites, I am led to the concluſion, that the forces of their attraction are equal, or very nearly ſo. This alſo appears from the following experiments: Into a mixture

ture of nearly equal parts of Strontitic and barytic waters, I threw distilled water impregnated with a quantity of fixed air less than was sufficient to saturate either of the earths. I shook the whole well for some time, in the expectation that the earth, whose attraction preponderated, would attach to itself all the acid, and become insoluble. On examination, however, I found, that the precipitate consisted of the carbonates of both. When a solution of lime, instead of barytes was used, the event was similar.

80. Strontites precipitates metallic calces from their solutions in acids, but with no particular phenomena. When Strontitic water is poured into a solution of muriate of mercury, a brownish yellow precipitate, like to that produced by barytic or lime water, presents itself. The same fluid causes a dark green precipitate in sulphate of iron, a greyish white in sulphate of zinc, a light blue in sulphate of copper, and a white one in acetite of lead.

TABLE to show the Place due to Strontites in the Order of Attractions.

Sulphuric Acid.	*Oxalic.*	*Tartarous.*	*Fluoric.*	*Nitric.*
Barytes	Barytes }	Lime	Lime	Barytes
Strontites	Lime } ?	Barytes	Barytes	Potass
Potass	Strontites }	Strontites	Strontites	Soda
Soda	Potass	Potass	Potass	Strontites
Lime	Soda	Soda	Soda	Lime

Muriatic.	*Phosphoric.*	*Arsenic.*	*Boracic.*	*Carbonic.*
Barytes	Lime	Lime	Barytes	Lime Barytes Strontites
Potass	Barytes	Barytes	Lime } ?	Potass
Soda	Strontites	Strontites	Strontites }	Soda
Strontites	Potass	Potass	Potass	
Lime	Soda	Soda	Soda	

To make a ſmall addition to the hiſtory of barytes, and to correct a miſtake that has prevailed reſpecting the native combination with carbonic acid, I beg leave to add a few words.

1. All the chemiſts who have made native carbonate of barytes the ſubject of their experiments, concur in aſſerting, that the carbonic acid cannot be diſengaged from it by heat alone; and upon this ſuppoſed fact, a theory of pretty extenſive application has been founded. Dr Withering, in his admirable paper, Phil. Tranſ. vol. lxxiv. p. 298. ſays, "It is very remarkable, that "the terra ponderoſa ſpar in its native ſtate will not burn to lime. "When urged with a ſtronger fire, it melts and unites to the cru-"cible, but does not become cauſtic." "May we not conjec-"ture then, that as cauſtic lime cannot unite to fixed air with-"out the intervention of moiſture, and as this ſpar ſeems to "contain no water in its compoſition, that it is the want of "water which prevents the fixed air aſſuming its elaſtic aërial "ſtate." This ſuppoſition becomes, in his opinion, ſtill more probable from the circumſtance, that the artificial aërated terra ponderoſa, which contains water, loſes its fixed air by the action of heat.

2. Dr Priestley adopted this notion, and adds his teſtimony to the fact upon which it reſts. In the Phil. Tranſ. vol. lxxviii. p. 152. we have the following words: "Terra ponderoſa aërata "gives no fixed air by mere heat. But I find, that when "ſteam is ſent over it in a red heat in an earthen tube, fixed "air is produced with the greateſt rapidity, and in the ſame "quantity, as when it is diſſolved in ſpirit of ſalt, and making "the experiment with the greateſt care, I find that fixed air "conſiſts

" conſiſts of about half its weight of water." From theſe obſervations Dr PRIESTLEY infers, that water enters into the compoſition of fixed air, nay, that it is this ingredient which is eſſential to the aëriform condition of the acid. He extends the idea to all aërial fluids, and hence draws a futile argument againſt Mr CAVENDISH's glorious diſcovery of the compoſition of water.

3. IT is unneceſſary to tranſcribe the words of Mr WATT *junior*, who ſpeaks on the authority of Mr JOSIAH WEDGEWOOD *junior*, to nearly the ſame purpoſe or thoſe of M. SAGE, FOURCROY and PELLETIER, who ſtrangely aſſert, that this ſubſtance is abſolutely unchangeable by heat.

4. FROM this general opinion, however, I am obliged to diſſent, having found, that the fixed air can be expelled from the native aërated barytes by heat alone, if ſufficiently intenſe; a circumſtance that muſt prove fatal to the theory founded on its ſuppoſed impracticability. The heat which anſwers this purpoſe is that of a ſmith's forge, when the fire is ſkilfully managed. By its aſſiſtance, I have oftentimes deprived the barytic ſpar of its acid either entirely or nearly ſo.

5. I NEED not detail the particulars of more than of one experiment. In ſeveral trials, however, it may not be improper to remark, I was diſappointed, in conſequence of the barytes, vehemently heated, acting as a flux on the clay of the crucible, corroding holes in it and making its eſcape, leaving as its only veſtige a green-coloured vitreous glazing on the inſide of the crucible. At firſt I employed crucibles made of pure Stourbridge clay, but was, from the circumſtance this moment mentioned, obliged to have recourſe to thoſe compoſed of black lead, which are able to reſiſt and confine the heated ſpar; yet ſometimes I ſucceeded even with thoſe of clay.

6. A SOLID and pure maſs of the ſpar, weighing 338.4 grains, was put into a black lead crucible, having a lid of the

fame fubftance fitted to it. The crucible, gradually heated, was kept in the ftrong fire of a fmith's forge for the fpace of half an hour, when it became very foft. On breaking it after it had cooled, indubitable proofs appeared of the mafs having undergone complete fufion. From being previoufly angulated, it now accommodated itfelf to the fhape of the crucible, and encrufted the bottom and fides of it a little way up. The cruft externally, where it flightly adhered to the crucible, was of a dark greyifh colour, internally it had a greenifh fhade. The matter was light, fpungy and porous like pumice ftone, and being carefully collected weighed only 261 grains. The fpar had therefore loft 77.4 grains, which is at the rate of 23 *per cent.* nearly.

7. THE calcined mafs imbibed water with a hiffing noife and confiderable increafe of temperature, but without fwelling or fplitting like lime, and was foluble in this fluid. On dropping it into diluted muriatic acid, a very flight effervefcence took place; but this foon ceafed, and the diffolution proceeded in perfect quiet. The folution had a greenifh caft.

8. FROM another mafs, weighing 530.5 grains, I expelled 136.5 grains or 25.60 *per cent.* and ftill it was not altogether non-effervefcent. I however obtained it once abfolutely cauftic or free from carbonic acid, having employed a crucible of Stourbridge clay, which endures a ftronger heat than the black lead. But I could not in this cafe afcertain the lofs of weight, as part of the mafs had efcaped through a hole it had made for itfelf.

9. EVEN by the common blowpipe and candle, a part of the acid may be difengaged. Suppofing that the heat excited by this inftrument, employed in the ufual way, would be very inadequate to produce the defired effect, I tried pure air, in the manner I had feen M. LAVOISIER ufe it. This mode confifts in directing a ftream of oxygenous gas againft ignited charcoal, and

and produces an extreme intenſity of heat. By this heat the ſpar was rapidly melted, but ſinking into the pores of the charcoal, it eluded further impreſſion. I then had recourſe to the ordinary blowpipe. The ſmall maſs readily melted, and on being kept in fuſion for ſome time, boiled with ſo much violence as to ſcatter around it minute particles of the liquid matter. After two or three minutes, it was kept fluid with more difficulty; and, finally, it covered the ſurface of the charcoal with a thin powdery cruſt. Though it ſtill effervefced briſkly with muriatic acid, a portion of the fixed air had been ſeparated; for a part of it, thrown into diſtilled water, imparted to it the power of changing to a green violet teſt-papers, and the water acquired a cruſt on its ſurface from expoſure to the air.

10. These experiments, I hope, ſatisfactorily ſhow, that the native carbonate of barytes can be decompoſed by heat alone, and further afford proof of the inſufficiency of the theory that has been deduced from the ſuppoſed impoſſibility of accompliſhing it.

11. I have found that barytes is vaſtly more ſoluble in hot than in cold water, and that it is depoſited from the former in the ſtate of cryſtals. To obtain theſe I commonly employ the calcined barytic ſpar, and the mode I follow conſiſts in throwing into water, that has juſt ceaſed to boil, ſome pieces of a recently burned maſs. The heat that is generated cauſes the water to boil, and I prolong the ebullition for a little time. The clear part of the liquor being decanted off and permitted to cool, depoſits ſooner or later a quantity of cryſtals. The ſhape and appearance of theſe vary conſiderably, according to the rapidity with which they have been formed, and this depends upon the greater or ſmaller quantity taken up by the hot water over what can be retained by it when cold; the moſt ſaturated yielding cryſtals the moſt ſpeedily, the leſs ſo not for ſeveral days.

12. The

12. The cryſtal in its perfect condition ſeems to be a flatted hexagonal priſm, having two broad ſides, with two intervening narrow ones, and terminated at either end by a quadrangular pyramid, which, in ſome caſes, conſtitutes the larger part of the cryſtal. When the cryſtallization goes on at great leiſure, the cryſtals are often diſtinct and ſolid, of no inconſiderable magnitude; but more commonly with a quicker depoſition, they are more ſlender and delicate, and are attached to each other in ſuch a manner as to aſſume a foliaceous form of beautiful appearance, reſembling ſome of the fern tribe in their pinnated frons, to ſpeak botanically; but in this arrangement, a conſiderable diverſity occaſionally happens.

13. The cryſtals obtained from calcined barytic ſpar, in the manner now deſcribed, diſſolve in water, and impart the qualities of barytic water; they change vegetable colours to a green, they unite with acids without efferveſcence, and generate with the muriatic and ſulphuric, compounds ſimilar to the ſulphate and muriate of barytes; hence I infer they conſiſt of pure barytes.

14. These cryſtals are perfectly tranſparent and colourleſs, but when expoſed to the air, become white, opaque and efferveſcent, loſing during this change nearly 30 *per cent.* of their weight. Subjected to the heat of boiling water, they undergo the aqueous fuſion and become fluid; from which ſtate, if allowed to cool ſlowly, they concrete into a ſolid cryſtalline maſs. When a ſtronger heat is applied, and continued till all the moiſture is diſſipated, there remains a white powder, lighter by one half than the cryſtals employed, which, urged by the heat produced by the blowpipe, is melted with more difficulty than the native carbonate.

15. The ſolubility of theſe cryſtals in water ſurpriſed me a good deal. One ounce of diſtilled water, at temperature 60, diſſolves almoſt twenty-five grains, while boiling water appears to

be capable of diſſolving any quantity of them, however great. This ariſes from the circumſtance, that the earth becomes ſo extremely ſoluble at an elevated temperature, that the water of cryſtallization itſelf, which ſcarcely ſurpaſſes the weight of the barytes, when heated to the two hundred and twelfth degree, is able to accompliſh the ſolution of the earth without the aſſiſtance of more fluid.

16. IN this amazing ſolubility barytes and Strontites nearly agree, but materially differ from lime, which, ſo far as I can diſcover, is diſſolved as ſparingly by hot water as it is by cold.

II. OBSERVATIONS *on the* NATURAL HISTORY *of* GUIANA: *In a Letter from* WILLIAM LOCHEAD, *Esq;* F. R. S. EDIN. *to the Rev. Dr* WALKER, F. R. S. EDIN. *Regius Professor of Natural History in the University of* EDINBURGH.

[*Read March* 3. 1794.]

DEAR SIR,

ALLOW me at present to trouble you with a few general observations on natural history, which I had an opportunity of making while on a botanical excursion, with my friend Mr ANDERSON, to the Dutch colony of Demerary. Guiana is a country but little known in Europe, though its animals and vegetables have added considerably to the catalogue of natural productions. It is not however the organic kingdom which I mean at present to touch upon; all I aim at is to give you some idea of the face of the country, as leading to the knowledge of its formation and present state. It is not a field for the mineralogist, as its interior is unexplored. But to the geologist, who wishes to trace revolutions of the latest date, it is not uninteresting to contemplate such a recent and singular country as Guiana.

I NEED not inform you, that under Guiana is comprehended all the coast of South America from the Amazons to the Oroonoko; that it trends nearly N. W. and S. E.; that it is in general a very low and flat country, especially the Dutch or westermost part of it; and that it is watered by several rivers and creeks, which rise in a chain of mountains running nearly E.

and W. and dividing Guiana from the inland parts of South America, which form the banks of the Amazons and its numerous branches.

Coaſt.—No coaſt can be more eaſy to make than that of Guiana. The changed colour of the water indicates ſoundings long before you make the land, and you may run on in ſeven fathoms before you can diſcover it from the deck. The bottom is at that diſtance a ſoft mud. All along the coaſt near Demerary, you have only about two fathom at a good league from the ſhore; to leeward of Eſſequebo, it deepens ſtill more gradually. In ſtanding off or on five or ſix miles, you will hardly deepen or ſhallow the water as many feet. When a high ſea ſets in upon ſuch a coaſt, it is eaſy to conceive, that at a very conſiderable diſtance from the land it muſt be affected by the bottom. The interval betwixt wave and wave becomes more diſtinct. As they roll on in ſucceſſion, the lower part is retarded, the upper ſurface accelerated, each billow of courſe becomes ſteeper and more abrupt, till at laſt it gradually ends in a breaker, when it has come to the depth of only a few feet. Theſe *rollers*, as they are called, are the dread of ſeamen, eſpecially betwixt Eſſequebo and Pomeroon, where the water is ſhallow, and the bearing of the coaſt very much north and ſouth, expoſes it fully to the action of the trade-winds. In ſmall craft, thoſe acquainted with the navigation do not heſitate to run along the coaſt, even among the rollers themſelves; but veſſels drawing from eight to twelve feet water, eſpecially if the ſwell be heavy and it falls calm, can hardly get off. If anchor and cables fail, they drift on till they are faſt in the mud, and there they will continue, ſometimes for weeks together, before they go to pieces. The ſea-water becomes exceedingly thick and muddy within a few leagues from the coaſt of Demerary, as much or more ſo than the Thames is at London. A ſtranger would naturally take this for the diſcharge of large flooded

flooded rivers after a rainy ſeaſon. By and by I ſhall explain the true cauſe of it.

On approaching the continent of South America, a change on the face of the *ſky* will ſtrike the attentive obſerver. The clouds become leſs diſtinct from each other, and the intervals between them leſs clear. They are blended into one another as it were, and ſuffuſed more generally over the atmoſphere. They appear to be ſurcharged with vapour, or to have a ſtronger diſpoſition to depoſit it.

There is a particular prevailing appearance of the heavens within the tropics when you are at a diſtance from continents or very high iſlands, which has ſo often ſtruck me that I wonder it has not been taken notice of. I call it a *tropical ſky*, and thus deſcribe it. The clouds in fine weather are in a ſingle ſeries or ſtratum, ſailing away regularly with the trade-wind. They are ſmall and diſtinctly ſeparated from each other. The intervals or ſky above them of a clear azure. The lower ſurface of the clouds is perfectly horizontal. As the temperature is commonly very equal over the ſea, the condenſation takes place every where at an equal height from the ſurface of the water. In the clouds that are over-head, you cannot indeed perceive this; but it becomes more and more viſible as the eye recedes from the zenith. The lower limb of each diſtant cloud appears perfectly level and well defined, brighter than the ſuperincumbent part. At a diſtance, nothing is to be ſeen but theſe limbs cloſer and cloſer in gradation one behind the other; and the whole horizon round reſembles the roof of a ſtage, with an infinity of half dropt curtains as far as the eye can reach. In two voyages from Europe, I have met with this tropical ſky as far north as Cape Finiſterre. It came with a fair wind, which continued with us like a regular trade-wind, accompanied with the ſame appearance of the clouds, till we made the Weſt Indies. In running down the trade-winds, every one has an opportunity of verifying this deſcription, and muſt be ſtruck with the beauties which this ſky preſents at the ſetting of the ſun. The inhabitants of the lower iſlands may alſo be well acquainted with it. In the higher ones, the attraction of the mountains ever forms ſets of clouds of other appearances, as being produced by other cauſes. With our preſent knowledge of meteorology, hardly any other cauſe can be aſſigned for the phenomena above mentioned, than the conſtant equal temperature that every where prevails on the intertropical ſeas. One analogous fact however may be mentioned; the exceedingly ſmall range of the barometer in the torrid zone. Does the ſame cauſe regulate ſo exactly the height of the clouds, and maintain the uniform ſuſpenſion of the mercury? We might almoſt ſuſpect it did, were it not well known, that the barometer varies as little upon continents, and in the vicinity of mountains, in theſe regions as elſewhere, though the condenſation of vapours is in ſuch caſes much more irregular. Upon the continent you will frequently obſerve this tropical ſky alſo, eſpecially in fine ſettled weather; but much more commonly you will find the ſky there, and even before you make the coaſt, covered with heavy large dark clouds in ſome places, and in others, at a greater height, the ſerene dappled ſky, ſo often ſeen in Europe.

Winds.—THE *trade-wind* generally prevails all the day long, and on the ſea-coaſt ſeldom fails even at night; but in leſs than fifty miles up the river it is a dead calm at night, and the breeze is not able to penetrate ſo far till towards noon. Still farther up we had whole days of a ſtark calm, and the heat very intenſe.

Dews, fogs and temperature.—THE dews, following the law which they generally obſerve, are very heavy when and wherever there is but little wind, and the hotter the day and evening, they fall the more copiouſly; they were of courſe more abundant up the river than near the ſea-coaſt. The exhalations in the day-time from

from a hot and mifty country covered with vegetables being very great, the condenfation occafioned by the abfence of the fun, and the cold accompanying that condenfation, are in proportion. Near the coaft the diurnal difference of temperature is but trifling, the conftant trade-wind preferving in the air nearly the fame medium of heat as in the body of the ocean; but far up the river the range of the thermometer was very great. The heat of the day was intolerable. In the fhade it was frequently above 90°. This, when there is no breeze, forces you into the woods for fhelter. Towards evening it cools; during the night the cold increafes, and is greateft about five in the morning. The thermometer would then be from 72° to 74°. The body of the river being large enough to retain its heat, the evaporation goes on from its furface through the night, and is condenfed into thick fog, which hangs over it, and is feldom difperfed before eight or ten next day. While the air was as above in the morning at 72°, the water along-fide gave 80° to 83°, and feldom rofe two degrees higher at noon-day. We had an opportunity of verifying an obfervation made by the few inhabitants who live far up the river Demerary, that when it feels very cool in the morning before day-break, they are fure of fine weather; when, on the contrary, it feels warm, they expect rain. They fleep in hammocks, and the houfes they have are pervious enough to the air, fo they are fenfibly affected by any change in its temperature.

Seafons.—As to the feafons, it is not an eafy matter, from the accounts given by the colonifts, to afcertain them exactly. All feem to agree, that fince cultivation has been fomewhat extended, they are not fo regular as before; that the dry feafon encroaches on the rainy, and that during the latter, they have often feveral dry days in fucceffion. The account given by Dr BANCROFT was the one generally allowed; that it is dry about the equinox, and rainy about the folftices; that of confequence

they

they have two wet and two dry ſeaſons every year. We thought it difficult to reconcile this with the account given of the ſeaſons of other countries in ſimilar climates, and with what actually takes place in the Carib iſlands. I will give you my ideas on the ſubject. It is within the tropics a very general rule, that the vicinity of the ſun brings the rainy ſeaſon. To the northward of the line therefore this muſt be in our ſummer months. It is another invariable law, that as in lunar influences, ſo in the change of ſeaſons produced by the ſun, ſome time is neceſſary after the maximum of the cauſe to produce the full effect. The higheſt tides are not till two or three days after the full and change. The greateſt heat of the day is two hours after noon, and the hotteſt months in Europe are July and Auguſt, not June, when the ſun is higheſt. Among the Weſt India iſlands, the full effect of the ſun's vicinity is ſtill later. I have found Auguſt, and more eſpecially September, to be the hotteſt months in the year, and they are accordingly the height of the rainy ſeaſon. It begins thus: No ſooner has the ſun come to the northward, and begun to be vertical among the iſlands in April and May, than his force is felt, the ſky is more diſturbed, the wind is more frequently from the ſouthward and in ſqualls, and now and then there are heavy ſhowers. In June the ſame effects continue, and increaſe in July, when the proper rainy ſeaſon may be ſaid to begin, and continues in force more or leſs till the middle of October. Auguſt and September, with part of July and October, when theſe effects are at their greateſt height, are ſtyled the hurricane months, and by the French *l'hivernage*. During them, the full force of the great luminary which diſtributes light and life, however neceſſary, ſeems ſometimes too much for nature. She is oppreſſed and ſickens; her reſpiration is diſordered by intenſe heat; ſometimes calms, ſometimes heavy ſqualls; the agitated elements vent themſelves in lightning, with thunder and torrents of rain, or are ſometimes thrown out into thoſe horrid convulſions, hurricanes which ſeem to threaten inſtant diſſolution. Guiana is happily free from theſe ſcourges of the Antilles. Their force has lately been partially felt at Tobago, which was thought beyond their reach. In Trinidad, the greateſt ſtorms they have hitherto experienced, do not deſerve the name of hurricanes; and to the ſouthward, on the main of America, they are utterly unknown. The difference then between Guiana and the iſlands is this: In the former, the rainy ſeaſon ſets in earlier, as indeed the ſun is ſooner vertical. Their principal rains are in the end of April, in May, June and July. They are alſo ſooner over; for Auguſt, September and October, and I believe part of July, are commonly fair weather. But again, November in part, December, January and February, reckoned dry months among the iſlands, are in Guiana a ſecond rainy ſeaſon. The cauſe of this I take to be as follows: North-eaſterly winds, pretty ſtiff, cold, and bleak comparatively in theſe climates, are frequent among the iſlands during the winter months. They are well known by the name of Norths. They are often accompanied with rain, but it is not very heavy, nor thought of conſequence enough to give the denomination of a rainy ſeaſon. Theſe winds we know to reach as far as the coaſt of Guiana; and there I have reaſon to believe they are productive of more rain than in the iſlands. The face of a large continent, and its effects upon the atmoſphere, may very probably make them give up more of their humidity than they do among the Antilles, though, at the ſame time, their force and bleakneſs may not be ſo much felt. If this conjecture hits the truth, the following ought to be corollaries, and are left to future obſervation. In this rainy ſeaſon, when the ſun is near the ſouthern ſolſtice, their rains will be with pretty ſteady northerly breezes on the coaſt. They may be of longer continuance at a time, but they will not be ſo heavy as thoſe of ſummer, and they will be chiefly on the ſea-coaſt, and probably will not extend a great way up the country. It remains even a query with me,

 whether

whether the rain that accompanies the norths among the iſlands, eſpecially thoſe moſt remote from the line, be not generally in a greater proportion than is commonly ſuppoſed.

Country.—I WILL now endeavour to give you ſome idea of the face of the country. Though, as is well known, Guiana is flat and ſwampy, yet it affords to the attentive eye an intereſting variety. The ſea-coaſt is little, if at all, raiſed above the level of high water, and it continues at this level for many miles inland. It is properly an immenſe woody ſwamp, never dry in the drieſt ſeaſon, covered with ſeveral feet of water in the wet. Next the ſhore, as far as the brackiſh water extends, it is covered with mangroves, which grow to a conſiderable height, and form a thick ſhade. They are elevated on their branchy intermingled roots from the bare wet clay or mud, on which there is ſcarcely one herb or plant, but which ſeems to be all in motion, from the prodigious number of crabs which make their holes in it. Further on, when the under-water is freſh, you meet with a new ſet of vegetables, principally ſmall trees, which, from their ſituation, are obliged to adopt the habits of mangroves, having the bottom of their trunks ſupported three or four feet above ground by their ramified roots. Several climbing plants are mixed with them. Arunis, in great variety and profuſion, emerge from the water, or embrace the ſtems of the trees; and ſeveral broad-leafed plants of the hexandria and triandria claſſes, aſſiſt the Arunis in forming an herbage. In all this low part of Demerary, there is not one tree of a large ſize, nor among them all above two or three ſpecies which can be applied to uſe as timber. Proceeding ſtill up the river, its banks are found generally to raiſe themſelves above the level of the water; and when you have gone up one tide, (betwixt twenty and thirty miles), they are ſo high, that there is no farther occaſion for dams to keep the plantations from being overflowed at high water, as below;

canals or ditches are ſufficient to drain the land, which is ſtill perfectly flat. The trees are here different in ſpecies and larger in ſize than below, and the woods are much more practicable. As they are drier, the ground has acquired a regular ſort of ſurface, and there is neither that plexus of roots, nor the ſame number of vines, (the common name in the Weſt Indies for all climbing plants), to entangle thoſe who chooſe to traverſe them. The ſoil here is generally a ſtiff, cold, reddiſh clay, mixed a-top with a portion of vegetable mould.

The ſand-hills preſent to the admiring eye a ſcene very different from what it had been accuſtomed to below. The firſt you meet with upon the Demerary, is upwards of thirty miles from the mouth of the river, and on the right hand aſcending, or on its weſtern ſhore. There are of them further down in the country, but not cloſe by the river-ſide. This one is the extremity of a ridge which extends to the weſtward ſeveral miles. As you aſcend the river, you meet with many more of the ſame kind on both ſides, whoſe direction ſeems likewiſe to be eaſt and weſt, or nearly at right-angles with the average courſe of the ſtream. They vary from 50 to 100, 150, or 200 feet of perpendicular height above the level of the river and the intervening flat country. Their breadth and extent varies ſometimes only a few hundred paces, ſometimes many miles. Their length is great; with ſome interruptions, I have reaſon to believe they are generally continued from one ſide of the colony to the other, only interſected in different places by the rivers and their branches. They conſiſt of a pure ſiliceous ſand, ſo white that it dazzles the eyes, commonly fine grained and looſe, but not unfrequently mixed with little ſtrata of coarſer pebbles, moſtly quartz, and ſometimes concreted into a proper ſand-ſtone. In the laſt caſe, a black or reddiſh tinge is in many caſes communicated to it, from clay, decayed vegetables, or other extraneous matter. There is no regular ſtratification to be found in it, more than what is common to all ſands, the produce of depoſitions of different dates, and as they are of different materials, thicker in one place, thinner in another, ſometimes horizontal, but oftener inclined, and convex or concave according to circumſtances. We could meet with no appearance of ſhells or other marine productions, but in a few places, pieces of broken vegetables buried in the ſand where it was concreted. They were black as all the foſſil vegetables that I have ever ſeen in ſand-ſtone. Upon, and by the ſides of the ſand-hills, grows the moſt valuable timber of theſe colonies. The trees there are of a good ſize, and very clear of obſtructing underwood or vines. The Wallabba, (Parivoa grandiflora of Aublet); the Sipiri or green-heart, (a new ſpecies of laurel); the Coumarou or Tonquæbean-tree, Coumarouna odorata of Aublet; the Mora, valuable for boat-timbers, and many others, whoſe wood is equally hard and beautiful.

Continuing to aſcend the river, the ſand-hills become rather more frequent, but the intervals ſtill remain a perfect flat, though now ſeveral feet above the level of the ſtream, and the ſoil is ſtill a ſtiff clay. Hitherto the river is deep all over, generally from two to five fathoms; the bottom is mud or clay, and the ſhores on either ſide at low water covered with ooze. About 130 miles up, however, or juſt before it begins to ſhallow, the bottom is covered with banks of a hard white or brown ſand. It was a problem for ſome time whence all this ſand originated in ſuch a country. It was ſoon ſolved. Leaving here the veſſel that had hitherto carried us, we proceeded in a canoe; and at about 160 or 170 miles diſtance from the mouth of the river, we met with the firſt proper hills of ſolid materials. The neareſt to us was a rock of granite projecting into the ſtream, whoſe direction it gave a change to at this place, and it ſerved for a landing-place to the higheſt piece of cleared land upon the river next to the poſt-holders. It was part of a low ridge of the ſame ſtone which croſſed the country, probably to Berbia or beyond it, and was ſucceeded by many other ſeries of hills

hills more inland, and as far as we could examine them, of the ſame materials. The granite was both of the red and the gray kinds, but chiefly of the latter. A number of ſeams or dikes croſſed it here and there in all directions, not diſtinctly ſeparate, but firmly united to the reſt, making as it were but one body with it, and conſiſting of the ſame materials differently modified. Their component parts were generally ſmaller; they were more compact and cloſer in the texture than what ſurrounded them; and where they had been equally expoſed to the action of the weather, they appeared to have born it much better than the ſurrounding granite. The origin of the ſand was now accounted for. This ſtone, in ſome caſes exceedingly firm and durable, is in others very liable to decay; and the waſh of theſe enormous chains of hills was able to furniſh abundance of ſuch ſand as we had met with below. The granite afforded many varieties, indeed every ſhade, from large and diſtinct grained, to that whoſe component parts of feltſpar, ſchorl or quartz, were ſo ſmall as to reſemble pretty compact, compound lavas, or ſome of our mixed whin-ſtones in Scotland. All theſe varieties would be found at no great diſtance from each other. I brought ſome ſpecimens, from Tiger's berg, a hill about 500 feet perpendicular height, which have every appearance of having undergone the action of fire. They reſemble half-vitrified ſcoriæ, and would be taken for them, but that they were actually broken off from the granite, and diſcover all its parts in the fracture. The ſummit of this hill is irregular, with ſeveral pits and holes among the rocks. A little higher than it, and I ſuppoſe nearly about 200 miles from the ſea, you meet what are called *the Falls*. They are only five or ſix rapids, within the ſpace of a mile or two, formed by ledges of very cloſe-grained gray granite that run acroſs the river. There are breaks in each of them, through which the dextrous Indians are able, in their light canoes, to paſs up at any ſeaſon, even the drieſt; and when the river is ſwelled by the rains, they become totally obliterated. Two days journey, or two and a half above this, is the great fall, where the ſtream comes over the face of a rock, as we were informed, twenty feet high.

Savannahs.—SAVANNAHS, ever ſince the diſcovery of America, have been known to occupy large ſpaces in the ſouthern parts of that continent. They are to be met with abundantly in Guiana, and are of two kinds very diſtinct from each other, the *wet* and the *dry*. Of the former, many are extenſive as the eye can reach, immenſe verdant plains occupying the whole face of a country, with or without a few ſtraggling inſulated patches of wood. In the dry ſeaſon, they appear meadows of long graſs or reeds, and are ſeldom practicable for any diſtance, for the bottom is very rarely dry. In the wet ſeaſon, they are all one entire plain of water, over the ſurface of which the graſs ſtill riſes, but which may be every where navigated in the courialls or canoes. Towards the end of the drought, the Indians ſet fire to them. The young growth which ſucceeds attracts the deer, and the native, on the return of the half-deucalion days, purſues them in his little bark acroſs their former plains. The ſoil upon theſe ſavannahs can neither be very deep nor very good; yet water may be always commanded, and labour and induſtry might convert theſe deſerts into *rice-fields*. It is a queſtion whether the days of ſlavery will ever ſee that event. The culture of this uſeful vegetable, which in the eaſt has for ages been the ſtanding food of millions, brings too moderate a return, at leaſt in an infant colony, for the rapacious agricultural ſyſtem of the Weſt Indies.

THE *dry* ſavannahs are neither ſo frequent nor ſo extenſive, yet we have paſſed through ſome of them ſeveral leagues in circumference. They are formed along the flats on the top of the ſand ridges, and covered by a very thin coat of verdure. They reſemble, exactly enough, ſome of the bare moors in Scotland. Many

Many beautiful plants of the claſs gynandria are their chief ornaments, as is alſo the orchis, which grows in ſimilar ſituations with you. Some Melaſtomas, and more Rhexias, ſupply the place, and bear ſomewhat of the habit of the Ericæ; for your Sedums and Saxifrages is the little Sauvageſia; and in hollows of the ſame ſavannahs, where moiſture prevails, what I never could have expected to ſee within five degrees of the line, and not more than 50 or 100 feet above the level of the ſea, the Droſera lifts its humble head from a bed of the Sphagnum paluſtre.

Besides theſe two kinds, there are alſo what we may denominate *half-ſavannahs*, formed upon the tops of ſand-hills, higher and more irregular than in the caſe of thoſe juſt deſcribed. Some of theſe are alſo very extenſive. Few herbaceous vegetables are to be met with upon them. Broad ſpaces of arid ſand are interſected by clumps of ſhrubery. Nothing grows to the height of a tree; but a particular ſet of plants, different from thoſe in other parts of the country, find ſubſiſtence enough to riſe to fifteen or thirty feet. How nature, after all her efforts, ſhould have failed to induce a ſoil upon theſe, is ſurpriſing. It appears chiefly owing to the great poroſity of the ſand, which every where admits the decayed vegetable matter deſtined for that purpoſe, to be carried down through it, and filtered off by rain. Even thoſe ſand-hills which are covered by tall trees, ſtill ſhew proofs of this. The trifling layer of mould formed upon them is exceedingly thin. When cleared they are very barren; and when you dig in them to a great depth, you ſtill find ſmall portions of black vegetable earth diſperſed among the ſand. What corroborates the above ſuppoſition, is the appearance of the ſprings. Abundance of theſe are found guſhing out copiouſly round the verges of the hills; and notwithſtanding the extreme whiteneſs and purity of the ſand from whence they flow, there is not one in an hundred whoſe waters are limpid. They come out not muddy, but of a browniſh colour, very much like the water which runs from

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peat-moſſes, and they are certainly tinged by the ſame cauſe. The rotten leaves of trees, and other decayed parts of vegetables on the hills, inſtead of being collected on the ſurface to form ſoil, are waſhed down into the ſandy ſtrata by every rain; ſo that the reſervoirs of the ſprings, and the water which proceeds from them, is always coloured with theſe ſubſtances. There follows a corollary alſo from this general principle, and when compared with facts I believe it will hold good: The more the ſand is concreted into ſtone in any of the hills, the more and better will be the ſoil upon them. Where clay in ſmall beds, or in a certain proportion, is mixed with the ſand, the vegetable mould will likewiſe be better retained.

Rivers.—I WILL next give you what general obſervations I have been able to make upon the rivers and creeks of this part of America. The courſe of nearly all thoſe of Guiana is from ſouth to north. They originate in a chain of hills running eaſt and weſt, which ſeparates Guiana from the country on the Amazons, and likewiſe gives riſe, on its ſouth ſide, to the numerous branches which fall into that river. The Demerary is a conſiderable ſtream, equal, if not ſuperior to the Thames; yet it is by no means among the largeſt of them. The Eſſequebo is five times larger at its mouth, forming a whole Archipelago of iſlands; but its ſtream ſoon divides, and, on account of rocks, ſhallows and rapids, none of its branches are navigable ſo high up as the former. Moſt of the particulars I am now to give you muſt be underſtood as applying to the Demerary. The bar, if it may be ſo called, is common to this with many other rivers, which diſcharge themſelves into a ſhallow ſea; but ſtill with circumſtances in the preſent caſe which diſtinguiſh it from others, where the bottom is not mud but ſand. It does not run like a ſingle narrow ridge, acroſs, or nearly acroſs the mouth of the river, but it is of great extent, and is properly a continuation of the mud-bank which runs all along the coaſt. To the eaſt and weſt, and for two miles or more in the offing, you have

have ten or twelve feet water with the utmoſt uniformity, and ſtanding in with the mouth of the river open, you neither deepen nor ſhallow till you enter it, when you find two, three, four or five fathom, and it continues to average that depth for a long way, ſo that any veſſel which can enter, may, for draught of water, proceed up the river for 100 miles or more.

THE mouth of the Eſſequebo, from the ſand-hills and rocks being very near it, is exceedingly different. Three large iſlands preſent themſelves in a breaſt, and divide its entrance into four channels. The length of theſe iſlands is with the current, ſouth and north; and from the tail or north end of each of them, as alſo from the banks of the main on either ſide, run out ſand-banks to a good diſtance. They are perfectly firm, quick in very few ſpots, and the body of them is above the level of low water. On the outſide of them you have the continuation of the mud-banks and ſhallow water as above, only that the entrance of theſe channels is ſtill ſhallower than that of the Demerary. The ſtream of this river runs very brown and muddy, and the ſea is ſtained with it for ſome leagues off. A ſtranger naturally imputes this to the waſhings of a large flat country, or the ſtirring up of the muddy bottom by the tides. The latter may in part be a cauſe, though I believe it contributes to it but very little, and the former, in a ſtate of uncultivation, none at all. On aſcending forty miles or ſo, you find the water clear again, or rather of a darkiſh hue, and ſo it continues above that. I was at firſt at a loſs how to account for this, but, from a number of circumſtances, was ſoon led to conclude, that the thickneſs, and light brown colour of the water near the mouth of the river and on the coaſt, were almoſt entirely the effect of cultivation. Numberleſs ditches and canals have been opened by the inhabitants, which are receiving or diſcharging water every tide, and each particular piece on a plantation is every way interſected with open little drains, which communicate with theſe ditches. In digging and hoeing this clayey ſoil, much of it is ſuſpended

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in the water, and carried off by the current of the tides. Nothing can be more certain, than that all up the river, and in all the creeks which difcharge themfelves into it, the colour of the water is conftantly clear or blackifh, even in the rainy fea-fon, when it is fwollen. On confidering thefe circumftances, I have been led to this general conclufion, which is fubmitted to the proof of obfervation in different parts of the world. The reddifh brown colour, fo common in frefhes of rivers, in Europe, and we may add every where, is almoft entirely the effect of cultivation; and the natural colour of rivers, even in the higheft and longeft continued floods, where all the country is ftill in woods or paftures, is ever that of a very dark brown, or blackifh, pretty much like that of the ftreams which rife among peat-moffes, but rather more diluted. It is comparatively very clear, and depofits but a trifling fediment. The other is thick and opaque, and its fediment copious. Thus is man, in his little workings, made, in a fmall degree, one of the engineers of nature. We cannot doubt, that entire ftrata will owe to him their exiftence, accumulated in a feries of ages at the bottom of the fea, and deftined, in future revolutions, to act a more diftinguifhed part. It may be curious too to confider the differences that may be expected betwixt the ftrata formed by thefe different depofitions, which may be fuppofed between them to have been the origin of moft of the clays upon our globe. Clay, earth or loam, ftirred up by the labourer, gives rife to the one; minutely decayed parts of vegetables form the body of the other.

It muft alfo be obferved, that clearing the ground along the coaft, by cutting down the trees, and opening ditches for the difcharge of water, has expofed the land very much to the wafhing of the fea. The roots of the mangroves formed a plexus able to refift its force; and the former equal, and very flow deepening of the water, prevented its making a ftrong impreffion impreſſion on any place. The diſcharge from the ditches at low water cut out channels in the mud, and left the ſides of theſe channels more expoſed to the returning waves, which here beat continually upon a lee-ſhore. We find therefore on the coaſt, that the ſea has made here and there conſiderable encroachments, which generally begin on the weſt ſide of the canals or ditches, as being the moſt acted upon by the waves. The mouth of the Demerary itſelf furniſhes us with a ſtrong inſtance. That river is now nearly twice as wide as it was when the country firſt began to be cleared; the ſea and the ſtream together having ſince that ſwept away a large portion of land from the weſtern ſhore.

Creeks.—A NUMBER of creeks fall into the Demerary on both ſides, but ſo ſmall that they bear no proportion to the ſize of the river. You can hardly diſtinguiſh their mouths in the woods which overhang the banks. They are ſo narrow that it is difficult to run a ſmall boat in them; yet you will find in them throughout from two and a half to four fathom water, and they run winding ſo far back that it will take five, ſix, eight hours, or more, to carry you up to their heads, where they terminate in ſmall ſtreams from among the ſand-hills. The banks of the creeks at their mouths are of the ſame height as thoſe of the river cloſe by, from five perhaps to twelve feet above the water in the dry ſeaſon. As you aſcend the creek, you might naturally expect to find them riſe. It is however the very reverſe; they become gradually lower and lower, till at laſt all round them is a ſwamp; and the trees on each ſide in like manner become ſmaller and ſmaller, and of different ſpecies from what they were. It is now in ſhort exactly a mangrove ſwamp, with this difference, that the water is quite freſh, the vegetables are not the ſame, and there are abundance of arunis and other low herbaceous plants. A little higher up, you lose the wood altogether, and find yourself in a beautiful deep canal, winding through a spacious wet savannah, which is sometimes many leagues in circumference. The first time we went up one of these creeks, (called Camouni), I was surprised at this appearance, and thought it must be a mere local circumstance peculiar to it. We found afterwards the same in one or two more instances, and were satisfied upon enquiry, that it is common to them all. It was natural to look for an explanation of this phenomenon, and I soon found it in one of those laws, which probably extend to all rivers subject to frequent inundations. It has been observed, in particular, of the Ganges *, that the banks of that river are higher than the adjacent lands at a distance from the stream, owing, no doubt, to the annual depositions of mud, *&c.* during the swell of the river. Apply the same rule to the Demerary, and the difficulty will be solved. The wet savannah behind, and the swampy woods around them, are the body of the low country at its natural level, scarcely a foot or two above the sea. Whatever additional height the land has in the vicinity of the river, from the time you have ascended about twenty miles or so, is all acquired. It has arisen from the sediment of the river during the rainy season, when the country is overflowed so as that all the lower part of it is under water. This deposition must be always more copious, in proportion as it is nearer the stream, where additional quantities are always brought, and where it is kept in motion both by the current and the tide. Every thing which we afterwards saw confirmed this theory, and nothing more directly than the canals which run out at right angles from the river. Some of these extend four miles inward, and they prove to a demonstration, that the land becomes lower and lower the farther you recede from the

* Account of the Ganges, &c. Phil. Transf. 1781, by M. Rennell.

the river. The maps of the colonies confirm it; for in all of them the main body of the low land of Guiana is laid down as ſavannah, and the woody country, which a ſtranger or ſuperficial obſerver would ſuppoſe to be the whole or much the greater part of it, is in fact only a border on the ſides of the rivers and of the ſea, but of conſiderable breadth, more or leſs, in proportion to the ſize of the adjoining river, or, which is generally the ſame thing, to the acquired height and extent of the ſoil on either bank. It followed as a conſequence, and, as far as we had opportunities of obſerving, we found it to be the caſe, that the low land was ſomewhat higher, and continued ſo farther down, about the Eſſequebo than the Demerary; the woods conſequently were of greater extent. We found, beſides, in the ſoil adjoining the Eſſequebo, at leaſt upon the eaſt ſide, a mixture of ſand. The river is full of ſand-banks; and it appears, that the finer parts of even this leſs ſuſpenſible ſubſtance are raiſed by the floods and carried among the adjacent woods to be depoſited with the mud. The Mahayka, a ſmall river or creek which falls into the ſea about twenty or thirty miles to the eaſtward of the Demerary, though it runs a long way up the country, and ſpreads into many branches, has but a very narrow, and often interrupted border of wood upon its banks; it runs through an immenſe ſavannah, and ſo do its branches, with little or no wood, till they approach the ſand-hills. The Deltas of the river of Oroonoko, and its numerous mouths, make a figure even in the map of the world. It is to be regretted, that its noble ſtream has been ſo long hid from ſcience. What I learned in Trinidad from a gentleman, who had ſailed from its mouth to the Anguſturas, about 300 miles up, confirms and illuſtrates, in the fulleſt manner, the above general rule. The weſtern mouths of it oppoſite Trinidad, are navigable only for launches drawing ſix or ſeven feet wa-

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ter. At and oppoſite them, the bottom is ſhallow and muddy, and the coaſt a low mangrove ſwamp, reſembling, in all reſpects, that of Guiana. You muſt aſcend thoſe branches ſeveral days before you reach the main ſtream; and in doing ſo, you find the ſame phenomena as in aſcending the Demerary, but in a ſtill greater degree. At firſt you have the mangrove, or ſome ſimilar ſwamp, and behind it on both ſides for about twenty leagues, the land, if you can call it ſo, hardly emerging from the water. Afterwards the ground appears; and, as you go up, riſes ſtill higher and higher on the banks above the common level of the ſtream. The trees become, in the ſame manner, of different ſpecies, and much taller than they were below. The channel in which you are, from being wide, grows narrower by degrees. It is from about one and a half to three-fourths of a mile broad near the entrance; and, when it joins the main ſtream, is not more than about 200 yards. It has then acquired a conſiderable depth, and the banks may be about twenty feet high. Along the main ſtream of the river, or Boca de Naſios, the gradual riſe, and other circumſtances attending it, are quite ſimilar. All this height of the bank, I can make no doubt, is entirely acquired ground, formed by the ſediment of the floods, greater near the ſtreams than at a diſtance from them; and though I have no knowledge of the nature of the land in the deltas and their vicinity, I would not heſitate to ſay, that great part of the interior body of each iſland, and moſt probably of the main on either ſide, where it is low country, conſiſts of nothing elſe than wet ſavannahs.

Floods.—BEFORE we leave the rivers, it may be proper to take notice of their *floods*. In no inſtance of a large river does the univerſal law within the tropics fail, that they annually overflow their banks for a certain ſeaſon. What was a prodigy in the Nile during the infancy of ſcience, is now a well known phenomenon to every inhabitant of a continent in the torrid zone. From the ſituation of the river Amazons, it amounts to a certainty, that the Demerary, Eſſequebo, and other rivers of Guiana, cannot originate very far up in the continent of South America. This is confirmed by what I could learn of the riſe and duration of the floods of theſe two rivers. Enquiring about them at the plantations below, is to little purpoſe, for there the floods are hardly diſcernible; but by the poſtholder and the ſettlers fartheſt up, I was informed, that they are there ſenſible enough, and that, independent of all partial ſwells from accidental rains, the Demerary generally roſe every year in the month of June, and continued high through July and part of Auguſt. The riſe there, upon the whole, might be about twelve feet; it is ſufficient to lay the level parts of the country under water, and to render the woods, that cover them in ſeveral places, paſſable in canoes. We could have wiſhed for more exact information. This, however, was ſufficient to prove, that the rivers did not riſe very far inland, elſe the floods would have been later in the year; but at the ſame time that they were of extent enough to follow the rule of all conſiderable intertropical rivers, ſo as to have a flood in the rainy ſeaſon, that is, in the months when the ſun is upon the ſame ſide of the line on which they have their origin and courſe.

The great Oroonoko, I have been informed, begins to riſe a little in May, it continues increaſing through the ſummer months, and the inundation is at its height in September. At that time, as far up as the Anguſturas, the riſe is about forty feet perpendicular above the low water-mark. It diminiſhes as you deſcend till about the mouth, where it is only a very few feet.

Tides

Tides are of the utmoſt conſequence to the inhabitants of the coaſt of Guiana. They enable them to drain a country which otherwiſe could never have been cleared, and they aſcertain their journeys which are made by water up and down the rivers, and even along the coaſt. At the mouth of the Demerary, it is high water at about half paſt five, at new and full moon. The riſe in ſpring tides, a little way up, is twelve feet, or more, above low water-mark. The tide runs very rapidly near the mouth of the river, ſeldom leſs than four or five miles in the hour. It continues to run with force for a long way up, and was ſufficient, without wind, to carry us up or down at 150 miles from the mouth. Above that it becomes feebler; and for a conſiderable diſtance below the rapids, though there is a ſenſible riſe and fall of two or three feet, yet, even in the dry ſeaſon, the current is conſtantly down, only more gentle during the riſe or flood, and there alſo the continuance of the riſe is very ſhort, not more than two or three hours.

Some obſervations upon the *Soil* of the different parts of the country, may be the ſubject of a future communication. I will only add at preſent, what I think has more than conjectural foundation, *viz.* That this moſt recent of countries, together with the large additional parts ſtill forming on its coaſt, appear to be the productions of two of the greateſt rivers on the globe, the Amazons and the Oroonoko. If you caſt your eye upon the map, you will obſerve from Cayenne to the bottom of the gulph of Paria, this immenſe tract of ſwamp, formed by the ſediment of theſe rivers, and a ſimilar tract of ſhallow muddy coaſt, which their continued operation will one day elevate. The ſediment of the Amazons is carried down thus to leeward (the weſtward) by the conſtant currents,

which

which ſet along from the ſouthward and the coaſt of Braſil. That of the Oroonoko is detained, and allowed to ſettle near its mouths, by the oppoſite iſlands of Trinidad, and ſtill more by the mountains on the main, which are only ſeparated from that iſland by the Bocos del Drago. The coaſt of Guiana has remained as it were the great eddy or reſting-place for the waſhings of great part of South America for ages; and its own comparatively ſmall ſtreams have but modified here and there the grand depoſit.

W. LOCHHEAD.

III.

III. *A ſhort Paper on the* PRINCIPLES *of the* ANTECEDENTAL CALCULUS. *By JAMES GLENIE, Eſq;* M. A. F. R. S. LOND. & EDIN.

[*Read Dec.* 1. 1794.]

SEVERAL of my friends have ſuggeſted to me the propriety of publiſhing ſomething of the kind now offered to the Society, obſerving, that the great brevity with which the *Antecedental Calculus* is written, and the very conciſe form in which it is delivered to the public, may lead ſome to form erroneous opinions reſpecting the principles on which it is founded. In compliance partly with their requeſt, I have drawn up this ſhort paper, which I hope will remove even the poſſibility of miſconception on that head, and convince every intelligent reader, that the antecedental calculus has the ſame geometrical principles for its ground-work, that the formulæ in the *Univerſal Compariſon* themſelves have, from which I originally derived it more than twenty years ago.

IN the third page of that treatiſe, I have ſhewn from the firſt formula in the third theorem of my *Univerſal Compariſon*, that, when R and Q are any two given magnitudes of the ſame kind, and A, N, B are any homogeneous magnitudes, the exceſs of the magnitude, which has to B a ratio having to the ratio of A+N to B the ratio of R to Q, above the magnitude, which has to B a ratio, having to the ratio of A to B the ſame ratio of R to Q, is geometrically expreſſed by

$$\frac{\frac{R}{Q}.A^{\frac{R-Q}{Q}}.N+\frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2+\frac{R}{Q}.\frac{R-Q}{2Q}.\frac{R-2Q}{3Q}.A^{\frac{R-3Q}{Q}}.N^3+}{B^{\frac{R-Q}{Q}}}$$

or, which comes to the ſame thing, that the expreſſion,

$$\frac{A^{\frac{R}{Q}}+\frac{R}{Q}.A^{\frac{R-Q}{Q}}.N+\frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2+\ \&c.}{B^{\frac{R-Q}{Q}}},$$ exceeds the geometrical expreſſion, $$\frac{A^{\frac{R}{Q}}}{B^{\frac{R-Q}{Q}}},$$ or

$$A+\frac{R-Q}{Q}.A.\frac{A-B}{B}+\frac{R-Q}{Q}.\frac{R-2Q}{2Q}.A.\overline{\frac{A-B}{B}}\Big|^2+\&c.$$ by the aforeſaid geometrical expreſſion.

In the ſame page, I have ſhewn, that the exceſs of the magnitude, which has to B a ratio, having to the ratio of A to B the ratio of R to Q, above the magnitude, which has to B a ratio having to the ratio of A—N to B the ratio of R to Q, is geometrically expreſſed by

$$\frac{\frac{R}{Q}.A^{\frac{R-Q}{Q}}.N-\frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2+\&c.}{B^{\frac{R-Q}{Q}}},$$ or, which comes to the ſame thing, that the expreſſion,

$$\frac{A^{\frac{R}{Q}}}{B^{\frac{R-Q}{Q}}},$$ or $$A+\frac{R-Q}{Q}.A.\frac{A-B}{B}+\frac{R-Q}{Q}.\frac{R-2Q}{2Q}.A.\overline{\frac{A-B}{B}}\Big|^2+\&c.$$ exceeds

ceeds the geometrical expreſſion,

$$\frac{A^{\frac{R}{Q}} - \frac{R}{Q}.A^{\frac{R-Q}{Q}}.N + \frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2 - + - \&c.}{B^{\frac{R-Q}{Q}}}$$, by the

aforeſaid geometrical expreſſion.

It is almoſt unneceſſary to obſerve, that the two expreſſions, which have reſpectively to B ratios, having to the ratios of A+N to B, and A−N to B the ratio of R to Q, give us

$$\frac{A^{\frac{R}{Q}} \pm \frac{R}{Q}.A^{\frac{R-Q}{Q}}.N + \frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2 \pm + \&c.}{B^{\frac{R-Q}{Q}}}$$ for the geo-

metrical magnitude, which has to B a ratio, having to the ratio of A±N to B the ratio of R to Q. But as this expreſſion muſt vary indefinitely with the endleſs variations in the quantity of the magnitude B, its geometrical ſtandard of compariſon, ſo, when we ſuppoſe it to become numerical, we get an indefinite number of arithmetical formulæ, referring to different ſtandards of compariſon. For B may be then repreſented by

$$1,\ 2,\ 3,\ 4,\ 5,\ \&c.$$
$$1,\ \surd 2,\ \surd 3,\ \surd 4,\ \surd 5,\ \&c.$$
$$\frac{1}{2},\ \frac{1}{3},\ \frac{1}{4},\ \frac{1}{5},\ \frac{1}{6},\ \&c.$$

or &c. &c. *ſine limite.*

And in that particular caſe, when it is repreſented by 1 or unit, this geometrical formula gives the arithmetical one, (putting *r* and *q* for R and Q,)

$$A^{\frac{r}{q}} \pm \frac{r}{q}.A^{\frac{r-q}{q}}.N + \frac{r}{q}.\frac{r-q}{2q}.A^{\frac{r-2q}{q}}.N^2 \pm \frac{r}{q}.\frac{r-q}{2q}.\frac{r-2q}{3q}.A^{\frac{r-3q}{q}}.N^3 + \pm \&c.$$

which

which has to 1, or unit, a ratio having to the ratio of A±N to 1 the ratio of r to q. In it A, N, r, q, may be any numerical or arithmetical magnitudes whatever, whole, fractional, ſurd or mixed. This formula, or antecedent, is exactly what is commonly called the Binomial Theorem.

If we ſuppoſe B to be repreſented by 2, we derive immediately from this geometrical antecedent or formula, the following arithmetical one:

$$A\frac{r}{q} \pm \frac{r}{q}.A\frac{r-q}{q}.N + \frac{r}{q}.\frac{r-q}{2q}.A\frac{r-2q}{q}.N^2 \pm \frac{r}{q}.\frac{r-q}{2q}.\frac{r-2q}{3q}.A\frac{r-3q}{q}.N^3 + \pm \text{ \&c.}$$

which has to 2 a ratio having to the ratio of A±N to 2, the ratio of r to q.

To ſuch arithmetical formulæ there is no end or limit. And this I take to be the true and ſyſtematic method of deriving them, *viz.* from geometrical antecedents or formulæ, when they are ſuppoſed to become numerical.

When 1 or unit is the ſtandard of compariſon, its various combinations with itſelf and the other numerical magnitudes, do not appear in the formula or antecedent. This circumſtance renders it of all others the moſt commodious for common uſe in algebra and arithmetic, though the leaſt calculated of any for ſhewing the rationalia or ground-work of the various operations in theſe two ſciences. For when the formula or antecedent ſhows the different combinations of the conſequent or ſtandard of compariſon with itſelf and the other numerical magnitudes, it is a ſort of language announcing or exhibiting the reaſons of its formation.

It is evident, that half the exceſs of the two geometrical expreſſions taken together, which have reſpectively to B ratios, having to the ratios of A+N to B and A—N to B, the ratio of R to Q, above twice $\dfrac{A\frac{R}{Q}}{B\frac{R-Q}{Q}}$, or twice the magnitude, which

has

has to B a ratio having to the ratio of A to B the ſame ratio of R to Q, is truly expreſſed by

$$\frac{\frac{R}{Q}.\frac{R-Q}{2Q}.A\frac{R-2Q}{Q}.N^2+\frac{R}{Q}.\frac{R-Q}{2Q}.\frac{R-2Q}{3Q}.\frac{R-3Q}{4Q}.A\frac{R-4Q}{Q}.N^4+\&c.}{B\frac{R-Q}{Q}},$$

and that half the difference of theſe expreſſions is

$$\frac{\frac{R}{Q}.A\frac{R-Q}{Q}.N+\frac{R}{Q}.\frac{R-Q}{2Q}.\frac{R-2Q}{3Q}.A\frac{R-3Q}{Q}.N^3+\&c.}{B\frac{R-Q}{Q}}.$$

Before I proceed farther, however, in the conſideration of theſe expreſſions, it may not perhaps be improper to premiſe the few following lemmata, which are almoſt too evident to require demonſtration.

LEMMA I.

If any ratio be compounded with its inverſe, or the inverſe of any ratio the ſame with it, the compoſition produces a ratio of equality.

For of the three magnitudes A, B, A, by the definition of compound ratio, (5. Euc. Simson's edit.), the ratio of A to B, compounded with the ratio of B to A, is the ratio of A to A, or a ratio of equality; and if the ratio of C to D be equal to, or the ſame with the ratio of A to B, its inverſe, D to C, is equal to, or the ſame with the ratio of B to A, (Prop. B. ibid.): Therefore, (Prop. F. Euc. 5. Simson's edit.), the ratio of A to B, compounded with the ratio of D to C, is the ſame with the

3 ratio

ratio of A to B compounded with the ratio of B to A, or a ratio of equality. Q. E. D.

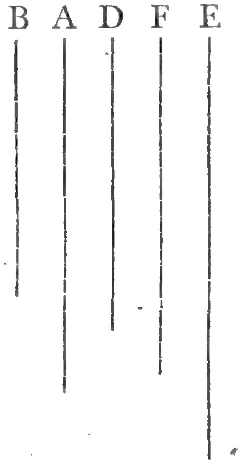
LEMMA II.

If with the inverſe of any ratio there be compounded a ratio greater than it, the compoſition produces a ratio of greater inequality, or a ratio of which the antecedent is greater than the conſequent; and if with the inverſe of any ratio, there be compounded a ratio leſs than it, the compoſition produces a ratio of leſs inequality, or a ratio of which the antecedent is leſs than the conſequent.

First, Let the ratio of C to D be greater than that of A to B. Then (10. Euc. 5.) the magnitude, which has to D the ratio of A to B, is leſs than C. If E therefore be that magnitude, the ratio of C to D, compounded with the ratio of B to A, is the ſame with the ratio of C to D, compounded with the ratio of D to E, (Propoſitions B. and F. 5. Euc. Sim.). Wherefore, the ratio produced by compounding the ratio of C to D with that of B to A, is the ſame with the ratio of C to E. But ſince C is greater than E, the ratio of C to E is greater than that of E to E, (10. Euc. 5.), or a ratio of equality. Q. E. D.

Secondly,

Secondly, Let the ratio of F to D be leſs than that of A to B. Then (10. Euc. 5.) the magnitude, which has to D the ſame ratio with that of A to B, is greater than F. If E therefore be that magnitude, the ratio of F to D, compounded with the ratio of B to A, is the ſame with the ratio of F to D, compounded with the ratio of D to E, (Propoſitions B. and F. 5. Euc. Sim.). Wherefore the ratio produced by compounding the ratio of F to D with that of B to A, is the ſame with the ratio of F to E. But ſince F is leſs than E, the ratio of F to E is leſs than that of E to E, (10. Euc. 5.), or a ratio of equality. Q. E. D.



LEMMA III.

If any ratio be compounded with a ratio of equality, it is not altered thereby.

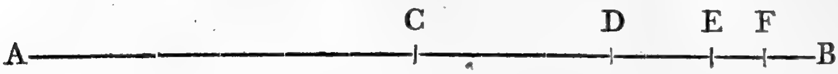
For the ratio of C to D, compounded with the ratio of A to A, is the ſame with the ratio of C to D, compounded with the ratio of D to D, (Prop. F. 5. Sim. Euc.), which, by the definition of compound ratio, is that of C to D. Q. E. D.

These three Lemmata are alſo evident from Formula 1. Theorem 1. *Univerſal Compariſon.*

Cor. From this and Lemma 1. with the definition of compound ratio, it is evident, that if with any ratio there be compounded a greater one, there ariſes a ratio greater than it; and that, if with any ratio there be compounded a leſs one, there ariſes a ratio leſs than it.

LEMMA IV.

If from any magnitude there be taken the half, and from the remainder its half, and so on, the halves so taken, be their number ever so great, are together less than the magnitude.



For let AB be any magnitude, AC the half of AB, CD the half of CB, DE the half of DB, EF the half of EB, and so on.

Then it is manifest, that AC, together with CD and DE and EF, &c. are less than AB, from which they are taken. Q. E. D.

Cor. 1. The ratio of AB to the successive halves AC, CD, DE, EF, &c. taken together, be their number ever so great, is greater than a ratio of equality; and the ratio of any one of the terms to all the succeeding ones taken together, be their number ever so great, is greater than a ratio of equality.

Cor. 2. Hence it follows, that of any series or succession of terms, in which the half of each term has to the immediately succeeding one a ratio of equality, each term has to all the succeeding ones, be their number ever so great, a ratio greater than that of equality.

Cor. 3. Hence it also follows, that if CD, instead of one half, be one third of AC or CB, DE one fourth of CD, EF one fifth of DE, and so on, the ratio of any term to all the succeeding ones taken together, exceeds a ratio of equality more than the ratio it has to the same number of succeeding terms, be that number ever so great, exceeds it, when each term has to the immediately succeeding one the ratio of two to one.

Scholium.

Scholium. In like manner is it ſhewn, that, if AC be a third part of AB, CD of AC, DE of CD, EF of DE, and ſo on, the ratio of each term to all the ſucceeding ones taken together, be their number ever ſo great, exceeds the ratio of two to one; and, in general, if the ratios AB to AC, AC to CD, CD to DE, DE to EF, &c. be reſpectively the ſame with that of A to N, that the ratio of each term to all the ſucceeding ones, be their number ever ſo great, exceeds the ratio of A—N to N. This is alſo evident from the well known method of finding the aggregates of geometrical progreſſions; and if the ratio of AC to CD be greater than that of AB to AC, the ratio of CD to DE greater than that of AC to CD, and ſo on, the ratio of any term to all the ſucceeding ones, be their number ever ſo great, exceeds the ratio of A—N to N, more, than the ratio it has to the ſame number of ſucceeding terms, exceeds it, when each term has to the immediately ſucceeding one the ratio of A to N.

I now proceed to prove, that each of the general geometrical expreſſions in p. 3. *Antecedental Calculus, viz.*

$$\frac{\frac{R}{Q}.A^{\frac{R-Q}{Q}}.N+\frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2+\frac{R}{Q}.\frac{R-Q}{2Q}.\frac{R-2Q}{3Q}.A^{\frac{R-3Q}{Q}}.N^3+\&c.}{B^{\frac{R-Q}{Q}}},$$

and

$$\frac{\frac{R}{Q}.A^{\frac{R-Q}{Q}}.N-\frac{R}{Q}.\frac{R-Q}{2Q}.A^{\frac{R-2Q}{Q}}.N^2+\frac{R}{Q}.\frac{R-Q}{2Q}.\frac{R-2Q}{3Q}.A^{\frac{R-3Q}{Q}}.N^3-+-\&c.}{B^{\frac{R-Q}{Q}}},$$

has to N a ratio nearer to the ratio of $\frac{\frac{R}{Q}.A^{\frac{R-Q}{Q}}}{B^{\frac{R-2Q}{Q}}}$ to B than any given or aſſigned ratio, or than by any given or aſſigned magnitude, when A+N and A−N have either to A or B ratios nearer to that of equality than any given, or aſſigned ratio, or

 than

than by any given, or aſſigned magnitude, and R and Q are two given magnitudes of the ſame kind.

PROPOSITION I.

In this caſe, the firſt term in each of theſe general expreſſions has to twice the ſecond, the ſecond to thrice the third, the third to four times the fourth, the fourth to five times the fifth, and ſo on, a ratio greater than any given ratio.

For, if this be denied, let C and D be two given homogeneous magnitudes, and let the ratio of C to D be greater.

In each, the ratio of the firſt term to twice the ſecond, is that of A to $\frac{R-Q}{Q} \cdot N$, and its inverſe $\frac{R-Q}{Q} \cdot N$, or $(N + N.\frac{R-2Q}{Q})$, to A, is the ratio compounded of the ratios of R—Q to Q, and N to A, (For. 1. Theor. 1. *Univerſal Compariſon*). Now, the ratio compounded of this ratio, and that of C to D, is a ratio compounded of the three ratios C to D, R—Q to Q, and N to A. But, ſince R and Q are given magnitudes, R—Q is a given magnitude, (4. Euc. Data), and the ratio of R—Q to Q a given ratio, (1. Data). Wherefore the ratio compounded of the ratios of C to D and R—Q to Q, is alſo given, (67. Data). This ratio, however, compounded with that of N to A, is the ſame with the ratio compounded of C to D, and $\frac{R-Q}{Q} N$ to A. But ſince that of A to N is by the hypotheſis greater than any given ratio, the ratio compounded of C to D and R—Q to Q, compounded with that of N to A, produces a ratio of leſs inequality, (Lemma 2.). Conſequently, the ratio of A to $\frac{R-Q}{Q} \cdot N$ is greater than any given ratio C to D. Wherefore, the ſuppoſition, fition, that any given ratio C to D is greater than it, is abfurd.

And, fince the ratio of the fecond term to thrice the third, is that of A to $\frac{R-2Q}{Q}.N$, it is proved exactly in the fame manner, that this ratio is greater than any given ratio. And precifely in the fame way is it demonftrated, that the ratio of the third term to four times the fourth, is greater than any given ratio; and fo on.

Cor. 1. If R—Q be equal to Q, the ratio compounded of C to D, and R—Q to Q, is the fame with that of C to D, (Lemma 3.); and if R—Q be greater or lefs than Q, the ratio compounded of C to D and R—Q to Q, is accordingly greater or lefs than that of C to D, (Cor. to Lemma 3.).

Cor. 2. The magnitudes, $\frac{2R}{Q}.\frac{A\frac{R-Q}{Q}}{B\frac{R-Q}{Q}}.N$, $\frac{R}{Q}.\frac{R-Q}{Q}.\frac{A\frac{R-2Q}{Q}}{B\frac{R-2Q}{Q}}.N$, &c. $\frac{2R}{Q}.N$, $\frac{R-Q}{Q}.N$, $\frac{R-2Q}{Q}.N$, &c. are lefs than any given or affigned magnitude.

Cor. 3. The ratio of each term to all the fucceeding ones, be their number ever fo great, is greater than any given ratio, (Scholium to Lemma 4.).

Cor. 4. The magnitudes $A \pm \frac{R-Q}{Q}.N$, $A \pm \frac{R-2Q}{Q}.N$, &c. have refpectively to A ratios nearer to that of equality than any given ratio, or than by any given magnitude.

Cor. 5. The magnitude which has to B a ratio, having to the ratio of A to B the ratio of R to Q, has to twice the firft term, in each of thefe general geometrical expreffions, a ratio greater than any given ratio.

PROPOSITION II.

The ratio of each of theſe two general geometrical expreſſions to N, is nearer to the ratio of $\frac{R}{Q} \cdot \frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}$ to B than any given or aſſigned ratio.

For, ſince the firſt term in each has to twice the ſecond a ratio greater than any given or aſſigned ratio, (Prop. 1.), and the ſecond has to all the ſucceeding terms, be their number ever ſo great, a ratio greater than any given ratio, (Cor. 3. Prop. 1.) the ratio of the firſt term to all the ſucceeding ones is *a fortiori* greater than any given ratio, being greater than that of A to $\frac{R-Q}{Q} \cdot N$. Wherefore each of theſe expreſſions has to the firſt term a ratio nearer to that of equality than any given or aſſigned ratio, or than by any given or aſſigned magnitude, (Cor. 4. Prop. 1.). Conſequently the ratios which theſe expreſſions have to N, are nearer to the ratio of the firſt term in each to N, than any given or aſſigned ratio. But the ratio of the firſt term in each to N, is that of $\frac{R}{Q} \cdot \frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}$ to B. Therefore, &c. Q.E.D.

OTHERWISE:

In the firſt expreſſion, the firſt term, with twice the ſecond, is much greater than the whole of it, (Cor. 3. Prop. 1.), and conſequently has to N a greater ratio than the expreſſion itſelf has to N, (8. E. 5.). But this ratio exceeds the ratio of the firſt term to N leſs than any given or aſſigned ratio. For, if the ratio

tio of the firſt term to N be decompounded with it, or its inverſe, the ratio of N to the firſt term, be compounded with it, there ariſes the ratio of $A+\frac{R-Q}{Q}.N$ to A, which (Cor. 4. Prop. 1.) is nearer to a ratio of equality than any given ratio.

In the ſecond, the exceſs of the firſt term above twice the ſecond is leſs than the whole expreſſion, and conſequently has to N a leſs ratio than the expreſſion itſelf has to N, (8. E. 5.). But if with it the ratio of N to the firſt term be compounded, there ariſes the ratio of $A-\frac{R-Q}{Q}.N$ to A, which (Cor. 4. Prop. 1.) is nearer to a ratio of equality than any given ratio. Q. E. D.

OTHERWISE:

If it be denied, that each expreſſion has to N a ratio nearer to the ratio of its firſt term to N than any given ratio, let the ratio of two given magnitudes C and D be nearer to it, and let the ratio of B to E, compounded with that of the firſt term to N, or with the given ratio $\frac{R}{Q}.\frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}$ to B, be equal to the given ratio C to D. But the magnitude, which has to B the ratio compounded of theſe two ratios, is (For. 1. Theorem 1. *Univerſal Compariſon),* $\frac{R}{Q}.\frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}+\frac{R}{Q}.\frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}.\frac{B-E}{E}$ to B, which is greater than the ratio of the firſt term to N, and leſs than the ratio of the firſt expreſſion to N, by the ſuppoſition, and conſequently leſs than the ratio of the firſt term with twice the

the ſecond to N. Therefore $\frac{R}{Q}\cdot\frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}\cdot\frac{B-E}{E}$ is leſs than $\frac{R}{Q}\cdot\frac{R-Q}{Q}\cdot\frac{A\frac{R-2Q}{Q}}{B\frac{R-2Q}{Q}}\cdot N$. But ſince the ratio of $\frac{R}{Q}\cdot\frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}$ to E, being compounded of the firſt term to N, and of B to E, is the ſame with the ratio of C to D, E is a given magnitude, (2. Data), and B—E a given magnitude, (4. Data). Wherefore the given magnitude, $\frac{R}{Q}\cdot\frac{A\frac{R-Q}{Q}}{B\frac{R-2Q}{Q}}\cdot\frac{B-E}{E}$, is leſs than $\frac{R}{Q}\cdot\frac{R-Q}{Q}\cdot\frac{A\frac{R-2Q}{Q}}{B\frac{R-2Q}{Q}}\cdot N$, which (Cor. 2. Prop. 1.) is leſs than any given magnitude, which is abſurd.

In like manner is it demonſtrated, that the ratio of the ſecond expreſſion to N, is nearer to the ratio of its firſt term to N than any given ratio. Q. E. D.

SCHOLIUM.

If the ſame reaſoning be applied to the expreſſion,

$$\frac{\frac{R}{Q}\cdot A\frac{R-Q}{Q}\cdot N+\frac{R}{Q}\cdot\frac{R-Q}{2Q}\cdot\frac{R-2Q}{3Q}\cdot A\frac{R-3Q}{Q}\cdot N^3+\&c.}{B\frac{R-Q}{Q}}$$

, which is half the difference of the two geometrical expreſſions that have reſpectively to B ratios having to the ratios of A+N to B, and A—N to B, the ratio of R to Q, we get the ratio of the firſt term to twice the ſecond, the ſame with that of A to $\frac{R-Q}{Q}\cdot\frac{R-2Q}{3Q}\cdot\frac{N^2}{A}$, and the ratio of the ſecond to four times the

third,

third the ſame with that of A to $\frac{R-3Q}{Q}.\frac{R-4Q}{5Q}.\frac{N^2}{A}$, and ſo on.

The general expreſſion, (p. 5. *Antecedental Calculus*), gives $\frac{A.N+C.M+M.N}{D}$ for the exceſs of the magnitude, which has to B the ratio, that is produced by compounding the ratio of C+N to D with that of A+M to B, above the magnitude, which has to B the ratio compounded of the ratios of A to B and C to D. But it is demonſtrated in the ſame manner as above, that if A+M and C+N have reſpectively to A and C ratios nearer to that of equality than any given or aſſigned ratio, or than by any given or aſſigned magnitude, this expreſſion alſo has to $\frac{A.N+C.M}{D}$ a ratio nearer to that of equality than any given ratio, or than by any given magnitude. And the demonſtration is exactly the ſame, when any number of ratios are compounded.

In like manner, if the ratio of C+N to D be decompounded with that of A+M to B, we get the difference between the expreſſion thence ariſing, and the magnitude which has to B the ratio produced by decompounding the ratio of C to D with that of A to B, equal to $\frac{CD.M-AD.N}{C.\overline{C+N}}$. But it is readily demonſtrated, as above, that if A+M and C+N have reſpectively to A and C ratios nearer to that of equality than any given or aſſigned ratio, or than by any given or aſſigned magnitude, this expreſſion alſo has to $\frac{CD.M-AD.N}{C^2}$ a ratio nearer to that of equality than any given ratio, or than by any given or aſſigned magnitude.

It is manifeſt then, that in this calculus no indefinitely ſmall or infinitely little magnitudes are ſuppoſed, but only magnitudes leſs than any that may be given or aſſigned, and ratios nearer to that of equality than any that may be given or aſſigned, ed, and that it is equally geometrical with the method of exhauſtions of the ancients, who never ſuppoſed lines, ſurfaces, or ſolids, to be reſolved into indefinitely ſmall or infinitely little elements. The expreſſion *infinitely little magnitude* indeed implies a contradiction. For what has magnitude cannot be infinitely little.

THIS geometrical calculus, though it has no connection with the various modifications of motion, is equally convenient in its application with the method of fluxions, (which is unqueſtionably a branch of general arithmetical proportion, in which 1 or unit is the common ſtandard of compariſon, as well as the conſequent of every ratio compounded, or decompounded).

EXAMPLE I.

IN the circle ATB, (Fig. I. Pl. I.) let the diameter AB be repreſented by D, TE perpendicular to it by Y, and AE by X. Then (13. E. 6.) Y^2 is equal to the rectangle $DX—X^2$. But the antecedental of Y^2 is $2Y\overset{a}{Y}$, and that of $DX—X^2$ is $D\overset{a}{X}—2X\overset{a}{X}$, (p. 6. *Antecedental Calculus*). Wherefore D—2X is to 2Y as $\overset{a}{Y}$ to $\overset{a}{X}$, that is, as TE to CE, (p. 9. *Ant. Cal.*). Conſequently CE is a third proportional to EO and TE.

EXAMPLE II.

To find the ſurface of the ſphere of which ATBA is a great circle, (Fig. I. Pl. I.).

THE ſurface of the ſpherical ſegment, cut off by the circle, of which TE is the radius, has to the ſquare on any given line B, a ratio compounded of the circumference of ſaid circle to B, and of the antecedental of the curve AT to B, (*Ant. Cal.* p. 9.) But the antecedental of the curve is a fourth proportional to 2YD and

and $\overset{a}{X}$, (*ibidem*). Wherefore, if $2Y \times p$ represent said circumference, the antecedental of the spherical segment is $pD\overset{a}{X}$, of which the antecedent is pDX.

EXAMPLE III.

If it be required to draw a tangent to the parabola (Fig. 1. Pl. 1.) ATG at the point T; let the latus rectum be represented by L. Then L.X is equal to Y^2, and $L.\overset{a}{X}$ to $2Y\overset{a}{Y}$. Wherefore L is to 2Y (2TE) as $\overset{a}{Y}$ to $\overset{a}{X}$, that is, (*Ant. Cal.* p. 9.) as TE to CE, which is consequently equal to twice AE.

EXAMPLE IV.

In finding the area of the parabola, since $\overset{a}{X}$ is equal to $\frac{2Y\overset{a}{Y}}{L}$, we get the antecedental of the area, or $Y\overset{a}{X}$, equal to $\frac{2Y^2\overset{a}{Y}}{L}$, the antecedent of which is $\frac{2Y^3}{3L}$, or its equal $\frac{2}{3} \times XY$.

OTHERWISE:

The ratios of the antecedentals of the area AET, and the rectangle under AE, and any given line B to the square on B, are $Y\overset{a}{X}$ and $B\overset{a}{X}$ to B^2. But $Y\overset{a}{X}$ is equal to $\frac{2Y^2\overset{a}{Y}}{L}$, the antecedent of which is $\frac{2Y^3}{3L}$, or its equal $\frac{2}{3} \times XY$; and the antecedent of $B\overset{a}{X}$ is BX. Wherefore the area of the parabola is two thirds of the rectangle AE, ET.

EXAMPLE V.

So to divide a ſtraight line AB, that the rectangle under the two parts AC, CB ſhall be the greateſt poſſible.

Let AB be repreſented by A, AC by X, and conſequently CB by A—X. Then the rectangle AC, CB is equal to $AX-X^2$, the antecedental of which is $A\overset{a}{X}-2X\overset{a}{X}$, which, when ſuppoſed equivalent to nothing, (according to *Ant. Cal.* p. 7.) gives A equal to 2X, or AC equal to CB.

To multiply examples would be uſeleſs. I will take an opportunity, as ſoon as I conveniently can, of applying this calculus to ſeveral phyſical problems of importance, and particularly ſome reſpecting the reſiſtance of fluids; and will ſhew, that as it furniſhes a much greater variety of ways for expreſſing antecedentals than the fluxionary calculus does for fluxions, ſo it will open new and extenſive rules for finding antecedents, as yet altogether unknown in the inverſe method of fluxions.

Although the notation be in reality of no importance, I prefer $\overset{a}{X}$, $\overset{a}{Y}$, &c. to $\dot{X}$, $\dot{Y}$, &c. as more indicative of the origin of this mode of reaſoning, which was derived from an examination of the antecedents of ratios in general geometrical compariſon.

IV. Ob-

IV. Observations on the Trigonometrical Tables of the Brahmins. By *John Playfair*, F. R. S. Edin. and *Professor of Mathematics in the University of Edinburgh.*

[*Read April* 6. 1795.]

1. IN the ſecond volume of the *Aſiatic Reſearches*, an extract is given from the *Surya Siddhanta*, the ancient book which has been long, though obſcurely, pointed out as the ſource of the aſtronomical knowledge of the Brahmins. The Surya Siddhanta is in the Sanſcrit language: It is one of the Saſtras, or inſpired writings of the Hindoos, and is called the Jyotiſh, or Aſtronomical, Saſtra. It profeſſes, as we learn from Mr Davis, the ingenious tranſlator, to be a revelation from heaven, communicated to Meya, a man of great ſanctity, about four millions of years ago, toward the cloſe of the Satya Jug, or of the Golden Age of the Indian mythologiſts; a period at which man is ſaid to have been incomparably better than he is at preſent; when his ſtature exceeded twenty-one cubits, and his life extended to ten thouſand years.

Interwoven, however, with all theſe extravagant fictions, this ſingular book contains a very ſober and rational ſyſtem of aſtronomical calculation; and even the principles and rules of trigonometry, a ſcience of all others the moſt remote from fable, and the leaſt ſuſceptible of poetical decoration. It is on the con-

 ſtruction

ſtruction of the tables contained in this trigonometry, that I now beg leave to offer a few remarks.

2. It is neceſſary to begin with obſerving, that the circumference of the circle is here divided into 360 equal parts, each of which is again ſubdivided into 60, and ſo on. The ſame diviſion was followed by the Greek mathematicians; and this coincidence is the more to be remarked, that it relates to a matter of arbitrary arrangement, and one by no means neceſſarily connected with the properties of the circle. There are indeed ſome very obvious properties of that curve, that make it, though not neceſſary, at leaſt convenient, that the number of parts, into which the circumference is divided, ſhould be a number diviſible both by 3 and by 4, that is, that it ſhould be a multiple of 12; but nothing more preciſe can be determined from the nature of the curve itſelf. The agreement of two nations, therefore, in dividing the circumference of the circle preciſely in the ſame manner, as it cannot well be attributed to chance, muſt be ſuppoſed to reſult from ſome communication having taken place between them, if it were not that another very probable cauſe may be aſſigned for it. In Greece, and no doubt in every other country, the diviſion of the circle, into equal parts, is of a much older date than the origin of trigonometry, and muſt be as ancient as the firſt circular inſtruments uſed for meaſuring angles in the heavens. The inventors of thoſe inſtruments naturally ſought to make the diviſions on them correſpond to the ſpace which the ſun deſcribed daily in the ecliptic; and they could eaſily diſcover, without any very preciſe knowledge of the length of the ſolar year, that this might be nearly effected by making each of them the 360th part of the whole circumference. Accordingly the famous circle of Osymandias, in Egypt, deſcribed by Herodotus, was divided into 360 equal parts.

This

This principle may therefore have guided the aſtronomers, both of the Eaſt and of the Weſt, to the ſame diviſion of the circle, without any intercourſe having taken place between them. It has certainly directed the Chineſe in their diviſion, though it has led them to adopt one different from the Hindoo and Egyptian aſtronomers. They divide the circle into 365 parts and $\frac{1}{4}$, which can have no other origin than the ſun's annual motion: and ſome ſuch diviſion as this, may perhaps have been the firſt that was employed by other nations, who changed it however to the number 360, which nearly anſwered the ſame purpoſe, and had beſides the great advantage of being diviſible into many aliquot parts. The Chineſe, again, with whom the ſciences became ſtationary almoſt from their birth, have never attempted to improve on the method that firſt occurred to them.

3. The next thing to be mentioned, is alſo a matter of arbitrary arrangement, but one in which the Brahmins follow a method peculiar to themſelves. They expreſs the radius of the circle in parts of the circumference, and ſuppoſe it equal to 3438 minutes, or 60ths of a degree. In this they are quite ſingular. Ptolemy, and the Greek mathematicians, after dividing the circumference, as we have already deſcribed, ſuppoſed the radius to be divided into 60 equal parts, without ſeeking to aſcertain, in this diviſion, any thing of the relation of the diameter to the circumference: and thus, throughout the whole of their tables, the chords are expreſſed in ſexageſimals of the radius, and the arches in ſexageſimals of the circumference. They had therefore two meaſures, and two units; one for the circumference, and another for the diameter. The Hindoo mathematicians, again, have but one meaſure and one unit for both, *viz.* a minute of a degree, or one of thoſe parts whereof the circumference contains 21600. From this identity of meaſures, they derive no inconſiderable advantage in many calculations, though it muſt be confeſſed, that the meaſuring of a ſtraight line, the radius,

radius, or diameter of a circle, by parts of a curve line, namely, the circumference, is a refinement not at all obvious, and has probably been ſuggeſted to them by ſome very particular view, which they have taken, of the nature and properties of the circle. As to the accuracy of the meaſure here aſſigned to the radius, *viz.* 3438 of the parts of which the circumference contains 21600, it is as great as can be attained, without taking in ſmaller diviſions than minutes, or 60ths of a degree. It is true to the neareſt minute, and this is all the exactneſs aimed at in theſe trigonometrical tables. It muſt not however be ſuppoſed, that the author of them meant to aſſert, that the circumference is to the radius, either accurately or even very nearly, as 21600 to 3438. I have ſhewn, in another place *, from the Inſtitutes of Akbar, that the Brahmins knew the ratio of the diameter to the circumference to great exactneſs, and ſuppoſed it to be that of 1 to 3.1416, which is much nearer than the preceding. Calculating, as we may ſuppoſe, by this or ſome other proportion, not leſs exact, the authors of the tables found, that the radius contained in truth $3437'. 44''. 48'''$, &c.; and as the fraction of a minute is here more than a half, they took, as their conſtant cuſtom is, the integer next above, and called the radius 3438 minutes. The method by which they came to ſuch an accurate knowledge of the ratio of the diameter to the circumference, may have been founded on the ſame theorems which were ſubſervient to the conſtruction of their trigonometrical tables †.

4. These tables are two, the one of ſines, and the other of verſed ſines. The ſine of an arch they call *cramajya* or *jyapinda*, and the verſed ſine *utcramajya*. They alſo make uſe of the coſine or *bhujajya*. Theſe terms ſeem all to be derived from the word *jya*, which ſignifies the chord of an arch, from which the name

* Tranſ. R. S. Edin. vol. II. p. 185. Phyſ. Cl.

† See Note, § 6.

name of the radius, or ſine of 90°, viz. *trijya*, is alſo taken. This regularity in their trigonometrical language, is a circumſtance not unworthy of remark. But what is of more conſequence to be obſerved, is, that the uſe of ſines, as it was unknown to the Greeks, who calculated by help of the chords, forms a ſtriking difference between the Indian trigonometry and theirs. The uſe of the ſine, inſtead of the chord, is an improvement which our modern trigonometry owes, as we have hitherto been taught to believe, to the Arabs; and it is certainly one of the acquiſitions which the mathematical ſciences made, when, on their expulſion from Europe, they took refuge in the Eaſt. But whether the Arabs are the authors of this invention, or whether they themſelves received it, as they did the numerical characters, from India, is a queſtion, which a more perfect knowledge of Hindoo literature will probably enable us to reſolve.

No mention is made in this trigonometry, of tangents or ſecants; a circumſtance not wonderful, when we conſider that the uſe of theſe was introduced in Europe no longer ago than the middle of the ſixteenth century. It is, on the other hand, not a little ſingular, that we ſhould find a table of verſed ſines in the Surya Siddhanta; for neither the Greek nor the Arabian mathematicians, had any ſuch, nor had we, in modern Europe, till after the time of PETISCUS, who wrote about the end of the century juſt mentioned.

5. NEXT, as to the extent and accuracy of theſe tables. The firſt of them exhibits the ſines to every twenty-fourth part of the quadrant, that is, the ſine of 3°. 45′, and of all the multiples of that arch, *viz.* 7°. 30′, 11°. 15′, *&c.* up to 90°. The table of verſed ſines does the ſame. In each, the ſine, or verſed ſine, is expreſſed in minutes of the circumference, but without any fractions of a minute, either decimal or ſexageſimal; and, agreeably to the obſervation already made, when the fraction that ought

to

to have been ſet down is greater than $\frac{1}{2}$, the integer next greater is placed in the table. Thus the ſine 3°. 45′ being, when accurately expreſſed in their way, 224′. 49″, is put down 225′; and ſo of the reſt. The numbers, therefore, in theſe tables, are only ſo far exact as never to differ more than half a minute from the truth, and this very limited degree of accuracy gives no doubt to their trigonometry the appearance of an infant ſcience: But when, on the other hand, we conſider the principles and rules of their calculations, rather than the numbers actually calculated, we find the marks of a ſcience in full vigour and maturity: and we will acknowledge, that the Hindoo mathematicians did not ſatisfy themſelves with the degree of accuracy above mentioned, from any incapacity of attaining to greater exactneſs.

THEIR rules for conſtructing their tables of ſines, may be reduced to two, *viz.* the one for finding the ſine of the leaſt arch in the table, that of 3°. 45′, and the other for finding the ſines of the multiples of that arch, its triple, quadruple, *&c.* Both of theſe Mr DAVIS has tranſlated, judging very rightly, that it was impoſſible to give two more curious ſpecimens of the geometrical knowledge of the Hindoo philoſophers: the firſt is extracted from a commentary on the Surya Siddhanta; the other from the Surya Siddhanta itſelf.

6. WITH reſpect to the firſt, the method proceeds by the continual biſection of the arch of 30°, and correſpondent extractions of the ſquare root, to find the ſine and co-ſine of the half, the fourth part, the eighth part, and ſo on, of that arch. The rule, when the ſine of an arch is given, to find that of half the arch, is preciſely the ſame with our own: "The ſine of an arch being given, find the co-ſine, and thence the verſed ſine, of the ſame arch: then multiply half the radius into the verſed ſine, and the ſquare root of the product is the ſine of half the given arch." Now, as the ſine of 30°, was well known to thoſe mathematicians to be half the radius, it was of conſequence given: thence, by

by the rule juſt laid down, was found the ſine of 15°, then of 7°. 30′, and laſtly of 3°. 45′, which is the ſine required. Thus the ſine of 3°. 45′ would be found equal to 224′, 44″, as above obſerved, and, the ſine of 7°. 30′, equal to 448′. 39″, and, taking the neareſt integers, the firſt was made equal to 225, and the ſecond to 449*.

7. WHEN, by the biſections that have juſt been deſcribed, the ſine of 3°. 45, or of 225′, was found equal to 225′, the reſt of the table was conſtructed by a rule, that, for its ſimplicity and elegance, as well as for ſome other reaſons, is entitled to particular attention. It is as follows: "Divide the firſt jyapinda, 225′ by 225; the quotient 1, deducted from the dividend, leaves 224′, which added to the firſt jyapinda, or ſine, gives the ſecond, or the ſine of 7°. 30′, equal to 449′. Divide the ſecond jyapinda, which is thus found, by 225, and deduct 2, the neareſt integer to the quotient, from the former remainder 224′, and this new remainder 222′, added to the ſecond jyapinda, will give the third jyapinda equal to 671′. Divide this laſt by 225, and ſubtract 3, the neareſt integer to the quotient, from the former remainder 222′, and there will be left 219′,

 which,

* BY ſuch continual biſections, the Hindoo mathematicians, like thoſe of Europe before the invention of infinite ſeries, may have approximated to the ratio of the diameter to the circumference, and found it to be nearly that of 1 to 3.1416 as above obſerved. A much leſs degree of geometrical knowledge than they poſſeſſed, would inform them, that ſmall arches are nearly equal to their ſines, and that the ſmaller they are, the nearer is this equality to the truth. If, therefore, they aſſumed the radius equal to 1, or any number at pleaſure, after carrying the biſection of the arch of 30, two ſteps farther than in the above conſtruction, they would find the ſine of the 384th part of the circle, which, therefore, multiplied by 384, would nearly be equal to the circumference itſelf, and would actually give the proportion of 1 to 3.14159, as ſomewhat greater than that of the diameter to the circumference. By carrying the biſections farther, they might verify this calculation, or eſtimate the degree of its exactneſs, and might aſſume the ratio of 1 to 3.1416 as more ſimple than that juſt mentioned, and ſufficiently near to the truth.

which, added to the third jyapinda, gives the fourth; and ſo on unto the twenty-fourth or laſt."

It is not immediately obvious on what geometrical principle this rule is founded, but a ſlight change in the enunciation will remove the difficulty. The remainder, it muſt be obſerved, from which the quotient is always directed to be taken away, is the difference between the two ſines laſt computed; and hence the rule may be expreſſed more generally: Divide any ſine by 225, and ſubtract the quotient, or the integer neareſt the quotient, from the difference between that ſine and the ſine next leſs; the remainder is the difference between the ſame ſine and the ſine next greater; and therefore if it be added to the former, will give the latter. If then, (fig. 3. Pl. I.), GA, GC, GE, be three contiguous arches in the table, of which the differences AC, CE, of conſequence are equal, and of which the ſines are AB, CD, and EF, the rule, as laſt ſtated, gives us $CD - AB - \frac{CD}{225}$, for the difference between CD and EF, and therefore $EF = CD + CD - AB - \frac{CD}{225} = 2CD - \frac{CD}{225} - AB$, and alſo $EF + AB = CD\left(2 - \frac{1}{225}\right) = CD\left(\frac{449}{225}\right)$. But 225 is the ſine of the arch 3°. 45′, and 449 of twice that arch, as already ſhewn; and, therefore, according to this rule, if there be three arches, of which the common difference is 3°. 45′, the ſine of the mean arch will always have to the ſum of the ſines of the extreme arches, a given ratio, that namely, which the ſine of 3°. 45′ has to the ſine of twice 3°. 45′, or of 7°. 30′; now, this is a true propoſition; and therefore we are in poſſeſſion of the principle on which the Hindoo canon is conſtructed.

8. The geometrical theorem, which is thus ſhewn to be the foundation of the trigonometry of Hindoſtan, may alſo be more generally enunciated. " If there be three arches in arithmetical progreſſion, the ſine of the middle arch is to the ſum of the ſines of

of the two extreme arches, as the ſine of the difference of the arches to the ſine of twice that difference." This theorem is well known in Europe; it is juſtly reckoned a very remarkable property of the circle; and it ſerves to ſhew, that the numbers in a table of ſines conſtitute a ſeries, in which every term is formed exactly in the ſame way, from the two preceding terms, *viz.* by multiplying the laſt by a certain, conſtant number, and ſubtracting the laſt but one from the product.

9. Now, it is worth remarking, that this property of the table of ſines, which has been ſo long known in the Eaſt, was not obſerved by the mathematicians of Europe till about two hundred years ago. The theorem, indeed, concerning the circle, from which it is deduced, under one ſhape or another, has been known to them from an early period, and may be traced up to the writings of EUCLID, where a propoſition nearly related to it forms the 97th of the Data: "If a ſtraight line be drawn within a circle given in magnitude, cutting off a ſegment containing a given angle, and if the angle in the ſegment be biſected by a ſtraight line produced till it meet the circumference; the ſtraight lines, which contain the given angle, ſhall both of them together have a given ratio to the ſtraight line which biſects the angle." This is not preciſely the ſame with the theorem which has been ſhewn to be the foundation of the Hindoo rule, but differs from it only by affirming a certain relation to hold among the chords of arches, which the other affirms to hold of their ſines. It is given by EUCLID as uſeful for the conſtruction of geometrical problems; and trigonometry being then unknown, he probably did not think of any other application of it. But what may ſeem extraordinary is, that when, about 400 years afterwards, PTOLEMY, the aſtronomer, conſtructed a ſet of trigonometrical tables, he never conſidered EUCLID's theorem, though he was probably not ignorant of it, as having any connection with the matter he had in hand. He, therefore,

therefore, founded his calculations on another propoſition, containing a property of quadrilateral figures inſcribed in a circle, which he ſeems to have inveſtigated on purpoſe, and which is ſtill diſtinguiſhed by his name. This propoſition comprehends in fact EUCLID's, and of courſe the Hindoo theorem, as a particular caſe; and though this caſe would have been the moſt uſeful to PTOLEMY, of all others, it appears to have eſcaped his obſervation; on which account he did not perceive that every number in his tables might be calculated from the two preceding numbers, by an operation extremely ſimple, and every where the ſame; and therefore his method of conſtructing them is infinitely more operoſe and complicated than it needed to have been.

NOT only did this eſcape PTOLEMY, but it remained unnoticed by the mathematicians, both Europeans and Arabians, who came after him, though they applied the force of their minds to nothing more than to trigonometry, and actually enriched that ſcience by a great number of valuable diſcoveries. They continued to conſtruct their tables by the ſame methods which PTOLEMY had employed, till about the end of the ſixteenth century, when the theorem in queſtion, or that on which the Hindoo rule is founded, was diſcovered by VIETA. We are however ignorant by what train of reaſoning that excellent geometer diſcovered it; for though it is publiſhed in his *Treatiſe on Angular Sections*, it appears there not with his own demonſtration, but with one given by an ingenious mathematician of our own country, ALEXANDER ANDERSON of Aberdeen. It was then regarded as a theorem entirely new, and I know not that any of the geometers of that age remarked its affinity to the propoſitions of EUCLID and PTOLEMY. It was ſoon after applied in Europe, as it had been ſo many ages before in Hindoſtan, and quickly gave to the conſtruction of the trigonometrical canon all the ſimplicity which it ſeems capable of attaining. From all this, I think it might fairly be concluded, even if we

had

had no knowledge of the antiquity of the Surya Siddhanta, that the trigonometry contained in it is not borrowed from Greece or Arabia, as its fundamental rule was unknown to the geometers of both thoſe countries, and is greatly preferable to that which they employed.

10. Considerable light may perhaps hereafter be thrown on this argument, if it be found that the Surya Siddhanta contains a demonſtration of this rule. It does not appear, however, from the fragment we are in poſſeſſion of, that any explanation of the rule is given, either in that work, or in the commentary. Indeed I am not certain that the Surya Siddhanta contains any thing but rules and maxims, or that the author of it condeſcends to give any demonſtrations of the propoſitions which he enunciates. He may have felt himſelf relieved from the neceſſity of doing ſo, by his claim to inſpiration; and as he probably valued himſelf more on the character of a prophet, than of a geometer, he may rather have inclined to exerciſe the faith, than the reaſon, of his diſciples.

However that be, by the rule above explained, the Brahmins have computed a ſet of tables, limited indeed in their accuracy, but extremely ſimple and compendious. The rule is eaſily remembered by one who has been accuſtomed to numerical calculation, and is ſuch, that, by help of it, he may at any time compoſe for himſelf a complete ſet of trigonometrical tables, in a few hours, without the aſſiſtance of any book whatever. For the purpoſe of rendering it thus ſimple, the contrivance of meaſuring the radius, and all the ſines, in parts of the circumference, ſeems to have been adopted: if we follow any other method, the rule, though it remain the ſame in reality, will aſſume a form much leſs eaſy to be retained in the memory *. It has the appearance, like many other things in the ſcience

* This ſeems to me the moſt probable reaſon that can be aſſigned for the meaſuring of the radius, and the other ſtraight lines in the circle, in parts of the circumference.

ſcience of thoſe eaſtern nations, of being drawn up by one who was more deeply verſed in the ſubject than may be at firſt imagined, and who knew much more than he thought it neceſſary to communicate. It is probably a compendium, formed by ſome ancient adept in geometry, for the uſe of others who were merely practical calculators.

11. If we were not already acquainted with the high antiquity of the aſtronomy of Indoſtan, nothing could appear more ſingular, than to find a ſyſtem of trigonometry, ſo perfect in its principles, in a book ſo ancient as the Surya Siddhanta. The antiquity of that book, the oldeſt of the Saſtras, can ſcarce be accounted leſs than 2000 years before our æra, even if we follow the very moderate ſyſtem of Indian chronology laid down by Sir William Jones *. Now, if we ſuppoſe its antiquity to be no higher than this, though it bears in itſelf internal marks of an age ſtill more remote †, yet it will ſufficiently excite our wonder, to find it contain the principles of a ſcience, of which the firſt rudiments

ference. It is remarkable that the Hindoos ſhould have been thus led, at ſo early a period, to put in practice a method, the ſame in the moſt material point, with one which has been but lately ſuggeſted in Europe as an important improvement in trigonometrical calculation. In the Phil. Tranſ. for 1783, Dr Hutton of Woolwich propoſed to divide the circumference, not into degrees, as is uſually done, but into decimals of the radius; and he has pointed out how the preſent trigonometrical tables might be accommodated to this new diviſion, with the leaſt poſſible labour, in a paper which diſplays that intimate acquaintance with the reſources, both of the numerical and algebraic calculus, for which he is ſo much diſtinguiſhed. His plan is, in one reſpect, the ſame with the Hindoo method, for it uſes the ſame unit to expreſs both the circumference and the diameter; in another reſpect it differs from it, *viz.* in making the radius the unit, while the other aſſumes for an unit the 360th part of the circumference. Dr Hutton's plan has never been executed, though it certainly would be of advantage to have, beſides the ordinary trigonometrical tables, others conſtructed according to that plan.

* Aſiatic Reſearches, vol. II. p. 111, &c.

† The obliquity of the ecliptic is ſtated at 24° in the Surya Siddhanta, as in all the other aſtronomical tables of the Hindoos which we are yet acquainted with. (Tranſ.

rudiments are not older in Greece than 130 years before our æra. The bare exiſtence of trigonometrical tables, though they belong undoubtedly to a very elementary branch of ſcience, yet argues a ſtate of greater advancement in the mathematics than may at firſt be imagined, and neceſſarily ſuppoſes the application of geometrical reaſoning to ſome of the more difficult problems of aſtronomy and geography.

As long as the ſurveying of land, and the ordinary menſuration of ſurfaces and ſolids, are the only practical arts to which the geometer applies his ſpeculations, he will naturally content himſelf with conſtructing his figures and plans by means of a ſcale, and an inſtrument for meaſuring angles, as by doing ſo he may attain to all the accuracy he can deſire. But when, in the figures that are to be thus delineated, the ſides happen to be extremely unequal, and ſome of the angles very acute, or very obtuſe, graphical operations become inaccurate, and a very ſmall error in the meaſuring of one thing produces an enormous error in the eſtimation of ſome other. Lines, therefore, that extend over a great tract of the earth's ſurface, and much more thoſe that extend to the heavens, cannot be compared with the ſmaller lines, which we have an opportunity of meaſuring, by the bare conſtruction

(Tranſ. R. S. Edin. vol. II. p. 164.) Mr Davis concludes from this, (Aſiatic Reſearches, vol. II. p. 238), that if the obliquity diminiſh, at the rate of 50″ in a hundred years, the Surya Siddhanta is at preſent about 3840 years old, which goes back nearly 2000 years before the Chriſtian æra. But the diminution of the obliquity of the ecliptic, is ſuppoſed conſiderably too rapid in this calculation. According to Mayer it is 46″ in a century; and according to De la Grange, (Mem. Berlin 1782), at a medium no more than 30″. This laſt is moſt to be depended on, as it proceeds on an accurate inquiry into the law of the ſecular variation of the obliquity, that variation being by no means uniform. Let us however take the mean, *viz.* 38″, and the obliquity at the beginning of the preſent century having been 23°. 28′. 41″, we ſhall have 5000 years for the age of the Surya Siddhanta, reckoned from that date, or about 3300 years before Christ, which is near the æra of the Caly Yug.

ſtruction of triangles and parallelograms; and when ever ſuch compariſons are to be made, ſome other method muſt be ſought for. It was preciſely in ſuch circumſtances, that the inventive genius of HIPPARCHUS ſuggeſted the application of arithmetic to aſcertain thoſe ratios among the ſides and angles of figures, which pure geometry afforded no method of expreſſing. This union of geometry and arithmetic did not happen, however, till each of theſe ſciences ſeparately had made great progreſs; for before the days of HIPPARCHUS, EUCLID, ARCHIMEDES, and APPOLONIUS, had all flouriſhed in ſucceſſion, and had produced thoſe immortal works, of which the luſtre has not been obſcured by the higheſt improvements of later ages. In the progreſs of ſcience, therefore, the invention of trigonometry is to be conſidered as a ſtep of great importance, and of conſiderable difficulty. It is an application of arithmetic to geometry, with which we are now too familiar, to perceive all the merit of the inventor; but a little reflection will convince us, that he, who firſt formed the idea of exhibiting, in arithmetical tables, the ratios of the ſides and angles of all poſſible triangles, and contrived the means of conſtructing ſuch tables, muſt have been a man of profound thought, and of extenſive knowledge. However ancient, therefore, any book may be, in which we meet with a ſyſtem of trigonometry, we may be aſſured, that it was not written in the infancy of ſcience.

12. As we cannot therefore ſuppoſe the art of trigonometrical calculation to have been introduced till after a long preparation of other acquiſitions, both geometrical and aſtronomical, we muſt reckon far back from the date of the Surya Siddhanta, before we come to the origin of the mathematical ſciences in India. In Greece, the conſtellations were firſt repreſented on the ſphere, if we take a medium between the chronology of NEWTON, and that which is now generally

nerally received, about 1140 years before the Chriſtian æra*; and HIPPARCHUS invented trigonometry 130 years before the ſame æra. Even among the Greeks, therefore, an interval, of at leaſt 1000 years, elapſed from the firſt obſervations in aſtronomy, to the invention of trigonometry; and we have ſurely no reaſon to ſuppoſe, that the progreſs of knowledge has been more rapid in other countries.

A THOUSAND years therefore muſt be added to the age of the Surya Siddhanta, which we ſuppoſe here to be 2000 before CHRIST, in order that we may reach the origin of the ſciences in Hindoſtan, and this brings us very nearly to the celebrated æra of the Caly Yug, to which M. BAILLY has already referred the conſtruction of the aſtronomical tables of that country. And here, I cannot help obſerving, in juſtice to an author, of whoſe talents and genius the world has been ſo unſeaſonably and ſo cruelly deprived, that his opinions, with reſpect to this æra, appear to have been often miſunderſtood. It certainly was not his intention to aſſert, that the Caly Yug was a *real* æra, conſidered with reſpect to the mythology of India, or even that at ſo remote a period the religion of Brahma had an exiſtence. The religious and civil inſtitutions of Hindoſtan, as they now exiſt, may be all poſterior to this date, and their antiquity is probably to be determined from principles that are not the objects of aſtronomical diſcuſſion. All, I think, therefore, that M. BAILLY meant to affirm, and certainly all that is neceſſary to his ſyſtem, is, that the Caly Yug, or the year 3102 before our æra, marks a point in the duration of the world, before which the

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* The ſphere of CHIRON and MUSÆUS was conſtructed, according to NEWTON, about the year 936 before CHRIST, (NEWTON's Chron. chap. i. § 30). According to the ſyſtem generally received, the ancient ſphere, deſcribed by EUDOXUS, was conſtructed about 1350 years before CHRIST, (Dr PLAYFAIR's Chronology, p. 37). The medium is 1143.

the foundations of aſtronomy were laid in the Eaſt, and thoſe obſervations made, from which the tables of the Brahmins have been compoſed.

On this, however, and on many more of the particulars of the hiſtory of thoſe remote ages, great additional light will undoubtedly be thrown, by the complete tranſlation of the Surya Siddhanta. From the ſpecimen which Mr Davis has given, we can neither doubt of the importance of ſuch a work, nor of his abilities to execute it; and we truſt, that, to the zeal and liberality of our brethren of the Aſiatic Society, the learned world will ſoon be indebted for the poſſeſſion of this ineſtimable treaſure.

V.

V. *Some* GEOMETRICAL PORISMS, *with* EXAMPLES *of their* APPLICATION *to the* SOLUTION *of* PROBLEMS. *By Mr* WILLIAM WALLACE, *Assistant-Teacher of the Mathematics in the Academy of Perth. Communicated by Mr* PLAYFAIR.

[*Read March* 7. 1796.]

THE nature of thoſe mathematical propoſitions, which were called Poriſms by the ancient geometers, is now no longer a matter of uncertainty. The relation which they bear to other mathematical truths, the way in which they may at firſt have been obſerved, the kind of analyſis to be employed in their inveſtigation, their application to the ſolution of problems, have all been conſidered by ſome eminent mathematicians of the preſent age.

THESE propoſitions appear to have been held in high eſtimation by the mathematicians of antiquity, becauſe of their great uſe in the analyſis of difficult problems, as we learn from the writings of PAPPUS of Alexandria: And ſome ſpecimens, which late inquirers into this ſubject have given us, of their application to the ſolution of problems, ſeem to juſtify his very high character of them.

THE following paper contains ſome poriſms intimately connected with each other, and which ſeem capable of being applied to the ſolution of a number of geometrical problems. Examples of their application are added, ſome of which are problems that have been long known, and others are new; but the conſtructions of the former, it is believed, differ from any hitherto publiſhed. Although there are ſeveral of theſe examples, in appearance, little related to each other, yet their ſolutions are effected by the ſame general principle, which is alſo the foundation of all the poriſms.

PROP. I. PORISM, Fig. 4, 5. Pl. I.

Let AB, AC, be two ſtraight lines given by poſition, let B, C, be given points in theſe lines, a point H may be found, ſuch, that any circle whatſoever paſſing through A, the interſection of the given lines, and H the point which may be found, ſhall cut off from the given lines ſegments BD, CE, adjacent to the given points, and having to each other the given ratio of α to β.

Suppose the poriſm to be true, and that the point H is found. If a circle be deſcribed through H, A, and B one of the given points, it muſt alſo paſs through C the other given point, that the propoſition may be univerſally true. Therefore H is in the circumference of a given circle. Join BH, CH, DH, EH. The angle DHE is equal to DAE, that is, to BHC, (fig. 4.) or DHE is the ſupplement of DAE, (fig. 5.) and therefore equal to BHC; hence BHD is equal to CHE, but BDH is equal to CEH, therefore the triangles BDH, CEH, are equiangular, and BH is to HC as BD to CE, that is by hypotheſis in the given ratio of α to β; therefore if BC be joined, the triangle BHC is given in ſpecies, and BC being given, BH and HC are given; therefore the point H is given, which was to be found.

If the ſegments BD, CE, cut off from the given lines, lie in the ſame direction with reſpect to AB, AC, (fig. 4.) the point H will

will be in the ſame ſegment of the circle with the angle BAC; but if BD, CE, lie in contrary directions to AB, AC, (fig. 5.) then H will be in that ſegment of the circle upon which BAC ſtands.

THE point H will be found by the following conſtruction: Deſcribe a circle through the points A, B, C. Join BC, which divide at G, ſo that BG may be to GC in the given ratio of BD to CE, that is of α to β, and if the ſegments to be cut off are to lie in the ſame direction with AB, AC, find F the vertex of the ſegment upon which the angle BAC ſtands, (fig. 4.); but if BD, CE are to lie in oppoſite directions, (fig. 5.) find F the vertex of the ſegment BAC, and in either caſe join FG, which produce to meet the circle in H the point to be found; that is, if any circle be deſcribed through H and A to meet the given lines in D and E, BD is to CE as α to β. Join HB, HC, HD, HE. The triangles BDH, CEH are ſimilar, for the angle BDH is equal to CEH, and becauſe the angle BHC is equal to DHE, therefore BHD is equal to CHE; hence BD is to CE as BH to HC, that is, (becauſe HG biſects the angle BHC), as BG to GC, or as α to β.

IT is evident that the point H may be alſo found, by taking any ſegments BD, CE, in the given ratio of α to β, and deſcribing a circle through the points D, A, E, to meet the circle BAFC in H the point required. If the given lines be parallel, and the points B, C, alſo the ratio of BD to CE, (fig. 6.) given as before, the indeterminate circle will be changed into a ſtraight line paſſing through a given point H, which will be without the given lines, or between them, according as BD, CE, are to lie in the ſame, or in contrary, directions with AB, AC.

PROP. II.

PROP. II. PORISM, Fig. 7. Pl. I.

LET AF, AG be two ſtraight lines given by poſition, a point H may be found, ſuch, that any circle whatſoever deſcribed through it, and A the interſection of the given lines, to meet them in D and E, ſhall cut off from them ſegments AD, AE, whoſe ſum ſhall be a given line M.

SUPPOSE the poriſm to be true, and that the point is found, and circle deſcribed as above, let given points B, C be ſo taken, that BA and AC may be together equal to DA and AE, that is, by hypotheſis to the given line M, then BD will be equal to CE. If a circle be deſcribed through the given points A, B, C, by hypotheſis it will meet the circle paſſing through A, D, E, in H the point which may be found. Join BH, CH, DH, EH. The angle BHC is equal to DHE, each being the ſupplement of BAC, therefore BHD is equal to CHE; now, HDB is equal to HEC, and BD is equal to CE, therefore the triangle HBD is equal to HCE, and BH is equal to CH, alſo DH to EH; hence the angle BAH is equal to CAH, and H is in a ſtraight line biſecting the angle FAG, but it is alſo in the given circle BAC; therefore the point H is given, as was required.

HENCE this conſtruction: Take B and C two given points, ſo that BA and AC may be together equal to M, and through A, B, C deſcribe a circle. Draw AK biſecting the given angle FAG, and meeting the circle ABC in H the point required, that is, if any circle be deſcribed through H and A, to meet the given lines in D and E, the ſum of DA and AE ſhall be equal to the ſum of BA and AC, that is, by conſtruction to the given line M. The ſynthetical demonſtration follows readily from the preceding analyſis.

PROP. III.

PROP. III. PORISM, Fig. 8. Pl. II.

Let AF, AG be two ſtraight lines given by poſition, a point H may be found, ſuch, that if any circle be deſcribed through it, and A the interſection of the given lines, to meet them in D and E, the difference between AD and AE ſhall be equal to a given line N.

The analyſis of this propoſition will differ in nothing material from the laſt, and the point required may be found thus: Take B and C, two given points, ſo that the difference between BA and AC may be equal to N. Through the points A, B, C, deſcribe a circle. Draw AK biſecting the angle contained by FA one of the given lines, and AL the other line produced at their interſection, and AK will meet the circle ABC in H the point which may be found; that is, if any circle be deſcribed through H and A, to meet the given lines in D, E, the difference between AD and AE is equal to N the given line.

Join AH, BH, CH, DH. The triangles HCE, HBD are equal to one another in every reſpect, for if BC be joined, the angle HBC is equal to HAL, that is, by conſtruction to HAB, therefore HB is equal to HC; in the ſame way it appears that HD is equal to HE; now, the angle DHE is equal to DAE, that is to BHC, therefore BHD is equal to CHE, hence BD is equal to CE, and the difference between DA and AE is the ſame with the difference between BA, AC, which by conſtruction is equal to the given line M.

These two laſt propoſitions may be conſidered as particular caſes of the following propoſition.

PROP. IV.

PROP. IV. PORISM, Fig. 4, 5. Pl. I.

Two ſtraight lines AB, AC being given by poſition, and two lines P, Q being given in magnitude, a point H may be found, (fig. 5.) ſuch, that any circle deſcribed through it and A the interſection of the given lines, to meet them in D, E, ſhall cut off from them ſegments AD, AE, ſo that P×AD+Q×AE, ſhall be equal to a given ſpace. Alſo, the ſame things being ſuppoſed, a point H may be found, (fig. 4.) ſo that P×AD−Q×AE, ſhall be equal to a given ſpace.

Let given points B, C, be taken in either caſe agreeing with the hypotheſis of the propoſition, or ſo that P×AB+Q×AC, (fig. 5.) may be equal to P×AD+Q×AE, and ſo hat P×AB−Q×AC may be equal to P×AD—Q×AE, (fig. 4.) then, in both caſes, P×BD will be equal to Q×CE; therefore BD is to CE as Q to P, that is, in a given ratio, and the points B, C being given, the point H may be found, (Prop. 1.).

Construction. Let given points B, C be taken as above directed, and if P×AD+Q×AE is to be a given ſpace, (fig. 5.) find a point H, (Prop. 1.) ſo that any circle deſcribed through A and H may meet the given lines in D, E, ſo that BD, CE may lie in contrary directions to AB, AC, and have to each other the given ratio of Q to P, then P×BD will be equal to Q×CE, and adding the common ſpace P×AB+Q×AE to each, we get P×AD+Q×AE, equal to P×AB+Q×AC, that is, to the given ſpace, as was required.

But if P×AD—Q×AE is to be a given ſpace, (fig. 4.) find H, (Prop. 1.) ſo that any circle paſſing through H, A may cut off ſegments BD, CE, in the given ratio of Q to P, and lying towards the ſame parts with AB, AC, then P×BD is equal to Q×CE, Q×CE, and P×AD—Q×AE, will be equal to P×AB—Q×AC, that is, by conſtruction to the given ſpace.

LEMMA, Fig. 9. Pl. II.

If circles be deſcribed through A and C any two angles of a triangle ABC, to meet each other at D a point in AC, and the remaining lines AB, BC, in E and F; their other interſection H, the remaining angle B, and the points E, F, are in the circumference of a circle.

Join DH, EH, FH. The angle AEH is equal to ADH or CFH, that is, BEH is equal to BFH, hence the points H, B, D, F are in a circle. Q. E. D.

PROP. V. PORISM, Fig. 10. Pl. II.

Let AB, AC, BC be three ſtraight lines given by poſition, a point H may be found, ſuch, that if any circle be deſcribed through H, and B the interſection of any two of the given lines, to meet them in D and F, and if DF be joined meeting the remaining line at E. The line DF ſhall be divided at E, into ſegments having to each other a given ratio.

Suppose that the point H is found. Join HA, HB, HC; join alſo HD, HE, HF. Since, by hypotheſis, a circle may paſs through the point which is to be found, the interſection of any two of the given lines, and the points where DF meets theſe lines, therefore the points H, A, D, E are in a circle, and the angle HEF is equal to HAD or HAB; now the points H, B, D, F are ſuppoſed to be in a circle; ſince therefore in the triangle ABC, circles paſs through two of its angles A, B, and meet each other at D, a point in AB, (Lemma.) the points H, C, E, F are alſo in a circle; therefore the angle HCF is equal to HEF, that is, (as has been ſhewn), to HAB; hence the point H, which may be found, is in a circle paſſing through the points A, B, C, whatever be the given ratio of DE to EF. Let this circle be deſcribed.

Because the points H, A, D, E are in a circle, the angle HAC is equal to HDE, and becauſe H, C, E, F are in a circle, the angle HFE is equal to HCA; therefore the triangles AHC, DHF are ſimilar. In the ſame manner it appears, that AHB is ſimilar to EHF, and CHB to EHD.

Let AC be divided at K, ſo that AK may be to KC, in the given ratio of DE to EF, the point K will thus be given. Join HK meeting the circle in G. The triangles AHC, DHF being ſimilar, and having AC, DF, ſimilarly divided at K, E, the triangles AHK, KHC will therefore be ſimilar to DHE, EHF, which have been proved ſimilar to BHC, AHB; therefore the angle AHB is equal to CHK or CHG, and the arch AB is equal to CG, hence G is a given point, and K being given, the line GH will be given by poſition; therefore the point H is given which was to be found.

Construction. Deſcribe a circle through the points A, B, C, let AB, BC, be the lines upon which D and F, the extremities of the indeterminate line, are to be placed, and let AC be the line which is to meet it in E, ſo that DE may be to EF, in the given ratio of *de* to *ef*. Find K, ſo that AK may be to KC as *de* to *ef*, draw BG parallel to AC, meeting the circle in G, join GK meeting the circle in H, the point which may be found; that is, if any circle be deſcribed through H, and B the interſection of any two of the given lines, to meet them in D and F, and if DF be joined, meeting the remaining line at E, the line DF ſhall be divided at E, ſimilarly to the given line *def*.

Let AH, BH, CH be joined, alſo DH, EH, FH. The angle HDF or HDE is equal to HBF, that is, to HAE, the points H, A, D, E are therefore in a circle, now the points H, B, D, F

are

are in a circle, therefore (Lemma.) the points H, C, E, F are alſo in a circle. The angle HDE is equal to HBC, that is, to HAK, and ſince HEF is equal to HCF, therefore HED is equal to HCB, that is, to HGB or HKA; hence the triangles HDE, HAK are ſimilar, and ſince HFE is equal to HCK, the triangles HEF, HKC are alſo ſimilar; therefore DE is to EF as AK to KC, that is, as *de* to *ef*.

Cor. 1. The lines DH, EH, FH contain given angles, and have to each other the given ratios of AH, KH, CH.

Cor. 2. The line DF cuts off ſegments DA, EK, FC from the given lines, adjacent to given points in them, and having to each other the given ratios of HA, HK, HC. For the angles HDB, HEK, HFC are equal among themſelves, and ſince BCH or BGH, that is, AKH, is the ſupplement of each of the angles HCF, HAD, HKE, the angles HAD, HKE, HCF are equal among themſelves, therefore the triangles HAD, HKE, HCF are ſimilar, and AD, KE, CF are proportional to the given lines AH, KH, CH.

PROP. VI. PORISM, Fig. 11. Pl. II.

Let AB, AC, BE, DE be four ſtraight lines given by poſition; a point P may be found, ſuch, that if any circle be deſcribed through it and B, any of the ſix interſections of the given lines, to meet the lines through whoſe interſection it paſſes in G and L, and if GL be joined, meeting the remaining lines in H and K, the ſegments GH, HK, KL have given ratios to one another, which ratios are to be found.

Because, by hypotheſis, the points P, A, G, H are in a circle, and alſo the points P, F, H, K, it will appear, as in the analyſis of laſt propoſition, that P is in a circle deſcribed about the triangle ADF; in the ſame way it will be found, that P muſt be in circles deſcribed about each of the triangles ABC, DBE,

 FCE.

FCE. Therefore, that the propofition may be univerfally true, thefe four circles muft interfect one another at the fame point.

About any two of thefe triangles, as ABC, DBE, let circles be defcribed, the point P muft be at their interfection.

Because ADF is a triangle, and through two of its angles A, D, circles are defcribed, meeting each other at B, a point in AD, therefore (Lemma.) P, their other interfection, and the points F, C, E, are in a circle; and becaufe FCE is a triangle, and circles pafs through C, E, two of its angles, and meet each other at B, a point in CE, therefore (Lemma.) the points P, A, D, F are in a circle. Thus, it appears, that circles defcribed about each of the four triangles ADF, ABC, DBE, CFE, pafs through the fame point P as was to be inveftigated. It remains to inquire, whether the ratios of GH, HK, KL to one another be given. Join PB, PC, PE, alfo PG, PH, PK, PL. The angle GPH is equal to GAH, that is, to BPC, and PGH is equal to PBC, therefore the triangles BPC, GPH are fimilar, and the angle PHK is equal to PCE; but HPK is equal to HFK, that is, to CFE or CPE, hence the triangles HPK, CPE are fimilar, and PKL is equal to PEL. Now, if PN be drawn, fo that the angle BPN may be equal to GPL, that is, to the given angle GBL, it is evident that the point N is given, and will be in a circle paffing through P, and touching AG at B; the angles NPE, LPK will thus be equal, and the triangles NPE, LPK fimilar. Since, therefore, the triangles BPC, CPE, EPN are fimilar to GPH, HPK, KPL, it follows, that BN, GL are fimilarly divided by the given lines CH, EK, therefore the ratios of GH, HK, KL are the fame with the given ratios of BC, CE, EN.

Construction. About ABC, DBE any two of the four triangles formed by the given lines, let circles be defcribed, they will meet each other at P, the point which is to be found.

Through

Through P and B, the interfection of any two of the given lines, let a circle be defcribed to touch one of them at B, and cut the other at N, the line BN will be given, and the ratios of GH, HK, KL, the fame with the given ratios of BC, CE, EN to one another.

The fynthetical demonftration follows readily from the analyfis, and for the fake of brevity is here omitted.

Cor. 1. The lines PG, PH, PK, PL, contain given angles, and have to each the given ratios of PB, PC, PE, PN.

Cor. 2. The line GL cuts off from the given lines, fegments BG, CH, EK, NL, adjacent to given points, and having to each other the given ratios of PB, PC, PE, PN. For the points P, A, G, H, being in a circle, the angle PGB is equal to PHC; and fince P, F, H, K, are in a circle, the angle PHC is equal to PKE, which in like manner will be found equal to PLN. Now, the angles PBA, PCF, PEF, PNB are equal among themfelves, therefore their fupplements PBG, PCH, PEK, PNL are equal, and the triangles PBG, PCH, PEK, PNL are fimilar, therefore BG, CH, EK, NL are proportional to the given lines BP, CP, EP, NP.

PROP. VII. THEOREM, Fig. 12. Pl. III.

Let PGAB, PFAC, PEAD, &c. be any number of given circles, each of which paffes through the fame two points A, P; from A, either of thefe points let a ftraight line, given by pofition, be drawn, meeting the circles at B, C, D, &c. and another meeting them at E, F, G, &c. Let ftraight lines GB, FC, ED, &c. be drawn, joining thefe points, fo as to form, with the lines paffing through A, triangles GAB, FAC, EAD, &c. in each of the circles. If, through P, the common interfection of the circles, and Q, the interfection of of any two of the lines, a circle be defcribed to meet them in K and L, a line joining KL, and meeting the remaining lines, will be divided by them into fegments HK, KL, LM, MN, &c. having to each other given ratios.

Let Q, R, S, &c. be the remaining interfections of GB, FC, ED, &c. Becaufe GRE is a triangle, and circles PGAB, PEAD pafs through G, E, two of its angles, and meet at A, a point in GE, the points P, R, B, D, are in a circle, (Lemma.) in the fame way it appears, that circles may pafs through P, S, C, D, and P, Q, B, C, &c. Becaufe it is now proved, that in the triangle CDS, a circle may pafs through P, C, B, Q, and another through P, D, B, R; therefore the points P, S, R, Q, are in a circle. (Lemma.) Thus it may be fhewn, that circles defcribed about each of the triangles, formed by the intercepted fegments of the ftraight lines, will all pafs through the fame point P. From P draw ftraight lines to the points of interfection of one of the given lines, with all the others, as PA, PB, PC, PD, &c. Join PH, PK, PL, PM, PN, &c.

Since P, Q, K, L, are in a circle, the angle BKP is equal to CLP; now, the angles PBG, PCF, are each equal to PAG; therefore the angles PBK, PCL, are equal, and the triangles PBK, PCL, fimilar; hence KP is to PL as BP to PC; now the angle KPL is equal to KQL, that is, to BPC; therefore the triangles KPL, BPC, are fimilar, and the angle PLM will be equal to PCD. But the points P, S, C, D, having been proved to lie in a circle, if PS be joined, the angle PCD will be equal to PSD, therefore PLM is equal to PSD or PSM, hence the points P, S, L, M are in a circle. In the fame way it may be fhewn, that P, G, H, K are in a circle, as alfo P, D, M, N, &c. and that the triangles PAH, PDM, &c. are each fimilar to PBK and PCL, and hence that PHK is fimilar to PAB, and PLM to PCD, &c. Through P defcribe a circle to touch AG at A, and meet AD in in V, which will be a given point, ſince GA, AD, are given by poſition.

Join PV, the angle PVA is equal to PAE or PDS, that is, (P, D, M, N being in a circle) to PNM, and PDV is equal to PMN, the triangle PMN is therefore ſimilar to PDV; and ſince the angle PVA is equal to PDS, alſo PNV to PMD, the triangles PDM, PVN are ſimilar. Thus it appears, that HN and AV are ſimilarly divided by the lines BK, CL, DM, &c.; now, the points A, B, C, D, V, &c. are given; therefore the ratios of HK, KL, LM, MN, &c. to one another are given. Q. E. D.

Cor. 1. The lines PH, PK, PL, PM, PN, &c. contain given angles, and have to each other the given ratios of PA, PB, PC, PD, PV, &c.

Cor. 2. The line HN cuts off from the given lines, ſegments HA, KB, LC, DM, VN, &c. adjacent to given points, and having alſo to one another the given ratios of PA, PB, PC, PD, PV, &c.; for the triangles PAH, PBK, PCL, PDM, PVN, &c. have been proved equiangular; and therefore AH, BK, CL, DM, VN, &c. are proportional to PA, PB, PC, PD, PV, &c.*.

PROP. VIII.

* It may be proper to remark here, that, in the preceding propoſitions, the ſtraight lines given by poſition, as well as the indeterminate ſtraight line, which is cut by them into ſegments, having to each other given ratios, and which alſo cuts off from them ſegments adjacent to given points, and having to each other given ratios, are tangents to a parabola, of which the point that is required to be found is the focus. This conſideration ſuggeſts ſome curious propoſitions, relating to tangents to the parabola. Some of them have been obſerved by Dr Halley, in his tranſlation of the *Sectio Rationis* of Appollonius.

One very obvious application of the propoſitions above hinted at, is to deſcribe parabolas that ſhall paſs through given points, and touch ſtraight lines given by poſition.

PROP. VIII. PORISM, Fig. 13. Pl. II.

Let CA, CB, AB be three ſtraight lines given by poſition, a point H may be found, ſuch, that if through H, and B, C, any two of the interſections of theſe lines, there be deſcribed circles HBEF, HCDE, to meet each other at E, a point in BC, and the remaining lines at D and F. If DE, EF, DF be joined, the triangle DEF ſhall be ſimilar to a given triangle *def*, and ſhall have its angles upon the given lines in a given order.

Because circles are deſcribed through C, B, and meeting each other at E, a point in CB, therefore their other interſection H, the remaining angle A, and the points D, F, are in a circle. (Lemma.) Let a circle be deſcribed through H, C, A, to meet CB in G, and another through H, B, G, to meet AB in K. Join HA, HG, HK, alſo HD, HE, HF. The angles ADH, GEH, KFH, are equal to one another, and the angles CAH, CGH, BKH are equal, therefore HAD, HGE, HKF are equal, and the triangles HAD, HGE, HKF are ſimilar; therefore DH is to HE as AH to HG, and EH is to HF as GH to HK; now, the angles DHE, EHF are equal to DCE, EBF, that is, to AHG, GHK; hence the quadrilateral HDEF is ſimilar to HAGK, and the triangle DEF is ſimilar to AGK; now, the angles EDF and DEF are given by hypotheſis, therefore GAK and AGK are given; but A is a given point, and AK is given by poſition, therefore AG and the point G are given; therefore GK and the point K are alſo given, and H, the interſection of the given circles GAC, GBK, will be given, which was to be found.

Construction. Take a given point, which, to render the conſtruction more ſimple, may be at A, one of the interſections of of the given lines. Let AG, GK be fo drawn as to form a triangle AGK, fimilar to the given triangle *def*, and having its angles placed upon the given lines, in the given order. Through A, G, any two of its angles, and C, the interfection of the lines upon which they are placed, defcribe a circle; through G, K, and B, the interfection of CG, AK, let another circle be defcribed, meeting the former in H, the point to be found, which will alfo be in a circle paffing through K, and touching CA at A.

THE demonftration follows eafily from the preceding analyfis.

COR. 1. The lines HD, HE, HF contain given angles, and have to each other the fame ratios, with the given lines HA, HG, HK.

COR. 2. The lines AD, GE, KF have alfo to each other the given ratios of HA, HG, HK.

PROP. IX. THEOREM, Fig. 14. Pl. III.

LET E*a*, E*b*, F*c*, G*d*, &c. be any number of ftraight lines given by pofition. Let P be a given point. Through P, and E, the interfection of any two of the given lines, let a circle be defcribed to meet them in A and B; through P, B, and H, the interfection of B*b*, with one of the remaining lines, let a circle be defcribed to meet that line in C. Through P, C, and K, the interfection of C*c*, with one of the remaining lines, let a circle be defcribed to meet that line in D, and fo on if there be more lines. Join AB, BC, CD, &c. DA. The rectilineal figure ABCD, &c. is given in fpecies.

TAKE *a*, a given point in EA, through P, E, *a*, defcribe a circle to meet EB in *b*, through P, H, *b*, defcribe a circle to meet HC in *c*, through P, K, *c*, defcribe a circle to meet KD in *d*, and fo on if there be more lines. Join P*a*, PA, alfo PB, P*b*, PC, P*c*, PD, P*d*, &c. Becauſe the points P, E, A, B, are in a circle, the angle PA*a* is equal to PB*b*; now P*a*A is equal to P*b*B; for P*a*E is equal to P*b*E, the triangles P*a*A, P*b*B are therefore ſimilar. In the ſame manner it may be ſhewn, that P*b*B is ſimilar to P*c*C, and that again to P*d*D, &c. Therefore PA is to PB as P*a* to P*b*, and PB to PC as P*b* to P*c*, and PC to PD as P*c* to P*d*, &c.; now the angles APB, BPC, CPD, &c. are equal to AEB, BHC, CKD, &c. that is, to *a*P*b*, *b*P*c*, *c*P*d*, &c. therefore if *ab*, *bc*, *cd*, &c. A*d* be joined, the rectilineal figure PABCD, &c. is ſimilar to P*abcd*, &c; and leaving out the ſimilar triangles PAD, P*ad*, the rectilineal figure ABCD, &c. is ſimilar to *abcd*, &c. Now the points P, E, *a*, being given, the circle paſſing through them is given; therefore *b* is a given point; in like manner *c*, *d*, &c. are given points; therefore the figure *abcd*, &c. is given; therefore ABCD, &c. to which it is ſimilar, is given in ſpecies. Q. E. D.

Cor. 1. The lines PA, PB, PC, PD, &c. contain given angles, and have to each other the given ratios of P*a*, P*b*, P*c*, P*d*, &c.

Cor. 2. The ſegments A*a*, B*b*, C*c*, D*d*, &c. of the given lines, adjacent to the given points *a*, *b*, *c*, *d*, &c. have alſo to each other the given ratios of P*a*, P*b*, P*c*, P*d*, &c.

Cor. 3. If there be any number of ſtraight lines given by poſition, there may be innumerable rectilineal figures ſimilar to one another, and having their angles upon the ſtraight lines given by poſition.

PROP. X. PORISM, Fig. 15. Pl. III.

Let A and B be two given points in the circumference of a given circle. Let C be a given point in KC, a ſtraight line given

given by position. There may be found a straight line KD given by position, and also a given point D in that line, such, that if AE, BE be inflected to any point in the circumference of the given circle, they shall cut off from KC, KD, segments FC, GD, adjacent to the given points, and having to each the given ratio of α to β.

SUPPOSE the line KD, and the point D to be found. If AH, BH be inflected to the circle, so that AH may pass through C, then BH must pass through D, the point which may be found, otherwise the proposition would not be universally true. Now, C being given, the point H, and the line BH, will be given by position. Let AL be drawn parallel to KC, then BL must be parallel to KD, the line to be found; hence it appears, that the angle GKF is equal to ALB, that is, to GEF; therefore the points E, K, G, F are in a circle, and the angle DGB is equal to CFA; now DBG is equal to CAF; therefore the triangles DBG, CAF are equiangular, and AC is to BD as CF to DG, that is, by hypothesis, as α to β; now AC is given, and BH is given by position, therefore the point D is given, but BDG is equal to the given angle ACF, therefore DG is given by position.

CONSTRUCTION. Join AC, meeting the circle in H. Join BH, and, as α is to β, so let AC be to BD. Through H, D, C describe a circle to meet FC in K. Join DK; then D is the given point, and DK is the line given by position, which are to be found; that is, if AE, BE be inflected to any point in the circumference, to meet the given lines in F, G; CF shall be to DG as AC to BD, or as α to β. The demonstration is easily derived from the analysis.

THE foregoing propositions, in one point of view, may be considered as exhibiting innumerable solutions of certain geometrical problems of the indeterminate kind, to each of which, if ſome condition, unconnected with the hypotheſis of the propoſition, be added, there will be formed a problem perfectly limited in its nature.

THE method of applying the poriſms to the ſolution of many problems is obvious enough; and, as ſome of theſe may be of a very extenſive nature, and ſuch as many others can be reduced to, therefore the utility of the poriſms will by this means be greatly extended. The condition that may be joined to the hypotheſis of each poriſmatic propoſition, it is evident, may be greatly varied: And, hence, it were eaſy to form abundance of problems, differing from any hitherto propoſed: but this would extend the paper to too great a length. We ſhall therefore only give a few examples, of which, let the firſt be the *Sectio Rationis* of the ancient geometers.

PROP. XI. PROBLEM, Fig. 16. Pl. III.

Two ſtraight lines AB, AC are given by poſition, and two points B, C are given in theſe lines. It is required to draw a line through P, a given point, without them, to meet them in D and E, ſo that BD may have to CE the given ratio of M to N.

BECAUSE the ratio of BD to CE is given; if a circle be deſcribed through the points A, B, C, there is given a point H in the circumference, ſuch, that the points A, H, D, E are in a circle, (Prop. 1.) therefore if HD, HA be joined, the angle HDP is equal to HAE, that is, to a given angle; now H and P are given points, therefore D is in the circumference of a given circle, but it is alſo in AB, a line given by poſition; therefore D is a given point, and PE is given by poſition, which was to be found.

CON-

Construction. Through A, B, C defcribe a circle; inflect BH, CH to the circumference, fo that BH may be to CH in the given ratio of BD to CE, or of M to N*, thus H will be a given point. If the fegments BD, CE to be cut off, are to lie in the fame direction with AB, AC, the point H muft be found in the fame fegment with BAC; but if they are to lie in contrary directions, then H muft be taken in that fegment upon which BAC ftands. Join AH and PH, upon which defcribe a fegment of a circle, that may contain an angle equal to HAC, which is given. This circle may cut AB in two points D, δ. Join PD and Pδ, meeting the remaining line in E and ε; thefe lines cut off fegments BD, CE, or Bδ, Cε, having to each other the given ratio of BH to HC, or of M to N.

Join HD, HE. Becaufe the angle PDH is by conftruction equal to HAE, the points A, H, D, E are in a circle; therefore the angle HEA is equal to HDA, that is HDB is equal to HEC; now, HBD is equal to HCE, for HBA is equal to HCA, therefore the triangles HCE, HBD are fimilar, and BD is to CE as BH to HC, that is, by conftruction, as M to N.

It is evident that this problem may admit of four folutions in general, if there be given no limitation with refpect to the direction in which the fegments are to be cut off from the given lines; but the data may be fuch as to render it capable of three and alfo of two folutions only.

The next example fhall be the *Sectio fpatii* of the ancients.

PROP. XII. PROBLEM, Fig. 17. Pl. III.

Two ftraight lines AB, AC are given by pofition, and two points B, C are given in thefe lines. It is required to draw a

* The manner of doing this has been fhewn in Prop. 1.

a ſtraight line through P, a given point, without them, to meet them in D and E, ſo that the rectangle BD, CE may be equal to a given ſpace.

Suppose that DE is drawn as required. Join PC which will be given in poſition and magnitude. Draw PF parallel to AC, and take F, ſo that the rectangle CP, PF may be equal to the given ſpace, the point F will therefore be given; draw FL parallel to CP, meeting AB in K, and PD in L, then FL and the point K will both be given by poſition. The triangles LFP, PCE are ſimilar; therefore LF is to FP as PC to CE, and the rectangle LF, CE is equal to the rectangle FP, PC, which, by hypotheſis, is equal to the rectangle BD, CE, therefore FL is equal to BD; now, B and F are given points, and BK, FK are lines given by poſition; therefore (Prop. 1.) if a circle be deſcribed through K, B, F, there is a given point H in the circumference, ſuch, that K, H, L, D are in a circle; therefore, if this point be found, and HD, HL, HK joined, the angle HDL is equal to HKL; therefore HDP is equal to HKF, that is, to a given angle; but H and P are given points, therefore D is in the circumference of a given circle; but it is alſo in a ſtraight line given by poſition; therefore D is a given point, and PD is given by poſition.

Construction. Join P and C, either of the given points in the given lines; draw PF parallel to CA, and take F, ſo that the given ſpace may be the rectangle CP, PF. Draw FL parallel to CP, meeting AB in K, and through the points F, B, K deſcribe a circle. Find H in the circumference, ſo that BH may be equal to FH. Join HK and HP, upon which deſcribe a ſegment of a circle, that may contain an angle equal to HKF; this circle may meet AB in two points D, δ. Join PD and Pδ, meeting

ing AC in E and ε. The rectangles BD, CE, and Bδ, Cε, are each equal to the given rectangle FP, PC.

Let ED meet FK in L, join HL, HD. Becauſe by conſtruction the angle HDP is equal to HKF; therefore HDL is equal to HKL; therefore the points H, K, D, L, are in a circle, and the angle HLK is equal to HDK, that is HLF is equal to HDB, now HFL is equal to HBD, alſo HF is equal to HB; therefore the triangles HFL, HBD are in all reſpects equal, and FL is equal to BD. Again, the triangles LFP, PCE are ſimilar, therefore FL is to FP as CP to CE, and the rectangle FL, CE is equal to the rectangle FP, PC, but FL is equal to BD, therefore the rectangle BD, CE is equal to the rectangle FP, PC, that is to the given ſpace. In the ſame way it may be ſhewn that the rectangle Bδ, Cε is equal to FP, PC.

PROP. XIII. PROBLEM, Fig. 18. Pl. IV.

Four ſtraight lines DB, DF, CG, BG are given by poſition, it is required to draw a line to meet them in the points N, O, P, Q, ſo that the line NQ may be divided at theſe points, ſimilarly to a given divided line *n o p q*.

Suppose the line NQ drawn as required. Becauſe DB, DF, BF are three ſtraight lines given by poſition, and that NQ is divided by one of them at O into ſegments, having to each other a given ratio, if a circle be deſcribed through the points B, D, F, there is a given point E in the circumference, ſuch, that the points E, B, N, Q are in a circle, (Prop. 5.) Again, becauſe CB, CG, BG are three lines given by poſition, and NQ is divided by one of them at P into ſegments, having to each other a given ratio, if a circle be deſcribed through B, C, G, there is a given point A in the circumference, ſuch, that A, N, B, Q are in a circle, (Prop. 5.) Thus it appears, that there are given

three

three points A, E, B in a circle, paſſing through N and Q, therefore NQ is given by poſition.

Construction. Let DB, BG be the lines upon which the extremities of NQ are to be placed. About the triangles BDF, BCG, deſcribe circles, draw BH parallel to FD, meeting the circle DBF in H, and draw BK parallel to CG, meeting the circle CBG in K. In DF find L, ſo that DL may be to LF as *n o* to *o q*, and in CG find M, ſo that CM may be to MG as *n p* to *p q*, join HL meeting the circle DBF in E, join alſo KM meeting the circle CBG in A. Through the points A, E, B deſcribe a circle meeting DB, BG in N and Q, join NQ meeting the other lines in O and P, and NQ ſhall be divided ſimilarly to *n q*.

It has been proved in Prop. 5. that the point E being found as above, if any circle paſs through E and B, and meet DB, GB in N and Q, the line joining NQ ſhall be divided at O, ſo that NO will be to OQ as DL to LF, that is by conſtruction as *n o* to *o q*. Likewiſe, that the point A being found as above, if any circle be deſcribed through A and B, to meet DB, BG in N and Q, the line NQ being drawn, ſhall be divided at P, ſo that NP will be to PQ as CM to MG, that is by conſtruction as *n p* to *p q*. Hence, it is obvious, that NQ is divided ſimilarly to *n q*.

It may be remarked, that the preceding conſtruction points out very clearly, a circumſtance which appears to have eſcaped the notice of ſome Mathematicians that have given ſolutions of the problem, with a view to its application to Aſtronomy. It is that the given ratios of NO, OP, PQ, to one another may be ſuch as to render the problem indeterminate. Now, this it is evident will be the caſe, if the points A, E ſhall both fall at Æ the interſection of the circles. This caſe forms Prop. VI. of this paper, ſo that it may be ſufficient to add here, that the ratios which

which render the problem indeterminate, are thoſe which are required to be found, in the propoſition juſt now quoted.

PROP. XIV. PROBLEM, Fig. 19. Pl. IV.

Three ſtraight lines AB, AC, BD are given by poſition, and P is a given point. It is required to draw PE to meet BD in E, and PG meeting AB in F, and AC in G, ſo that the angle EPG may be given, and ſo that EP may have to FG the given ratio of α to β.

Suppose the lines drawn as required. In GP take PH equal to FG, therefore the ratio of EP to PH will be given, now the angle EPH is given, therefore H is in a ſtraight line given by poſition, (Apoll. Loci Plani, Lib. 1. Prop. 6.) let this line be LC. Biſect PF in K, then becauſe P is a given point, and AB is given by poſition, the point K will be in a ſtraight line given by poſition, (Loci Plani, Lib. 1. Prop. 4.) let this line be LM. Becauſe GF is equal to PH, and FK to PK, therefore GK is equal to KH, but the lines ML, MC, CL are given by poſition, therefore, (Prop. 5.) a given point N may be found in the circumference of a circle paſſing through M, C, L, ſuch, that the points N, M, G, K are in a circle, therefore if this point be found, and NG, NM joined, the angle NGK or NGP is equal to the given angle NML, now N and P are given points, therefore G is in the circumference of a given circle, but it is alſo in a ſtraight line given by poſition, therefore the point G is given.

Construction. Find LC a ſtraight line given by poſition, ſuch, that if PE, PH be drawn meeting BD, CL, and containing an angle EPH equal to the ſupplement of the given angle

EPG, the ratio of EP to PH may be the ſame with the given ratio of α to β. (Loci Plani, Prop. 6. Lib. 1.) Find alſo a ſtraight line LM given by poſition, ſuch, that PF drawn to any point in AB, may be biſected by it in K. Through L, M, C, the interſections of the given lines LM, AC, LC, deſcribe a circle. Draw CO parallel to LM, meeting the circle in O; biſect ML in Q; join OQ meeting the circle in N; join NM, and inflect NG, PG to AC, ſo that the angle NGP may be equal to NML; draw PE, ſo that the angle EPG may be ſuch as is required.

Let GP meet CL in H, and AB in F, alſo LM in K; join NH, NK, NL. Since NGP is equal to NML, the points N, K, G, M are in a circle, and the angle NKH is equal to NMG or NMC, that is to NLH; therefore the points N, K, L, H are in a circle, and the angle NHK is equal to NLQ; now NKH is equal to NMG or NOC, that is (OC being parallel to ML) to NQL; therefore the triangles NKH, NQL are ſimilar. In like manner it appears, that NKG, NQM are ſimilar; therefore ML and GH are ſimilarly divided at Q and K, but ML is biſected at Q; therefore GH is biſected at K; now PF is alſo biſected at K; therefore GF is equal to PH, and EP is to FG as EP to PH, that is, by conſtruction, as α to β.

PROP. XV. PROBLEM, Fig. 20. Pl. IV.

Three ſtraight lines AB, AC, BC are given by poſition, and three points D, E, F are given in theſe lines. It is required to draw a ſtraight line GHK to meet them, ſo that DG, EH, FK may have to each other the given ratios that P, Q, R have among themſelves.

Suppoſe

Suppose that the line is drawn as required. Becaufe the ratio of DG to EH is given, there is given (prop. 1.) a point M in the circumference of a circle paffing through A, D, E, fuch, that the points A, M, G, H are in a circle. If this point be found, and MG, MH, MD, ME joined, the angle GMH is equal to GAH or to DME. Alfo if MA, DE be joined, the angle MHG is equal to MAG or to MED. Therefore the triangle MHG is fimilar to thegiven triangle MED, and the angle MHG is given.

In like manner, becaufe the ratio of EH to FK is given, there is given a point N in the circumference of a circle paffing through E, C, F, fuch, that N, C, H, K are in a circle. If NH, NK, NE, NF, NC, EF be joined, it may be proved, in the fame way, that the triangle NHK is fimilar to NEF, hence the angle NHK is given. Now, the angles MHG, NHK being each proved to be given, the angle MHN is given, and the points M, N being alfo given, the point H is in the circumference of a given circle; but it is alfo in a ftraight line given by pofition; therefore the point H is given, and the angles MHG, NHK being given, the line GK is given by pofition, which was to be found.

Construction. Through the points A, D, E defcribe a circle, and inflect DM, EM to the circumference, fo that DM may be to EM as P to Q. Defcribe alfo a circle through C, E, F, and inflect EN, FN to the circumference, fo that EN may be to FN as Q to R. Join DE, EF, and inflect MH, NH to the ftraight line AE, fo that the angle MHN may be the fupplement of the fum of MED and NEF; draw HG, fo that the angle MHG may be equal to MED; then NHK is equal to NEF.

Join MG, MA. Becaufe the angle MHG is equal to MED or to MAG, the points M, A, H, G are in a circle; hence the angle MHE is equal to MGD; now MEH is equal to MDG; for MEA is equal to MDA; therefore the triangles MEH, MDG are fimilar, and DG is to EH as DM to ME, that is as P to Q.

In like manner it may be proved, that becauſe the angle NEF is equal to NHK, the points N, C, H, K are in a circle, and hence that the triangle NEH is ſimilar to NFK; hence EH is to FK as EN to FN, that is as Q to R. Therefore GHK is drawn as required.

PROP. XVI. PROBLEM, Fig. 20. Pl. IV.

It is required to deſcribe a triangle DEF ſimilar to a given triangle *def*, having one of its ſides EF paſſing through P a given point, and having its angles in a given order upon three ſtraight lines AB, AC, BC given by poſition.

The conſtruction of this problem follows readily from the 8th propoſition, as follows:

Draw AG, GK, ſo as to form a triangle AGK, ſimilar to the given triangle *def*, and having its angles upon the given lines in the given order.

Through A, G, any two of its angles, and C, the interſection of the lines upon which they are placed, deſcribe a circle. Through G, K, and B, the interſection of GC, KA, deſcribe a circle meeting the former in H. From the points H, P inflect HE, PE to CB, ſo that the angle HEP may be equal to HGK; let PE meet AB in F. Through H, C, E deſcribe a circle to meet CA in D; join DE, DF, and the triangle DEF ſhall be ſimilar to AGK or to *def*.

Join HD, HF, HA, HK, HB, HC. Becauſe, by conſtruction, the angle HEF is equal to HGK or to HBK, the points H, B, E, F are in a circle, and the angle FHE is equal to FBE or KHG, therefore the triangles EHF, GHK are ſimilar. In like manner, becauſe a circle paſſes through H, C, D, E, the angle DHE is equal to DCE or AHG, and HDE is equal to HCE or HAG, therefore the

the triangles EHD, GHA are ſimilar. Now the triangle HEF was proved ſimilar to HGK. Therefore the quadrilateral HDEF is ſimilar to HAGK, and the angle DEF is equal to AGK; alſo DE is to EF as AG to GK; therefore the triangle DEF is ſimilar to AGK or to *def*, as was required.

PROP. XVII. PROBLEM, Fig. 21. Pl. IV.

A and B are two given points in the circumference of a given circle. C and D are two given points in ſtraight lines CE, DE given by poſition. It is required to inflect AF, BF to the given circumference, meeting the given lines in G and H, ſo that the rectangle CG, DH may be equal to a given ſpace.

Because A and B are given points in the circumference of a given circle, and D is a given point in a line DE given by poſition, a line LM, and a point M in it, both given by poſition, may be found, (prop. 10.), ſo that BF, AF being inflected to any point in the circumference, meeting the given line DE in H; and the line LM, which may be found in N, the ratio of DH to MN, may be given.

Suppose the line ML found, ſo that MN may be equal to DH, then the rectangle MN, CG is equal to DH, CG, which by hypotheſis is given. Now A is a given point, and C, M are given points in ſtraight lines given by poſition. Therefore the problem is now reduced to the 12th propoſition of this paper.

Construction. Join B and D, the given point, in the line whoſe ſegment is to be intercepted by BF. Let BD meet the circle in K; join AK, and take AM equal to BD. Through the points D, M, K deſcribe a circle cutting DE in L, and AK in M. Join LM, and from the point A (by prop. 12.) draw a ſtraight line to meet CE in G, and LM in N, ſo that the rectangle

tangle MN, CG may be equal to that which is to be contained by CG, DH. Let AN meet the circle in F; join BF meeting DE in H.

The angle HDB is equal to LMK or AMN, and the angle DBH is equal to MAN; now BD is equal to AM; therefore the triangles BDH, AMN are in all reſpects equal, and DH is equal to MN. Therefore the rectangle DH, CG is equal to MN, CG, that is, (by conſtruction), to the given ſpace as required.

It is eaſy to ſee, how, in like manner, by drawing AGN, ſo that CG may be to MN in a given ratio, (prop. 11.), the lines BF, AF ſhall cut off ſegments DH, CG, having to each other a given ratio.

V.

PLATE I.

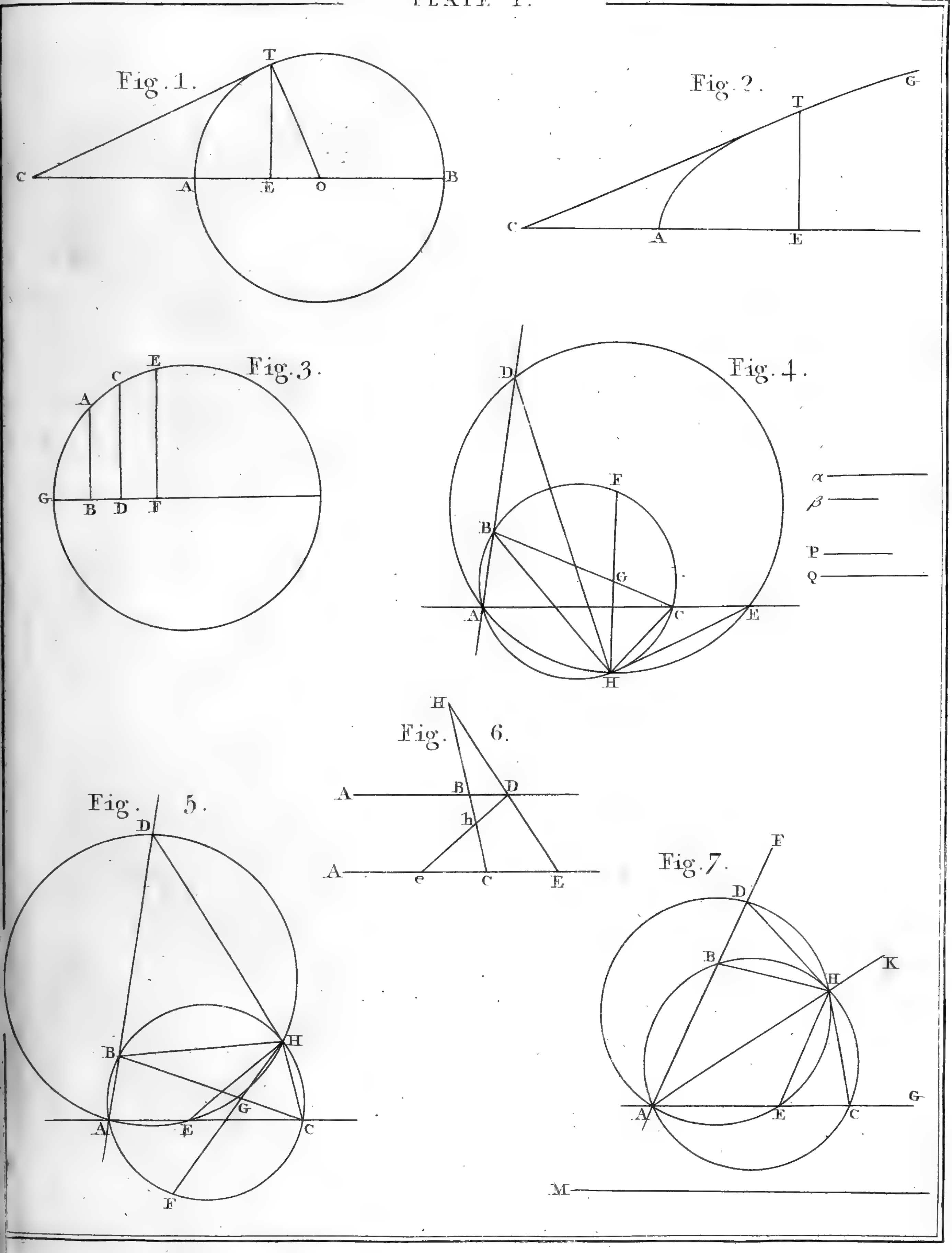
Fig. 1.
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Fig. 5.
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Fig. 6.
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Fig. 7.
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To face Page 134. Phy. Cl.

Fig. 8.

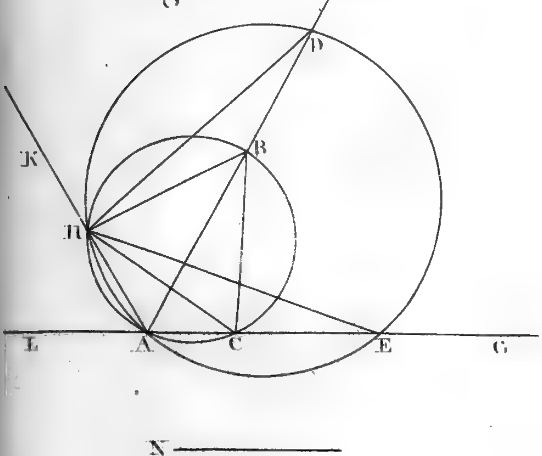


Fig. 11.

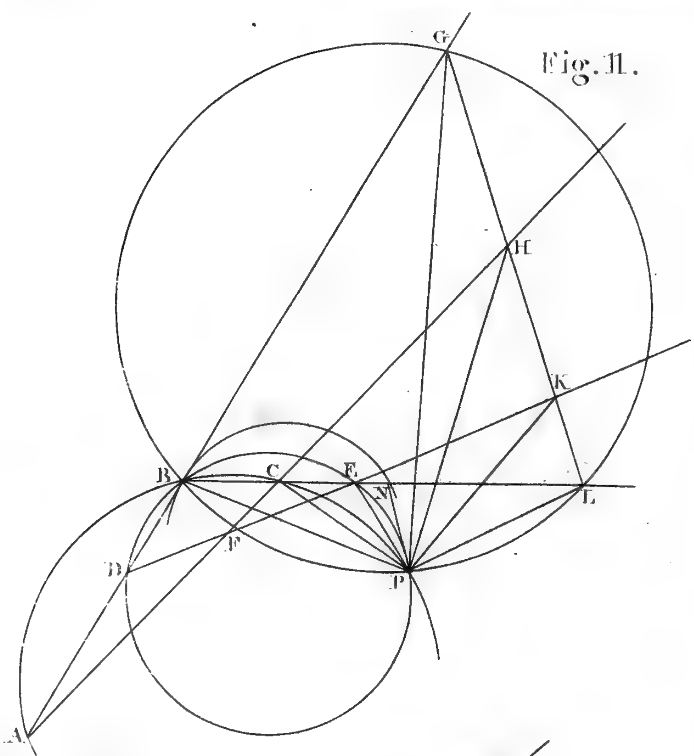


Fig. 9.

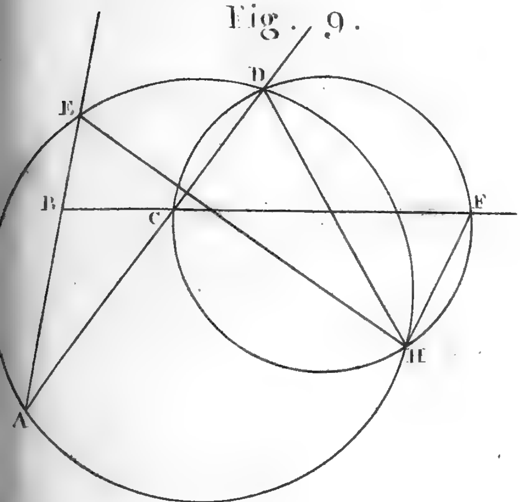


Fig. 10.

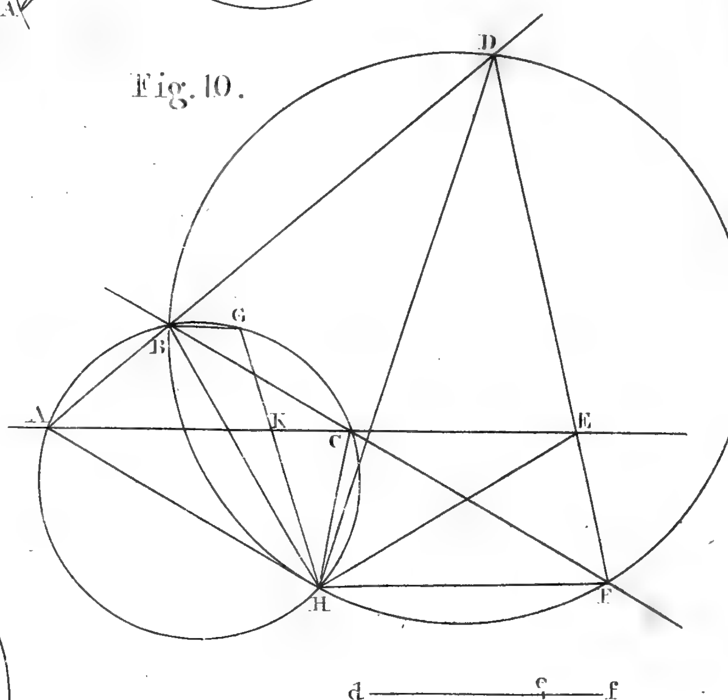


Fig. 13.

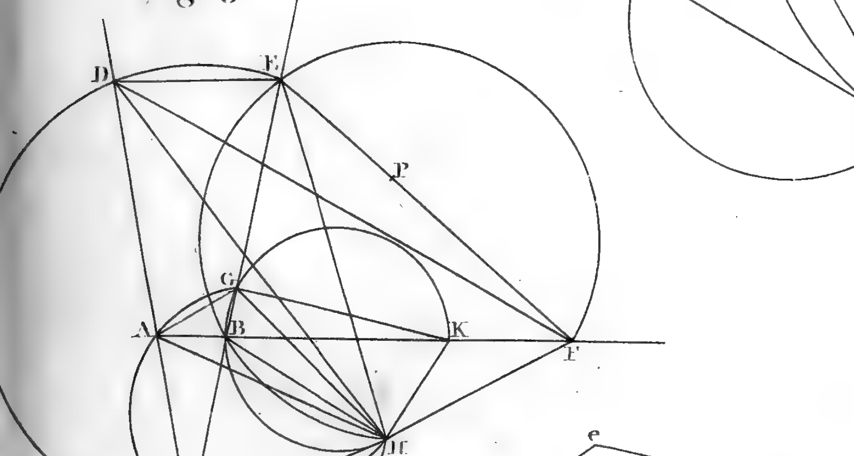


Fig. 12.

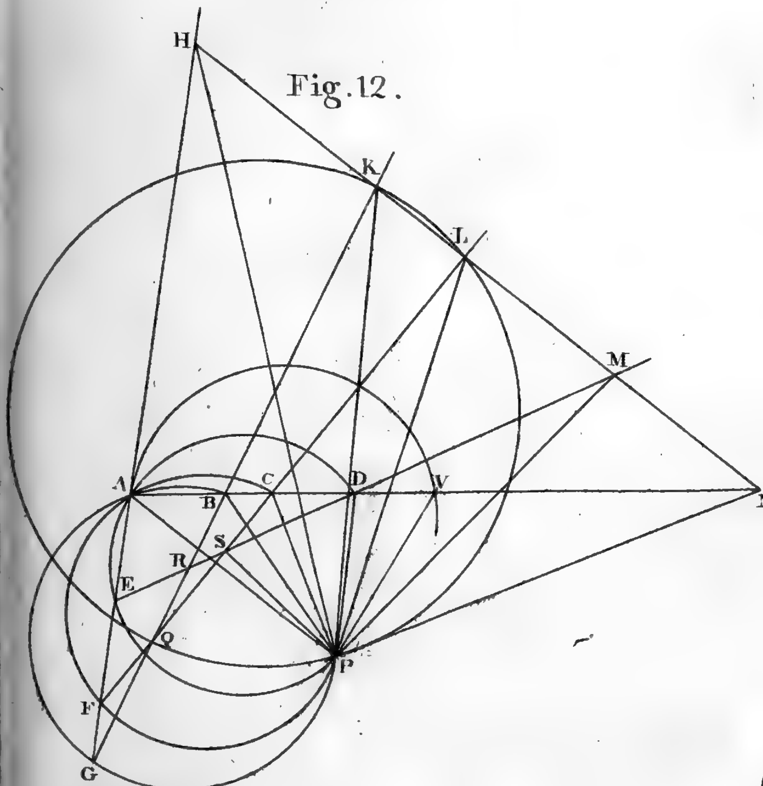


Fig. 15.

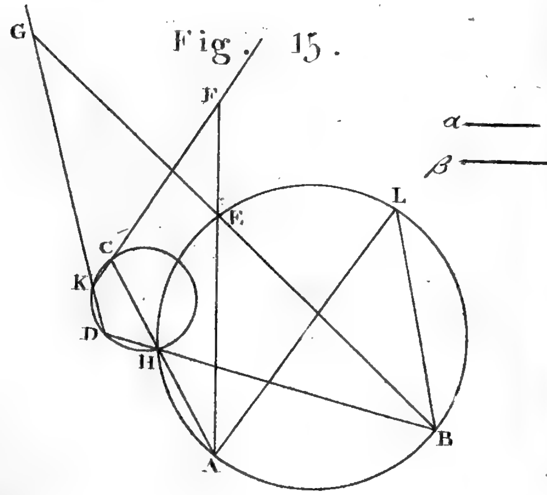


Fig. 17.

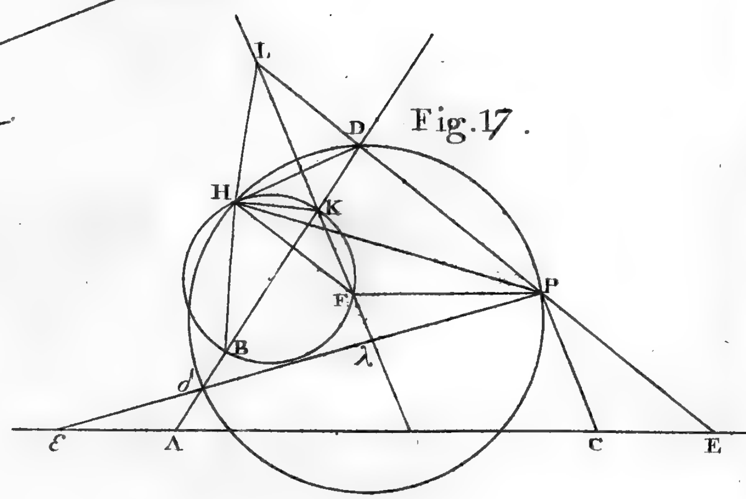


Fig. 14.

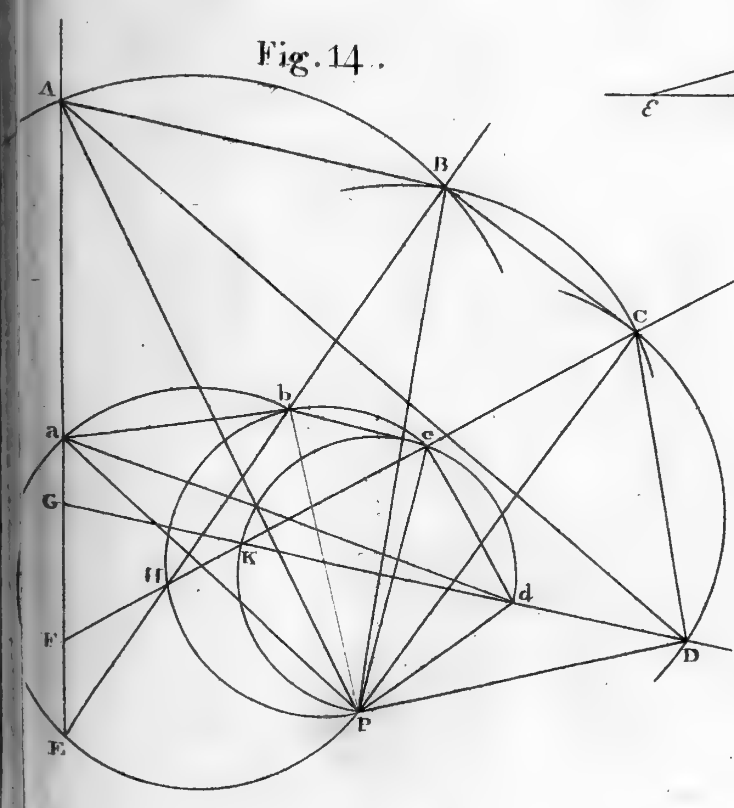
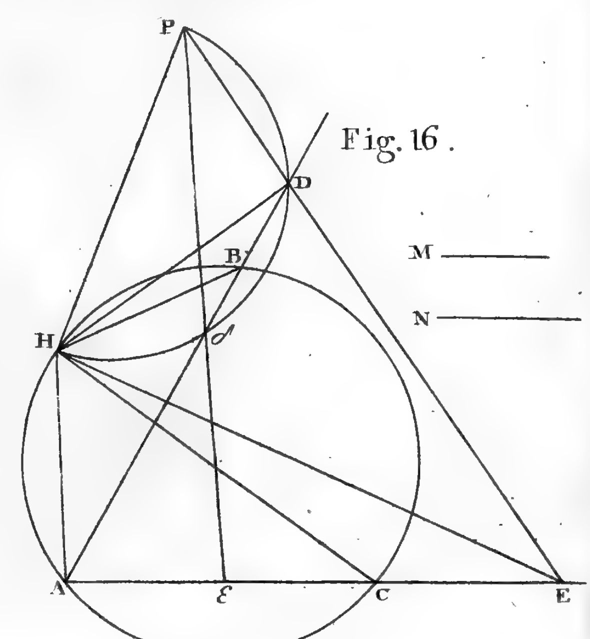


Fig. 16.



V. DETERMINATION *of the* LATITUDE *and* LONGITUDE *of the* OBSERVATORY *at* ABERDEEN : *In Two* LETTERS *from* *ANDREW MACKAY*, L L. D. & F. R. S. EDIN. to *JOHN PLAYFAIR*, F. R. S. EDIN. *and Professor of Mathematics in the University of Edinburgh*.

LETTER I.

[*Read 2d Dec.* 1793.]

DEAR SIR, *Aberdeen, 18th September* 1793.

SOME time ago I promised to send you the result of a series of observations, made to determine the situation of this place. Having, however, been much hurried of late, I am only able at present to transmit you the determination of the latitude, deduced from a series of observations of the sun's meridian zenith distances. With respect to the longitude, as soon as it is in my power, I will reduce some observations of occultations, and of the late solar eclipse, and send you the results.

THE following observations of the sun's meridian zenith distances were made with a moveable quadrant of two feet radius, constructed by Mr MACCULLOCH of London. This quadrant has two separate sets of divisions: the quadrantal arc of the inner set is divided into ninety degrees as usual; and the exterior arc is divided into ninety-six primary divisions; each of

which

which is ſubdivided into eight equal parts; and the vernier gives one thirty-ſecond part of a ſubdiviſion, or 13″,18. A micrometer ſcrew is attached to the vernier, which ſerves to regulate the motion of the index, and by which, the exceſs in ſeconds above the next leſs diviſion of the vernier is ſhown.

EACH zenith diſtance was read off, at leaſt, three times, both from the ninety and ninety-ſix arcs, and the means of each were taken. Theſe ſerved as a check on each other; however, the zenith diſtance, as given by the ninety-ſix arc only, is uſed for obvious reaſons. The ninety-ſix arc was found to be about 12″ leſs than 90°; and the error of the line of collimation at the vertical radius was about a ſecond and a half, ſubtractive.

As the tranſit inſtrument and quadrant were placed in adjacent rooms, it was therefore in my power to obſerve both the ſun's tranſit and zenith diſtance the ſame day; however, the paſſage of the ſun's weſt limb over the fifth wire, and that of the eaſt limb over the firſt wire, were by this means loſt. Hence, alſo, the zenith diſtance of one limb only of the ſun could be obſerved; and the true zenith diſtance will be affected by the error of the ſun's ſemidiameter, as given in the *Nautical Almanac*, and by the irradiation, which according to M. DU SEJOUR, exceeds three ſeconds.

THE middle wire in the teleſcope of the quadrant ſubtended an angle of no leſs than 20″,6; therefore, as it was ſcarce poſſible to bring the ſun's limb exactly to the middle of the wire, I conſtantly made the lower edge of the wire a tangent to the ſun's apparent lower limb. The zenith diſtances in the following table are the differences between thoſe obſerved and the ſemidiameter of the wire, the tenths of a ſecond being neglected.

THE fifth column of the table contains the error of the line of collimation, combined with that of the ninety-ſix arc, taking it for granted that this arc is accurately divided. In column ſixth is the ſun's ſemidiameter, from the *Nautical Almanac*, to the

 neareſt

neareſt ſecond. The next column contains the aggregate of the three preceding columns, and is the ſun's apparent central zenith diſtance. The eighth column contains the mean refraction, anſwering to the apparent zenith diſtance of the ſun's limb; hence the allowance for the contraction of the ſemidiameter at low altitudes is avoided. The next column contains the mean refraction reduced to the true, by the application of the corrections depending on the heights of the barometer and thermometer, as they are found in Table VIII. of my book on the Longitude: In column tenth is the ſun's parallax; and the quantities in the two laſt columns, applied to thoſe in column ſeventh, give theſe in column eleventh, being the true zenith diſtances of the ſun's centre. The following column contains the ſun's declination, reduced to the meridian of this place; and in the laſt column is the latitude.

Obferved Diftances of the Sun's Upper Limb from the Zenith of the Obfervatory.

1786.	H. of Bar.	Th.	Zen. dift.	Err. Qua. +	Sun's Semid. add.	Appar. Zen. diftance.	M.Ref.	Red. Ref.	Par. —	True Zenith diftance.	Declination.	Latitude.
☿ May 17.	29.78	48°	37° 26′ 46″	3″	15′ 51″	37° 42′ 40″	0′ 44″	0′ 44″	5″	37° 43′ 19″	19° 25′ 49″	57° 9′ 8″
♄ June 3.	30.15	62½	34 29 55	3	15 49	34 45 47	0 39	0 39	5	34 46 21	22 22 49	57 9 10
☉ — 4.	30.26	60	34 22 56	3	15 48	34 38 47	0 39	0 39	5	34 39 21	22 29 52	57 9 13
☽ — 5.	30.36	61	34 16 14	3	15 48	34 32 5	0 38	0 38	5	34 32 38	22 36 31	57 9 9
☿ — 7.	30.23	59	34 4 0	3	15 48	34 19 51	0 38	0 38	5	34 20 24	22 48 39	57 9 3
♃ — 8.	29.99	55½	33 58 45	3	15 48	34 14 36	0 38	0 38	5	34 15 9	22 54 7	57 9 16
♄ — 10.	29.83	54½	33 49 0	3	15 48	34 4 51	0 38	0 37	5	34 5 23	23 3 50	57 9 13
☉ — 11.	30.00	53	33 44 40	3	15 48	34 0 31	0 38	0 38	5	34 1 4	23 8 4	57 9 8
☽ — 12.	29.98	54½	33 40 47	3	15 48	33 56 38	0 38	0 38	5	33 57 11	23 11 55	57 9 6
♃ — 15.	30.05	58	33 31 36	3	15 47	33 47 26	0 38	0 38	5	33 47 59	23 21 1	57 9 0
☉ — 18.	30.06	55	33 26 20	3	15 47	33 42 10	0 37	0 37	5	33 42 42	23 26 24	57 6 6
☽ — 19.	30.05	56	33 25 30	3	15 47	33 41 20	0 37	0 37	5	33 41 52	23 27 22	57 9 14
♂ — 20.	30.08	60	33 24 45	3	15 47	33 40 35	0 37	0 37	5	33 41 7	23 27 56	57 9 3
☿ — 21.	30.05	63	33 24 37	3	15 47	33 40 27	0 37	0 37	5	33 40 59	23 28 5	57 9 4
♃ — 22.	29.89	65	33 24 53	3	15 47	33 40 43	0 37	0 36	5	33 41 14	23 27 49	57 9 3
♄ — 24.	29.70	65	33 26 42	3	15 47	33 42 32	0 37	0 36	5	33 43 3	23 26 2	57 9 5
☉ — 25.	29.86	66	33 28 10	3	15 47	33 44 0	0 37	0 36	5	33 44 31	23 24 32	57 9 3
♂ — 27.	29.65	58	33 32 28	3	15 47	33 48 18	0 38	0 37	5	33 48 50	23 20 16	57 9 6
☉ July 2.	30.00	57	33 50 13	3	15 47	34 6 3	0 38	0 38	5	34 6 36	23 2 28	57 9 4
☽ — 3.	29.71	63	33 54 56	3	15 47	34 10 46	0 38	0 37	5	34 11 18	22 57 42	57 9 0
☿ — 5.	30.29	61½	34 5 52	3	15 47	34 21 42	0 38	0 38	5	34 22 15	22 46 58	57 9 13
♄ — 15.	30.31	66	34 22 36	3	15 47	34 38 26	0 39	0 39	5	34 39 0	21 29 59	57 8 59
♂ — 18.	30.31	63	35 52 56	3	15 47	36 8 46	0 41	0 41	5	36 9 22	20 59 35	57 8 57
♀ — 21.	30.02	57	36 26 30	3	15 48	36 42 21	0 42	0 42	5	36 42 58	20 26 0	57 8 58
☉ — 23.	29.55	65	36 50 43	3	15 48	37 6 34	0 43	0 42	5	37 7 11	20 1 53	57 9 4
♃ Aug. 3.	30.00	58	39 26 25	4	15 49	39 42 18	0 47	0 47	5	39 43 0	17 26 12	57 9 12
♀ — 4.	29.86	60	39 42 13	4	15 50	39 58 7	0 48	0 47	5	39 58 49	17 10 16	57 9 5
♄ — 5.	29.49	59	39 58 26	4	15 50	40 14 20	0 48	0 47	5	40 15 2	16 54 4	57 9 6
♄ — 26.	29.94	64	46 34 11	5	15 53	46 50 9	1 0	0 59	6	46 51 2	10 18 0	57 9 2
☿ — 30.	29.36	58	47 59 20	5	15 54	48 15 19	1 3	1 2	6	48 16 15	8 52 49	57 9 4
♃ — 31.	29.22	58	48 20 49	5	15 55	48 36 49	1 4	1 2	6	48 37 45	8 31 9	57 8 54
♄ Sept. 2.	29.44	60½	49 4 44	5	15 55	49 20 44	1 5	1 3	6	49 21 41	7 47 27	57 9 8
♂ — 5.	29.93	54	50 11 15	5	15 51	50 27 16	1 9	1 10	7	50 28 19	6 40 58	57 9 16
☿ — 20.	30.24	56	55 55 8	6	16 0	56 11 14	1 24	1 25	7	56 12 32	0 56 30	57 9 2
♃ — 21.	29.87	57	56 18 42	6	16 0	56 34 48	1 25	1 25	7	56 36 6	0 33 6	57 9 12
☿ — 27.	29.68	48	58 39 7	6	16 1	58 55 14	1 33	1 33	8	58 56 39	1 47 33	57 9 6
☿ Oct. 18.	30.34	47	66 37 58	7	16 7	66 54 12	2 13	2 17	8	66 56 21	9 47 18	57 9 3
♃ — 26.	30.42	44	69 26 57	8	16 10	69 43 15	2 31	2 37	8	69 45 44	12 36 48	57 8 56
♄ Dec. 2.	29.53	40	78 51 12	9	16 17	79 7 38	4 43	4 50	9	78 12 19	22 3 25	57 8 54
☉ — 10	29.34	44	79 46 27	9	16 18	80 2 54	5 9	5 11	9	80 7 56	22 59 8	57 8 48
♀ — 15.	29.36	37	80 6 29	9	16 19	80 22 57	5 19	5 27	9	80 28 15	23 19 17	57 8 58
☉ — 17.	29.54	34	80 11 7	9	16 19	80 27 35	5 21	5 34	9	80 33 0	23 24 5	57 8 55
♃ — 21.	30.02	28	80 14 50	9	16 19	80 31 18	5 23	5 45	9	80 36 54	23 28 3	57 8 51
☉ — 24.	30.24	35	80 12 55	9	16 19	80 29 23	5 22	5 41	9	80 34 55	23 26 4	57 8 51
☽ — 25.	30.08	28	80 11 19	9	16 19	80 27 47	5 21	5 43	9	80 33 21	23 24 27	57 8 54
1787.												
☽ Apr. 30.	29.56	44	42 2 15	4	15 55	42 18 14	0 51	0 52	6	42 19 0	14 50 3	57 9 3
♀ May 4.	29.81	52	40 50 53	4	15 54	41 6 51	0 49	0 49	6	41 7 34	16 1 25	57 8 59
☽ — 14.	30.06	46½	38 11 40	4	15 52	38 27 36	0 44	0 45	5	38 28 16	18 40 40	57 8 56
♂ — 22.	29.87	59½	36 26 33	3	15 50	36 42 26	0 42	0 41	5	36 43 2	20 25 49	57 8 51
♂ June 12.	30.12	60	33 41 35	3	15 48	33 57 26	0 38	0 38	5	33 57 59	23 10 59	57 8 58
♀ — 15.	29.61	56	33 32 11	3	15 47	33 48 1	0 38	0 37	5	33 48 33	23 20 23	57 8 56
♄ — 16.	29.66	60	33 29 53	3	15 47	33 45 43	0 38	0 37	5	33 46 15	23 22 42	57 8 57
♄ Sept. 1.	30.52	64	48 37 8	5	15 55	48 53 8	1 4	1 4	6	48 54 6	8 14 40	57 8 46
☿ — 19.	29.25	56	55 26 8	6	15 59	55 42 13	1 22	1 20	7	55 43 26	1 25 23	57 8 49
♄ — 22.	29.49	56	56 36 9	6	16 0	56 52 15	1 26	1 25	7	56 53 33	0 15 16	57 8 49
☉ — 23.	29.49	57	56 59 32	6	16 1	57 15 39	1 28	1 27	7	57 16 59	0 8 10	57 8 49
☽ — 24	29.71	57	57 23 0	6	16 1	57 39 7	1 29	1 28	7	57 40 28	0 31 35	57 8 53
♀ — 28.	29.98	54	58 56 38	6	16 2	59 12 46	1 35	1 36	8	59 14 14	2 5 16	57 8 58
♃ Oct. 18.	29.48	50	66 32 51	7	16 7	66 49 5	2 11	2 10	8	66 51 7	9 42 7	57 9 0
♂ — 23.	29.41	48	68 19 49	7	16 9	68 36 5	2 23	2 23	8	66 38 20	11 29 27	57 8 53
☉ Dec. 16.	29.59	35	80 8 21	9	16 19	80 24 49	5 20	5 33	9	80 30 13	23 21 16	57 8 57
♀ — 21.	29.93	35	80 14 48	9	16 19	80 31 16	5 23	5 39	9	80 36 46	23 27 58	57 8 48
♄ — 22.	29.85	32	80 14 55	9	16 19	80 31 23	5 23	5 40	9	80 36 54	23 27 54	57 9 0
1788.												
☽ Sept. 8.	30.04	62	51 30 10	5	15 56	51 46 11	1 11	1 10	7	51 47 14	5 21 41	57 8 55

Latitude, 57 9 0.9
or 57 9 1

Having the following obſervations of fixed ſtars reduced, I have alſo ſent them.

Obſerved Diſtances of Fixed Stars from the Zenith of the Obſervatory.

1786.	Bar.	Th.	Name of Stars.	Zen. diſt.	Error Quad.	Mean Ref.	True Ref.	T. Zen. diſt.	M. Declina.	Ab.	Nut.	App! Decl.	Latitude.
♃ June 22.	29.82	55	Arcturus	36° 50′ 14″	+ 3″	0′ 43″	0′ 43″	36° 51′ 0″	20° 18′ 2″	+ 6″	— 7″	20° 18′ 1″	57° 9′ 1″
♀ Sept: 1.	29.49	55	α Lyra.	18 32 37	1	0 19	0 19	18 32 57	38 35 45	16	+ 8	8 36 9	57 9 6
☿ Oct. 25.	30.37	44	Altair.	48 48 31	5	1 5	1 8	48 49 44	8 19 20	— 9	0	8 19 11	57 8 55
♃ — 26.	30.42	44	———	48 48 29	5	1 5	1 8	48 49 42	8 19 20	9	0	8 19 11	57 8 53
♄ Dec. 2.	29.50	37	Pole Star.	31 1 0	2	0 34	0 35	31 1 37	88 10 8	+ 17	7	88 10 32	57 8 55
☉ — 24.	29.93	24	γ Caſs. arc Exceſs.	87 35 12	— 1	0 2	0 2	87 35 13	59 33 53	17	3	59 34 13	57 9 0
— — —	—	—	δ Caſſiopeia.	88 1 23	1	0 2	0 2	88 1 24	59 7 12	16	5	59 7 33	57 8 57
☿ — 27.	28.95	36	α Caſſiopeia.	1 46 47	1	0 2	0 2	1 46 48	55 51 59	16	3	55 52 19	57 9 7
												Latitude,	57 8 59¼

The declinations of the above ſtars were taken from M. de la Lande's catalogue of the declinations of 350 ſtars, adapted to the beginning of the year 1790.

I shall conclude by obſerving, that the differences in the above latitudes are to be attributed to the error of obſervation, to the inaccuracy of the diviſion of the quadrant, and to the uncertainty of the refraction, eſpecially at low altitudes. If the refraction at 45° be aſſumed a little greater than that by Dr Bradley, the reſults will agree much better. It muſt alſo be obſerved, that the ſmoke of the town will increaſe the refraction.

I am,

Dear Sir,

Your obedient ſervant,

Andrew Mackay.

LETTER II*.

DEAR SIR, *Aberdeen, 20th September* 1796.

HAVING finiſhed the compariſon of a conſiderable number of obſervations, made in this place, in order to determine its longitude, with correſponding obſervations made at Greenwich, I now ſend you the ſeveral reſults. The obſervations uſed for this purpoſe are, eclipſes of the ſatellites of Jupiter, particularly thoſe of the firſt and ſecond ſatellites, ſolar and lunar eclipſes, occultations, *&c.* Theſe obſervations were made with one of DOLLOND's three and a half foot achromatic teleſcopes, and powers of about ſeventy, and one hundred and fifteen, were applied to the teleſcope, according to circumſtances. The obſervations at Greenwich were made with one of DOLLOND's forty-ſix inch achromatic teleſcopes.

As the reſults, deduced from a compariſon of the correſponding obſervations of the firſt and ſecond ſatellites of Jupiter, are much

* COMMUNICATED 7th November 1796.

much more to be depended on than thoſe inferred from the obſervations of the third and fourth ſatellites, I have therefore rejected the obſervations of the two laſt. This I was inclined to do, partly from the diſagreement of the reſults of the correſponding obſervations of theſe two ſatellites, and partly upon account of the ſmallneſs of the number of correſponding obſervations. Indeed, as theſe two ſatellites take a conſiderable time to immerge into, and emerge out of the ſhadow of Jupiter, and as the ſtate of the atmoſphere, at the times of obſervation at Greenwich and Aberdeen, may be very different, and as powers will be applied to the teleſcopes according to the ſtate of the atmoſphere, it is not wonderful, that there ſhould be a conſiderable difference between the reſults of the actual obſervations; and hence the propriety of rejecting the obſervations of the third and fourth ſatellite will be obvious; eſpecially in the caſe when the correſponding obſervations are very few, and the number of immerſions unequal to that of the emerſions. The longitude of this place, as deduced from the compariſon of the actual obſervations of the firſt and ſecond ſatellites of Jupiter, made here and at Greenwich, ſeems to be leſs than the truth, or, at leaſt, leſs than what I had been accuſtomed to ſtate it; but the near agreement of the final reſults of each of theſe ſatellites is really ſurpriſing.

Of all the other obſervations which I have compared, I have ſent you only two, as being the moſt to be relied on, namely, a ſolar eclipſe, and an occultation, beſides a lunar eclipſe, which I had publiſhed formerly in my *Treatiſe on the Longitude*, and which is not far from being a mean between the reſults of the other obſervations. I had, indeed, only one other occultation, of which the obſervations at Greenwich and Aberdeen were complete, namely, that of β ♑ of 15th October 1790; my other obſervations of that kind, being either incomplete, or having no correſponding obſervations at Greenwich.

I

I HAVE made the calculations for the longitude from the ſolar eclipſe and occultation, firſt, on the ſuppoſition that the figure of the earth is a perfect ſphere; and, ſecondly, upon Sir ISAAC NEWTON's ſpheroidal hypotheſis, in which the equatorial diameter is to the axis of the earth as 230 : 229; between which limits, it is probable, is the real figure of the earth. In the rules which I gave, in my *Treatiſe on the Longitude*, for making the calculations by means of the nonageſimal, I followed the method of calculating the parallaxes in latitude and longitude, which had been given by M. DE LA LANDE, in the firſt and ſecond editions of his *Aſtronomie:* But, in the preſent calculations, I have uſed the method which was given for the firſt time by M. MAYER, in the ſecond volume of the *Memoirs of Gottingen*, publiſhed in the year 1753; and, again, in his *Solar and Lunar Tables*, printed at London, by order of the Board of Longitude, in the year 1770. This ſame method has alſo been employed by Meſſrs LEXELL, DE LA GRANGE, and DE LAMBRE: And it has been adopted by M. DE LA LANDE, in the ſecond volume of the third edition of his *Aſtronomie*, printed at Paris in the year 1792*. It may alſo be proper to mention, that I have followed M. DU SEJOUR, and M. DE LA LANDE, in uſing an irradiation of $3\frac{1}{2}''$ for the ſun's ſemidiameter, and an inflexion of the ſame quantity for the moon's. See SEJOUR's *Traité Analytique*, &c. vol. I. p. 253 and 264; and DE LA LANDE's *Aſtronomie*, third edition, vol. II. p. 445.

As ſome perhaps will be inclined to repeat the calculations for the longitude, from the obſervations of the ſolar eclipſe and occultation, it will therefore be neceſſary to inform

* IN making theſe calculations, I was led to diſcover an error in the method I had given in my Treatiſe on the Longitude, for finding the longitude of a place by an occultation. That error, and ſeveral others, will be corrected in a new edition of that work.

inform them what tables I uſed for that purpoſe. The logarithmic tables were TAYLOR'S, CALLET'S, and SHERWIN'S. From TAYLOR'S *Tables* were taken the logarithm ſines and tangents of arches, and converſely. The logarithm ſines, and converſely of the parallaxes, were taken from CALLET'S *Tables*: and the logarithms of numbers from SHERWIN'S. By this means much time was ſaved in theſe extenſive calculations. The natural verſed ſines were taken from my *Treatiſe on the Longitude*; and the augmentation of the moon's ſemidiameter was taken from M. DE LAMBRE'S *Tables*, for finding it by means of the altitude and longitude of the nonageſimal, which, therefore, ſaved the trouble of calculating the altitude of the moon. The ſun's parallax was taken from the *Connoiſſance des Temps*; and, as I had not the *Nautical Almanac* for the year 1788, the elements for the ſolar eclipſe were taken from the *Connoiſſance des Temps* for that year; but the elements for the occultation were taken from the *Nautical Almanac* for 1787.

DETER-

Determination of the Longitude of the Obfervatory at Aberdeen, by the Eclipfes of the Firft and Second Satellites of Jupiter.

FIRST SATELLITE.

Year, Month, and Day.	Apparent Time of Obfervation at Greenwich. Immer.	Greenwich. Emer.	Aberdeen. Immer.	Aberdeen. Emer.	Longitude in Time, by Immer.	Longitude in Time, by Emer.
	h. ′ ″	h. ′ ″	h. ′ ″	h. ′ ″	′ ″	′ ″
♂ Jan. 3. 1786.		8 15 54		8 7 39		8 15
☽ Sept. 18. ——	16 7 37		15 58 57		8 40	
☿ —— 20. ——	10 36 38		10 27 40		8 58	
♄ Dec. 30. ——		9 45 20		9 37 43		7 37
☿ Jan. 31. 1787.		6 15 32		6 7 8		8 24
♀ Feb. 23. ——		6 31 57		6 23 46		8 11
☉ Dec. 14. 1788.	8 34 55		8 27 12		7 43	
♂ Mar. 1. 1791.	9 14 8		9 5 23		8 45	
♄ Apr. 9. ——		10 4 48		9 56 49		7 59
					126	26
Longitude,					8 31.5	8 5.2
						8 31.5
Mean, -						8 18.3

SECOND SATELLITE.

Year, Month, and Day.	Greenwich Immer.	Greenwich Emer.	Aberdeen Immer.	Aberdeen Emer.	Longitude Immer.	Longitude Emer.
	h. ′ ″	h. ′ ″	h. ′ ″	h. ′ ″	′ ″	′ ″
♂ Nov. 7. 1786.	9 10 27		9 1 23		9 4	
♃ Mar. 8. 1787.		7 48 3		7 40 14		7 49
♀ Dec. 21. ——		5 14 30		5 6 27		8 3
☽ Nov. 9. 1789.	14 23 42		14 15 24		8 18	
					17 22	15 52
Longitude,					8 41	7 56
						8 41
						16 37
Mean,						8 18.5
Mean by 1ft Sat.						8 18.3
Mean Longitude,						8 18.4

Deter-

DETERMINATION of the Longitude of the Obfervatory at Aberdeen, from the Apparent Times of Obfervation of the Beginning and End of the Solar Eclipfe of 3d June 1788: Obferved at Greenwich and Aberdeen.

	h. ′ ″		h. ′ ″
Apparent time of begin. at Greenwich,	19 24 46½	at Aberdeen,	19 33 19
of end. -	21 1 24		20 57 37
Interval, - -	1 36 37½		1 24 18

COMPUTATION of the Apparent Time of Conjunction at Greenwich, on the Spherical Hypothefis.

	s. ° ′ ″		s. ° ′ ″
Moon's true longitude at beginning,	2 13 19 37	at ending,	2 14 18 59
Computed parallax in longitude, -	+ 30 11		+ 22 32
Moon's apparent longitude nearly, -	2 13 49 48		2 14 41 31
Moon's equat. hor. parallax, -	60 33.0		60 34.9
Sun's horizontal parallax, - -	8.7		8.7
Difference of parallax of fun and moon,	60 24.3		60 26.2

	h. ′ ″				
App. time beg.	19 24 46½				
Sun's R. A.	4 51 30½				
R. A. meridian,	0 16 17				
	6				
Arch, -	6 16 17	v. fine,	0.0297853	co-fecant,	0.0010971
Latitude, -	51 28 40	co-fine,	9.7943612	fecant,	0.2056388
Ob. ecliptic,	23 28 3	fine,	9.6001327		
Sum, -	74 56 43	co. v. s. 034322			
		265631	9.4242792		
Alt. nonag.	45 34 9	v. fine, 299953		fine,	9.8537566

	° ′ ″				
Long. nonag.	29 32 39			ſecant,	0.0604925
Moon's app. long.	73 49 48				
Diff. -	44 17 9	ſine,	9.8440037		
Alt. nonag.	45 34 9	ſine,	9.8537566	co-ſine,	9.8451277
Diff. hor. par.	60 24.3	ſine,	8.2447766	ſine,	8.2447766
Par. in long.	30 7.0	ſine,	7.9425369	P. in lat. 42′ 17.″1,	8.0899043

	h. ′ ″				
App. time end.	21 1 24				
Sun's R. A.	4 51 47				
R. A. mer.	1 53 11				
	6				
Arch, -	7 53 11	v. ſine,	0.1685046	co-ſecant,	0.0552648
Latitude and obl.	74 56 43	co. v. s. 034322	9.3944939		0.2056388
		365593	9.5629985		
Alt. nonag.	53 7 26	v. ſine, 399915		ſine,	9.9030547
Long. nonag.	46 43 15			ſecant,	0.1639583
Moon's app. long.	74 41 31				
Diſt. ☽ à Non.	27 58 16	ſine,	9.6711972		
Alt. nonag.	46 43 15	ſine,	9.9030547	co-ſine,	9.7782140
Diff. hor. par.	60 26.2	ſine,	8.2450042	ſine,	8.2450042
Par. in long.	22 34.2	ſine,	7.8172561	P. in lat. 36′ 16.″0,	8.0232182

	′ ″		′ ″
Moon's true mot. in long. in ob. int. -	59 22.0	True mot. in lat.	5 30.3
Sun's true mot. in long. - -	3 51.0	Par. in lat. at end.	36 16.0
Moon's true rel. mot. in long. -	55 31.0	Sum,	41 46.3
Par. in long. at beginning, - -	30 7.0	Par. in lat. at begin.	42 17.1
at ending, - -	+ 22 34.2	App. mot. in lat.	30.8
App. rel. mot. in longitude, -	47 58.2		

Apparent

	″			
Apparent mot. in lat.	30.8	1.4885507		
Apparent mot. in long.	47 58.2	3.4591210		3.4591210
Apparent inclination 36′ 47″,	tang.	8.0294297	co-ſine,	9.9999751
Moon's apparent mot. in relative orbit, 2878.″3			-	3.4591459

	′ ″		′ ″		′ ″
Moon's ſemidiameter at begin.	16 30	at end.	16 30	Sun's ſemid.	15 48.5
Augmentation, -	+ 9.0		+ 12.5	Irradiation,	3.5
Inflexion, -	— 3.5		— 3.5	Cor. ſemid.	15 45.0
Corrected ſemidiameter,	16 35.5		16 39.0		
Sun's ſemidiameter; -	15 45.0		15 45.0		
Sum, - -	32 20.5		32 24.0		

	″				
Sum of ſemid. at end.	1944.0	-	-	ar. co. log.	6.7113037
at begin.	1940.5	ar. co. log.	6.7120864		3.2879136
App. mot. in rel. orbit,	2878.3	ar. co. log.	6.5408639		
Sum, -	6762.8				
Half, -	3381.4	log.	3.5290965		
Remainder, -	1437.4	log.	3.1575776		
			19.9396244		
	21 6 59	co-ſine,	9.9698122		
Central angle at begin.	42 13 58	-	-	ſine,	9.8274625
		° ′ ″			
Central angle at end.		42 8 21		ſine,	9.8266798

	° ′ ″			° ′ ″		
Central angle at begin.	42 13 58		at end.	42 8 21		
App. inclination,	36 47		App. in.	36 47		
Arch, -	42 50 45	co-s. 9.8652142	Arch,	41 31 34	co-s.	9.8742810
Sum of ſemidiameters,	32 20.5	3.2879136	ſum ſem.	32 24		3.2886963
	23 42.8	3.1531278		24 15.4		3.1629773

Par

	° ′ ″				
Par. in long. at begin.	30 7.0		at end.	22 34.2	
Sum, -	53 49.8	3.5091756	Diff.	1 41.2	2.0051805
Rel. mot. in long. -	55 31	ar. co. 6.4774254			6.4774254
Obſerved interval,	1 36 37½	3.7632408			3.7632408
	h. ′ ″			′ ″	
Int. bet. beg. and conj.	1 33 41.4	3.7498418	bet. end & con.	2 56.1	2.2458467
App. time of beg.	19 24 46.5		Apparent time of ending,	21 1 24.	
App. time of conj.	20 58 27.9			20 58 27.9	

Computation of the Apparent Time of Conjunction at Aberdeen.

	h. ′ ″		h. ′ ″
App. time of begin. -	19 33 19	App. time of end.	20 49 29
Eſtimated longitude, -	+ 8 36		+ 8 36
Reduced time, -	19 41 55		20 58 5
Moon's true long. -	2 13 30 8	at end.	2 14 16 57
Par. in long. nearly, -	+ 24 49		+ 19 45
Moon's app. long. nearly,	2 13 54 57		2 14 36 42
Moon's hor. parallax,	60 33.3		60 34.8
Sun's	8.7		8.7
Diff. hor. par. -	60 24.6		60 26.1
App. time of begin. -	19 33 19	App. time of end.	20 49 29
Sun's right aſcenſion, -	4 51 34		4 51 47
Right aſcen. meridian,	0 24 53		1 41 16

Now, with the right aſcenſion of the meridian at the beginning, increaſed by ſix hours, or 6h 24′ 53″, the latitude of the place of obſervation 57° 9′ 0″, and the obliquity of the ecliptic 23° 28′ 3″, the altitude of the nonageſimal is 41° 39′ 6″, and its longitude 35° 46′ 6″; hence the moon's apparent diſtance from the nonageſimal is 38° 8′ 51″, with which the altitude of the

the nonagesimal, and difference of the horizontal parallaxes of the sun and moon, the parallax in longitude is 24′ 47″.9, and in latitude 45′ 8″.2.

AGAIN, with 7h 41′ 16″, the sum of the right ascension of the meridian and six hours, the latitude and obliquity of the ecliptic, the altitude of the nonagesimal, is 47° 17′ 40″, and longitude 48° 8′ 35″; the apparent distance of the moon from the nonagesimal is, therefore, 26° 28′ 7″; from whence, the altitude of the nonagesimal, and the difference of the horizontal parallaxes of the sun and moon, the parallax in longitude is 19′ 47″.6, and parallax in latitude 40′ 59″.3.

THE true motion of the moon in longitude is 46′ 48″.2, and that of the sun 3′ 2″.1; hence the moon's relative motion in longitude is 43′ 46″.1; from which, subtracting the difference of the parallaxes in longitude 5′ 0″.3, the remainder 38′ 45″.8 is the apparent relative motion of the moon in longitude.

THE true motion of the moon in latitude, in the observed interval, is 4′ 20″.4; from which, subtracting 4′ 8″.9, the difference of the parallaxes in latitude, the remainder is the moon's apparent motion in latitude.

Now, with the apparent motions of the moon in longitude and latitude, the apparent inclination is found to be 17′ 0″, and the apparent motion of the moon in its relative orbit is 2325″.8.

WITH the altitude and longitude of the moon at the beginning and end of the eclipse, the augmentation of the moon's semidiameter at the beginning is 9″.0, and at the end 11″.4; hence the moon's semidiameter, corrected by the augmentation and inflexion, is 16′ 35″.5 at the beginning of the eclipse, and 16′ 37″.9 at the end; and the sum of the semidiameters of the sun and moon, at those times, are 32′ 20″.5, and 32′ 22″.9 respectively; with which, and the moon's apparent motion in relative orbit, the central angle at the beginning of the eclipse is

53°

53° 15′ 20″, and at the end 53° 9′ 39″; hence arch first is 53° 32′ 20″, and arch second 52° 52′ 39″.

With these arches, and the sum of the semidiameters of the sun and moon at the beginning and end of the eclipse, arches third and fourth will be found equal to 19′ 13″.2 and 19′ 32″.6 respectively. Now, the sum of arch third, and the parallax in longitude at the beginning is 44′ 1″.1, and the difference between arch fourth, and the parallax in longitude at the end, is 15″.0. Now, with this sum and difference, the moon's true relative motion in longitude, and the observed interval, the difference between the beginning of the eclipse and the conjunction is 1 h 16′ 36″.1, and between the end and the conjunction 26″.1. Hence the apparent time of conjunction, inferred from the beginning, is 20h 49′ 55″.1, and from the end it is also 20h 49′ 55″.1, But the apparent time of conjunction at Greenwich is 20h 58′ 27″.9; hence the longitude of Aberdeen in time is 8′ 32″.8 west.

Computation of the Apparent Time of Conjunction, on the Spheroidal Hypothesis, at Greenwich.

	h. ′ ″		h. ′ ″
Appt. time of beginning,	19 24 46½	Appt. time of ending,	21 1 24
Sun's right ascension,	4 51 30½		4 51 47
Right ascen. meridian,	0 16 17		1 53 11
Moon's true long.	2 13 19 37		2 14 18 59
Est. par. in long.	+ 30 10		22 51
Estimated app. long.	2 13 49 47		2 14 41 50
Moon's hor. par.	60 33.0		60 34.9
Reduction,	— 9.6		9.6
Reduced hor. par.	60 23.4		60 25.3

Sun's

	° ′ ″		° ′ ″
Sun's hor. par.	8.7		8.7
Difference,	60 14.7		60 16.6
Altitude nonag.	45 46 19		53 20 35
Long. nonag.	29 21 19		46 35 16
Par. in long.	30 14.6		22 46.9
Par. in lat.	42 1.2		35 19.1
Moon's true rel. mot. in lon.	55 31.0	Moon's true mot. in lat.	5 30.3
Diff. par. in longitude,	7 27.7	Diff. par. in latitude,	6 2.1
☽'s app. rel. mot. in long.	48 3.3	App. mot. in lat.	31.8
App. inclination,	37 55	App. mot. in rel. orbit,	48 3.5
Moon's ſemidiameter,	16 30.0		16 30.0
Augmentation,	+ 9.0		+ 12.5
Inflexion,	— 3.5		— 3.5
Corrected ſemidiameter,	16 35.5		16 39.0
Sun's ſemid. — Irrad.	15 45.0		15 45.0
Sum,	32 20.5		32 24.0
Central angle,	42 7 6		42 1 30
App. inclination,	37 55		37 55
Arch firſt,	42 45 1	Arch ſecond,	41 23 35
Arch third,	23 44.9	Arch fourth,	24 18.4
Par. in long. at beginning,	30 14.6	At end.	22 46.9
Sum,	53 59.5	Difference,	1 31.5
	h. ′ ″		h. ′ ″
Hence interval between the beg. and conj.	1 33 58.3	Interval between the end and conjunction,	0 2 39.2
App. time of begin.	19 24 46.5	App. time of ending,	21 1 24.0
App. time of conj.	20 58 44.8		20 58 44.8

At Aberdeen.

	h. ′ ″		h. ′ ″
App. time of beginning,	19 33 19	App. time of end,	20 49 29
Sun's right aſcenſion,	4 51 34		4 51 47
Right aſcen. of meridian,	0 24 53		1 41 16

Moon's

	s. ° ′ ″		s. ° ′ ″
Moon's true longitude,	2 13 30 8		2 14 16 57
Eſtimate par. in longitude,	+ 24 55		+ 19 54
Eſtimated apparent long.	2 13 55 3		2 14 36 51
Moon's hor. parallax,	60 33.3		60 34 8
Reduction, -	— 11.1		— 11.1
Reduced parallax, -	60 22.2		60 23.7
Sun's hor. par. -	— 8.7		8.7
Difference, -	60 13.5		60 15.0
Altitude nonag. -	41 50 6		47 29 32
Longitude nonag. -	35 33 53		47 59 26
Par. in longitude, -	24 55.4		19 54.2
Par. in latitude, -	44 52.2		40 42.6
Moon's true rel. mot. in long.	43 46.1	Moon's true mot. in lat.	4 20.4
Diff. par. in longitude, -	5 1.2	Diff. par. in latitude,	4 9.6
App. mot. in longitude, -	38 44.9	App. mot. in latitude,	10.8
App. inclination, -	15 58	App. mot. in rel. orbit,	38 44.9
Moon's ſemidiameter,	16 30.0		16 30.0
Augmentation, -	+ 9.2		+ 11.6
Inflexion, - -	— 3.5		— 3.5
Corrected ſemidiameter,	16 35.7		16 38.1
Sun's ſemid. — Irrad.	15 45.0		15 45.0
Sum, - -	32 20.7		32 23.1
Central angle, -	53 16 36		53 10 55
App. inclination, -	15 58		15 58
Arch firſt, -	53 32 34	Arch ſecond,	52 54 57
Arch third, -	19 13.2	Arch fourth,	19 31.7
Par. in longitude, -	24 55.4		19 54.2
Sum, - -	44 8.6	Difference,	22.5

Hence

	h. ′ ″		h. ′ ″
Hence the interval between the beg. and conj. is -	1 16 49.2	Interval between the end and conjunction is	39.2
App. time of beginning,	19 33 19.	App. time of ending,	20 49 29.
App. time of conj. -	20 50 8.2		20 50 8.2
App. time of conj. at Green.	20 58 44.8		
Longitude in time, -	8 36.6		

DETERMINATION of the Longitude of the late Obſervatory at Aberdeen, from the Apparent Times of Obſervation of the Immerſion and Emerſion of η II: Obſerved at Greenwich and Aberdeen, ☽ November 26. 1787.

	h. ′ ″		h. ′ ″
App. time of immer. at Gr.	11 22 51.7	At Aberdeen,	11 18 8
Emer.	12 31 45.		12 23 12
Obſerved interval, -	1 8 53.3		1 5 4

COMPUTATION of the Apparent Time of Conjunction in the Spherical Hypotheſis, at Greenwich.

	h. ′ ″		h. ′ ″
App. time of immer.	11 22 51.7	App. time of emer.	12 31 45
Sun's right aſcenſion,	16 10 56.7		16 11 8
Right aſcen. of meridian,	3 33 48.4		4 42 53
	s. ° ′ ″		s. ° ′ ″
Moon's true longitude,	2 29 50 23		3 0 33 32
Eſtimate par. in long.	+ 23 9		+ 13 3
Eſt. apparent longitude,	3 0 13 32		3 0 33 32
Moon's true latitude,	0 20 3.5		0 24 1.8
Eſtimate par. in latitude,	+ 32 9.5		+ 30 5.2
Eſt. apparent latitude,	0 52 14. S.		0 54 7. S.

	° ′ ″		° ′ ″
Horizontal parallax, -	61 11.3		61 10.6
Alt. nonag. -	58 49 53		61 4 57
Long nonag. -	64 18 46		76 24 45
Par. in longitude, -	22 52.7		13 17.0
Par. in latitude, -	32 22.7		30 23.6
Moon's true rel. mot. in long.	43 8.4	Moon's true mot. in latitude,	3 58.3
Diff. par. in longitude,	9 35.7	Diff. par. in latitude,	1 59.1
Moon's appt. mot. in long.	33 32.7	Appt. mot in latitude,	1 59.2
Appt. inclination, -	3 23 22	Appt. mot. in orbit,	33 36.2
Moon's femidiameter,	16 40.1		16 39.9
Augmentation, -	+ 13.7		+ 15.2
Inflexion, - -	— 3.5		— 3.5
Corrected femidiameter,	16 50.3		16 51.6
Central angle at immer.	4 18 24	At emerfion,	4 18 4
Apparent inclination,	3 23 22		3 23 22
Arch firft, -	7 41 46	Arch fecond,	0 54 42
Arch third, -	16 41.2	Arch fourth,	16 51.5
Parallax in longitude,	22 52.7		13 17.0
Sum, - -	39 33.9	Difference,	3 34.5
Hence interval between immer. and conj.	1 3 10.8	Interval between the emerfion and conjunction,	5 42.5
Appt. time of immer.	11 22 51.7	Appt. time of emer.	12 31 45.
Appt. time of conjunct.	12 26 2.5		12 26 2.5

At Aberdeen.

	h. ′ ″		h. ′ ″
Appt. time of immer.	11 18 8	Appt. time of emerfion,	12 23 12
Sun's right afcenfion,	16 10 57.4		16 11 9
Right afcen. of meridian,	3 29 5.4		4 34 21
	s. ° ′ ″		s. ° ′ ″
Moon's true longitude,	2 29 52 48.8		3 0 33 33.6

Eft.

	° ′ ″		° ′ ″
Eſt. par. in longitude,	+ 20 45.2		+ 12 38.4
Eſt. appt. longitude,	3 0 13 34		3 0 46 12,
	′ ″		′ ″
Moon's true latitude,	20 16.9		24 2.0
Eſt. par. in latitude,	- 37 6.1		35 18.0
Approx. appt. latitude,	57 23.0 S.		59 20.0 S.
Horizontal parallax,	61 11.3		61 10.6
Alt. nonag. -	53 8 59.		55 17 2
Longitude nonag.	65 29 36		76 3 32
Par. in longitude,	20 29.1		12 46.2
Par. in latitude,	37 24.9		35 40.4
Moon's true mot. in long.	40 44.8	Moon's true mot. in latitude,	3 45.1
Diff. of par. in longitude,	7 42.9	Diff. of par. in latitude,	1 44.5
Moon's appt. mot. in long.	33 1.9	Appt. mot. in latitude,	2 0.6
Appt. inclination,	3 28 56	Appt. mot. in orbit,	33 5.5
Moon's ſemidiameter,	16 40.1		16 39.9
Augmentation, -	+ 12.9		14.1
Inflexion, -	— 3.5		3.5
Moon's corrected ſemid.	16 49.5		16 50.5
Central angle, -	10 35 40		10 35 2
Appt. inclination,	3 28 56		3 28 56
Arch firſt, -	7 6 44	Arch ſecond,	14 3 58
Arch third, -	16 41.7	Arch fourth,	16 20.[illegible]
Par. in longitude, -	20 29.1		12 46.[illegible]
Sum, -	37 10.8	Difference,	3 34.0
Hence the interval between im. and conj.	h. ′ ″ 0 59 22.3	Interval between the emer. and conjunction,	h. ′ ″ 0 5 41.7
Appt. time of immer.	11 18 8	Appt. time of emerſion,	12 23 12
Appt. time of conj.	12 17 30.3		12 17 30.3
At Greenwich,	12 26 2.5		
Longitude in time,	8 32.2		

Computation of the Apparent Times of Conjunction in the Spheroidal Hypothesis, at Greenwich.

	s. ° ′ ″		s. ° ′ ″
Moon's true long. at im.	2 29 50 23	At emersion,	3 0 33 32
Est. parallax in longitude,	+ 22 57		13 19
Appt. longitude nearly,	3 0 13 20		3 0 46 51
Moon's true latitude,	20 35		24 1.8
Est. parallax in latitude,	32 5 5		30 5.2
Appt. latitude nearly,	52 9.		54 7.
Horizontal parallax,	61 11.3		61 10.6
Reduction, -	9.8		9.8
Reduced parallax,	61 1.5		61 0.8
Latitude of Greenwich,	51 28 40		
Reduction, -	14 37		
Reduced latitude, -	51 14 3		
Alt. nonagesimal, -	59 3 56		61 19 24
Longitude nonagesimal,	64 14 2		76 22 15
Par. in longitude, -	22 56.2		13 19.3
Par. in latitude, -	32 4.8		30 5.5
Moon's true mot. in long.	43 8.4	Moon's true mot. in latitude,	3 58.3
Diff. of par. in long.	9 36.9	Diff. par. in latitude,	1 59.3
Appt. mot. in longitude,	33 31.5	Appt. mot. in latitude,	1 59.0
Appt. inclination, -	3 23 8	Appt. mot. in orbit,	33 35.0
Central angle at immer.	4 44 16	At emersion,	4 43 54
Arch first, -	8 7 24	Arch second,	1 20 46
Arch third, -	16 40.2	Arch fourth,	16 51.3
Parallax in longitude,	22 56.2		13 19.3
Sum, -	39 36.4	Difference,	3 32.0
Hence the interval between the immer. and conj.	h. ′ ″ 1 3 14.8	Interval between the emer. and conjunction,	5 38.5
Appt. time of immer.	11 22 51.7	Appt. time of emer.	12 31 45.
Appt. time of conj.	12 26 6.5		12 26 6.5

At

At Aberdeen.

	s. ° ′ ″		s. ° ′ ″
Moon's true long. at immer.	2 29 52 49	At emer.	3 0 33 34
Eſt. par. in long. -	+ 20 45		12 34
Appt. longitude nearly,	3 0 13 34		3 0 46 8
Moon's true latitude,	20 17		24 2
Eſtimated par. in latitude,	37 6		35 18
Appt. latitude nearly, -	57 23		59 20
Moon's horizontal parallax,	61 11.3		61 10.6
Reduction, -	— 11.3		— 11.3
Reduced parallax, -	61 0.0		60 59.3
Latitude Aberdeen, -	57 9 0		
Reduction, -	13 41		
			° ′ ″
Reduced latitude, -	56 55 19		
Altitude nonag. -	53 21 52		55 30 30
Longitude nonag. -	65 24 42		76 0 36
Par. in longitude, -	20 32.8		12 48.3
Par. in latitude, -	37 7.2		35 22.1
☽'s true mot. in long. -	40 44.8	True mot. in latitude,	3 45.1
Diff. of par. in longitude,	7 44.5	Diff. parallax in latitude,	1 45.1
Appt. mot. in longitude,	33 0.3	Appt. mot. in latitude,	2 0.0
Appt. inclination, -	3 28 4	Mot. in appt. orbit,	33 3.9
Central angle at immer.	10 51 14	At emer.	10 50 35
Arch firſt -	7 23 10	Arch ſecond,	14 18 39
Arch third, -	16 41.1	Arch fourth,	16 19.2
Par. in longitude, -	20 32.8		12 48.3
Sum, - -	37 13.9	Difference,	3 30.9
Interval between the immer.	h. ′ ″	Interval between the emer.	h. ′ ″
and conj. -	0 59 27.2	and conj.	0 5 36.8
Appt. time of immer.	11 18 8	Appt. time of emer.	12 23 12
Appt. time of conj.	12 17 35.2		12 17 35.2
Appt. time of conj. at Gr.	12 26 6.5		

Longitude

	′ ″		′ ″
Longitude in time, -	8 31.3	Long. on fpherical hyp. by occult.	8 32.2
Long. by folar eclipfe, -	8 36.6	by eclipfe,	8 32.8
Mean, - -	8 33.9	Mean,	8 32.5

If we fuppofe, with Meffrs du Sejour and la Lande, that the difference between the equatorial and polar diameters is $\frac{1}{300}$ of the equatorial diameter, in that cafe the longitude will be 8′ 33″.6.

Deter-

DETERMINATION of the Longitude of the Obſervatory at Aberdeen, by Obſervations of the Lunar Eclipſe of 10th September 1783, made at Aberdeen and at Chiſlehurſt in Kent, 19″ in Time Eaſt of the Royal Obſervatory at Greenwich.

	Names of Spots.	Apparent Time of Obſervation at Aberdeen.	Apparent Time of Obſervation at Chiſlehurſt.	Diff. of Mer.
		h. ′ ″	h. ′ ″	′ ″
INGRESS.	Ariſtarchus,	9 42 42.5	9 50 55	8 12.5
	Kepler,	9 44 9.6	9 52 20	8 10.4
	Copernicus,	9 54 8.7	10 2 24	8 15.3
	Manilius covered,	10 7 35.8	10 15 30	7 54.2
	Tycho covered,	10 8 57.8	10 17 5	8 19.2
	Menelaus covered,	10 10 51.9	10 19 10	8 18.1
	Dionyſius covered,	10 13 46.9	10 21 38	7 51.1
	Plinius covered,	10 14 55.9	10 22 40	7 44.1
	Mare Criſium E. end,	10 25 51.0	10 34 34	8 43.0
	——— W. end,	10 30 53.0	10 39 45	8 52.0
	Total darkneſs,	10 36 39.0	10 46 34	9 55.0
			Sum, -	254.9
			Mean, -	8 23.17
		h. ′ ″	h. ′ ″	′ ″
EGRESS.	Ariſtarchus,	12 24 4.3	12 33 52	9 47.7
	Kepler,	12 27 5.3	12 37 26	10 20.7
	Copernicus,	12 35 34.4	12 45 52	10 18.6
	Plato E. end,	12 38 32.4	12 47 22	8 49.6
	Tycho E. end,	12 40 4.4	12 48 30	8 25.6
	———W. end,	12 41 5.4	12 49 58	8 53.6
	Menelaus,	12 53 0.6	13 1 40	8 39.4
	Dionyſius,	12 54 45.6	13 3 18	8 32.4
	Plinius,	12 56 48.6	13 5 40	8 51.4
	Mare Criſium E. end,	13 7 10.7	13 16 35	9 24.3
	W. end,	13 12 20.8	13 20 53	8 32.2
	Sum, -		-	95.5
	Mean *per* egreſs,		-	9 8.68
	Mean *per* ingreſs,	-	-	8 23.17
				17 31.85
	Diff. mer. Aber. and Chiſlehurſt in time nearly,			8 45.92
	Longitude of Chiſlehurſt in time E.			19.
	Longitude of Aberdeen nearly,		-	8 26.92
	Change of equation of time in 8′ 26″.9			.12
	Longitude of Aberdeen,		-	8 26.8 W.

DETER-

DETERMINATION of the Longitude of the Obſervatory at Aberdeen by a Chronometer, conſtructed by Mr ARNOLD of London*.

THE chronometer was ſet to mean ſolar time at Greenwich, 16th June 1788, and loſt 7″.5 in eleven days. It was ſent to Aberdeen by ſea; and being compared with the Obſervatory clock, 15th July, it was found to be 7′ 26″.6 faſt, and was loſing 6″.4 daily: It is hence probable that the motion of the ſhip had altered its rate. Now, ſuppoſing this alteration to have commenced when the ſhip left London, which was on the 8th of July, its error at that time, for the meridian of Greenwich, would therefore be 15″.0; from this time, till 15th July, it loſt 44″.8, (=6″.4×7,) its rate being ſuppoſed uniform. Hence its error, for the meridian of Greenwich, 15th July at noon, was —59″.8. But its error, for the meridian of the Obſervatory at Aberdeen, at the ſame time, was +7′ 26″.6. Hence the longitude of Aberdeen, in time, is 8′ 26″.4 weſt.

THIS laſt method of aſcertaining the longitude of Aberdeen, although it agrees very well with the former, yet it is not to be ſo much depended on, as there are ſome ſuppoſitions introduced which may be objected to.

FROM a compariſon of the preceding reſults, it may be preſumed, that the longitude of this place, in time, is probably not leſs than 8′ 18″, as deduced from the obſervations of the eclipſes of the firſt and ſecond ſatellites of Jupiter, nor greater than 8′ 36″, as inferred from the ſolar eclipſe of 3d June 1788. The difference between theſe limits is only 18″ in time; which in this latitude does not amount to two miles and an half. Upon account of the near agreement of the reſults of the ſolar eclipſe and occultation, as well as from other obſervations, I am led to believe

* SEE Theory and Practice of finding the Longitude, &c. vol. I. p. 208.

believe that 8′ 32″ or 2° 8′ is not far from the exact longitude of this place. Hence the latitude of the Girdleneſs is 57° 8′, and longitude 2° 6′ W. and the latitude of Greigſneſs 57° 7′ 20″, and longitude 2° 6′ W. alſo.

The latitude and longitude of Aberdeen, as determined above, differ conſiderably from the ſame as given in moſt books of geography and navigation, where indeed they are uſually ſtated with great inaccuracy. Mr Downie, to whom, at his requeſt, I communicated the reſult of my obſervations, has, in his *New Pilot*, placed Aberdeen nearly as above, and of courſe has laid down the adjacent coaſt, with much more preciſion than had been formerly done. This was in 1793; I then ſuppoſed the longitude 2° 9′ W. which is 1′ greater than the above determination.

VI. *An* ACCOUNT *of certain* MOTIONS *which Small Lighted* WICKS *acquire, when ſwimming in a* BASON *of* OIL; *together with* OBSERVATIONS *upon the* PHENOMENA *tending to explain the* PRINCIPLES *upon which ſuch* MOTIONS *depend: Communicated in a Letter from* PATRICK WILSON, F. R. S. EDIN. *and Profeſſor of Practical Aſtronomy in the Univerſity of Glaſgow, to* JOHN PLAYFAIR, F. R. S. EDIN. *and Profeſſor of Mathematics in the Univerſity of Edinburgh.*

[*Read May* 5. 1795.]

DEAR SIR, *Glaſgow College, April* 28. 1795.

I Now ſit down to give you ſome account of the little hydroſtatical lamp, which I ſo briefly mentioned to you in a former letter. As I am far from being ſure whether what I have to offer upon this ſubject may be entitled to the notice of the Edinburgh Royal Society, ſo I will refer this point to your determination, after you have had leiſure to conſider the contents.

THE phenomena, treated of in the ſequel, were quite new to me a few months ago, and, ſo far as I know, have not hitherto been attended to, or deſcribed by any body elſe. What I have called the *Hydroſtatical Lamp*, conſiſts of a ſmall circular patch of common writing paper, about three eighths of an inch in diameter, having about a quarter of an inch of ſoft cotton thread

 ſtanding

ſtanding up through a puncture in the middle to ſerve as a wick; and the phenomena, in queſtion, are certain motions which ſuch minikin lamps acquire, when lighted and made to ſwim in very pure ſalad oil.

A SHALLOW glaſs baſon, with ſides riſing nearly perpendicular, or a common glaſs ſalver, will conveniently contain the oil for theſe experiments. As ſoon as the lamp is lighted, it will immediately ſail briſkly forward, in ſome direction, till it meets the ſide of the veſſel, and afterwards will take a circular courſe, always bearing up to the ſides, and ſo will perform many revolutions.

SOMETIMES the circulation is from right to left, and ſometimes in the contrary direction, according as that point of the paper baſe, which in the direct ſailing kept always foremoſt, turns away from the ſide of the glaſs a little to the right or to the left hand of that which comes to be the point of contact. This turning away, of what may be called the LEADING POINT of the baſe, is diſtinctly obſervable by a partial rotation of the lamp round the wick as an axis, as ſoon as it arrives at the ſide of the veſſel. Sometimes, though rarely, the leading point itſelf attaches to the ſide, and forms the *vinculum*, in conſequence of the well known corpuſcular attraction between the elevation of oil around the baſe, and that belonging to the ſides of the glaſs; and when the vinculum ſo correſponds to the leading point, the lamp will be found to ſtand ſtill, without any tendency to circulate.

WHEN the little wick has any ſenſible excentricity upon the circular paper baſe, the lamp will ſail ſo as to make that part of the baſe which lies neareſt to the wick the *ſtern;* and if the baſe of the lamp be clipped of an oval form, and the wick placed in the longer axis excentrical, that end of the baſe, neareſt the wick, will alſo keep hindmoſt, when the lamp ſails acroſs the ſalver. In the ſame manner, if the baſe be an equilateral triangle, having its wick in the perpendicular which bisects any of the sides, either the vertex or side will become the *stern*, and keep hindmost, according as the wick is placed nearest the one or the other. Lamps, so constructed, are found also to circulate upon their arrival at the side of the vessel, when the leading point turns away from the glass, as it commonly happens.

Whatever be the cause of the sailing of the lamp directly foreward, the perpetual circulation, after it arrives at the side, seems to proceed from the force, which formerly impelled it, still acting in the same manner, but in a direction inclined to that of the corpuscular attraction, which forms the vinculum; and it is evident, that this inclination will be greater or less, according as the leading point is more or less averted from the glass. When it so happens that the leading point and vinculum coincide, it should seem that both forces, just now mentioned, must urge the lamp in a direction perpendicular to the side of the glass; in which case it must stand still, agreeable to observation.

The next thing which I had occasion to take notice of, when the lamp sailed in a direct course, was, a seemingly very active repulsion between its stern and the oil at the surface contiguous to it. This became manifest, when very fine charcoal dust was lightly scattered around the lamp. As it then proceeded in its course, it marked out a spreading or diverging *wake* behind it, entirely clear of all dust, in consequence of the particles being chaced backwards, and laterally with a motion much more than merely relative.

Desirous of learning how this dispersion of the dust would take place when the lamp was stationary, I constructed one of a fine wafer, and with an excentric wick, consisting of a soft cotton thread doubled; and to prevent the wafer or base from catching fire, I coated its upper surface with gold leaf. When this

this was made to reſt immoveably upon the oil, the duſt retired in all directions, ſo as to leave the ſpace, adjacent to the wafer quite free from every particle. But here it was obſervable, that this diſperſion of the duſt, by the ſeeming repulſion of the baſe of the lamp, was much more rapid at that ſide which lay neareſt to the wick than at any other part, and leaſt of all ſenſible at the ſide diametrically oppoſite.

The circumſtances laſt mentioned, ſeem ſufficiently to account both for the progreſſive motion of the lamp, and for the general law of this motion, formerly deſcribed. For, regarding this diſperſion of the duſt, as yet, only in a general way, and as the effect of ſome repulſion between the baſe and the oil contiguous to it, the facts above mentioned plainly indicate, that, in all caſes, this repulſion is ſtrongeſt at that part of the baſe neareſt the wick or flame: and as action and reaction are equal and contrary, the lamp muſt therefore be impelled, in the direction of a line drawn through the wick, towards that part of the baſe moſt remote from it, and where the reaction is the leaſt.

But in order to obtain a ſtill more competent knowledge of the phyſical cauſe of theſe motions, it ſeemed now neceſſary to inquire more particularly into this apparent repulſion between the baſe of the lamp and the ſurrounding oil, as indicated by the diſperſion of the duſt, in the manner above deſcribed: and here the following conſiderations preſented themſelves.

The oil in the baſon, when of an uniform temperature, has all its parts in a ſtate of equilibrium and of reſt. When the lamp is lighted, it is evident we have a very active cauſe introduced, tending to deſtroy that equilibrium. This cauſe is the *flame*, which broods over a ſmall portion of the oil, and is ſeparated from it only by the intervention of a piece of paper or a waffer. The oil, in ſuch circumſtances, in conſequence of being violently heated, muſt ſuddenly increaſe in volume, and muſt now, on account of the decreaſe of its ſpecific gravity, be preſſed

pressed upwards by a force sufficient to raise part of it above the general level. But this heated portion of oil, in its endeavour thus to rise up, will meet with a resistance equal to the weight of the incumbent lamp, which will determine it, in seeking a vent, to slide out from under the base in *a thin superficial stream*; and it seems to follow, with equal certainty, that this constant stream will flow most readily and most copiously towards that side of the base of the lamp where the resistance is least, or where it has the shortest way to press forward; that is, from under the wick or flame, to the edge of the base which is the nearest, according to what we have seen to be agreeable to the phenomena. But, from the laws of motion, it is certain, that the reaction of this stream of rarified oil, thus issuing most rapidly and most copiously from a particular side of the base, must impel the lamp in the contrary direction, and make it sail in the manner we have seen. It may further be remarked, that the heated oil, so retreating from the flame, and endeavouring to rise somewhat above the general level, in consequence of its diminished specific gravity, may more or less lift up that side of the base nearest the wick, and aid the reaction of the recoiling stream, by making the lamp sail in the opposite direction, as it were *down-hill*.

THAT the rarified oil under the base has really a constant tendency to rise above the general level, seems undeniable, from the following facts, namely, that after any of the lamps has burned a little while, and has got its base soaked with the oil, as soon as the flame is blown out the lamp sinks to the bottom; and even a lamp, with its base made of a thin lamina of talck, sails very well till the flame is extinguished, and then it immediately sinks.

AGREEABLE to the explanation which has now been attempted, I found, that when a *topical heat* was applied to the surface of the oil, by bringing the point of a poker, dully red hot, nearly ly into contact, there was soon produced a superficial stream or efflux from the iron in all directions, which cleared the face of the oil from the charcoal dust, in a wider and a wider circle, till at last the whole particles were crowded together at the confines of the bason.

When the oil in this experiment was shallow, having gold leaf beat into very minute parts mixed with it, an opposite stream was observed below, setting in towards the poker in all directions, and then rising upwards. But this general tendency of all the parts of the fluid of moving in quest of an equilibrium, is illustrated in a very entertaining manner as follows: Into a tea-cup or punch-glass, nearly filled with pure water, pour a desert spoonful of very clean salad oil, with minute particles of gold leaf in it. If the water be cold, the oil, when poured on at the centre, leisurely and continuedly, will rest upon the surface in the form of a lens, and remain insulated or equidistant from the sides of the vessel. A little lamp, when put upon this lens of oil, and lighted, will sail and circulate as larger ones do in the bason. If it be now made to stand still, it is very amusing to observe the minute particles of the gold perpetually thrown out briskly at the stern in the superficial current, whilst the particles in the fund of the lens creep in all directions towards the lamp, and at last rise up under the base towards the flame, as the great centre of attraction, till they are caught by the retreating superficial stream, in which they rapidly trend off to some distance, when again they sink to renew the circulation.

When a patch of paper, or a wafer, or such light body, swims upon the oil in the bason, the point of a hot iron held near to it makes it flit its place, and move away by a seeming repulsion; but, in reality, by the heat generating a superficial stream, flowing from the iron in all directions.

Again,

Again, if upon oil of turpentine, æther, alcohol, or any of the inflammable fluids poſſeſſing much tenuity, you throw a wafer much heated, it will immediately glide away, and continue in motion till it cools; when the ſtream, which iſſued from ſome part of it moſt copiouſly, ceaſes. Double rum, melted tallow, bees wax, and roſin, alſo afford the ſame continued efflux at the ſurface, upon a topical application of heat, and the ſame phenomena as the oil does, when little lamps are made to ſwim in them. It is ſomewhat remarkable, however, that though the inflammable fluids all agree in this, yet the topical application of heat, at the ſurface of water, does not produce ſimilar effects.

For if the point of a poker nearly red hot be held very cloſe to the ſurface of water in a baſon, the particles of the charcoal duſt do not at all glide away as they do in the caſe of oil, but ſeem to acquire only a ſlow irregular circular motion, which in time ſpreads wider, whilſt the floating motes or particles of duſt keep nearly their relative places; and the ſame thing happens, though the point of the iron touches the water, ſo as to make it ſimmer.

I do not well know how to account for this, unleſs it may be a conſequence of the known much leſs expanſibility of water by heat, compared to that of the inflammable fluids, and which may be ſo inconſiderable as not to deſtroy the equilibrium, ſo far as to produce an efflux from the lighter and expanded fluid immediately under the heated body. Poſſibly, too, the parts of the water, as ſoon as heated, may tranſmit the ſurplus temperature to the contiguous colder water much more rapidly than the inflammable fluids do in like circumſtances, and thereby reſiſt the high temperature, neceſſary to that degree of expanſion, which would diſturb the equilibrium, and produce an efflux; not to mention that the maximum of this temperature can never, at any rate, exceed 212°, the boiling point of water.

THAT the equilibrium, however, amongſt the parts of water, is diſturbed by the local application of heat, though in a much ſmaller degree that what obtains among the inflammable fluids, appears from an experiment I was led to make with a ſmall thin cup ſwimming on water, and ſo contrived as to carry and feed with oil a wick, placed a little way down from the lip in the inſide, ſo as to be on a level with the water. The conſequence of this conſtruction was, that the cup moved upon the water very ſlowly, but always with the flame evidently ſternmoſt. The ſame cup, when taken from the water, and put into a baſon of ſtrong rum, ſailed a great deal faſter, and according to the ſame uſual law.

I AM much afraid, that by this time I have wearied you by ſuch a detail of minute facts and circumſtances, and by thoſe frequent repetitions which every new ſubject more or leſs requires. And I ever remain,

Dear Sir,

Your moſt obedient faithful ſervant,

PAT. WILSON.

P. S. SHOULD you be inclined to repeat any of the experiments, the following directions and miſcellaneous obſervations may be attended to: The thread I made uſe of for the wicks was of that ſoft kind commonly employed in the flowering of muſlin. After making the puncture in the baſe, you put through a bit of the thread, which clip ſhort off below, and with a pin force in the burr gently round the thread, to give the baſe a proper hold of it. Then clip away the ſuperfluous thread above, leaving the wick about a quarter of an inch long; and ſo the lamp is completed. Set it then upon the oil, by taking hold of the wick, that the paper baſe may not be bent or diſtorted by handling

handling it; and, after the wick is touched with a drop of oil, it is ready for being lighted. For this purpose, a bit of pack thread, which has been steeped in oil, is a cleanly and convenient match, and sheds no impurities on the oil, as a candle or wax taper would do.

WHEN you want the lamps to circulate, the oil must be very pure, and brought into full contact with the sides of the glass. The oil, and the bason or salver, should all be allowed to come to the same temperature, between 55° and 60° of Fahrenheit. For if any part of the brim be much hotter than the rest, the lamp, on arriving there, will leave the side, by the current issuing from the heated part forcing it away.

SOMETIMES the lamp, when sailing, veers a little into a different direction, by the base altering or warping by the scorching heat of the flame, which determines the stream to flow out most copiously at a different part of the base.

IN the melted grease which lies round the wick of a common candle when lighted, there are sometimes observed atoms, which have been left by the snuffers, moving to and from the flame continually. These motions have been conceived by some as occasioned by attractions and repulsions, in consequence of an electrical quality imputed to the flame. It should seem, however, that they depend merely upon opposite currents at the surface, and immediately below the surface of the melted grease, according to the principle above explained.

VII. *An* ACCOUNT *of a* SINGULAR HALO *of the* MOON. *Communicated in a Letter from WILLIAM HALL, Esq; of White-Hall*, F. R. S. EDIN. *to Sir JAMES HALL, Bart.* F. R. S. EDIN.

[*Read May* 2. 1796.]

DEAR SIR JAMES, *Whitehall, near Berwick, April* 2. 1796.

I SEND under cover the reprefentation of a very fingular Halo of the Moon, (See Pl. V.), feen here on the night of the 18th of February laft, about 10 o'clock, and this I have hitherto delayed, in order, if poffible, to gain farther information in the neighbourhood concerning it.

DURING the fhort continuance of the fmall halo, which did not exceed 10 minutes after I got notice of it, I could not lay my hands on any other inftrument to take the angles, but a SISSON'S theodolite, which, unluckily, having been conftructed fo as not to admit of a vertical angle fo great as the moon's altitude then was, I laid it afide, not recollecting that it might have meafured feveral of the fmaller angles. But I obferved fundry marks, from which I took the angles as exactly as I could next day.

THE moon was about S. W. and her altitude nearly 54°, which of confequence was alfo the altitude of the limb of the greater halo, where it was higheft, and where it paffed through the

the moon; the altitude of its oppoſite limb was 14°; ſo that its diameter ſubtended an angle of no leſs than a hundred and twelve degrees.

THE diameter of the ſmall halo, which appeared to be a perfect circle, with the moon in its centre, I found, after repeated trials, was under 12°, and more than 8°; but as the different diameters of the large halo were not meaſured, it cannot poſitively be affirmed that it was an exact circle; on the contrary, its limb did not ſeem to interſect the ſmall circle quite ſo much at right angles, as the circular arch delineated in the plan. It may therefore have been ſomewhat eliptical.

THE ſmall circle was remarkably bright, particularly at *Weſt Reſton*, about five miles to the northward, the only other place where the halo was obſerved, and where it was thought to ſend forth flame. The ſmall halo alſo continued there much longer than here, where ſome thin fleecy clouds ſoon put an end to it, but the large halo continued with us near an hour.

THE weather about this time was, for the ſeaſon, remarkably mild, particularly on the day of the halo. The ſky was pretty clear all that day, and alſo in the evening; but at the time of the halo there was a ſmall degree of hazineſs, particularly towards the north, which did not however prevent the moon from ſhining with brightneſs; and the ſtars were even viſible within the circle of the ſmall halo: there was little or no wind.

THE circles or belts of both halos are repreſented in the plan, nearly of their apparent breadth, or perhaps a little broader; the light of both was whitiſh, and conſiderably bright, without colour; that of the large circle was the paler of the two, particularly where it paſſed through the ſmall circle: to the northward it was ſomewhat obſcure.

BY means of the angles taken as above, after having aſcertained, on a vertical circle of the heavens, the ſituations of the moon,

moon, of the ſmall halo, and of the north-eaſtern limb of the large halo, whoſe ſouth-weſtern limb paſſed through the moon, the whole was projected on the horizontal plane, as in the figure already referred to. The moon, a little more than half, is placed in the centre of the ſmaller halo; and both halos are repreſented in their true ſituations, relatively to the horizon, and in the circular ſhape which they appeared to have, though they ought perhaps to have been ſomewhat foreſhortened, and thrown into an elliptic form.

THIS halo, as you will ſee by the above deſcription, appears to be of the kind called by the learned a *Corona*; and as it ſomewhat reſembles the famous one of the ſun, obſerved at Rome in the year 1629, and deſcribed by SCHEINER*, it deſerves the more attention, eſpecially as the great halo, on the preſent occaſion, having its ſouth-weſtern limb elevated to the height of 54°, and its north-eaſtern depreſſed to within 14° of the horizon, was in an oblique poſition, not eaſily reconciled with the theory of HUYGENS, which ſeems to require that ſuch circles ſhould be equally elevated above the horizon all round. It alſo ſhews, that SCHEINER's original plan of the halo at Rome, which repreſented it as oblique, may have been right, and that HUYGENS's correction, which makes it parallel to the horizon, was probably an erroneous conjecture.

I am,

Dear Sir JAMES,

Your humble ſervant,

WILL. HALL.

* SMITH's Optics, vol. I. § 534.

VIII.

[illegible] and halo, and of the [illegible] of the [illegible] whole double [illegible] passed through the moon, [illegible] was projected on the [illegible] the figure [illegible] referred to. The moon, a little [illegible], is placed in the centre of the smaller halo; and both [illegible] are [illegible] in their true situations relatively to the horizon, and in [illegible] circular shape which they appeared to have, though they [illegible] have been somewhat shortened, and thrown [illegible].

This halo, as you will see by the above description, appears [illegible] kind called by the learned a Corona; and as it [illegible] that the [illegible] of the [illegible] observed at [illegible] and described by Scheiner*, it deserves [illegible] especially as the great halo, on the present [illegible] to the height [illegible] and its north-eastern depressed to within 14° of the horizon [illegible] in an oblique position, not easily reconciled with the [illegible], which seems to require that such circles [illegible] equally elevated above the horizon all round. It also [illegible] that Scheiner's original plan of the halo at Rome, [illegible] represented it as oblique, may have been right, and that H[illegible]'s correction, which makes it parallel to the horizon, [illegible] probably an erroneous conjecture.

I am,

Dear Sir James,

Your humble servant,

W[illegible].

* Scheiner [illegible]

VIII.

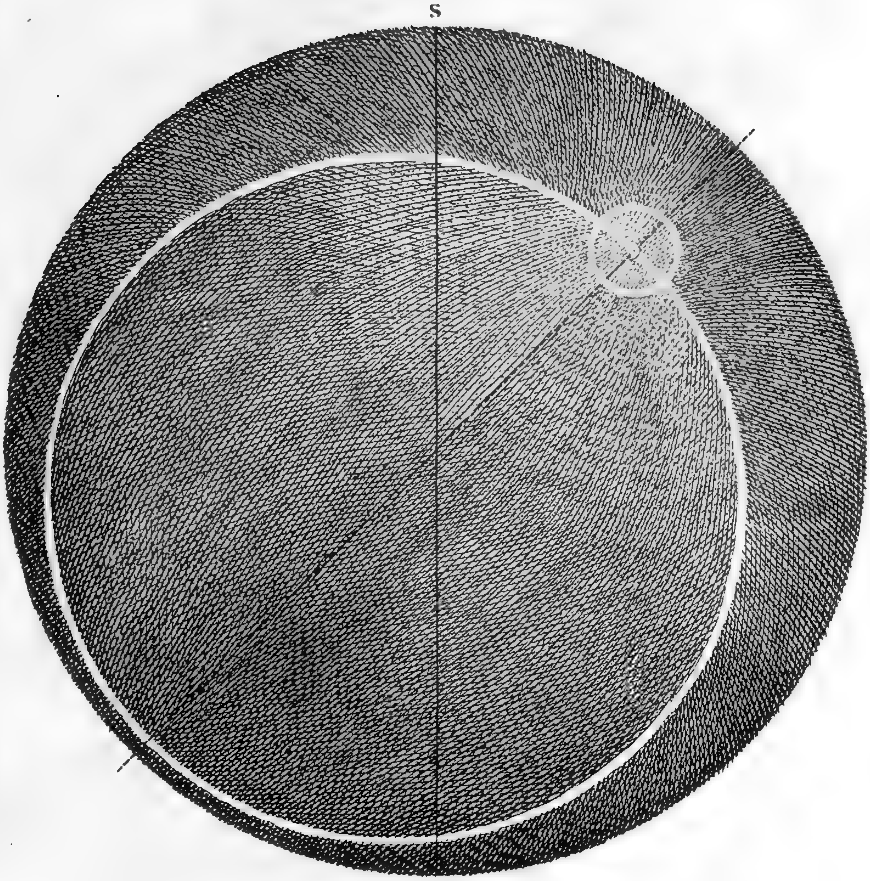


Figure of a Halo about the Moon seen in
Berwick shire on the 18th of Feby. 1796.

D. Lizars Sculp.

VIII. *A* New Series *for the* Rectification *of the* Ellipsis; *together with some* Observations *on the* Evolution *of the* Formula $(a^2 + b^2 - 2ab\cos\phi)^n$. *By James Ivory,* A. M. *Communicated by John Playfair, Professor of Mathematics in the University of Edinburgh.*

[*Read Nov.* 7. 1796.]

Dear Sir,

HAVING, as you know, bestowed a good deal of time and attention on the study of that part of physical astronomy which relates to the mutual disturbances of the planets, I have, naturally, been led to consider the various methods of resolving the formula $(a^2 + b^2 - 2ab\cos\phi)^n$ into infinite series of the form $A + B\cos\phi + C\cos 2\phi +$ &c. In the course of these investigations, a series for the rectification of the ellipsis occurred to me, remarkable for its simplicity, as well as its rapid convergency. As I believe it to be new, I send it you, inclosed, together with some remarks on the evolution of the formula just mentioned, which, if you think proper, you may submit to the consideration of the Royal Society.

I am, Dear Sir,
Your's, &c.
James Ivory.

Douglastown, near Forfar,
20th October 1796.

To Mr John Playfair, Professor of Mathematics, &c.

Let

Let ε denote the excentricity of an ellipſe, of which the ſemi-tranſverſe axis is unity, and ϖ the length of the ſemicircle, radius being unity: Then,

$$\text{if we put } e = \frac{1 - \sqrt{1 - \varepsilon^2}}{1 + \sqrt{1 - \varepsilon^2}},$$

half the periphery of the ellipſis will be

$$= \frac{\varpi}{1+e}\left(1 + \frac{1^2}{2^2} e + \frac{1^2 . 1^2}{2^2 . 4^2} e^4 + \frac{1^2 . 1^2 . 3^2}{2^2 . 4^2 . 6^2} e^6 + \frac{1^2 . 1^2 . 3^2 . 5^2}{2^2 . 4^2 . 6^2 . 8^2} e^8 + \&c.\right),$$

the coefficients being the ſquares of the coefficients of the radical $\sqrt{1 - \varepsilon^2}$.

The common ſeries is,

$$\varpi \times \left(1 - \frac{1}{2} . \frac{1}{2} \varepsilon^2 - \frac{1 . 1}{2 . 4} . \frac{1 . 3}{2 . 4} \varepsilon^4 - \frac{1 . 1 . 3}{2 . 4 . 6} . \frac{1 . 3 . 5}{2 . 4 . 6} \varepsilon^6 - \&c.\right).$$

The firſt of theſe ſeries converges faſter than the other on two accounts: firſt, becauſe the coefficients decreaſe more rapidly; and, next, becauſe e is very ſmall in compariſon of ε, even when ε is great: Thus, if ε be $\frac{4}{5}$, e will be $\frac{1}{4}$, and $e^2 = \frac{1}{16}$.

In order to point out the way in which the preceding ſeries was diſcovered, let us ſuppoſe $(a^2 + b^2 - 2ab \operatorname{cof} \varphi)^n = A + B \operatorname{cof} \varphi + C \operatorname{cof} 2\varphi + \&c.$; and to determine the coefficients, A, B, C, &c. let us, with M. de la Grange, conſider the quantity $(a^2 + b^2 - 2ab \operatorname{cof} \varphi)$ as the product of the two imaginary expreſſions $\left(a - bc^{\varphi\sqrt{-1}}\right)$, and $\left(a - bc^{-\varphi\sqrt{-1}}\right)$, where c denotes the number whoſe hyperbolic logarithm is unity. Then, by expanding the powers $\left(a - bc^{\varphi\sqrt{-1}}\right)^n$, and $\left(a - bc^{-\varphi\sqrt{-1}}\right)^n$ into the ſeries $a^n\left(1 - \alpha . \frac{b}{a} c^{\varphi\sqrt{-1}} + \beta c^{2\varphi\sqrt{-1}} - \gamma c^{3\varphi\sqrt{-1}} + \&c.\right)$

and

and $a^n\left(1 - \alpha . \frac{b}{a} c^{-\varphi\sqrt{-1}} + \beta c^{-2\varphi\sqrt{-1}} - \gamma c^{-3\varphi\sqrt{-1}} + \&c.\right.$

we have $\alpha = n$, $\beta = \frac{n.\overline{n-1}}{1.2}$, $\gamma = \frac{n.\overline{n-1}.\overline{n-2}}{1.2.3}$ &c.

Then multiplying these two series together, and putting $2\cos m\varphi$ for its imaginary value $c^{+m\varphi\sqrt{-1}} + c^{-m\varphi\sqrt{-1}}$, we shall find, on equating the terms,

$$A = a^{2n} \times \left(1 + \alpha^2 . \frac{b^2}{a^2} + \beta^2 . \frac{b^4}{a^4} + \gamma^2 . \frac{b^6}{a^6} + \&c.\right),$$

$$B = -2a^{2n} \times \left(\alpha \cdot \frac{b}{a} + \alpha\beta \cdot \frac{b^3}{a^3} + \beta\gamma \cdot \frac{b^5}{a^5} + \&c.\right),$$

and so on.

Of the several series for A, B, C, &c. the first deserves particular attention, on account of the simplicity of the law of its terms. It deserves the more attention, too, that the whole fluent $\int \dot{\varphi}\,(a^2 + b^2 - 2ab\cos\varphi)^n$, generated while φ from o becomes $= \varpi$, half the circumference of the circle, is $= A + \varpi$: all the other terms of the fluent then vanishing.

Suppose now, in an ellipsis, the semi-transverse $= 1$, the excentricity $= \varepsilon$, and φ an arch of the circumscribing circle, reckoned from the extremity of the transverse: then the fluxion of the correspondent arch of the ellipsis, cut off by the same ordinate, will be $= \dot{\varphi}\sqrt{1 - \varepsilon^2\cos^2\varphi}$.

In this expression, I write $\frac{1}{2} + \frac{1}{2}\cos 2\varphi$, for $\cos.^2\varphi$: and put the result, $\dot{\varphi}\sqrt{1 - \frac{\varepsilon^2}{2} - \frac{\varepsilon^2}{2}\cos 2\varphi} = \dot{\varphi}\sqrt{a^2 + b^2 - 2ab\cos 2\varphi}$, a and b being indeterminate quantities.

To determine a and b, we have $a^2 + b^2 = 1 - \frac{\varepsilon^2}{2}$, and $2ab = \frac{\varepsilon^2}{2}$: whence $a + b = 1$, and $a - b = \sqrt{1 - \varepsilon^2}$ so that $a = \frac{1 + \sqrt{1 - \varepsilon^2}}{2}$ and $b = \frac{1 - \sqrt{1 - \varepsilon^2}}{2}$.

I THUS obtain $\dot{\varphi}\sqrt{1 - \varepsilon^2 \cos^2\varphi} = \dot{\varphi}\sqrt{a^2 + b^2 - 2ab \cos 2\varphi}$: and, taking the whole fluent, while φ from o becomes $= \varpi$, it is manifeſt, from what has been premiſed, that the ſemiperiphery of the ellipſis is $=$

$$\varpi \times a \times \left(1 + \frac{1}{2^2} \cdot \frac{b^2}{a^2} + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} \cdot \frac{b^4}{a^4} + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} \cdot \frac{b^6}{a^6} + \&c.\right),$$

or putting $\frac{b}{a} = e = \frac{1 - \sqrt{1 - \varepsilon^2}}{1 + \sqrt{1 - \varepsilon^2}}$, and $a = \frac{a}{a+b} = \frac{1}{1 + \frac{b}{a}} = \frac{1}{1 + e}$,

the ſemiperiphery of the ellipſis $= \frac{\varpi}{1 + e} \times$

$$\left(1 + \frac{1^2}{2^2} e^2 + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} e^4 + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} e^6 + \&c.\right)$$

IN this ſeries, as was before obſerved, e is a ſmall fraction even when ε is very conſiderable, and the coefficients are more ſimple in the law of progreſſion, and converge faſter, (eſpecially in the firſt terms), than in the common ſeries.

IF we ſuppoſe the ellipſis to be infinitely flattened, in which caſe $\varepsilon = 1$, and $e = 1$, and the ſemiperiphery $= 2$, this ſeries gives $2 = \frac{\varpi}{2} \times \left(1 + \frac{1^2}{2^2} + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} + \&c.\right)$, and ſo

$$\frac{4}{\varpi} = 1 + \frac{1^2}{2^2} + \frac{1^2 \cdot 1^2}{2^2 \cdot 4^2} + \frac{1^2 \cdot 1^2 \cdot 3^2}{2^2 \cdot 4^2 \cdot 6^2} + \frac{1^2 \cdot 1^2 \cdot 3^2 \cdot 5^2}{2^2 \cdot 4^2 \cdot 6^2 \cdot 8^2} + \&c.$$

BUT, we may remark, that as we have here obtained the ſum of the ſquares of the coefficients of the binomial when the exponent is $\frac{1}{2}$; ſo, from the ſame ſource, we may determine the ſum of the ſquares of the coefficients correſponding to any other exponent, at leaſt by a fluent.

FOR taking the whole fluent when $\varphi = \varpi$, we have

$$\int \left(a^2 + b^2 - 2ab \cos\varphi\right)^n \dot{\varphi} = a^{2n} \varpi \left(1 + \alpha^2 \cdot \frac{b^2}{a^2} + \beta^2 \cdot \frac{b^4}{a^4} + \gamma^2 \cdot \frac{b^6}{a^6} + \&c.\right)$$

and ſo when $a = 1$, and $b = 1$,

$$\int \left(\frac{a^2 + b^2 - 2ab \cos\varphi}{\varpi}\right)^n \dot{\varphi} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c.$$

NOW,

Now, when $a = 1$, and $b = 1$, $\int \dot{\varphi} (a^2 + b^2 - 2ab \operatorname{cof} \varphi)^n = 2^{2n} \times \int \dot{\varphi} (\operatorname{fin} \frac{\varphi}{2})^{2n}$, becaufe $2 (\operatorname{fin} \frac{\varphi}{2})^2 = 1 - \operatorname{cof} \varphi$: we thus obtain

$$\frac{2^{2n} \times \int \dot{\varphi} (\operatorname{fin} \frac{\varphi}{2})^{2n}}{\varpi} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c.$$

the whole fluent to be taken when $\varphi = \varpi$, or $\frac{\varphi}{2} = \frac{\varpi}{2}$.

If we put $x = \operatorname{fin} \frac{\varphi}{2}$, we fhall have

$$\frac{2^{2n} \times \int \frac{x^{2n} \dot{x}}{\sqrt{1 - x^2}}}{\frac{1}{2}\varpi} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c,$$

the whole fluent to be taken when $x = 1$; and in this formula n is any number fractional or integral, pofitive or negative; and α, β, γ, &c. the coefficients of the binomial raifed to a power of which the exponent is n.

When n is a whole pofitive number,

$\int \frac{x^{2n} \dot{x}}{\sqrt{1 - x^2}} = \frac{1 . 3 . 5 \ldots . (2n - 1)}{2 . 4 . 6 \ldots . \quad 2n} . \frac{\varpi}{2}$, in the cafe when $x = 1$:

And fo, $2^{2n} \times \frac{1 . 3 . 5 \ldots . (2n - 1)}{2 . 4 . 6 \ldots . \quad 2n} = 1 + \alpha^2 + \beta^2 + \gamma^2 + \&c.$

Now, $2^{2n} \times \frac{1 . 3 . 5 \ldots (2n - 1)}{2 . 4 . 6 \ldots . \quad 2n}$ is no other than the coefficient of the middle term of a binomial, raifed to the power expreffed by $2n$: Hence we have a very curious property of thofe numbers: viz. *that the fum of the fquares of the coefficients of a binomial, the exponent being n, is equal to the coefficient of the middle term of a binomial, of which the exponent is 2n.*

Another remark, which I have to offer on this fubject, may be confidered not only as curious, in an analytical point of view, but as, in fome meafure, accomplifhing an object that has much engaged the attention of mathematicians.

In the computation of the planetary difturbances, it becomes neceffary to evolve the fraction $(a^2 + b^2 - 2ab \operatorname{cof} \varphi)^{-\frac{3}{2}}$ into a feries ſeries of this form, A + B coſϕ + C coſ 2ϕ + &c. The quantities a and b repreſent the diſtances of the diſturbing planets from the ſun; and when theſe bear ſo great a proportion to one another, (as in the caſe of Jupiter and Saturn, or Venus and the Earth), that the fraction $\frac{b}{a}$ is large, it becomes extremely difficult to compute the coefficients A, B, &c. by ſeries, on account of the great number of terms that muſt be taken in. This matter not a little perplexed the firſt geometers who conſidered this ſubject, and they were obliged to approximate to the quantities ſought by the method of quadratures, and by other artifices.

Two things are to be attended to with regard to the quantities A, B, C, &c. The firſt is, That it is not neceſſary to compute all of them ſeparately by ſeries, or by other methods: They form a recurring ſeries; and the two firſt being ſo computed, all the reſt may be derived from them. The ſecond thing is, That the quantities A and B having been computed for any exponent n, the correſpondent quantities are thence derived, by eaſy formulæ, for the exponents $n+1$, $n+2$; $n-1$, $n-2$; and in general for the exponent $n+m$, m being any integer number, poſitive or negative.

From theſe remarks, it follows, that the whole difficulty lies in the computation of the two firſt quantities, A and B; and that we are not confined to a given exponent n, but may chooſe any one in the ſeries, $n+1$, $n+2$, &c.; $n-1$, $n-2$, &c.; that will render the computation moſt eaſy and expeditious.

Thus, in order to compute the quantities A and B, for the exponent $-\frac{3}{2}$, M. de la Grange makes choice of the exponent $+\frac{1}{2}$, which, in the whole ſeries of exponents $+\frac{3}{2}$, $+\frac{1}{2}$, $-\frac{1}{2}$, $-\frac{3}{2}$, &c. is the moſt favourable for computation, on account of the convergency of the coefficients of the ſeries for A and B.

In

In confidering thefe fubjects, however, I have fallen upon a method of computing the quantities A and B for the exponent $-\frac{1}{2}$ by feries that converge fo faft, that, even taking the moft unfavourable cafe that occurs in the theory of the planets, two or three terms give the values required with a fufficient degree of exactnefs. This is what I am now to communicate.

We are then to confider the expreffion $(a^2+b^2-2ab\cos\varphi)^{-\frac{1}{2}}$ $= \frac{1}{\sqrt{a^2+b^2-2ab\cos\varphi}}$: for the fake of fimplicity in calculation, I write $\frac{b}{a} = c$, throwing out a altogether; and I fuppofe

$$\frac{1}{\sqrt{(1+c^2-c\cos\varphi)}} = A + B\cos\varphi + C\cos 2\varphi + \&c.$$

Let ψ be an angle, fo related to φ, that $\sin(\psi-\varphi) = c\sin\psi$: It is obvious, from this formula, that $\psi = \varphi$ when $\sin\psi = 0$, that is, when ψ is equal to 0, or to ϖ, 2ϖ, &c.

We have then, $\cos(\psi-\varphi) = \sqrt{1-c^2\sin^2\psi}$: and taking the fluxions, $\dot{\psi} - \dot{\varphi} = \frac{c\cos\psi\times\dot{\psi}}{\cos(\psi-\psi)} = \frac{c\cos\psi\times\dot{\psi}}{\sqrt{(1-c^2\sin^2\psi)}}$;

whence $\dot{\varphi} = \dot{\psi} \times \frac{\sqrt{1-c^2\sin^2\psi}-c\cos\psi}{\sqrt{1-c^2\sin^2\psi}}$

But $(\sqrt{1-c^2\sin^2\psi}-c\cos\psi)^2 = 1-c^2\sin^2\psi + c^2\cos^2\psi - 2c\cos\psi\sqrt{1-c^2\sin^2\psi} = 1+c^2-2c^2\sin^2\psi - 2c\cos\psi \sqrt{1-c^2\sin 2\psi}$, (becaufe $c^2\cos^2\psi = c^2 - c^2\sin^2\psi$) $= 1+c^2 - 2c\times(c\sin\psi\times\sin\psi + \cos\psi\sqrt{1-c^2\sin^2\psi})$. Now, if we write for $c\sin\psi$ its equal, $\sin(\psi-\varphi)$, and for $\sqrt{1-c^2\sin^2\psi}$ its equal, $\cos(\psi-\varphi)$, we fhall have $c\sin\psi\times\sin\psi + \cos\psi\times\sqrt{1-c^2\sin^2\psi} = \sin(\psi-\varphi)\times\sin\psi + \cos\psi\times\cos(\psi-\varphi) = \cos\varphi$: which being fubftituted, there comes out $(\sqrt{1-c^2\sin^2\psi}-c\cos\psi)^2 = 1+c^2-2c\cos\varphi$.

Our

Our fluxional formula thus becomes $\dot{\phi} = \dot{\psi}\frac{\sqrt{1+c^2-2c\cos\phi}}{\sqrt{1-c^2\sin^2\psi}}$: whence $\frac{\dot{\phi}}{\sqrt{1+c^2-2c\cos\phi}} = \frac{\dot{\psi}}{\sqrt{(1-c^2\sin^2\psi}}$.

I next transform the quantity $\sqrt{1-c^2\sin^2\psi}$ as in the investigation for the elliptic series, and putting $c' = \frac{1-\sqrt{1-c^2}}{1+\sqrt{1-c^2}}$, I find $\sqrt{1-c^2\sin^2\psi} = \frac{\sqrt{1+c'^2+2c'\cos 2\psi}}{1+c'}$, and so $\frac{\dot{\phi}}{\sqrt{1+c^2-2c\cos\phi}} = \frac{(1+c')\dot{\psi}}{\sqrt{1+c'^2+2c'\cos 2\psi}}$.

Now, taking the fluents when $\phi = \varpi$, and $\psi = \varpi$, we shall have $\int\frac{\dot{\phi}}{\sqrt{1+c^2-2c\cos\phi}} = A\times\varpi$: And according to the method of M. de la Grange, $\int\frac{\dot{\psi}}{\sqrt{1+c'^2+2c'\cos 2\psi}} = \varpi \times \left(1+\frac{1^2}{2^2}c'^2+\frac{1^2.3^2}{2^2.4^2}c'^4+\&c.\right)$: Hence $A = (1+c')\times\left(1+\frac{1^2}{2^2}c'^2+\frac{1^2.3^2}{2^2.4^2}c'^4+\&c.\right)$. And in this value of A, c' will be a small fraction, even though c be large; and the series will therefore converge very fast.

But, taking the value of A directly in a series, we have $A = 1+\frac{1^2}{2^2}c^2+\frac{1^2.3^2}{2^2.4^2}c^4+\&c.$ And so $1+\frac{1^2}{2^2}c^2+\frac{1^2.3^2}{2^2.4^2}c^4+\&c. = (1+c')\times\left(1+\frac{1^2}{2^2}c'^2+\frac{1^2.3^2}{2^2.4^2}c'^4+\&c.\right)$. Now, the two series being exactly alike, it is evident that we may transform the one, as we have transformed the other, and that, if we put $c'' = \frac{1-\sqrt{1-c'^2}}{1+\sqrt{1-c'^2}}$ we shall have $1+\frac{1^2}{2^2}c'^2+\frac{1^2.3^2}{2^2.4^2}c'^4 = (1+c'')\times\left(1+\frac{1^2}{2^2}c''^2+\frac{1^2.3^2}{2^2.4^2}c''^4+\&c.\right)$: whence $A = (1+c')(1+c'')\left(1+\frac{1^2}{2^2}c''^2+\frac{1^2.3^2}{2^2.4^2}c''^4+\&c.\right)$.

It

It is manifeſt we may proceed in this manner as far as we pleaſe, and that, if we put $c''' = \frac{1-\sqrt{1-c''^2}}{1+\sqrt{1-c''^2}}$; $c'''' = \frac{1-\sqrt{1-c'''^2}}{1+\sqrt{1-c'''^2}}$ and ſo on, we ſhall have the value of A in an infinite product, $A = (1+c') \times (1+c'') \times (1+c''') (1+c'''') \times$ &c, the quantities c', c'', c''', c'''', &c. converging very rapidly.

Nothing more ſeems to be wiſhed for, with regard to the computation of the quantity A: ſince we can, by methods ſufficiently ſimple, exhibit the value of it in ſeries that ſhall converge as faſt as we pleaſe. By a ſimilar mode of reaſoning, I find the ſeries $1 - \frac{1}{2^2}\gamma^2 + \frac{1^2.3^2}{2^2.4^2}\gamma^4 - \frac{1^2.3^2.5^2}{2^2.4^2.6^2}\gamma^6 +$ &c. (which occurs in determining the time of a body's deſcent in the arch of a circle), $= (1-c) \times \left(1 + \frac{1^2}{2^2}c^2 + \frac{1^2.3^2}{2^2.4^2}c^4 + \frac{1^2.3^2.5^2}{2^2.4^2.6^2}c^6 + \&c.\right)$ where $c = \frac{\sqrt{1+\gamma^2}-1}{\sqrt{1+\gamma^2}+1}$: ſo that the ſummation of this ſeries alſo is accompliſhed by the method above.

I have now only to explain the method of computing B. For this purpoſe I reſume,

$$\frac{1}{\sqrt{1+c^2-2c\cos\varphi}} = A + B\cos\varphi + C\cos 2\varphi + \&c.$$

Multiply by $2\cos\varphi$, and there reſults

$$\frac{2\cos\varphi}{\sqrt{1+c^2-2c\cos\varphi}} = B + (2A+C)\cos\varphi + \&c.$$

whence it is manifeſt that the whole fluent

$$\int\frac{2\cos\varphi \times \dot{\varphi}}{\sqrt{1+c^2-2c\cos\varphi}},\ \text{when } \varphi = \varpi, \text{ is equal to } B \times \varpi.$$

From the preceding inveſtigation we have $\frac{\dot{\varphi}}{\sqrt{1+c^2-2c\cos\varphi}} = \frac{\dot{\psi}}{\sqrt{1-c^2\sin^2\psi}}$, and $\cos\varphi = c\sin^2\psi + \cos\psi\sqrt{1-c^2\sin^2\psi}$,

 whence

whence $\frac{2\dot{\phi}\cos\phi}{\sqrt{1+c^2-2c\cos\phi}} = \frac{2c\dot{\psi}\sin^2\psi}{\sqrt{1-c^2\sin^2\psi}} + 2\dot{\psi}\cos\psi$. Again, $2\sin^2\psi = 1 - \cos 2\psi$, and $\frac{1}{\sqrt{1-c^2\sin^2\psi}} = \frac{(1+c')}{\sqrt{1+c'^2+2c'\cos 2\psi}}$, c' being $= \frac{1-\sqrt{1-c^2}}{1+\sqrt{1-c^2}}$: these substitutions being made, we get

$$\frac{2\dot{\phi}\cos\phi}{\sqrt{1+c^2-2c\cos\phi}} = c \times \frac{(1+c')\dot{\psi}}{\sqrt{1+c'^2+2c'\cos 2\psi}} - c \times \frac{(1+c')\dot{\psi}\cos 2\psi}{\sqrt{1+c'^2+2c'\cos 2\psi}}$$
$$+ 2\dot{\psi}\cos\psi.$$

Suppose now, $\frac{1}{\sqrt{1+c'^2+2c'\cos 2\psi}} = A' - B'\cos 2\psi + C'\cos 4\psi - \&c.$ it is evident, from what goes before, that, taking the fluents of the above fluxions, when ϕ and $\psi = \varpi$, we shall have $B \times \varpi = c \times (1+c') \times (A' + \frac{B'}{2}) \times \varpi$, and so $B = c \times (1+c') \times (A' + \frac{B'}{2})$.

The values of A′ and B′, in series according to the method of M. de la Grange, are

$$A' = 1 + \frac{1^2}{2^2}c'^2 + \frac{1^2.3^2}{2^2.4^2}c'^4 + \frac{1^2.3^2.5^2}{2^2.4^2.6^2}c'^6 + \&c.$$

$$\frac{1}{2}B' = \left(\frac{1}{2}c' + \frac{1}{2}\cdot\frac{1.3}{2.4}c'^3 + \frac{1.3}{2.4}\cdot\frac{1.3.5}{2.4.6}c'^5 + \&c.\right)$$

which series converge very fast, on account of the smallness of c' in respect of c.

If, however, it be required to find the value of B by series still more converging, we may easily do so: For it is manifest that B and B′ are similar functions of c and c': and that if we make $c'' = \frac{1-\sqrt{1-c'^2}}{1+\sqrt{1-c'^2}}$, $c''' = \frac{1-\sqrt{1-c''^2}}{1+\sqrt{1-c''^2}}$, and so on, and put

A″,

A'', A''', &c.; B'', B''', &c. to denote the correſponding values of A' and B', we ſhall have

$$B = c.(1+c')(A' + \frac{B'}{2})$$

$$B' = c'.(1+c'')(A'' + \frac{B''}{2})$$

$$B'' = c''.(1+c''')(A''' + \frac{B'''}{2}) \text{ \&c.}:$$

Now, remarking that $A' = (1+c'')A''$; $A'' = (1+c''')A'''$, &c. we have the following values of B:

$$B = c \times (1 + \frac{c'}{2}).(1+c').(1+c'')A'' + \frac{c}{2}.\frac{c'}{2}(1+c')(1+c'')B''.$$

$$B = c \times (1 + \frac{c'}{2} + \frac{c'}{2}.\frac{c''}{2})(1+c')(1+c'')(1+c''')A''' + \frac{c}{2}.\frac{c'}{2}.\frac{c''}{2}(1+c')$$
$$(1+c'')(1+c''')B'''.$$

And we may proceed in this manner to find the value of B in ſeries that ſhall converge as faſt as we pleaſe.

As the quantities c', c'', c''', &c. diminiſh very faſt, the ſeries A', A'', A''' will approach rapidly to unity, and B', B'', B''' will decreaſe rapidly to nothing: Hence we have ultimately,

$$B = c \times (1 + \frac{c'}{2} + \frac{c'}{2}.\frac{c''}{2} + \frac{c'}{2}.\frac{c''}{2}.\frac{c'''}{2} + \text{\&c.}) \times (1+c')(1+c'')(1+c''')$$
&c.

or, ſince $A = (1+c')(1+c'')(1+c''')$ &c.:

$$B = c \times (1 + \frac{c'}{2} + \frac{c'}{2}.\frac{c''}{2} + \frac{c'}{2}.\frac{c''}{2}.\frac{c'''}{2} + \text{\&c.}) \times A.$$

We ſhall beſt ſee the degree of convergency of the quantities c, c', c'', &c. if we take the infinite ſeries by which they are derived one from another. Now, if $y = \frac{1-\sqrt{1-x^2}}{1+\sqrt{1-x^2}}$, then alſo $y = \frac{x^2}{4} + \frac{x^4}{8} + \frac{5x^6}{64} + \frac{7x^8}{128} + \text{\&c.}$: whence it is obvious, that in the ſeries of quantities c, c', c'', &c. the fourth part of the ſquare of

 any

any term is nearly equal to the following term, and the rapidity with which the series decreases is therefore very great.

THE method, then, that results from the preceding investigations for computing A and B, is shortly this:

Put $c' = \frac{1 - \sqrt{1 - c^2}}{1 + \sqrt{1 - c^2}}$: and compute

$$1 + \frac{1^2}{2^2} c'^2 + \frac{1^2 . 3^2}{2^2 . 4^2} c'^4 + \frac{1^2 . 3^2 . 5^2}{2^2 . 5^2 . 6^2} c'^6 + \&c. = M,$$

$$\text{and } \frac{1}{2} c' + \frac{1}{2} . \frac{1 . 3}{2 . 4} c'^3 + \frac{1 . 3}{2 . 4} . \frac{1 . 3 . 5}{2 . 4 . 6} c'^5 + \&c. = N.$$

Then $A = (1 + c') \times M$, and

$$B = c \times (1 + c') \times (M + N).$$

THE series M and N will converge so fast, even in the most unfavourable case that occurs in the theory of the planets, that the first three terms will give the sums sufficiently exact; and it will therefore not be necessary to have recourse to the more converging series A'' and B''.

SUCH is the method that I had first imagined, for facilitating these sort of computations. I have since found, however, that by means of the common tables of sines and tangents, the quantities A and B may be computed in a still easier way from the expressions,

$$A = (1 + c') (1 + c'') (1 + c''') \&c.$$

$$B = c \times \left(1 + \frac{c'}{2} + \frac{c'}{2} . \frac{c''}{2} + \frac{c'}{2} . \frac{c''}{2} . \frac{c'''}{2} + \&c.\right) \times A.$$

FOR if $c = \sin m$, then $\sqrt{1 - c^2} = \cos m$ and $c' = \frac{1 - \cos m}{1 + \cos m}$ $= \tan^2 \frac{m}{2}$: consequently $1 + c' = \sec^2 \frac{m}{2}$. In like manner, if $c' = \sin m'$, $c'' = \sin m''$, &c. we shall have $\sin m' = \tan^2 \frac{m}{2}$;

sin m''

$\text{ſin}\, m'' = \tan^2 \frac{m'}{2}$, and ſo on: And $1 + c'' = \text{ſec}^2 \frac{m'}{2}$; $1 + c''' = \text{ſec}^2 \frac{m''}{2}$, and ſo on. Thus:

$$A = \text{ſec}^2 \frac{m}{2} \times \text{ſec}^2 \frac{m'}{2} \times \text{ſec}^2 \frac{m''}{2} \times \text{\&c.}$$

To find the logarithm of A, we have then only to add together the logarithm ſecants of the angles $\frac{m}{2}, \frac{m'}{2}, \frac{m''}{2}$, &c. to diminiſh the ſum by as many times the radius as there are ſecants, and to take twice the remainder. As the angles m, m', m'', &c. decreaſe very faſt, it will ſeldom be neceſſary to compute more than two or three of them.

THE ſeries $\left(1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} + \frac{c'}{2} \cdot \frac{c''}{2} \cdot \frac{c'''}{2} + \text{\&c.}\right)$ is alſo readily computed from the tables; becauſe the logarithms of c', c'', c''', &c. being the ſines of the angles m', m'', &c. are all found in the tables.

As an example, let $c = 0.72333$: which is the fraction that ariſes from dividing the mean diſtance of Venus from the ſun, by the mean diſtance of the Earth; and this is the moſt unfavourable caſe that occurs in the theory of the planets: Then to compute A, I find, in the table of natural ſines, that 0.72333 correſponds to 46° 19′ 48⅓″: we have therefore

$m = 46° \; 19' \; 48\frac{1}{3}''$	
$\text{L.} \tan \frac{m}{2} = \text{l.} \tan 23° \; 9' \; 54\frac{1}{6}'' = 9.6313206$	$\text{L. ſec} \frac{m}{2} = 10.0365070$
2	
$\text{L. ſin}\, m' = 9.2626412$	
$\text{L.}\, m' = 10° \; 32' \; 57''$	
$\text{L.} \tan \frac{m'}{2} = \text{l.} \tan 5° \; 16' \; 28\frac{1}{2}'' = 8.9652949$	$\text{L. ſec} \frac{m'}{2} = 10.0018429$
2	
$\text{L. ſin}\, m'' = 7.9305898$	
$\text{L.}\, m'' = 0° \; 29' \; 18''$	

L. tan

$L.\ \tan \frac{m''}{2} = l.\ \tan 0^\circ\ 14'\ 39'' = 7.6295664$

$\qquad\qquad\qquad\qquad\qquad\qquad 2$

$L.\ \sin m''' = 5.2591328$

As m''' will only be a few seconds, it may be neglected.

Hence $A = 1.19318$

$L.\ \sec \frac{m''}{2} = 10.0000039$

$\qquad 0.0383538$

$\qquad\qquad 2$

$L.\ A = 0.0767076$

To compute B, let $S = 1 + \frac{c'}{2} + \frac{c'}{2} \cdot \frac{c''}{2} + \&c.$

$L.\ c' = l.\ \sin m' = 9.2626412$;

$L.\ c'' = l.\ \sin m'' = 7.9305898$

$l.\ c' . c'' = 7.1932310$

$1 = 1.000000$

$\frac{c'}{2} = 0.091540$

$\frac{c'}{2} \cdot \frac{c''}{2} = 0.000390$

$S = 1.091830$

$B = c \times S \times A.$

$L.\ c = \bar{1}.8593365$

$L.\ S = 0.0381948$

$L.\ A = 0.0767076$

$L.\ B = \bar{1}.9742389$, and $B = 0.942408$

IX.

IX. *A* SHORT MINERALOGICAL DESCRIPTION *of the* MOUNTAIN *of* GIBRALTAR. *By Major* IMRIE. *Communicated by the Reverend* JOHN WALKER, *D. D. Profeſſor of Natural Hiſtory in the Univerſity of Edinburgh.*

[*Read July* 3. 1797.]

THE mountain of Gibraltar is ſituated in 36°. 9′ north latitude, and in 5°. 17′ eaſt longitude from Greenwich. It is the promontory which, with that of Ceuta upon the oppoſite coaſt of Barbary, forms the entrance of the Straits of Gibraltar from the Mediterranean; and Europa Point, which is the part of the mountain that advances moſt towards Africa, is generally regarded as the moſt ſouthern promontory in Europe. The form of this mountain is oblong; its ſummit a ſharp craggy ridge; its direction is nearly from north to ſouth; and its greateſt length, in that direction, falls very little ſhort of three miles. Its breadth varies with the indentations of the ſhore, but it no where exceeds three quarters of a mile. The line of its ridge is undulated, and the two extremes are ſomewhat higher than its centre.

THE ſummit of the Sugar Loaf, which is the point of its greateſt elevation towards the ſouth, is 1439 feet; the Rock Mortar, which is the higheſt point to the north, is 1350; and the Signal Houſe, which is nearly the central point between theſe two, is 1276 feet above the level of the ſea. The weſtern

ſide

ſide of the mountain is a ſeries of rugged ſlopes, interſperſed with abrupt precipices. Its northern extremity is perfectly perpendicular, except towards the north-weſt, where what are called the Lines intervene, and a narrow paſſage of flat ground that leads to the iſthmus, and is entirely covered with fortification. The eaſtern ſide of the mountain moſtly conſiſts of a range of precipices; but a bank of ſand, riſing from the Mediterranean in a rapid acclivity, covers a third of its perpendicular height. Its ſouthern extremity falls, in a rapid ſlope, from the ſummit of the Sugar Loaf, into a rocky flat, of conſiderable extent, called Windmill Hill. This flat forms half an oval, and is bounded by a range of precipices, at the ſouthern baſe of which a ſecond rocky flat takes place, ſimilar in form and extent to Windmill Hill; and alſo, like it, ſurrounded by a precipice, the ſouthern extremity of which is waſhed by the ſea, and forms Europa Point. Upon the weſtern ſide, this peninſular mountain is bounded by the bay of Gibraltar, which is in length nearly eight miles and a half, and in breadth upwards of five miles. In this bay the tide frequently riſes four feet. Upon the north the mountain is attached to Spain by a low ſandy iſthmus, the greateſt elevation of which, above the level of the ſea, does not exceed 10 feet, and its breadth, at the baſe of the rock, is not more than three quarters of a mile. This iſthmus ſeparates the Mediterranean, on the eaſt, from the bay of Gibraltar on the weſt.

THIS mountain is much more curious in its botanical, than in its mineralogical productions. In reſpect to the firſt, it connects, in ſome degree, the Flora of Africa with that of Europe. In reſpect to the latter, it produces little variety; perhaps a few ſubſtances and phænomena that are rare, but none that are peculiar.

THE principal maſs of the mountain rock conſiſts of a grey, denſe (what is generally called primary) marble; the different beds

beds of which are to be examined in a face of 1350 feet of perpendicular height, which it preſents to Spain in a conical form. Theſe beds, or ſtrata, are of various thickneſs, from 20 to upwards of 40 feet, dipping in a direction from eaſt to weſt, nearly at an angle of 35 degrees. In ſome parts of the ſolid maſs of this rock, I have found teſtaceous bodies entirely tranſmuted into the conſtituent matter of the rock, and their interior hollows filled up with calcareous ſpar; but theſe do not occur often in its compoſition, and its beds are not ſeparated by any intermediate ſtrata.

In all parts of the globe, where this ſpecies of rock conſtitutes large diſtricts, it is found to be cavernous. The caves of Gibraltar are many, and ſome of them of great extent. That which moſt deſerves attention and examination is called St Michael's Cave, which is ſituated upon the ſouthern part of the mountain, almoſt equally diſtant from the Signal Tower and the Sugar Loaf. Its entrance is 1000 feet above the level of the ſea: This entrance is formed by a rapid ſlope of earth, which has fallen into it at various periods, and which leads to a ſpacious hall, incruſted with ſpar, and apparently ſupported in the centre by a large maſſy ſtalactitical pillar. To this ſucceeds a long ſeries of caves of difficult acceſs. The paſſages from the one to the other of theſe are over precipices, which can only be paſſed by the aſſiſtance of ropes and ſcaling ladders. I have, myſelf, paſſed over many of theſe to the depth of 300 feet from the upper cave; but at that depth the ſmoke of our torches became ſo diſagreeable, that we were obliged to give up our purſuit, and leave caves ſtill under us unexamined. In theſe cavernous receſſes, the formation and proceſs of ſtalactites is to be traced, from the flimſy quilt-like cone, ſuſpended from the roof, to the robuſt trunk of a pillar, three feet in diameter, which riſes from the floor, and ſeems intended by nature to ſupport the roof from which it originated.

The variety of form, which this matter takes in its different ſituations and directions, renders this ſubterraneous ſcenery ſtrikingly groteſque, and in ſome places beautifully pictureſque. The ſtalactites of theſe caves, when near the ſurface of the mountain, are of a browniſh yellow colour; but, as we deſcended towards the lower caves, we found them begin to loſe their darkneſs of colour, which by degrees ſhaded off to a whitiſh yellow.

The only inhabitants of theſe caves are bats, ſome of which are of a large ſize. The ſoil, in general, upon the mountain of Gibraltar, is but thinly ſown; and in many parts that thin covering has been waſhed off by the heavy autumnal rains, which have left the ſuperficies of the rock, for a conſiderable extent, bare and open to inſpection. In thoſe ſituations, an obſerving eye may trace the effects of the ſlow, but conſtant, decompoſition of the rock, cauſed by its expoſure to the air, and the corroſion of ſea-ſalts, which, in the heavy gales of eaſterly winds, are depoſited with the ſpray on every part of the mountain. Thoſe uncovered parts of the mountain rock alſo expoſe to the eye a phænomenon worthy of ſome attention, as it tends clearly to demonſtrate, that, however high the ſurface of this rock may now be elevated above the level of the ſea, it has once been the bed of agitated waters. This phænomenon is to be obſerved in many parts of the rock, and is conſtantly found in the beds of torrents. It conſiſts of pot-like holes, of various ſizes, hollowed out of the ſolid rock, and formed apparently by the attrition of gravel or pebbles, ſet in motion by the rapidity of rivers, or currents in the ſea. One of thoſe, which had been recently laid open, I examined with attention. I found it to be five feet deep, and three feet in diameter; the edge of its mouth rounded off as if by art, and its ſides and bottom retaining a conſiderable degree of poliſh. From its mouth, for three and a half feet down, it was filled with a red argillaceous earth, thinly mixed with minute parts of tranſparent quartz cryſtals; the remaining foot and a half, to the bottom, contained an aggregate of water-worn ſtones, which were from the ſize of a gooſe's egg to that of a ſmall walnut, and conſiſted of red jaſpers, yellowiſh white flints, white quartz, and bluiſh white agates, firmly combined by a yellowiſh brown ſtalactitical calcareous ſpar. In this breccia I could not diſcover any fragment of the mountain rock, or any other calcareous matter, except the cement with which it was combined. This pot is 940 feet above the level of the ſea.

Upon the weſt ſide of the mountain, towards its baſe, ſome ſtrata occur, which are heterogenial to the mountain rock: the firſt, or higheſt, forms the ſegment of a circle; its convex ſide is towards the mountain, and it ſlopes alſo in that direction. This ſtratum conſiſts of a number of thin beds; the outward one, being the thineſt, is in a ſtate of decompoſition, and is mouldering down into a blackiſh brown or ferruginous coloured earth. The beds, inferior to this, progreſſively increaſe in breadth to 17 inches, where the ſtratification reſts upon a rock of an argillaceous nature.

This laſt bed, which is 17 inches thick, conſiſts of quartz of a blackiſh blue colour, in the ſepta or cracks of which are found fine quartz cryſtals, colourleſs, and perfectly tranſparent. Theſe cryſtals are compoſed of eighteen planes, diſpoſed in hexangular columns, terminated at both extremities by hexangular pyramids. The largeſt of thoſe that I have ſeen does not exceed two-eighths of an inch in length: They, in general, adhere to the rock by the ſides of the column, but are detached without difficulty. Their great degree of tranſparency has obtained them the name of Gibraltar diamonds.

At no great diſtance from where theſe cryſtals are found, upon the ſame ſlope of the mountain, but rather nearer to the level of the ſea, a ſtratum of argillaceous matter has been laid open, divided into many thin beds, the broadeſt of which does not exceed a foot in thickneſs. Its general colour is of a whitiſh grey, with a ſmall mixture of yellow, and it is divided tranſverſely by ſtraight ſepta or cracks, both ſides of which are covered with dendritical figures, of a yellowiſh brown colour, beautifully repreſenting the objects of landſcape. At the weſtern baſe of the mountain, on a level with the ſea by which it is waſhed, a very extenſive ſtratum occurs, of the ſame nature as the laſt deſcribed, bearing from north to ſouth, parallel with, and dipping towards, the mountain, nearly at an angle of 40 degrees.

In ſome parts of the weſtern ſlope of the mountain, towards the ſouth, are found neſts of a dark red ſhivery clay, in which are embedded flints of a dirty ſap green colour: Of thoſe no regular ſtratum is to be perceived; many of them are unſhapely maſſes; but they, in general, tend to the rhomboidal form, and are from three to four inches long, by two or three broad, and an inch and a half thick. They are not incruſted as the flints found in chalk, nor have they the appearance of having been worn by attrition.

Upon different parts of the mountain, towards its baſe, are found large quantities of ſand, compoſed of different materials, and aſſuming various appearances as to colour. The largeſt bank of this arenaceous matter is upon the weſtern ſide of the mountain, and conſiſts of ſmall particles of cryſtallized quartz, colourleſs, and perfectly tranſparent *perſe*, but of an ochreous colour in the maſs, on account of a red argillaceous earth which adheres to them. The ſand of this bank is perfectly looſe and uncombined: one half of it has been levelled into an extenſive parade, its ſurface having been combined by the lime and rubbiſh from the ruins of the town. The ſouthern extremity of the bank is ſtill to be ſeen in its natural ſtate, and forms the burying-ground of the garriſon.

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Upon the eaſt ſide of the mountain is found another of theſe banks, of conſiderable extent, and, as I mentioned before, riſing from the Mediterranean in a rapid acclivity, and reaching to one-third of its entire elevation. This bank is compoſed of ſmall particles of cryſtallized quartz, of teſtaceous bodies rounded by attrition, and of a few minute particles of the calcareous rock; the whole has a whitiſh grey colour. The rain-water, which falls from the bare mountain rock above the ſand, brings along with it calcareous matter, which is depoſited upon the bank, and combines its ſurface into a cruſt, which in ſome places is ſo much indurated as to bear the preſſure of the foot.

In other parts of the mountain, where this ſand is ſurrounded by the calcareous rock, and covered in and protected from the action of the air, and corroſion of the ſea-ſalts, it is found in a perfect indurated ſtate, combined by ſtalactitical ſpar, and forming a minute breccia. A quarry of this arenaceous ſtone has been opened upon the ſouth-eaſt quarter of the mountain, and is made uſe of, with great propriety, to line the embraſures of ſome of the new works belonging to the garriſon. Its inaptitude to fly off in ſplinters, when ſtruck by a ball, gives, in ſuch ſituations, additional ſafety to the defenders of the place.

The weſtern ſide of the mountain's baſe, around Roſia Bay, and the new Mole, is a rock compoſed of an aggregate of ſmall fragments of every foſſil that has been here deſcribed, with the addition of two different ſpecies of marble that are probably adventitious, as their native beds have not been found in the mountain. The one of thoſe is black, and the other of an olive green colour. The whole of this mixture produces a moſt beautiful breccia, and is firmly combined by a calcareous cement of a yellow, verging towards an orange colour. It is ſuſceptible of a high poliſh, except where fragments of the argillaceous ſtrata occur: Theſe can be eaſily ſmoothed down, but cannot be brought to a perfect poliſh. The fragments in this breccia are angular,

angular, and none of them have the appearance of being water-worn.

It only now remains for me to mention what are generally called the foſſil bones, found in the rock of Gibraltar. Theſe have been much talked of, and by ſome looked upon as a phænomenon beyond the power of explanation. The general idea, which exiſts concerning them, is, that they are found in a petrified ſtate, and incloſed in the ſolid calcareous rock; but theſe are miſtakes, which could only ariſe from inaccurate obſervation and falſe deſcription.

In the perpendicular fiſſures of the rock, and in ſome of the caverns of the mountain, (all of which afford evident proofs of their former communication with the ſurface), a calcareous concretion is found, of a reddiſh brown ferruginous colour, with an earthy fracture, and conſiderable induration, incloſing the bones of various animals, ſome of which have the appearance of being human. Theſe bones are of various ſizes, and lie in all directions, intermixed with ſhells of ſnails, fragments of the calcareous rock, and particles of ſpar; all of which materials are ſtill to be ſeen in their natural uncombined ſtates, partially ſcattered over the ſurface of the mountain. Theſe having been ſwept, by heavy rains at different periods, from the ſurface into the ſituations above deſcribed, and having remained for a long ſeries of years in thoſe places of reſt, expoſed to the permeating action of water, have become enveloped in, and cemented by, the calcareous matter which it depoſits.

The bones, in this compoſition, have not the ſmalleſt appearance of being petrified; and if they have undergone any change, it is more like that of calcination than that of petrifaction, as the moſt ſolid parts of them generally admit of being cut and ſcraped down with the ſame eaſe as chalk.

Bones combined in ſuch concretions are not peculiar to Gibraltar: They are found in ſuch large quantities in the country

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of Dalmatia, and upon its coasts in the islands of Cherso and Osero, that some naturalists have been induced to go so far as to assert, that there has been a regular stratum of such matter in that country, and that its present broken and interrupted appearance has been caused by earthquakes, or other convulsions, experienced in that part of the globe. But, of late years, a traveller, (Abbé ALBERTO FORTIS), has given a minute description of the concretion in which the bones are found in that country: And by his account it appears, that with regard to situation, composition and colour, it is perfectly similar to that found at Gibraltar. By his description it also appears, that the two mountain rocks of Gibraltar and Dalmatia consist of the same species of calcareous stone; from which it is to be presumed, that the concretions in both have been formed in the same manner and about the same periods.

PERHAPS if the fissures and caves of the rock of Dalmatia were still more minutely examined, their former communications with the surface might yet be traced, as in those described above; and, in that case, there would be at least a strong probability, that the materials of the concretions of that country have been brought together by the same accidental cause, which, in my opinion, has collected those found in the caverns of Gibraltar. I have traced, in Gibraltar, this concretion, from the lowest part of a deep perpendicular fissure, up to the surface of the mountain. As it approached to the surface, the concretion became less firmly combined, and, when it had no covering of the calcareous rock, a small degree of adhesion only remained, which was evidently produced by the argillaceous earth, in its composition, having been moistened by rain and baked by the sun.

THE depth, at which these materials had been penetrated by that proportion of stalactitical matter, capable of giving to the concretion its greatest adhesion and solidity, I found to vary according to its situation, and to the quantity of matter to be com-

bined:

bined. In fiffures, narrow and contracted, I found the concretion poffeffing a great degree of hardnefs at fix feet from the furface; but in other fituations more extended, and where a larger quantity of the materials had been accumulated, I found it had not gained its greateft degree of adhefion at double that depth. In one of the caves, where the mafs of concretion is of confiderable fize, I perceived it to be divided into different beds, each bed being covered with a cruft of the ftalactitical fpar, from one inch to an inch and a half in thicknefs, which feems to indicate, that the materials have been carried in at various periods, and that thofe periods have been very remote from each other.

At Rofia Bay, upon the weft fide of Gibraltar, this concretion is found in what has evidently been a cavern, originally formed by huge unfhapely maffes of the rock, which have tumbled in together. The fiffure, or cavern, formed by the difruption and fubfidence of thofe maffes, has been entirely filled up with the concretion, and is now expofed to full view by the outward mafs having dropped down, in confequence of the encroachments of the fea. It is to this fpot that ftrangers are generally led to examine the phænomenon; and the compofition, having here attained to its greateft degree of hardnefs and folidity, the hafty obferver, feeing the bones inclofed in what has fo little the appearance of having been a vacuity, examines no further, but immediately adopts the idea of their being incafed in the folid rock. The communication from this former chafm, to the furface from which it has received the materials of the concretion, is ftill to be traced in the face of the rock, but its opening is at prefent covered by the bafe of the line wall of the garrifon. Here bones are found that are apparently human; and thofe of them that appear to be of the legs, arms, and vertebræ of the back, are fcattered among others of various kinds and fizes, even down to the fmalleft bones of fmall birds. I found here the complete jaw-bone of a fheep; it contained its

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full complement of teeth, the enamel of which was perfect, and its whitenefs and luftre in no degree impaired. In the hollow parts of fome of the large bones was contained a minute cryftallization of pure and colourlefs calcareous fpar; but, in moft, the interior part confifted of a fparry cruft of a reddifh colour, fcarcely in any degree tranfparent.

At the northern extremity of the mountain, the concretion is generally found in perpendicular fiffures. The miners there, employed upon the fortifications, in excavating one of thofe fiffures, found, at a great depth from the furface, two fkulls, which were fuppofed to be human; but, to me, one of them, if not both, appeared to be too fmall for the human fpecies. The bone of each was perfectly firm and folid; from which it is to be prefumed, that they were in a ftate of maturity before they were inclofed in the concretion. Had they appertained to very young children, perhaps the bone would have been more porous, and of a lefs firm texture. The probability is, that they belonged to a fpecies of monkey, which ftill continues to inhabit, in confiderable numbers, thofe parts of the rock which are to us inacceffible.

This concretion varies, in its compofition, according to the fituation in which it is found. At the extremity of Princes Lines, high in the rock which looks towards Spain, it is found to confift only of a reddifh calcareous earth, and the bones of fmall birds cemented thereby. The rock around this fpot is inhabited by a number of hawks, that, in the breeding feafon, neftle here, and rear their young; the bones in this concretion are probably the remains of the food of thofe birds. At the bafe of the rock, below King's Lines, the concretion confifts of pebbles of the prevailing calcareous rock. In this concretion, at a very confiderable depth under the furface, was found the under parts of a glafs bottle, uncommonly fhaped, and of great thicknefs; the colour of the glafs was of a dark green.

In many parts of the rock I have found concretions, in which there are no bones of any kind; and on the elevated parts of the mountain, where the ſlopes are rapid, I have found a breccia, (if I may ſo call it), entirely conſiſting of ſnail-ſhells, combined in a maſs of opaque ſtalactitical ſpar of a yellowiſh brown colour. The various progreſſive augmentations of this matter were to be traced in various ſhades of the ſame colour, which, like the zones of the antique alabaſter, curve round, and follow the form of the ſhell. The purer matter of this ſpar has penetrated the ſhells, and in their interior hollows has formed a lining of ſmall cryſtals, generally colourleſs and perfectly tranſparent.

I have beſtowed more time in endeavouring to deſcribe the compoſition, and the real ſituation, of this concretion of bones, than the ſubject, in the eſtimation of many, will ſeem to deſerve, and indeed more than it deſerves in my own opinion; but where an erroneous opinion has obtained a footing, in conſequence of inaccurate obſervations and partial deſcription, it is the duty of every new obſerver to endeavour to correct it.

X.

X. Description *of a* Thermometer, *which marks the greatest* Degree *of* Heat *and* Cold, *from one* Time *of* Observation *to another, and may also register its own* Height *at every* Instant. *By* Alexander Keith, *Esq;* F. R. S. & F. A. S. Edin.

[*Read August* 3. 1795.]

THERMOMETERS have hitherto been defective for meteorological purposes, in so far as they only point out the degree of heat at the moment of inspecting them, but do not show what the difference of temperature has been, from the time of one observation to that of another: Nor has any instrument been yet constructed, so far as I have been able to learn, which will record the intermediate degrees of heat.

The ingenious Robert Hook, in the end of the last century, mentions his intention of making a thermometer for the above purpose; but it does not appear that it was ever executed: Neither does he explain how it was to have been done.

The thermometer, invented by M. James Six, as described in the 72d volume of the *Philosophical Transactions* of the Royal Society of London, is made to show its greatest rise or fall from one period of observation to another. This is done by means of two small pieces of black glass, which float on two different ſurfaces of mercury, within two glaſs tubes hermetically ſealed. Theſe floats, when raiſed to their greateſt height, adhere to the ſide of the tube, by means of a ſpring of glaſs, and become ſtationary, although the mercury falls. After the obſerver has taken a note of the temperature, he, by a magnet held in his hand, draws down the float to the ſurface of the mercury, in conſequence of a ſmall bit of ſteel wire incloſed in the float, and the inſtrument is prepared for another obſervation. This is an ingenious invention, but requires too delicate workmanſhip to be fit for common uſe; beſides, it cannot be made to record the degrees of heat at intermediate periods. The thermometer, lately invented by Dr RUTHERFORD of Baliliſh, and deſcribed in the 3d volume of the *Tranſactions* of this Society, is alſo an ingenious contrivance, but has the ſame defect of marking only the extreme points, to which the liquor has riſen or fallen, in two ſeparate glaſs tubes.

SEVERAL years ago it occurred to me, that an air thermometer might be uſed for the purpoſes required, providing the weight of the atmoſphere could be excluded, or a counter-balance formed to it; and as the whole inſtrument could be made to riſe and fall by the temperature of the atmoſphere alone, it might be adapted to a piece of clock-work, which would record the degrees of heat at every inſtant through the year: And accordingly I read to this Society a deſcription of the inſtrument. But having formed another inſtrument, of a more ſimple conſtruction, to anſwer the ſame purpoſe, I beg leave to give a deſcription of it.

AB is a tube about 14 inches long, (Pl. VI.) and three-fourths of an inch caliber, of thin glaſs, ſealed or cloſe at top. To the bottom, which is bent upwards, there is joined a glaſs tube 7 inches long, and four-tenths of an inch caliber, open at top. The tube AB

AB is filled with the ſtrongeſt ſpirit of wine or alcohol, and from B to E is filled with mercury.

It will be evident, from inſpection, that if the ſpirit of wine is expanded by heat, the mercury in the ſmaller tube will riſe, and, if the ſpirit of wine is contracted by cold, the mercury will fall: And although they are both ſubjected to the preſſure of the atmoſphere, yet, as liquids are incompreſſible by weight in any perceptible degree, neither the ſpirit of wine nor mercury will be altered in bulk by the different weight of the atmoſphere.

FD is a ſcale of braſs or ivory, about $6\frac{1}{2}$ inches long, divided in the uſual way.

E is a ſmall conical piece of ivory or glaſs, of a proper weight, made to float on the ſurface of the mercury in the ſmaller tube: to which float is joined a wire, reaching to H, having a knee bent at a right angle, which raiſes one index, and depreſſes another index, according as the mercury riſes or falls, which wire ſhall be termed the *float-wire*.

II is a glaſs tube, 7 inches and a half long, cloſed at top and open at bottom, ſo wide as to ſlide eaſily over the ſcale, and, by means of a braſs rim cemented to it, is made to fit exactly to the circular baſe of the ſcale, ſo that, when this tube is put on, it covers the whole ſcale and indexes, and defends them from wind or rain. This cover need not be taken off, except when the inſtrument is to be prepared for an obſervation.

The operation of the float and indexes will be better underſtood from fig. 2. which repreſents them of the full ſize.

FG is the ſcale fixed to a circular piece of wood or braſs, through which the top of the ſmall tube is made to paſs.

From G to K is a piece of the ſmalleſt harpſichord wire, or rather of the ſmalleſt gold wire, ſtretched along the ſcale, fixed at the ends by two braſs pins.

LL are two indexes, formed of thin black oiled ſilk, pierced by the ſmall wire in ſuch a manner as to ſlide upwards and downwards with a very ſmall force, not more than two grains.

H, the knee of the float-wire before deſcribed, is made to encompaſs the ſmall wire between the two indexes, ſo that, when the float riſes, the upper index is moved upwards, and, when it deſcends, it leaves the upper index ſtationary, and puſhes down the lower index, which is alſo left ſtationary, when the float riſes.

When the inſtrument is to be prepared for an obſervation, the one index is to be pulled down, and the other raiſed, by means of a bit of wire bent for the purpoſe, until both indexes touch the knee of the float-wire: And, when it is again obſerved, the upper index will point out the greateſt degree of heat, and the lower the greateſt degree of cold, ſince the time they were ſet.

If this thermometer is to be adapted to a piece of clock-work, in order to record the degrees of heat at each hour and minute of time, it ought to be made of larger dimenſions. The large tube may be 40 inches long, and not increaſed in diameter, but the ſmall tube ought to be enlarged in diameter, and not in length. By enlarging the tube, which contains the ſpirit of wine, in length only, it will be affected by heat and cold in as ſhort a time as that before deſcribed.

It is unneceſſary at preſent to explain the clock-work. It is ſufficient to ſay, that a hollow cylinder of any light ſubſtance, 7 inches long, and 5 inches diameter, is made to revolve upon a vertical axis once in thirty-one days or a month; a piece of ſmooth or vellum paper is put round this cylinder, paſted only at the joining, but ſo as to make it adhere cloſe to the cylinder; on this paper are drawn thirty-one equal perpendicular diviſions, numbered at the top 1, 2, 3, &c. to correſpond to the thirty-one days of the month, each of which is ſubdivided into ſix parts, to anſwer to four hours. The length of this cylinder is is divided by lines ſurrounding it, or zones, in ſuch number as correſpond to the ſcale of FAHRENHEIT's thermometer, viz. from 0 to 100 degrees. Theſe diviſions ought to be engraved on copperplate, and a great number of impreſſions thrown off on ſmooth or vellum paper, in order that one may be ready to put on each month.

FIG. 3. MN repreſents the cylinder covered with one of theſe impreſſions. PP is the ſcale fixed to the frame on which the cylinder turns. This ſcale is divided into 100 of FAHRENHEIT's degrees, exactly correſponding to the diviſions of the cylinder.

Q is a piece of black-lead pencil, joined to the end of the ſlot-wire in the place of the knee before mentioned. This pencil is made to preſs lightly on the cylinder, by means of the ſmall weight R. And as the pencil riſes or falls by heat and cold, it will mark the degrees on the ſcale of the cylinder; and the cylinder being conſtantly revolving, the diviſion for each day and parts of a day will ſucceſſively be marked by the pencil, which will leave a trace, deſcribing an undulated line, diſtinctly delineating the temperature of each day through the month. Theſe papers, when taken off and bound together, will make a complete regiſter of the temperature for the year; or, if they are paſted to one another, they will form a thermometrical chart, by which the variations of heat and cold, during the year, may all be ſeen and compared by one glance of the eye.

BY inſpecting fig. 3. the effect of the inſtrument may be ſeen. It appears that the paper had been put on the cylinder the firſt day of the month, at midday, when the thermometer ſtood at 45°; that it fell gradually till midnight to 25°; thereafter it roſe till the 2d at 1 P. M. when it ſtood at 42°; then it deſcended at midnight to 35, &c.; that on the 4th, at midday, it roſe to 50; and at noon, the 10th of the month, it ſtands at 40°.

IF

If three inches be added to the length of the cylinder, it may be made to delineate the variations of the barometer as well as the thermometer, and thereby to form a complete chart or view of the progrefs of both of them. And if inftruments of this kind were kept in different parts of the country, and their charts compared together, it would afford much information with regard to meteorology.

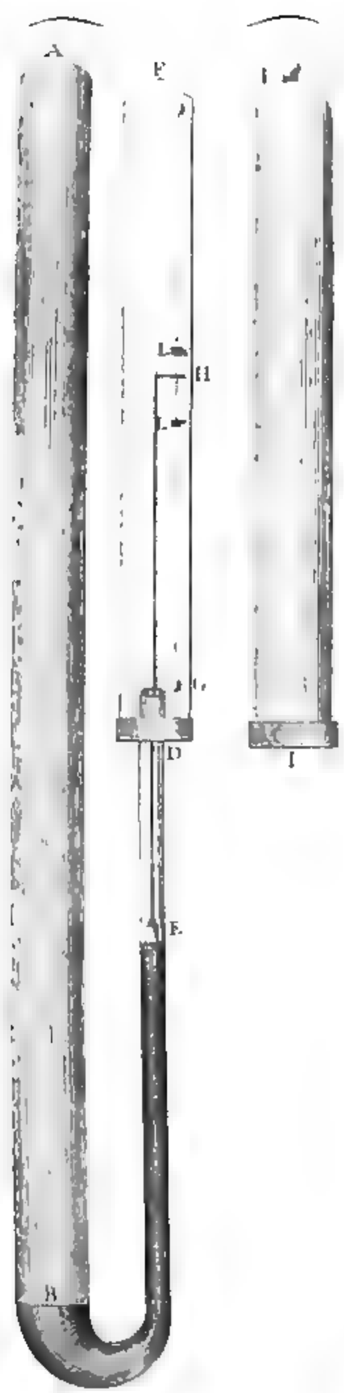

Fig 2d

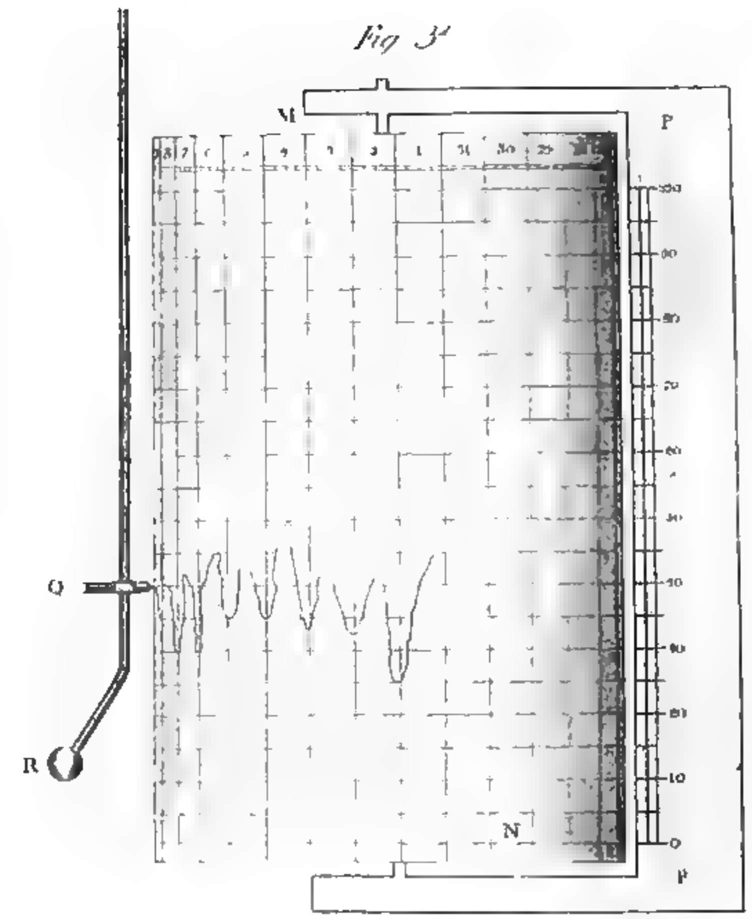

Fig 3d

Fig. 4th

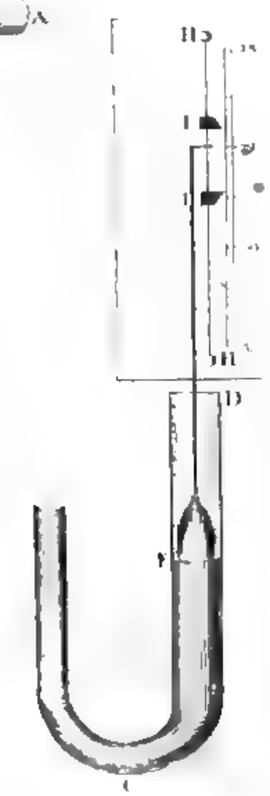

Fig. 5th

XI. Description *of a* Barometer, *which marks the* Rise *and* Fall *of the* Mercury *from two different* Times *of* Observation. *By ALEXANDER KEITH, Esq;* F. R. S. & F. A. S. Edin.

[*Read Jan.* 5. 1796.]

IN Auguft laft, I read to this Society the Defcription of an Air Thermometer, intended to record the various degrees of heat at every inftant; and mentioned my intention of conftructing a barometer, which would, in the fame manner, record the variations of the weight of the atmofphere: Both which I propofed to adapt to one piece of clock-work.

This piece of machinery appearing too complicated and expenfive for general ufe, I contrived a *thermometer*, which marks the extreme points of heat and cold from any two times of obfervation. Of which inftrument I alfo lately read an account, and produced the machine itfelf.

I now intend further to lay before this Society the defcription of a *barometer* upon fimilar principles, of a very fimple conftruction, which alfo marks the variation of the atmofphere from one time of obfervation to another.

 Fig. 1.

FIG. 4. ABCD is a glaſs tube, bent in the manner repreſented, open at D, and hermetically ſealed at A. From A to B is 8 inches long, and about $\frac{3}{4}$ of an inch caliber. From B to C $31\frac{1}{4}$ inches long, and about $\frac{1}{4}$ of an inch caliber. And from C to D $4\frac{1}{2}$ inches long, and $\frac{1}{2}$ inch caliber.

THE tube is filled with mercury, the length from B to E being $29\frac{1}{2}$ inches. When the tube is hung perpendicular, the mercury will fall from B to E, leaving a vacuum in the upper half of the tube from B to A. When the atmoſphere becomes heavier, the mercury falls in the tube DC, and when lighter it riſes. The range of the ſcale is about 3 inches, being equal to that of a common barometer of the beſt conſtruction, which has a baſon with a very broad ſurface. This inſtrument moves in a direction contrary to the common barometer, the one riſing while the other falls.

FIG. 5. repreſents the tube DC, with the ſcale placed above it, of half the real dimenſions. F is a piece of ivory or glaſs, of a conical ſhape, of a proper weight, made to float on the ſurface of the mercury, having a wire fixed to it reaching to G. From H to H is a piece of ſmall harpſichord-wire, or rather gold-wire, ſtretched along the ivory or braſs plate on which the ſcale is engraved. II are two indexes formed of the thinneſt black oiled ſilk, pierced in ſuch a manner by the ſmall wire as to move upwards and downwards upon it with a very ſmall force, not more than two grain weight; and theſe indexes, being not the weight of half a grain, they do not deſcend the wire by their own weight, but remain where they are placed.

THE wire fixed to the float, (which we ſhall call the float-wire), has a knee bent at a right angle, and made to encompaſs the ſmall wire between the two indexes, ſo that, when the float riſes, the upper index is carried up, and, when it falls, it leaves the upper index, and puſhes down the under index.

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In order to prepare this barometer for an obſervation, the one index is to be brought down, and the other raiſed, until both touch the knee of the float-wire.

The next time the inſtrument is obſerved, the upper index will point out the greateſt depreſſion of the mercury, or lightneſs of the atmoſphere, and the lower index the greateſt riſe of the mercury or weight of the atmoſphere, from the time the ſcale was prepared.

By this means the variations of the atmoſphere are much more truly pointed out than by the common barometer. For it often happens, that, during tempeſtuous weather, or before it, the mercury both riſes and falls within the ſpace of a few hours, or during the night time, which variations cannot be diſcovered by any of the barometers preſently in uſe.

During the late very high winds, in November and December laſt 1795, I have frequently obſerved the mercury to riſe and fall within the ſpace of two or three hours before the wind begins; and, during tempeſtuous weather, it will fall very conſiderably, and ſoon after riſe higher than before, and oſcillate, or rather undulate, upwards and downwards, the undulations becoming gradually leſs, until the atmoſphere is more ſettled; which ſhows, that, like other fluids, when put in agitation, it undulates till it come near an equilibrium; for it appears ſeldom to be in a ſtate of perfect tranquillity.

The ſudden fall and riſe, or even the riſe and fall of the mercury, always denote an extraordinary agitation in the atmoſphere. And therefore, to foretell tempeſtuous weather, it becomes of importance to obſerve how many degrees the one index is removed from the other; for example, at night, I take note of the common barometer as ſtanding at 29½ inches, and when I examine it in the morning find it at the ſame height; from which I naturally conclude, that, as there has been no agitation of the mercury, there will be calm or ſettled wea-

 ther.

ther. But, if I ufe the barometer before defcribed, and examine it in the morning, I find the common barometer has deceived me; for although the furface of the mercury ftands at 29$\frac{1}{2}$ inches, yet I obferve, that one of the indexes has been raifed $\frac{2}{10}$, and the other lowered $\frac{4}{20}$ during the night. Hence, inftead of denoting calm weather, it fhows that, the mercury having been agitated, tempeftuous weather is to be expected.

THE regifter of the weather, kept from an inftrument of this kind, will be much more fatisfactory than thofe hitherto ufed, and regifters kept at different places can be more accurately compared with one another.

THE levity of the atmofphere, at great heights, might alfo be difcovered, by fufpending this inftrument to an air-balloon.

XII.

XII. METEOROLOGICAL ABSTRACT *for the* YEARS 1794, 1795, *and* 1796. *Communicated by JOHN PLAYFAIR*, F. R. S. EDIN. *and Professor of Mathematics in the University of Edinburgh.*

[*Read at the Meetings in Feb.* 1795, 1796, & 1797.]

THE Journal of the Weather, of which an abstract is here communicated, has been kept in a house in Windmill Street, on the south side of Edinburgh. The latitude of Edinburgh College, as deduced from a series of astronomical observations made at Hawkhill, is 55°. 57′. 5″ nearly. Windmill Street is about 500 yards farther to the south.

THE barometer used in these observations is a portable one, of the construction invented by Dr LIND, physician at Windsor; the mercury was boiled in the tube, and the scale is divided into the five-hundredth parts of an inch. The place where it stands is 265 feet above the level of the sea, or of the mean high-water mark at Leith. The height of it is marked every morning at 10 o'clock, as well as that of a thermometer, in the same room, which gives the temperature of the mercury.

THE thermometer, which gives the temperature of the air, is placed on the outside of a window that looks towards the N. W. about

about 18 feet above the ſurface of the ground; and though, in a town, it is impoſſible to prevent local cauſes from affecting the thermometer, yet the current of air is generally ſo conſiderable as to prevent theſe irregularities from riſing to any great amount.

The regiſter contains the ſtate of the thermometer for three different hours of the day, viz. 8 A. M. 10 P. M and alſo about 2 o'clock, when the thermometer is higheſt. The hour of this laſt obſervation is not however fixed; it is ſuch as to give nearly the greateſt heat of the day, and varies from 1 to half paſt 2, or even 3 o'clock. The abſtract contains the greateſt and leaſt heights of the thermometer, that have been obſerved at any of theſe hours in the courſe of each month: It contains alſo the mean of the morning, mid-day, and evening obſervations; and likewiſe the mean of all theſe means, as being nearly the medium temperature of the whole month.

The rain is put down for 1794 and 1795 from a rain-gage kept in Edinburgh, and for 1796 from one kept in the Botanic Garden with great accuracy, under Dr Rutherford's particular inſpection. The Botanic Garden is half-a-mile north of Edinburgh, and about 100 feet above the level of the ſea.

In the remarks, reference is ſometimes made to the Meteorological Journal kept ſome years ago at Hawkhill, near Edinburgh, of which an account is given in the *Philoſophical Tranſactions of London* 1775, p. 462.

METEO-

METEOROLOGICAL TABLE FOR 1794.

Months.	Mean Height of the Bar. 8. A. M.	Mean Temp. of the Merc. in Bar.	Greatest Height of the Ther. in the Air.	Least Height of ditto.	Mean Height of Ther. 8 A. M.	Mean Height of Ther. at Noon.	Mean Height of Ther. 10 P. M.	Mean of the last three Means.	Quantity of Rain.
January,	29.661	49.30	51.5	21.0	39.32	41.43	41 20	40.65	1.40
February,	29.397	59.0	54.25	35.5	43.5	46.00	44.30	44.10	2.145
March,	29.631	51.00	53.0	38.5	44.43	48.09	45.93	46.15	0.995
April,	29.595	55.25	64.5	39.25	49.50	52.98	48.30	50.26	2.150
May,	29.752	56.32	62.0	42.0	50.22	56.16	47.22	51.20	1.910
June,	29.884	64.50	73.0	48.5	60.4	62.30	57.40	60.70	1.07
July,	29.768	66.70	75.0	52.0	61.7	66.42	58.61	62.24	2.12
August,	29.720	64.32	72.0	49.0	59.98	63.03	55.40	59.47	1.84
September,	29.662	58.71	64.0	41.0	54.90	57.45	52.06	54.08	3.14
October,	29.516	54.85	62.0	36.5	50.26	52.43	47.29	49.66	3.53
November,	29.416	48.90	53.5	32.5	43.58	45.54	43.47	44.19	4.51
December,	29.691	48.58	50.5	26.25	41.33	42.50	40.10	41.31	3.92
Means,	29.641	55.72			49.79	52.84	48.34	50.32	
Total Rain,									28.73

R E M A R K S.

THE weather in January and February 1794 was very mild and open. The prevailing winds were from S. W. and S. S. W.; usually a brisk steady gale, but sometimes more violent, particularly in February. The thermometer was as high as 50½ in January, and 54 in February; and once in January so low as 21, only for a short time, however, during a N. W. wind; the frost lasted some days. Very little snow fell. The temperature of these months was 6° or 7° above the mean of the Hawkhill observations. There was a great deal of clear weather, and, though the atmosphere was moist, there fell but little rain.

MARCH and April continued to maintain a superiority of 3 or 4 degrees in temperature above the same months in ordinary seasons. March was very dry, and the wind frequently in the east. In the end of April, the weather was squally, with the wind varying from S. W. to S. E.

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In May the heat fell down nearly to the common average of that month, viz. 50½, ſo that it ſeemed cold, compared with the reſt of the ſeaſon. The wind was often in the eaſt, and the nights cold.

June and July were very favourable: warmer than the mean by 1 or 2 degrees. In June, the temperature was remarkably uniform; and the wind was moſtly in the weſt. The weather in July was alſo fine; the wind moderate, and generally weſt.

The Harveſt began with Auguſt; the weather tolerable, though more rainy than uſual, and colder. The temperature of this month is almoſt 2° below the mean.

The wind was generally weſt; but a ſurface wind was to be obſerved at the ſame time blowing from the eaſt. This is often obſerved with us in the fineſt weather: it ſeldom fails to happen at the time of the great changes of the wind from the eaſt to the weſt.

September was rainy; its temperature rather below the mean, with eaſterly winds about the middle and end of the month.

October rainy; the wind variable, though moſtly S. W.; the barometer low; and the mean temperature 49°. 66, a very little under the mean.

November was warm for the ſeaſon, though rainy, with the wind variable, and often very high from S. W.

December was alſo warmer than uſual, by nearly two degrees: The wind was eaſterly till near the end of the month, when it changed to the N. E: A good deal of ſnow fell on the 25th; and, on the laſt day of the year, the thermometer, in the evening, was at 26: The weather clear, with little wind.

On the whole, the mean temperature of this year exceeded that of ordinary ſeaſons by almoſt 2°. This exceſs of heat is very conſiderable; but, as it fell chiefly in the winter months, it was not attended with any particular advantage. The rain that fell was 28.73 inches.

METEO-

METEOROLOGICAL TABLE FOR 1795.

Months.	Greateſt Height of the Bar. at 10 A. M.	Leaſt Height of the Bar. at 10 A. M.	Mean Height of Bar. 10 A. M.	Mean Temp. of Merc. in Barometer.	Greateſt Height of Ther. in the Air.	Leaſt Height of Ther. in the Air.	Mean Height of Ther. 8 A. M.	Mean Height of Ther. at Noon.	Mean Height of Ther. 10 P. M.	Mean of the three laſt Columns.	Quantity of Rain.	Days of weſterly wind.	Days of eaſterly wind.
	Inches.	Inches.	Inches.	°	°	°	°	°	°	°	Inches.		
Jan.	30.306	28.885	29.891	42.0	46.0	16.5	31.11	32.80	31.20	31.70	2.732	14	17
Feb.	30.450	28.636	29.484	41.8	40.0	21.0	30.14	30.89	28.46	29.83	3.875	16	12
March,	30.125	28.992	29.573	46.5	51.5	26.0	39.92	42.96	37.80	40.23	1.372	23	8
April,	30.146	28.948	29.503	52.0	56.5	39.0	47.09	49.52	44.73	47.11	2.110	16	14
May,	30.320	29.275	29.913	55.1	65.5	39.5	50.98	53.83	47.03	50.34	1.200	18	13
June,	30.272	29.128	29.743	57.5	67.0	42.5	54.49	57.17	50.54	54.06	3.920	10	20
July,	30.238	29.286	29.806	60.2	72.0	50.0	60.42	62.85	54.97	59.41	2.520	15	16
Aug.	30.040	29.210	29.674	64.2	73.5	52.0	61.11	64.21	58.58	61.30	3.620	24	7
Sept.	30.282	29.314	29.853	62.0	73.0	53.2	59.89	63.48	57.63	60.00	1.120	21	9
Oct.	29.944	28.340	29.280	57.5	63.5	44.5	53.66	55.55	51.48	53.56	4.870	23	8
Nov.	30.490	28.475	29.570	47.5	51.5	25.2	40.60	41.61	39.27	40.49	4.580	26	4
Dec.	30.220	29.080	29.560	50.5	55.7	36.0	45.43	46.23	42.96	44.87	3.810	25	6
Means,			29.654	53.1			47.90	50.04	45.44	47.75			
Totals,											35.729	231	134

THE mean temperature of the whole year is 47.75.

R E M A R K S.

THE winter of 1795 was remarkable for the ſeverity and continuance of the cold. The year began with a ſharp froſt, which had ſet in on the 26th of the preceding month, but which laſted only till the 3d of January, when the wind came round to the S. W. and was followed by a thaw. On the 10th the froſt returned, the wind varying from N. W. to N. E. with heavy falls of ſnow between the 15th and 20th. On the 20th the cold became very ſevere; and on the 22d the thermometer, about 8 in the evening, ſtood at $14\frac{1}{2}°$, the loweſt that I obſerved it during the whole ſeaſon. This intenſity of the cold laſted, however, but a ſhort time, for by 10 o'clock the thermometer had riſen to $16\frac{1}{2}°$. On the ſame night, in the Botanical Garden, which lies between Edinburgh and the Frith, and is about 150 feet lower than the place where I obferved, a thermometer, which marks its loweft point, according to the conftruction defcribed in the 3d volume of thefe *Tranfactions*, fell as low as 5°. The cold at Glafgow, on this night, was ftill more intenfe. Mr Profeffor Wilfon, who watched the motions of the thermometer, with his ufual diligence and accuracy, found it ftand at *zero*, from 11 at night till 3 in the morning, when it began to rife, and about break of day was at 10°.

THE night preceding this was alfo obferved, in fome places, to be remarkably cold. At White Hall, in Berwickfhire, 7 miles W. N. W. of Berwick upon Tweed, and about 38 E. S. E of Edinburgh, Mr HALL obferved the thermometer, in the open air, about 10 that evening, at 6° below *zero*. This was the greateft cold that I have heard of being obferved in Scotland; and is, at the fame time, an example of the locality of thefe great colds. The weather at this time was clear; the wind very gentle, between N. N. W. and N. N. E.; a great deal of fnow had fallen from the 15th to the 20th, and lay at this time more than a yard thick on the ground.

FROM about the 22d the intenfity of the cold relaxed gradually for feveral days; the thermometer was a degree above freezing on the 24th. From that time the cold increafed; on the 29th the thermometer was at 16½° in the evening; in the Botanic Garden at 4°; and at Glafgow, on the afternoon of the 30th, it was between 4° and zero for feveral hours together. This was again followed by a relaxation of the cold, though not fo confiderable as before. On the 5th and 6th of February it was again very cold, the thermometer here was at 19°, at Glafgow it defcended to *zero*.

AFTER another remiffion the cold became very fevere on the 13th, both here and at Glafgow. This was fucceeded by a fimilar change, only the remiffion was longer and more confiderable, fo that a good deal of fnow was melted on the 24th and 26th; but on the 27th and 28th the cold once more became fevere, the thermometer ftanding at 19 and 20 degrees. It continued much in this ftate till the 3d of March, when the wind came about to the S. W.; the thermometer rofe in the evening to 40½°; and a very moderate thaw fucceeded, which carried off the fnow, without any of thofe great inundations which did fo much mifchief in the fouthern part of the Ifland.

THE whole duration of the froft was 52 or 53 days; and the medium temperature, during that time, 29°.6. The alternate intenfions and remiffions of the cold, all the while were very remarkable; our climate feemed to lofe nothing of its ufual inconftancy, and its viciffitudes were only lower down in the fcale of heat. By this means, however, many of the bad confequences of a long and fevere winter were prevented. The infides of houfes were never fo much cooled, that fpirits or beer, or even water, was frozen in them. The room where my barometer is kept, though without fire, was never colder than 37°, and this only for a few days in the end of January. From the fame caufe, the mills in the country were rarely ftopped; and, except from the blocking up of the roads by the fnow, almoft no inconvenience was experienced.

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The roads were rendered impaſſable, both from the depth of the ſnow, and the degree of thaw which now and then took place, by which they became ſlippery, and uneven in the extreme. The whole ſnow that fell, reduced to water, meaſured 6.607 inches, which, had it fallen at once, would have covered the ground to the depth of about 7 feet.

THE ſeverity of this winter extended over all Europe; and, on the Continent, the freezing over of the Rhine and the Meuſe was accompanied with circumſtances that will be long remembered.

THE barometer was above 30.3 at the beginning of the froſt, and continued high till the end of January, notwithſtanding the heavy falls of ſnow, which came almoſt all from eaſt and N. E. On the 31ſt of January it fell greatly, with ſnow; and, during the firſt 12 days of February, it was generally below 29 inches. It ſtood at 30.4 on the 17th, from which it fell gradually till the thaw, when it was under 29.5. No connection could be traced between the oſcillations of the barometer, and the intenſions and remiſſions of the cold.

FROM the breaking up of the froſt on the 3d, till about the 20th of March, the ſnow did not diſappear entirely, even in the plains; it uſually froze a little in the night, and the medium temperature was under 38°. On the diſappearance of the ſnow, the thermometer roſe ſuddenly about 10°, which muſt be aſcribed to the ceaſing, at that time, of the abſorption of the latent heat, that had taken place during the melting of the ſnow.

THE ſpring which ſucceeded was tolerable; and the temperature of the latter part of March, the whole of April, and the beginning of May, rather above the mean. About the 10th of May the wind, which had for ſome time been in the S. W. came to the eaſt and N. E.; the weather, of courſe, was cold, and continued ſo, with the wind generally N. E. all the month of June, and till the 24th of July. June and July were alſo very rainy months. The weſterly winds prevailed in Auguſt, and the weather was good, though a conſiderable quantity of rain fell. September was uncommonly favourable; and the crop, which was extremely late, owed much of its maturity to this month. It proved, however, very ſcanty, and was got in but indifferently, October being a very rainy month.

NOVEMBER was cold, and very wet: On the 18th the rain was remarkably heavy, and was followed by the greateſt floods that had been known for ſeveral years. In December the weather became much milder, and ſomewhat leſs rainy; but, on the whole, the rain of this year very much exceeded the average, and amounted to 35.729 inches.

N. B. In the two laſt columns of the table for this year, it is marked whether the wind blew from the weſtern or eaſtern ſemicircle. The ſouth wind is ſuppoſed to belong to the firſt of theſe; the north wind to the ſecond.

METEO-

METEOROLOGICAL TABLE FOR 1796.

Months.	Greatest Height of the Barometer.	Least Height of the Barometer.	Mean Height of the Barometer.	Mean Temp. of the Merc. in Bar.	Greatest Height of the Thermometer.	Least Height of the Thermometer.	Mean Height of the Ther. at 8 A. M.	Mean Height of the Ther. at Noon.	Mean Height of the Ther. at 10 P. M.	Mean of the three preceding.	Rain in Inches and Decimals.	Days of westerly Wind.	Days of easterly Wind.
	Inches.	Inches.	Inches.	°	°	°	°	°	°	°	Inches.		
Jan.	29.792	28.175	29.194	50.0	56.0	35.0	43.94	47.12	45.94	45.66	3.280	30	1
Feb.	30.380	28.682	29.556	49.0	51.5	34.0	39.85	43.77	40.79	41.47	1.093	16	13
March,	30.408	29.375	28.886	48.5	51.0	30.0	38.35	43.88	38.67	40.30	.414	12	19
April,	30.208	29.040	29.873	56.0	68.25	41.0	48.37	55.40	47.49	50.42	1.156	16	14
May,	29.995	28.530	29.585	56.75	66.5	40.5	47.77	53.60	46.33	49.23	1.852	17	14
June,	30.100	29.315	29.662	59.0	73.0	47.0	53.80	60.20	52.23	55.41	1.070	26	4
July,	30.021	29.054	29.445	61.25	66.5	47.0	55.99	61.45	54.57	57.33	2.305	25	6
Aug.	30.240	29.316	29.828	64.75	74.25	50.0	58.86	68.50	57.22	61.52	.323	26	5
Sept.	30.166	29.362	29.739	61.62	70.5	45.5	54.85	60.12	54.63	56.66	2.187	18	12
Oct.	30.492	29.114	29.339	54.0	62.0	34.0	45.02	50.49	44.47	46.66	1.668	28	3
Nov.	30.322	29.026	29.638	47.75	48.5	26.0	39.0	42.00	39.40	40.13	2.393	19	11
Dec.	30.262	28.978	29.660	40.37	51.5	29.0	31.76	34.05	31.66	32.49	1.664	20	11
Means,			29.614	54.08			47.38	51.71	47.10	48.1			
Totals,											19.395	253	113

THE mean temperature of the whole year is 48°. 1.

R E M A R K S.

THE winter of this year was remarkable for its mildneſs, and, compared with that of the former year, may give an idea of the two extremes between which the winters of this part of the Iſland will generally be confined. About the middle of January, the thermometer ſtood for 10 days conſtantly above 50°, day and night; and the mean temperature of the month, viz. 45°. 6, is at leaſt 11° above the medium, and nearly the ſame with that of the ordinary January of Marſeilles. This extraordi-

nary

nary degree of warmth was maintained by a high wind, that blew conftantly from S. W. and S. S. W. bringing with it the air and temperature of the fouthern parts of the Atlantic. This wind prevailed over fuch an extent of the ocean, and blew with fuch violence, that it forced back a fleet of Britifh men of war, after it had endeavoured, in vain, for fix weeks, to make its paffage to the Weft Indies.

It muft be remembered, that the great cold of the preceding winter was with a wind N. N. E. and fometimes N. N. W which blew very moderately.

On the 23d of January there was a hurricane from S. S. W. that blew down trees and unroofed houfes: The barometer fell very low, and did not rife to its ordinary height for more than ten days.

In March the weather was cold, 5° below the middle temperature of February; eaft winds prevailed, and the premature appearances of vegetation, produced by the mildnefs of the preceding feafon, fuffered a fevere check. April was more favourable; but in May the weather again became cold, with eaft winds, remarkably dry and parching. The grafs every where fuffered extremely from this month.

On the 30th there was a hurricane at London, and at Portfmouth on the 31ft. On both thefe days the barometer here was very low, 28.53, though the wind was no more than a brifk gale at S. W.

In June the mean temperature was not fo high by 2° as in ordinary feafons. The wind, though weft, was ufually from the northern points of the femicircle.

July was worfe than June, and its mean temperature 3° under that of a tolerable feafon. Great apprehenfions were entertained for the crops, which, without the fine weather that fucceeded in Auguft, muft have been ruined. The heat of this month, which was at a medium about $61\frac{1}{2}$°, was not fo remarkable for being great as for being uniform; the thermometer, for a great part of the month, was not below 63°, even in the night. There was a great deal of funfhine, and the wind almoft conftantly W. S. W.

The firft half of September was little inferior to Auguft. On the 21ft, the wind, from the S. W. came round to the N. E.; a confiderable fall of rain followed, and the weather became colder, and continued to be fo in October: the medium temperature of which was 3 degrees lower than the average.

A smart froft fet in on the 29th of November, and next morning the thermometer ftood at 26°. This froft continued till the 10th of December, with an intenfity very unufual fo early in the winter. On the evening of the 5th the thermometer was at 21°. Between the 10th and 13th the froft had almoft difappeared; but it returned on the 14th with confiderable feverity, and continued till the 28th, when it broke up entirely. The thermometer was at 19° on the 26th, and in many places lower. The fame froft was felt in England, where there were local colds of much greater intenfity, the thermometer, in fome places, having been as low, it was faid, as — 10. A tract of very mild and open weather began on the 31ft of December.

The mean temperature of the whole year is 48°.1, about $\frac{1}{5}$ of a degree greater than the common average.

The greateſt ſingularity in this year is its dryneſs. The whole rain amounted to no more than 19.395 inches, not much above the half of what fell in 1795. This quantity of rain was, however, perfectly ſufficient for the purpoſes of vegetation, as the crop of corn was very plentiful.

END OF PAPERS OF THE PHYSICAL CLASS.

II.

PAPERS OF THE LITERARY CLASS.

I. *On the* ORIGIN *and* PRINCIPLES *of* GOTHIC ARCHITECTURE. *By Sir JAMES HALL, Bart.* F. R. & A. SS. EDIN.

[*Read April* 6. 1797.]

INTRODUCTION.

LONG after the arts of ancient Greece and Rome had been loſt, and before any effectual attempt was made to revive them, a ſtyle of building, known among us by the name of Gothic Architecture, began to appear in Europe.

AT firſt, a few only of its peculiar forms were employed, which, in ſome old buildings, are to be met with, intermixed with the remains of a ſtill more ancient ſtyle. Afterwards, riſing by degrees into favour, it ſupplanted, in all the departments of architecture, every other ſpecies of deſign, and maintained an unrivalled dominion during three hundred years.

In the early part of the ſixteenth century it underwent a ſudden reverſe of fortune; not, however, (I am inclined to think), from any diſcovery of its defects, or any inquiry into its merits, but entirely from the general temper of the times. A paſſionate admiration of the works of antiquity, which had then recently attracted the attention of the moderns, produced a contempt for whatever was not profeſſedly formed upon the models of Greece and Rome. At the ſame time, an indiſcriminate hatred againſt every production of the middle ages, ſtrongly felt by men juſt emerging from the gloom of that period, led them to overlook the merit of this very brilliant exception to its general barbariſm.

But the exceſs of theſe impreſſions has of late very much abated; authors of the greateſt eminence have teſtified a reſpect for Gothic architecture, by advancing various ſyſtems to account for its forms; and, whilſt they acknowledge the ſuperior excellence of the works of the ancient Greeks, they allow that, in airy lightneſs, and in bold grandeur of effect, thoſe of the Gothic ſtyle have not been ſurpaſſed, if ever equalled, by the moſt celebrated of our modern productions. The period, too, in which it prevailed, being at a diſtance from our times, and that diſtance being magnified in our imagination by the obſcurity of its hiſtory, we are inclined to rank its monuments with the works of remote antiquity, which ſeldom fail to excite even a greater intereſt than thoſe poſſeſſing the charm of novelty.

In concurrence with theſe favourable ſentiments, my object, in the following Eſſay, is to reſtore to Gothic architecture its due ſhare of public eſteem, chiefly by ſhewing, that all its forms may be traced to the imitation of one very ſimple original; and, conſequently, that they are connected together by a regular ſyſtem: thus proving, that its authors have been guided by principle, and not, as many have alleged, by mere fancy and caprice.

Having

HAVING endeavoured to inveſtigate the theory of Gothic architecture, I ſhall preſent a view of what I have been able to collect concerning its hiſtory; and, without pretending to diſpel the very deep obſcurity which ſtill ſurrounds this curious ſubject, I ſhall venture to ſuggeſt ſome hints, which may be of ſervice in guiding the reſearches of antiquaries. By this hiſtorical view, I hope, likewiſe, to refute an opinion, which has contributed greatly to diſcredit the Gothic ſtyle, namely, that it prevailed only in barbarous times; ſince I ſhall ſhow, that, although it made its firſt appearance in a period of that deſcription, it continued to flouriſh, while the arts of deſign were advancing in excellence, and ſtill maintained its pre-eminence, when they had attained to the higheſt degree of modern ſplendour.

LASTLY, by inſtituting, between the Gothic and other ſtyles, a compariſon, founded upon the general and fundamental principles of architecture, I ſhall endeavour fairly to appreciate its merits, and to ſhow the high eſtimation to which it is entitled, in point both of beauty and of utility*.

BEFORE

* THIS plan is now nearly completed, the whole Eſſay being written out, and accompanied with a ſet of drawings ſufficient to render it intelligible, but by no means in a ſtate for publication. To bring them to ſuch a ſtate muſt be a work of much labour and time, eſpecially ſince the nature of the ſubject has hitherto compelled me to execute all of them with my own hands.

I HAVE judged it adviſeable, therefore, to lay before the Society a part of the Eſſay, which requires but few drawings, while it announces the fundamental and eſſential views of the theory; reſerving the full illuſtration of it to another occaſion, when I hope to produce the whole in a ſeparate work.

IN the mean time, it may not be improper to obſerve, further, with reſpect to my general plan, that the firſt part, comprehending the theory of Gothic architecture, has been arranged under three ſubdiviſions; the firſt of theſe contains a view of its elements, all its forms being reduced to their ſimpleſt ſtate; the ſecond treats of the deviations from thoſe elements, which, in the courſe of practice, have been occaſioned by various circumſtances; and, the laſt, combining the other two, contains an examination

BEFORE we enter upon this inquiry, which is chiefly directed towards the investigation of a principle of Imitation, it will be proper to premise a few observations, on the mode in which the forms of nature have been introduced into works of art; a subject which hitherto seems not to have met with the attention it deserves.

ALTHOUGH the connexion between beauty and utility be still involved in such obscurity, that we are unable to decide concerning the universality of that connexion, of one thing we are certain, that, in a work intended to answer some useful purpose, whatever visibly counteracts that purpose always occasions deformity. Hence it is, that, even where ornament is principally intended, the ostensibly useful object of the work, if it have any such, must be provided for, in the first place, in preference to every other consideration.

BUT, in most useful works, some parts occur, the shape of which is quite indifferent with respect to the proposed utility, and which, therefore, the artist is at liberty to execute as he pleases; a liberty, which has opened a wide field to the taste and invention of ingenious men of every age and country, who have turned their attention to the composition of ornaments; and whose exertions have been more or less influenced by the state of civilization in which they lived. It would seem, however, if we may judge by those various efforts, that little has been effected by mere human ingenuity; since we see, that recourse has been had, almost universally, to Nature, the great and legitimate source of beauty; and that ornament has been attained, by the imitation

mination of the monuments of the art now in existence, and an application of our principles to every part of them.

THE present publication consists of the introduction to the whole Essay, together with the elementary part, illustrated by six plates.

imitation of objects, to which she has given a determinate and characteristic form.

THUS, among the Greeks, in the period of their highest refinement, we find the handles of vases in the shape of vine branches, or of serpents twisted round each other. Some urns of ancient Egyptian workmanship terminate in the head of an owl. The heads of our ships are decorated with figures of men and of animals; and the hatchets and canoes of Nootka Sound are covered with rude images of various natural objects.

THE imitation, however, in such cases, differs from that in a statue or in a picture. In the one, the sole object is to represent some natural object; whereas, in the other, the forms of nature have been partially adopted, and modified in various ways, in order to suit the useful destination of the work. In this manner, artists of every age have been led to select, among the forms of a natural object, such as answered their purpose, to the exclusion of the rest; and have exhibited modified imitations of nature, which, being justified by the circumstances of the case, do not suggest the idea of mutilation. Thus we meet with the foot of a table executed like that of a lion, or the hilt of a sword like the head of an eagle, without asking what has become of the body of the animal, and without being struck with any impropriety in the omission.

FREQUENTLY, where the materials employed are themselves possessed of variety and elegance, the object of ornament has been sufficiently attained, by allowing the natural forms, in whole or in part, to remain in the finished work. For instance, cups are made of shells, of cocoa nuts, or of ostrich eggs, the character and beauty of which depend upon the natural form of the materials. And in the case of the bottles, used by the Roman Catholic pilgrims, an example occurs of an utensil, in which the

the natural form has undergone little or no variation, ſince it conſiſts of the hard outward ſkin of a gourd, of the ſame ſhape in which it grew upon the plant*.

This laſt claſs of forms has been introduced, by Imitation, into works compoſed of ſhapeleſs materials. Thus we have ſilver cups in the form of thoſe made of ſhells, and fruit-diſhes of ſtoneware in the form of baſkets. The ancient Peruvian vaſes of pottery are executed in exact imitation of gourds; a practice which had probably ſucceeded the uſe of gourds as bottles. In ſuch caſes, the defect of real character in the object is ſupplied by a fictitious one, which, in the hands of a man of genius, is often productive of the moſt happy effects; ſince it enables him to confer upon his work the merit of conſiſtency, and truth of character; qualities, which influence the mind of the ſpectator as powerfully, when founded on fiction as on reality. For we judge of ſuch a work, as we do of a romance, in which we are ſcarcely leſs intereſted than if we believed it to be true.

We may now conſider the application of theſe principles to every kind of ornamental architecture. As ſtone is not naturally poſſeſſed of any peculiar ſhape, and as the uſeful object propoſed, by ſtructures formed of it, may be accompliſhed in various ways, very great latitude is left to the invention of the artiſt. We ſee, accordingly, that, in every country where much refinement has been introduced, great pains have been beſtowed in ornamenting ſtone buildings, with figures repreſenting various natural objects. It would ſeem, that the latitude has even been too great; for experience ſhews, that the [illegible] artiſt

* Even in this caſe, however, the natural form undergoes a certain degree of modification, by the device employed to produce the neck of the bottle. The fruit, while ſmall and tender, is ſurrounded with a ſtring, which remaining during its growth, prevents the part, thus bound, from ſwelling with the reſt.

artiſt has ſucceeded beſt, where his imagination has been circumſcribed, and forced into a regular channel.

For this purpoſe, recourſe has frequently been had to the device laſt mentioned; the building being executed in imitation of a ſtructure, compoſed of materials, which naturally poſſeſs a determinate and characteriſtic form. Such was the method followed by the architects of ancient Greece, who conſtructed temples, and other public edifices, in imitation of a ruſtic fabric, compoſed of ſquare beams, ſupported upon round poſts or ſtems of trees; and who derived the numerous ornaments of that beautiful ſtyle, from circumſtances which would naturally take place in ſuch a ſtructure*.

* That they really did imitate a building of wood, is ſtated, in the cleareſt manner, in the work of Vitruvius, particularly in his chapter, " De Ornamentis Columnarum." He there ſpeaks of architectural work in ſtone or marble, as a repreſentation, *(imago)*, and of the timber fabric as a reality, *(in veritate)*, as will appear by the following quotation.

" Itaque, in Græcis operibus, nemo ſub mutulo denticulos conſtituit, non enim poſſunt ſubtus cantherios aſſeres eſſe. Quod ergo ſupra cantherios et templa in *veritate* debèt eſſe collocatum, id in *imaginibus*, ſi infra conſtitutum fuerit, mendoſam habebit operis rationem. Etiamque antiqui non probaverunt neque inſtituerunt in faſtigiis mutulos, aut denticulos fieri, ſed puras coronas; ideo quod nec cantherii nec aſſeres contra faſtigiorum frontes diſtribuuntur, nec poſſunt prominere, ſed ad ſtillicidia proclinati collocantur.

" Ita quod non poteſt in veritate fieri, id non putaverunt in imaginibus factum, poſſe certam rationem habere. Omnia, enim, certa proprietate, et a veris naturæ deductis moribus, traduxerunt in operum perfectiones. Et ea probaverunt, quorum explicationes, in diſputationibus, rationem poſſunt habere veritatis."

In one reſpect, this paſſage is extremely obſcure, but, in another view, it is ſufficiently clear to anſwer the preſent purpoſe. The obſcurity ariſes from the difficulty, or rather impoſſibility, of diſcovering the meaning of ſeveral of the technical terms employed, theſe being very rarely uſed by authors, and relating to a mode of building different from any now practiſed. But, whilſt commentators differ as to the preciſe meaning of the words *cantherius*, *aſſer*, and *templum*, as uſed in this paſſage, they all agree in conſidering them as denoting parts of the timber frame of a roof. At the ſame time, *mutulus* and *denticulus* are well known terms of architecture, and appropriated

A FAINT and diſtant reſemblance, however, of the original, has generally been found to anſwer all the end propoſed by the imitation; a reſemblance, which may ſometimes be traced in the general diſtribution of the edifice, ſometimes in its minute parts, and not unfrequently in both.

BUT the forms of nature, thus introduced, have been greatly modified by thoſe of maſonry. For though ſtone is by nature ſhapeleſs, yet, in the courſe of practice, many peculiar forms have been long eſtabliſhed, and currently employed, in working it; ſuch as ſtraight lines, plain ſurfaces, ſquare angles, and various mouldings uſed to ſoften the effect of abrupt terminations; all of which, originating in motives of mechanical convenience, and of ſimple ornament, had, in very early times, been appropriated to maſonry, and conſidered as eſſential in every finiſhed work of ſtone; ſo that, when the imitation of nature was introduced, theſe maſonic forms ſtill maintained their ground, and, being blended with the forms of nature, the two claſſes reciprocally modified each other.

THIS combination of art with nature, of which we ſee the moſt perfect example in the Corinthian capital, produces what are

appropriated to buildings of ſtone. The latter part, which relates to the principle of imitation in general, is ſufficiently clear. The paſſage, in Engliſh, is nearly as follows:

"THUS, in the works of the Greeks, denticles were never placed under a modillion, becauſe it is impoſſible that the aſſeres can be under the cantherii. If, then, what is ſituated over the cantherii and templa *in reality*, be exhibited as under them in the *imitation*, the principle on which the work proceeds is belied.

"IN the ſame manner, the ancients never approved of, or directed, the introduction of modillions or denticles in the frontiſpiece, but preferred a plain cornice; for this reaſon, that neither the cantherii nor aſſeres lie towards the gable, nor can they project beyond it, but are placed with an inclination to the guttur.

"THUS, they eſteemed it a departure from principle to exhibit, in an imitation, what could not occur in reality. For in finiſhing their works, they introduced every ornament in an appropriated manner, and according to a real analogy borrowed from nature; and they approved of nothing, which could not be theoretically accounted for, on the principle of its reſemblance to truth."

are called architectonic forms, in which the variety of nature, being fubjected to the regularity of art, the work acquires that peculiar character, which, in a natural object, we confider as offenfive, under the name of FORMALITY; but which, in architecture, we admire as a beauty, under the name of SYMMETRY: thus, we reprobate the formality of an avenue, and praife the fymmetry of a colonnade.

SUCH is the nature of architectonic imitation; a device, which probably originated in accident, but to which architecture is indebted for its higheft attainments.

I WAS firft led by Mr BYRES, a very refpectable member of this Society, to obferve, among the remains of antiquity at Rome, many beautiful examples of the application of thefe principles by the ancients; and though my view of the fubject was then very obfcure, the theoretical folution of the queftion not having occurred till long after, I was fully aware of the very great practical advantages which they had derived from the employment of the principle of imitation.

OCCUPIED with this view of ancient art, as I was travelling through the weftern provinces of France, in my return from Italy, in the end of 1785, I was ftruck with the beauty of many Gothic edifices, which, far from appearing contemptible, after the mafterpieces of art I had feen in Italy and Sicily, now pleafed me more than ever. I was thus induced to believe, that thofe extenfive works, poffeffed throughout of fo peculiar a character, and fo eminent for unity of ftyle, could not have been carried on, unlefs the architects who built them, like thofe of ancient Greece, had been guided, in their execution, by fome peculiar principle; and being diffatisfied with all the theories of the art which I had heard of, I undertook the inveftigation, which has given rife to the following Effay *.

 CONCEIVING

* AFTER ftating my own views at full length, I fhall enumerate and examine the various opinions of others on the fubject of Gothic architecture, no lefs than five in

Conceiving that ſome ruſtic building, differing widely from the Grecian original, might have ſuggeſted the Gothic forms, I had made it my buſineſs to ſearch for ſuch a one, when the following accidental circumſtance greatly aſſiſted my ſpeculations.

It happened that the peaſants of the country through which I was travelling were then employed in collecting and carrying home the long rods or poles which they make uſe of to ſupport their vines, or to ſplit into hoops; and theſe were to be ſeen, in every village, ſtanding in bundles, or waving, partly looſe, upon carts. It occurred to me, that a ruſtic dwelling might be conſtructed of ſuch rods, bearing a reſemblance to works of Gothic architecture, and from which the peculiar forms of that ſtyle might have been derived †. This conjecture was at firſt employed to account for the main parts of the ſtructure, and for its general appearance only; but after an inveſtigation carried on, at different intervals, during the courſe of theſe eleven years, with the aſſiſtance of ſome friends, both in the collection of materials, and in the ſolution of difficulties, I have been enabled to

in number. At the time here alluded to, I was acquainted with an opinion, which I have ſince found to have originated with Dr Warburton, that the Gothic ſtyle was copied from an alley of trees. I was aware of the advantages of this theory in ſome eſſential points, yet it always appeared to me unſatisfactory in many others; and I conceive it to be at beſt far too vague to ſerve as a guide to the artiſt.

† This reſemblance, though very obvious in many caſes, has not, to my knowledge, been obſerved by any one but the late Mr Grose; to whom it ſeems to have occurred in a tranſient way. He makes uſe of the ſhape of a bower to aſſiſt his deſcription of a Gothic roof, (Antiquities of England and Wales, p. 75.); but he does not go ſo far as to aſcribe the architectonic forms to this origin; a view, which probably, would not have eſcaped him, had he not been preoccupied with a different one; for he conſiders the rudiments of a Gothic arch as formed " of two flat ſtones with their tops inclined to each other, and touching." I did not meet with this paſſage till ſeveral years after I had undertaken the preſent inquiry, and had carried it a conſiderable length.

to reduce even the moſt intricate forms of this elaborate ſtyle to the ſame ſimple origin.

In the preſent ſtate of the queſtion, the following inquiry muſt be conſidered as falling under the denomination of, what is called by Mr Stewart *, "*Theoretical Hiſtory*," and by ſome French authors, "*Hiſtoire raiſonnée;* being an attempt to trace, by conjecture, the ſteps through which an art has paſſed, in attaining the ſtate in which we obſerve it. Indeed it is probable, that few inveſtigations have been undertaken, which more completely correſpond to that definition, ſince, in moſt ſubjects of this kind, many ſteps of the progreſs are known, and nothing is required but to fill up, by theory, the interval between them; whereas, in the preſent caſe, as all direct teſtimony is wanting, and as no ſteps of the actual progreſs of the art have come to our knowledge, our opinions on the ſubject, hitherto, can only amount to preſumptions, founded upon the correſpondence of the theory with the monuments of the art now in exiſtence; and, the more numerous and complicated the caſes are, in which this coincidence takes place, the greater probability there is in favour of the ſyſtem.

But, though ſuch be the actual ſituation of the inquiry, we may hope to ſee it, hereafter, aſſume a different form; for, ſhould the conjecture, brought forward in the following Eſſay, carry with it ſufficient plauſibility to excite a ſpirit of reſearch among perſons beſt qualified to purſue the ſubject, there is reaſon to expect, that diſcoveries may be made, of a literary or architectural nature, by which its truth or falſehood will be eſtabliſhed beyond diſpute.

What has juſt been ſaid will, it is hoped, ſerve as my apology for having advanced a ſyſtem, which, ſtrictly ſpeaking, is founded on conjecture alone; and, on the other hand, for having enumerated a multitude of particulars, many of which might

* Biographical Account of Mr Smith.

might juſtly be conſidered as ſuperfluous, were the theory ſupported by direct teſtimony.

OF THE ELEMENTS OF GOTHIC ARCHITECTURE.

When we enter a Gothic church, our attention is firſt attracted by a double row of cluſtered pillars, compoſed of an aſſemblage of long and ſlender ſhafts, which, reaching from the ground nearly to the ſummit, there ſeparate and ſpread in all directions, forming the ribs or *groins* (as they are called) of a vaulted roof. In the meeting of theſe groins, and in the windows of the ſides and ends, we ſee the form of the pointed arch, the principal characteriſtic of Gothic architecture.

Such buildings have, I conceive, been executed in imitation of a ruſtic dwelling, conſtructed in the following manner:

Suppose a ſet of round poſts, (Pl. I. fig. 1. & 5.), driven firmly into the ground in two oppoſite rows, the interval between the neighbouring poſts in the ſame row being equal to that between the rows, and each poſt being raiſed above the ground to a height equal to three of thoſe intervals.

Then a ſet of long and flexible rods of willow, being applied to each poſt, (fig. 2. & 6.), let them be thruſt into the ground at its baſe, and bound to it by two tyings, one near the ground, and another at two-thirds of its height; the rods being left looſe, from this laſt point upwards, and free to be moved in any direction. Let three rods be connected with each outſide corner poſt, (as A or H of the ground-plan fig. 6.), and five with each

each of the others, (as B or G), and let their poſition be ſuch as to cover the inſide of the poſt, (as marked by little circles in fig. 6.), ſo that, when ſeen from between the rows, the lower part of each poſt ſhall be concealed from the view, and preſent the appearance of a bundle of rods, (fig. 2.).

Things being thus diſpoſed, the ſkeleton of a thatched roof may be formed, by means of the looſe ends of the rods. This is repreſented complete in Plate II. figure 15. & 16.; but the ſtructure being rendered intricate, by the mixture of different ſets of forms, I have, for the ſake of diſtinctneſs, deſcribed each of them ſeparately, and have repreſented them by ſeparate drawings, with each of which a ground-plan is connected.

A rod from one of the poſts, being ſo bent as to meet a ſimilar one from the poſt immediately oppoſite to it, in the middle of the ſpace between them, let the two rods be made to croſs each other, and let them be bound together at their croſſing, (Pl. I. fig. 3.). Thus will be produced the exact form of the Gothic arch. The ſame being done with each pair of oppoſite poſts, and a ſet of pointed arches being formed, let them be connected together by means of a ſtraight pole, laid upon the forks of the croſſing-rods, and bound to each of them, (fig. 7. & 11.).

Then let a looſe rod be brought from each of any two contiguous poſts in the ſame row, ſo as to form a pointed arch, ſimilar to that juſt deſcribed, and nearly of the ſame height. This being done with every two contiguous poſts, (fig. 8. & 12.), and a new ſet of pointed arches being thus produced, ſtanding oppoſite to each other in pairs, let each pair be bound by a horizontal pole lying on the oppoſite forks, and croſſing the longitudinal pole, deſcribed above.

Two of the rods of each corner poſt, and three of thoſe of each of the others, being thus diſpoſed of, we have one of each corner poſt, and two of each middle poſt ſtill to employ;

ploy; which is done as follows: A pair of theſe unoccupied rods being brought from any two poſts which ſtand diagonally to each other, (A and F, fig. 6.), and made to meet in the middle, not as in the firſt caſe, croſſing in an angle, but ſide by ſide, forming a ſemicircle, and joined together after the manner of a hoop, (fig. 4.); and the ſame being done with every pair of diagonal poſts, (fig. 9. & 13.), the whole rods will have been employed.

Each of the three ſets of arches having thus been ſeparately deſcribed, (fig. 7, 8, & 9,), the complete ſtructure, in which they are all combined, may eaſily be underſtood, (Pl. I. fig. 10. and 14., and Pl. II. fig. 15, & 16.).

In this manner a frame would be conſtructed, fit to ſupport thatch or other covering, and ſuch a one has probably been often uſed. It would ſeem, however, that, for the ſake of ſtrength, the number of rods has been increaſed in each cluſter, by the introduction, between every two of them, of an additional rod, which, riſing with them to the roof, ſtill continues its middle poſition, as they ſpread aſunder, and meets the horizontal pole at an intermediate point. This is ſhown in Plate III. figure 19, which is drawn with its covering of thatch; and the ſame is expreſſed in the correſponding ground-plan, figure 20.

From the imitation of a dwelling, ſo conſtructed, we may now trace the three leading characteriſtics of Gothic Architecture, the pointed arch, the cluſtered column, and the branching roof, (Pl. II. fig. 17, & 18., and Pl. III. fig. 21, & 22.)*.

The

* In buildings of ſtone, the arch or groin, which joins the diagonal piers, is very generally a real ſemicircle, like that in the willow ſtructure juſt deſcribed; as I have found to be accurately the caſe at Beverley and Melroſe. This rule of execution, with the deviations from it, which we meet with occaſionally, will be fully conſidered in a ſubſequent part of the Eſſay; in which it will be ſhown, that in the uſual roof, where the diagonal groin is a ſemicircle, it becomes the regulator of all the reſt, determining their height and form in every reſpect.

THE ruſtic fabric might thus be covered completely, but would not be habitable, unleſs the openings of the ſides and ends were cloſed, ſo as to reſiſt the weather. This might eaſily be accompliſhed, by means of baſket-work, covered, as is ſtill practiſed in many countries, with a mixture of clay and ſtraw. In order to furniſh ribs for the baſket-work, a ſet of upright rods would be thruſt into the ground below, and bound to the arch above, dividing the opening into ſpaces reaching from top to bottom, (Pl. IV. fig. 23.), which, being filled up with twigs wattled through them, would be entirely cloſed, (fig. 24.), and the work would be tolerably ſtrong. It might however be thought adviſeable, for the ſake of greater ſtrength, to ſplit all the upright rods, down to the level of the points at which the main rods of the opening ſeparate from their reſpective poſts; or, to borrow a term from architecture, down to the level of the impoſts of the arch; and then to carry the half rods, ſo ſplit, acroſs the reſt, in ſuch a manner as to afford the opportunity of repeatedly binding them to each other, (fig. 25.).

BUT were the ſpaces all ſhut in this manner, the houſe would be rendered abſolutely dark. It would therefore be neceſſary to provide for the admiſſion of light, which might be done, without materially weakening the ſtructure, by omitting ſome of the wattled work in the middle, ſo as to leave part of the ribs open and bare, (fig. 25.).

THESE naked ribs ſeem to have ſuggeſted the forms of the ſlender bars of ſtone, called Mullions, which conſtitute the frame-work of the glaſs, in all Gothic windows; the moſt common example of which may be ſeen in (fig. 27.).

THE window, in the fabric of ſtone, as well as in that of willow, being very conſpicuous, would naturally become an object of attention in point of beauty. Accordingly we find, that, in the compoſition of Gothic edifices, much pains have been beſtowed in ornamenting the windows, by the introduction of a number of figures, which are often extremely elegant, and ſometimes ſurpriſingly complicated, though without confuſion; for they can all be traced to ſome variety or modification of the ſimple elements juſt laid down ; as will be ſhown, when we treat of the more complicated works of Gothic architecture ; at preſent, it is neceſſary to mention only one other deſign.

In this window, (fig. 26.), the halves of the neighbouring rods are brought to meet, but not to croſs, and are bound together ſo as to touch each other, back to back ; next, the halves of each rod being brought together again, they are bound face to face ; then again ſeparated, and bound a ſecond time back to back, with the halves of the neighbouring rods ; and ſo on, till the whole ſpace is filled with a ſet of regular and equal compartments, bounded by waving lines, (fig. 26. & 29.).

The form of the Gothic door may be traced to an origin ſimilar to that of the laſt mentioned window. One pair of rods, (fig. 31.), being brought from the poſts which form the upright ſides of the door, are made to meet in a pointed arch, in the manner deſcribed above ; then, another pair of rods, longer than the firſt, and connected with the ſame poſts, are brought to meet above them, and are bound together face to face, like the half rods in the laſt mentioned window ; the ſpace between the two pairs of rods being occupied by a circular hoop.

The repreſentation of the upper pair of rods, when dreſſed with ſome ſmall ornaments, as in many Gothic buildings, produces a moſt elegant effect. Figure 33. is a door of St Mary's, Beverley, reduced from a drawing taken on the ſpot, at my deſire, by Mr J. Halfpenny.

The form of the ſteeple, however various and apparently different from what has hitherto been mentioned, can eaſily be reduced

duced to the fame principles. The common fteeple, or fharp pointed fpire, feems to have for its origin fimply eight long and ftraight poles thruft into the ground, one in each of the angles of an octagon; and fo inclined, that they all meet in a point, directly over the centre of the bafe, and raifed above it four or five of its diameters, the rods, thus placed, forming together a very acute octagonal pyramid, (fig. 34.). The original object of a ftructure of this kind would probably be mere ornament, as it is not calculated to anfwer any purpofe we know of, unlefs it were to fupport a bell. Perhaps the firft works of this kind, even thofe executed in ftone, were placed upon the ground; but as a fpire is feen to beft advantage from a diftance, an architect would naturally think of raifing it in the air, by placing it on the fummit of a tower; which is the cafe with all the fpires of this kind I have feen. Figure 35. is a view of the fpire of Tuxford in Nottinghamfhire.

Besides the rectilineal fpire, we fometimes meet with others of a curved form, which may be accounted for in a manner no lefs fatisfactory, as fhall be fhewn in a fubfequent part of this Effay.

Having now taken a view of all thofe parts of Gothic architecture, which conftitute its folid mafs, it remains, in order to complete the elements of the art, that we confider two fets of fmall ornaments, which very often occur, and which, though not neceffary in theory, nor univerfally obferved in practice, arife naturally from the principles already laid down, and contribute very much to give to Gothic architecture that peculiar appearance by which it is diftinguifhed. Both thefe ornaments may be traced to the effects of time upon the materials employed in the conftruction of our ruftic fabric; one fet being connected with the vegetation of the rods, and the other with their death and confequent decay.

As it would frequently happen, that the willow rods, thruſt into the ground, would ſtrike root and grow, the architect ſeems to have taken advantage of this circumſtance, by repreſenting them as decorated with buds and tufts of leaves, whenever he thought that ſuch ornaments could be introduced with good effect.

THIS practice has been very generally followed in the execution of the door, as in that exhibited in figure 33. the upper part of which is a repreſentation of living rods, covered with tufts of leaves, like thoſe in actual vegetation, (fig. 32.). Upon the ſpire, too, a ſet of ſmall projections, placed at regular intervals, often occur, as in that of Bunny, in Nottinghamſhire, (fig. 37.), which ſeem to be the repreſentation of buds ſpringing from the poles of the original, (fig. 36.).

THESE ornaments, known by the name of *Crockets*, when placed on the ſloping part of doors, ſteeples, pinnacles, &c. and of *Finials*, where they form a tuft on their ſummit, univerſally and unequivocally repreſent foliage. The leaves, it muſt be owned, however, ſeldom reſemble thoſe of trees, but more commonly ſome plant of the cabbage kind. On this occaſion, the artiſt has uſed the freedom to deviate from the ſtrictneſs of the imitation, and has contented himſelf with adhering to the general idea of foliage. But, in ſo doing, he has been in a great meaſure juſtified by the circumſtances of the caſe; for the foliage of a tree, eſpecially that of the willow, being compoſed of a multitude of ſmall and detached parts, could not, without much difficulty, be executed in ſtone, and would produce a very frail and periſhable work, which could only be placed with advantage in very protected ſituations. He has thus been induced, in moſt caſes, to chooſe ſome plant having a maſſy and compact form, better adapted to ſculpture. This however is not without exception, as we do meet ſometimes with crockets

kets formed of the leaves of various trees, eſpecially of thoſe of the vine; as may be ſeen in York-Minſter in ſeveral places; particularly in that very intereſting collection of pediments and pinnacles, ſurrounding the inſide of the nave and its aiſles. Theſe are executed with amazing delicacy and elegance, and with ſuch fertility of invention, that, though eighty-eight in number, not only every two of the pediments, but every two crockets on the ſame pediment, differ from each other *.

UPON

* ONE of theſe pediments, with its pinnacles, crockets, and finials, executed on a large ſcale, may be ſeen in that beautiful collection of the ornaments of York-Minſter, now publiſhing in numbers by Mr HALFPENNY: in which work, likewiſe, are many other things applicable to the preſent ſubject. I am happy to have it in my power to bear teſtimony to the faithful accuracy with which the objects are there repreſented, from having examined ſeveral of the originals in that view, in the courſe of laſt ſummer, (1796), particularly that of Plate XLI. of which I made a drawing myſelf, in company with Mr HALFPENNY; ſo that I can vouch for its exactneſs in every reſpect. I have been induced thus particularly to mention the ſubject, by a ſuſpicion mentioned in Mr HALFPENNY's ſeventh number, concerning the accuracy of his drawings; ſome gentlemen having imagined, that he had placed the ſculpture in too advantageous a light. To this he anſwered, that "in truth he has not been able, "in many inſtances, to come up to the ſpirit and elegance of the originals." A declaration no leſs true than it is modeſt. I am well convinced that the gentlemen, with whom this ſuſpicion has originated, have not been much accuſtomed to examine our Gothic buildings of eminence, ſince, in any of theſe, they would have met with numberleſs works, executed in too high a ſtyle of deſign to admit of embelliſhment in the preſent ſtate of the arts. Nor is it wonderful that ſuch ſhould be the caſe, when we reflect, that they belong to the 14th and 15th centuries; during which, a ſeries of artiſts flouriſhed in Italy, who, in point of chaſte deſign, and careful imitation of nature, have never ſince been equalled, though they had not attained to many of the refinements which were introduced in the ſubſequent age. Theſe artiſts travelling over Europe, contributed greatly to the ornament of the Gothic edifices which were then building, as we learn from many curious facts collected by Lord ORFORD, in his Anecdotes of Painters.

I SHALL enter more fully into this ſubject, when I ſpeak of the Hiſtory of Gothic Architecture; and I am led to touch upon it now, though out of place, in order to call the attention of men of taſte to the fate of numberleſs beautiful ornaments of the

UPON the monument of King JOHN I. and Queen PHILIPPA, in the church of Batalha, are two canopies of frittered-work, conſtructed in a manner which I ſhall endeavour to explain in a ſubſequent part of this Eſſay. The lower part of each of them conſiſts of an arch of contrary flexure, like that of the door of St Mary's, Beverley, (fig. 33.), but ornamented in a manner ſomewhat different, having, in place of the crockets, a ſet of leaves, in form and arrangement, greatly reſembling thoſe of the willow *.

WHOEVER

the Gothic ſtyle, which are daily periſhing by the exertions of a miſtaken zeal in their favour.

EVERY year, great ſums are beſtowed in dreſſing up the old churches, in many parts of England, much to the detriment of theſe noble edifices. In ſome caſes, this is done by beſmearing the building with white or yellow paint, which chokes and confounds all the delicacy and elegance of the ſculpture. This evil, however, is not of the deepeſt kind ; ſince, here, the original forms of the work remain entire, and may be again reſtored to their purity, when a better taſte prevails. But an injury of a much more ſerious nature is occaſioned by the operation of chipping, in which the maſon, with a barbarous hand, actually goes over the whole work, and chiſels off the ſurface to a certain depth, leaving but a poor ſhadow of the original form. By both operations, the building acquires the harſh and glaring appearance of new work ; which, however, is removed in a few years, by the influence of the weather, and the edifice recovers its former grandeur, as far as colour is concerned. But the havock committed by chipping is quite irreparable ; for the ſculpture, when once removed, can return no more.

I HAVE been told, in vindication of this practice, that the forms of the old work were reſtored exactly as they originally ſtood. An idea worthy of the ſimplicity of MUMMIUS the Roman general, who demoliſhed Corinth. As if it were in the power of every ſtone-cutter to replace a maſter-piece of the 15th century !

I WAS happy to find, at York, that a different ſpirit prevailed in the operations carrying on in the Minſter. In all theſe repairs, the ancient ſculpture has been moſt ſcrupulouſly reſpected ; and, in many places, the ſtone has been carefully freed from its load of paint, ſo as to reſtore it to its original purity. For theſe attentions, the public is greatly indebted to the good taſte and judgment of the Rev. Mr EYRE, one of the reſidentiaries.

* SEE Mr MURPHY's admirable publication ; a work to which I ſhall have very often occaſion to refer, when I ſpeak of the more complicated forms of Gothic architecture.

Whoever pays any attention to Gothic architecture, muſt obſerve, in the upper part of moſt windows, an ornament projecting from the bars, formed by two curved lines meeting in a point. It would be difficult to deſcribe this form in words, but it may be underſtood eaſily by figures 27, & 28. of Plate IV. which repreſent two contiguous windows of St Mary's, Beverley; in one of which the bars have been executed plain, and in the other they have been ornamented in this manner. Figure 30. is the window that lately ſtood in the chapel of Holyroodhouſe at Edinburgh, and figure 29. the ſame general form executed quite plain, as it ſometimes occurs. As this ornament has not, that I know of, been characteriſed by any peculiar name, I ſhall apply to it that of *cuſp*, by which mathematicians denote a figure of the ſame kind *.

It was long before any ſatisfactory explanation of this form occurred, though the frequency of its appearance, and the uniform manner in which it is introduced in all Gothic works, left little room to doubt that it had an origin, in common with the more ſubſtantial forms of the ſtyle. At laſt a friend ſuggeſted to me, that it may have been borrowed from the appearance aſſumed by the bark of the rods, when about to fall off, in conſequence of decay. With this view, having attended particularly to branches in a ſimilar ſituation, I have met with ſeveral facts, which tend to confirm this conjecture. The dead branches of every kind of tree, after being expoſed to the weather during three or four years, throw off their bark, which, immediately before it drops, curls into various ſhapes, owing

* Assemblages of theſe cuſps are ſpoken of in the deſcriptions of Gothic works, by the names of trefoil, quadrefoil, ſemi-trefoil, &c. but no proper word has been uſed to deſcribe the form, wherever it occurs, or however combined. This, I truſt, will ſufficiently apologiſe for the liberty I have taken, of introducing a new term into architecture.

An application of the word cuſp, as uſed by mathematicians, may be ſeen in Dr Smith's Optics, Vol. I. p. 172. where he uſes it in deſcribing the cauſtics formed by reflection.

owing to the unequal contraction of its different layers. This takes place varioufly in different woods; in fome, the bark bends inwards, in fome outwards, in fome acrofs the branch, and in fome lengthways. I have had occafion to obferve, that, univerfally, the bark of the willow bends concave outwards, and lengthways with refpect to the branch. One of the firft diftinct examples I met with, of this kind, was on a rail at St Mary's Ifle in Galloway, in the fummer of 1792, (Pl. V. fig. 38.). The rail had been made entirely of frefh willow, and the pofts had all ftruck root, having then the third year's growth upon them; the horizontal bars had died of courfe, and were in the act of lofing their bark. This, in fome places, was feen feparated from the wood at one end, and adhering to it at the other, forming a gentle and continued curve with the mafs of bark, which ftill remained attached to the wood; fome pieces of bark, a few inches in length, had feparated at both ends, and remained adhering only by the middle; in fome places two contiguous pieces of rifing bark met, and exhibited a fhape very much refembling that of the cufped ornament which I have juft defcribed. In the fummer of 1795, I faw, at the fame place, a ftill more ftriking example of this, upon an upright poft of willow, (fig. 40.), in which the two pieces of curling bark formed, together, a cufp from nine inches to a foot in length. In a few days, the under piece of bark fell off; but the upper one remained for more than a month, lying clofe to the wood during rain, and rifing from it when the weather was dry. Figure 39. reprefents a large branch, which I cut from an old willow, having the curled bark upon it, and which, being kept dry, ftill retains its fhape.

There is great reafon to fuppofe, that this accident has fuggefted the cufped ornament: For if we fuppofe a window of the willow houfe, (fig. 41.), in the fame ftate of decay with the rails juft mentioned, to have come under the obfervation of an architect

tect of genius, in the habit of borrowing all his ideas from a houſe of this kind, and eager to ſeize upon whatever contributed to add beauty or novelty to his work, it is natural to believe, that he would take advantage of the circumſtance, by imitating, in ſtone, the curling bark; and this being executed with that regular ſymmetry, which architecture beſtows upon the natural objects it repreſents, (fig. 42.), would produce a light and elegant effect, and the ornament would ſoon become general.

We know that to ſuch accidents, the architecture of the Greeks was indebted for many of its principal embelliſhments; of which the origin of the Corinthian capital is a ſtriking and authentic example.

Finding that all the eſſential parts of Gothic architecture could thus be explained, by tracing its origin to the imitation of a very ſimple ruſtic edifice, I was deſirous of ſubmitting the theory to a kind of experimental teſt, by endeavouring actually to conſtruct a building ſuch as has been deſcribed. With the help of a very ingenious country workman*, I began this in ſpring 1792, and completed it, in the courſe of the winter following, in a manner which far ſurpaſſed my expectation, and which has already met with the approbation of ſeveral Members of this Society. The method of conſtruction anſwered ſo well in practice, that I doubt if a better could be followed, with ſuch ſimple materials; and ſo primitive is the mode of execution, that I believe, with a little ingenuity, the whole might be executed without the help of a ſharp inſtrument, or of any materials but ſuch as the woods afford.

A set of poſts of aſh, about three inches in diameter, were placed in two rows, four feet aſunder, and at the interval of four

* John White, cooper, in the village of Cockburnſpath, in Berwickſhire.

feet in the rows. Then a number of ſlender and tapering willow rods, ten feet in length, were applied to the poſts, and formed in the manner already deſcribed, into a frame, which being covered with thatch, produced a very ſubſtantial roof, under which a perſon can walk with eaſe *.

THIS little ſtructure exhibits, in miniature, all the characteriſtic features of the Gothic ſtyle. It is in the form of a Croſs, with a Nave, a Choir, and a north and ſouth Tranſept. The thatch, being ſo diſpoſed on the frame, as not to hide the rods of which it is compoſed, they repreſent accurately the pointed and ſemicircular arches, and all the other peculiarities of a groined roof. The door is copied from that of Beverley. The windows are occupied by a number of deſigns, executed, (by means of ſplit rods), in exact reſemblance of thoſe which actually occur in various Gothic edifices. Round each window is a border of compact wicker-work, which, by deepening the ſhade, adds greatly to the general effect. At a little diſtance ſtands the ſpire, formed of eight ſtraight poles of willow planted in the earth, and riſing in an octagonal pyramid to the height nearly of twenty feet. Various other Gothic forms are likewiſe introduced, which being of the more complicated kind, will be explained in a ſubſequent part of this Eſſay.

THE appearance of the whole, whether ſeen from within or from without, bears, I flatter myſelf, no ſmall reſemblance to a cathedral.

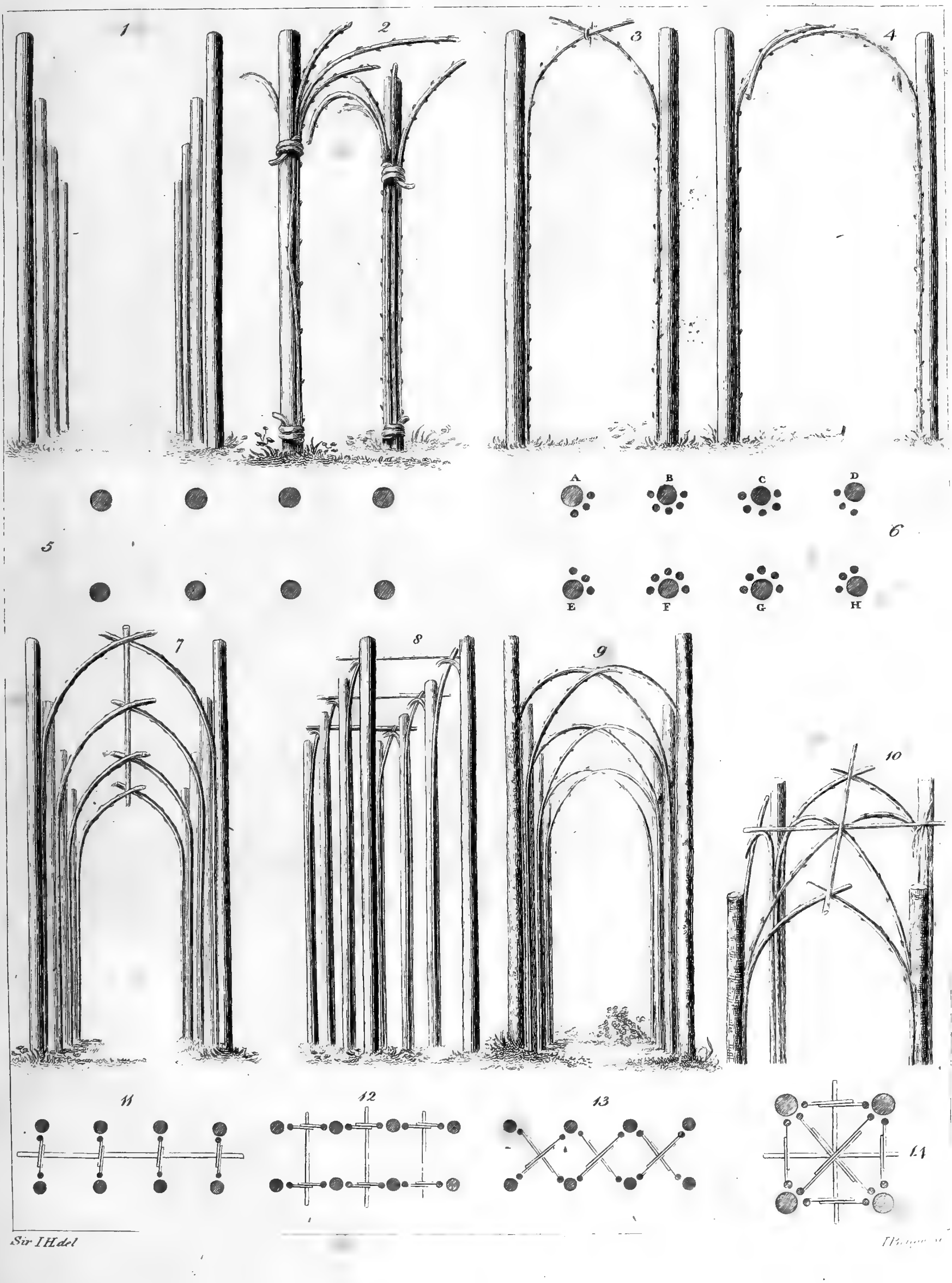
IN the courſe of ſpring and ſummer 1793, a great number of the rods ſtruck root, and throve well. Thoſe of the door, in particular,

* THE roof, being protected from the weather, is ſtill in perfect preſervation, though it has now ſtood about five years; but the windows and other parts, which are more expoſed, are going faſt to decay, though they have been often repaired. Soon after the work was finiſhed, a very accurate drawing of it was made by an ingenious young artiſt, Mr A. CARSE, which it is propoſed to engrave for the illuſtration of this Eſſay, when publiſhed at full length.

particular, produced tufts of leaves along the bent part, exactly where they occur in ſtone-work; the vegetation did not however reach, as had been wiſhed, to the very ſummit, but was more than ſufficient to juſtify an artiſt in the execution of doors like that of Beverley, (fig. 33.). Three of the rods of the ſteeple, alſo, ſent out buds, at ſmall intervals, to the height of eight or ten feet from the ground, ſo as, at one ſtage of their growth, to reſemble the budded ſpire already deſcribed.

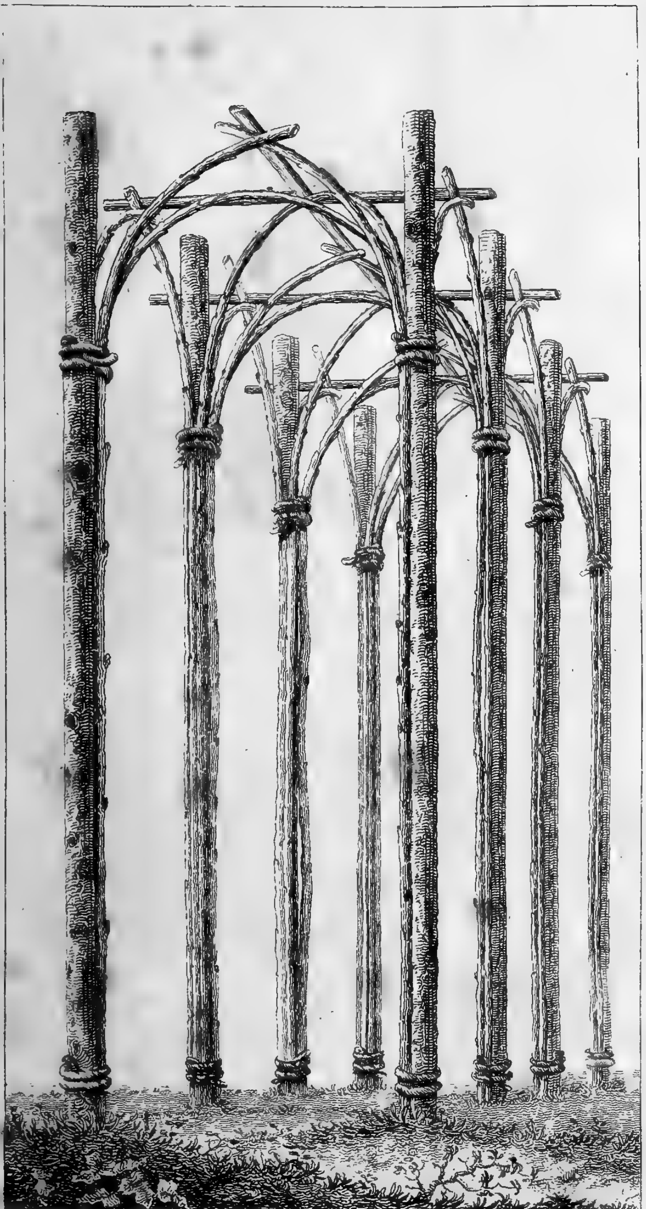
I HAVE likewiſe had the ſatisfaction, in the courſe of laſt autumn, (1796), of finding one entire cuſp formed by the bark in a ſtate of decay, in a place correſponding exactly to thoſe we ſee executed in Gothic works.

IN this manner, all the original forms of Gothic architecture may be accounted for. But they ſeldom occur in the ſtate of ſimplicity, which, in order to facilitate their deſcription, I have hitherto ſuppoſed; for, in a Gothic edifice, they are for the moſt part complicated by varieties in execution, and by intermixture with each other. They have been modified, likewiſe, and ſometimes diſguiſed, by the circumſtances attending the tranſition from wicker-work to maſonry, which have occaſioned changes, both in the general deſign of theſe works and in the execution of their minute details. I ſhall endeavour to ſhow, however, (in the work I have already announced), by an examination of the actual monuments of the art, that the moſt intricate of theſe forms may be traced to the ſame ſimple original. But to accompliſh this, it will be neceſſary previouſly to inveſtigate the tranſition to Maſonry; an inquiry too extenſive to be compriſed within the limits of an academical memoir.



Sir I H del

Plate II



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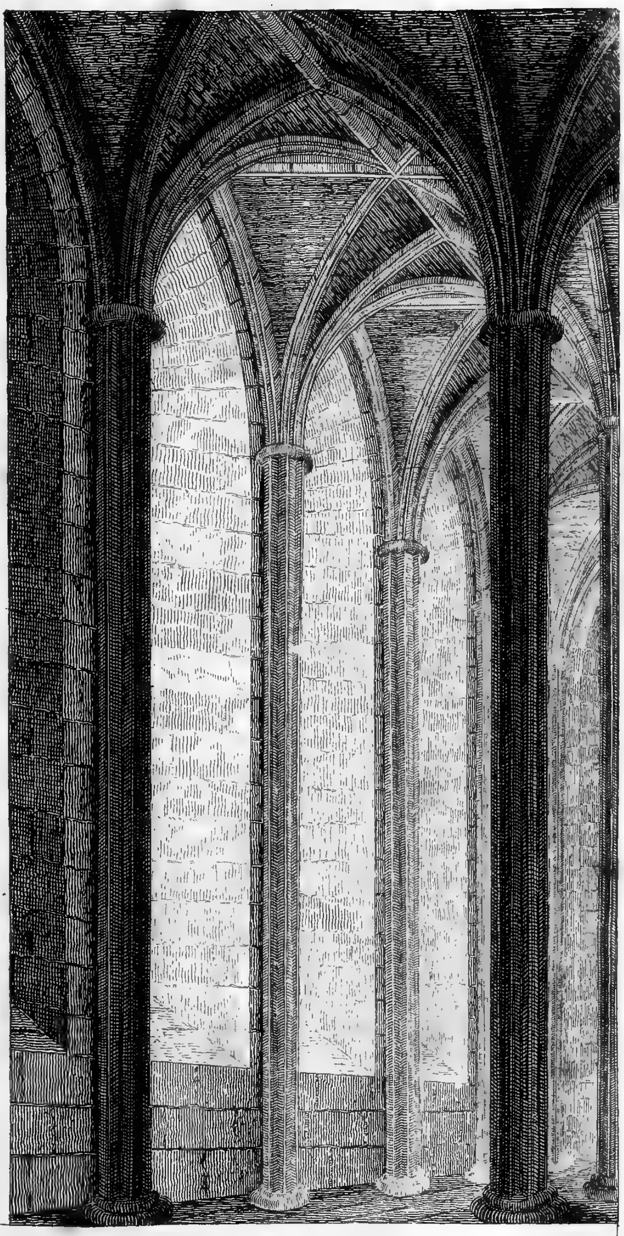

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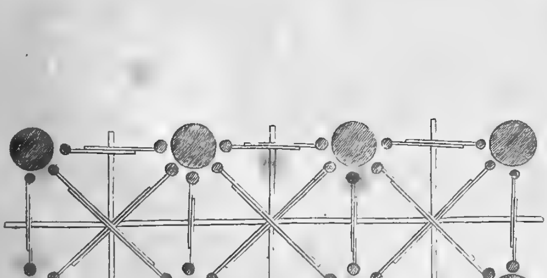

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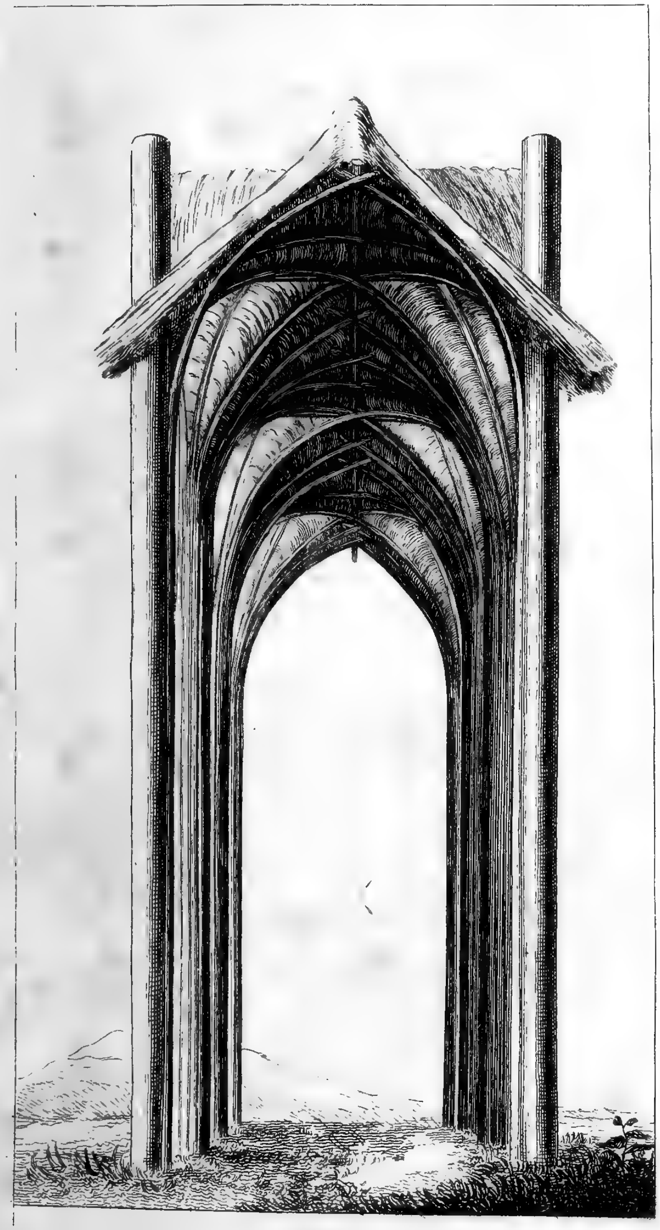
Sir I.H. del.　　　　　I.Beugo sc.

Plate III



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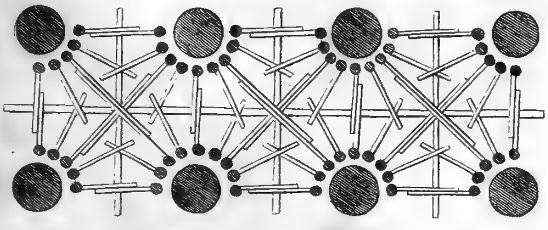

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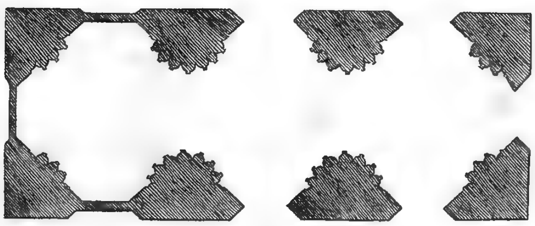

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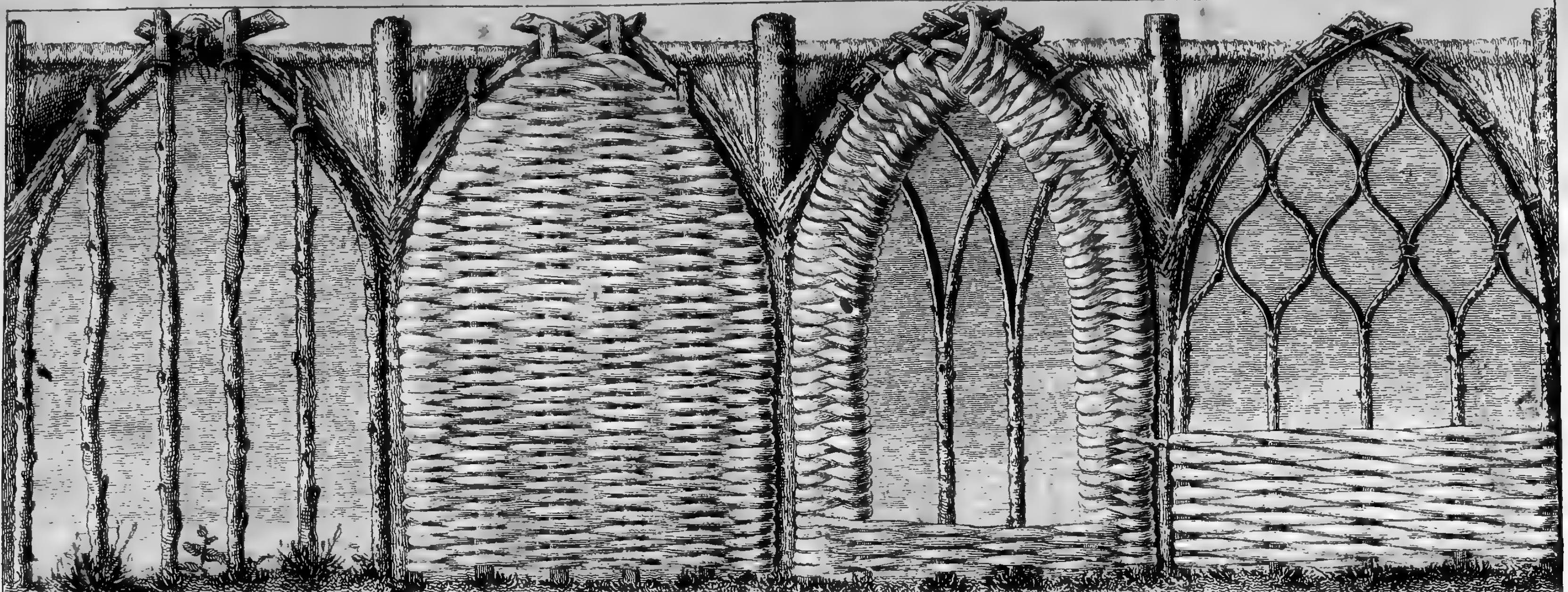
Sir I H. del. *I Beugo sc.*

Plate IV



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Sir I.H. del. 27 28 29 30 I.Bugo sc

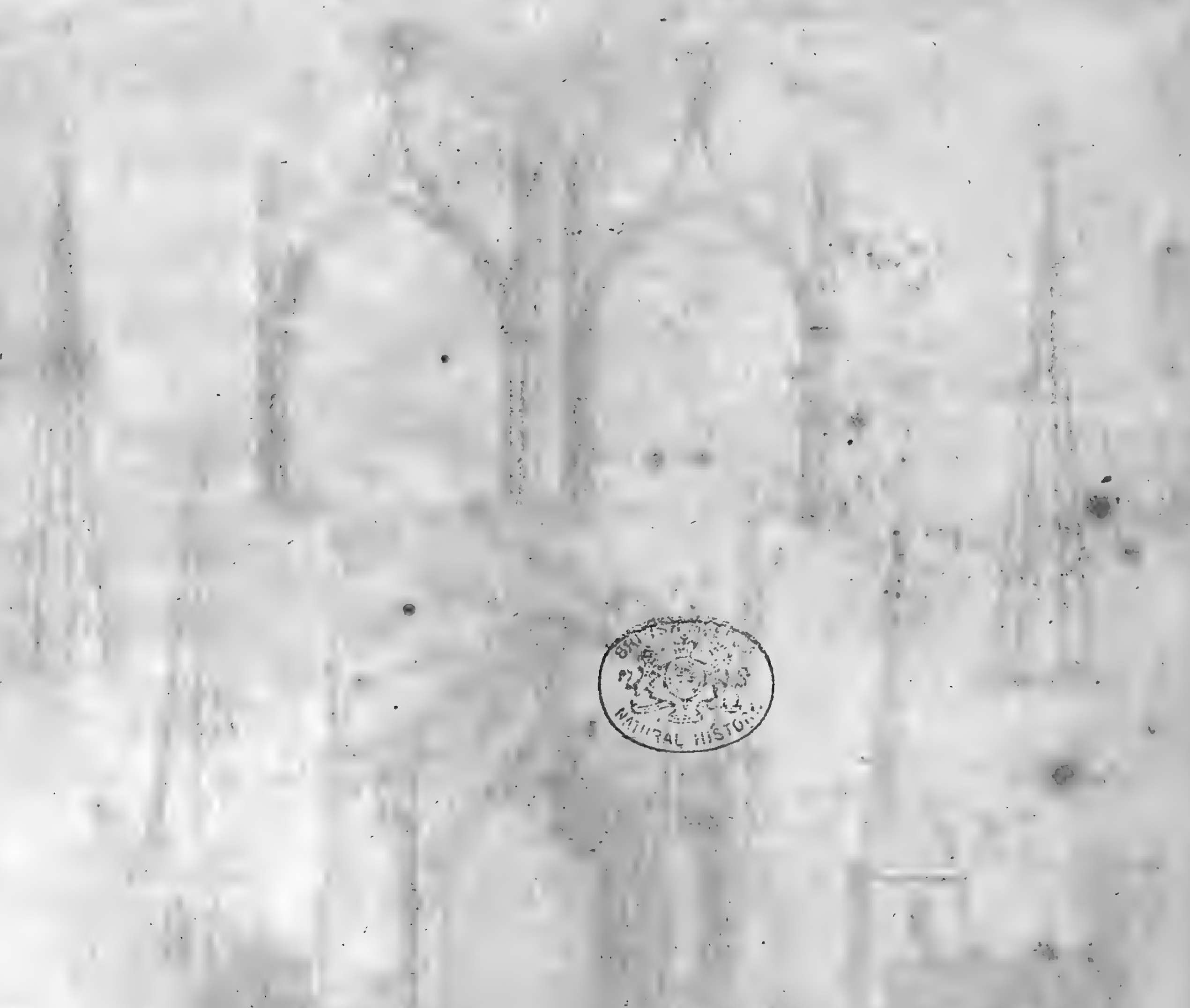
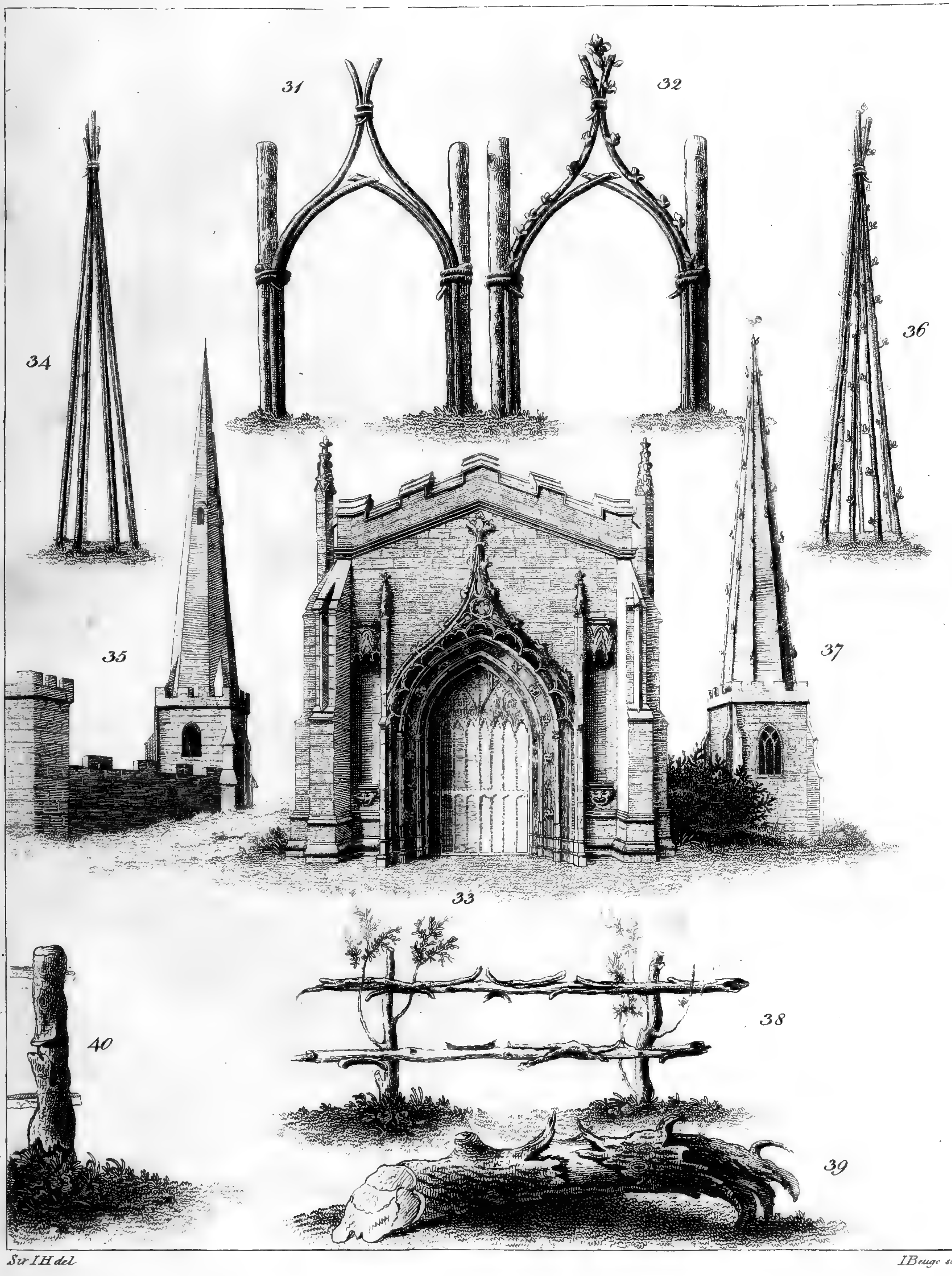


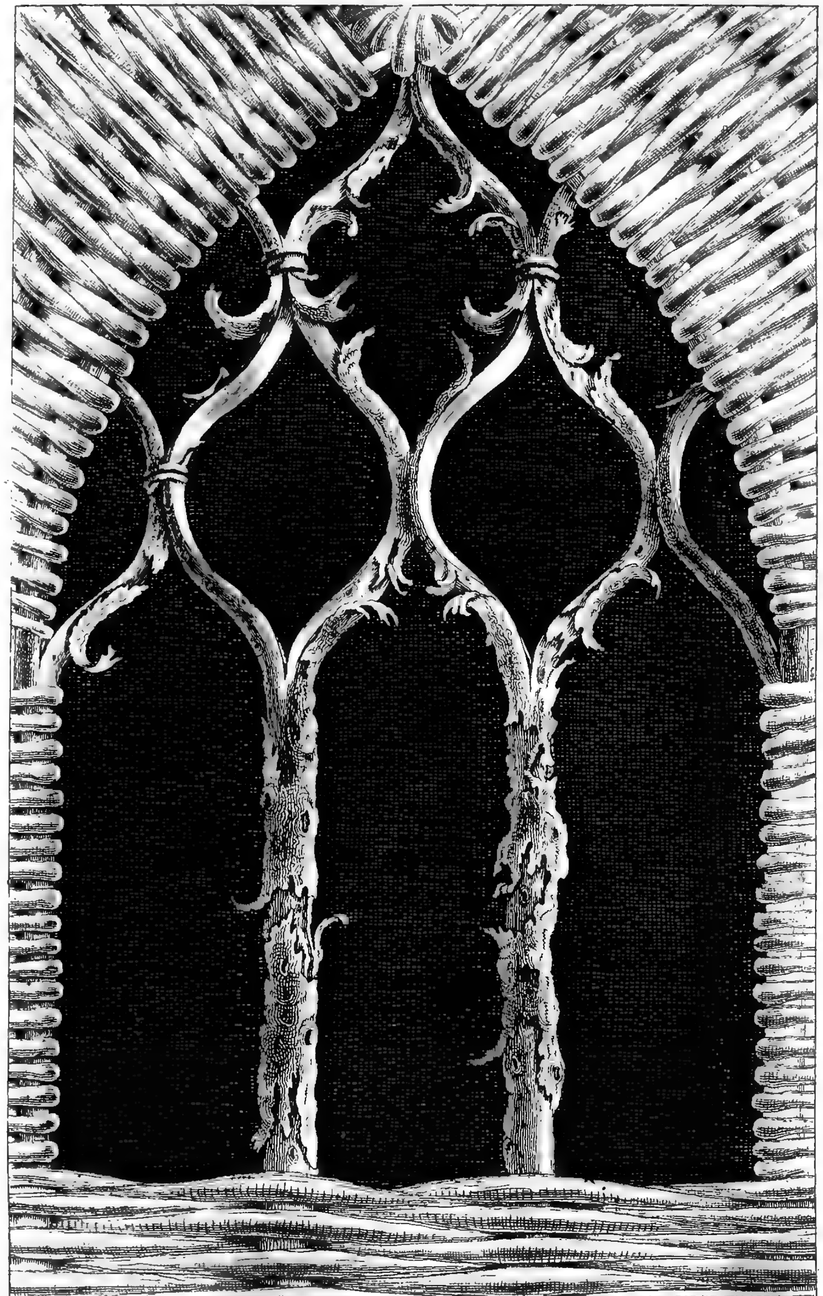
Plate V



Sir I H del

I Beuge sc

Plate VI



Sir J.H. del

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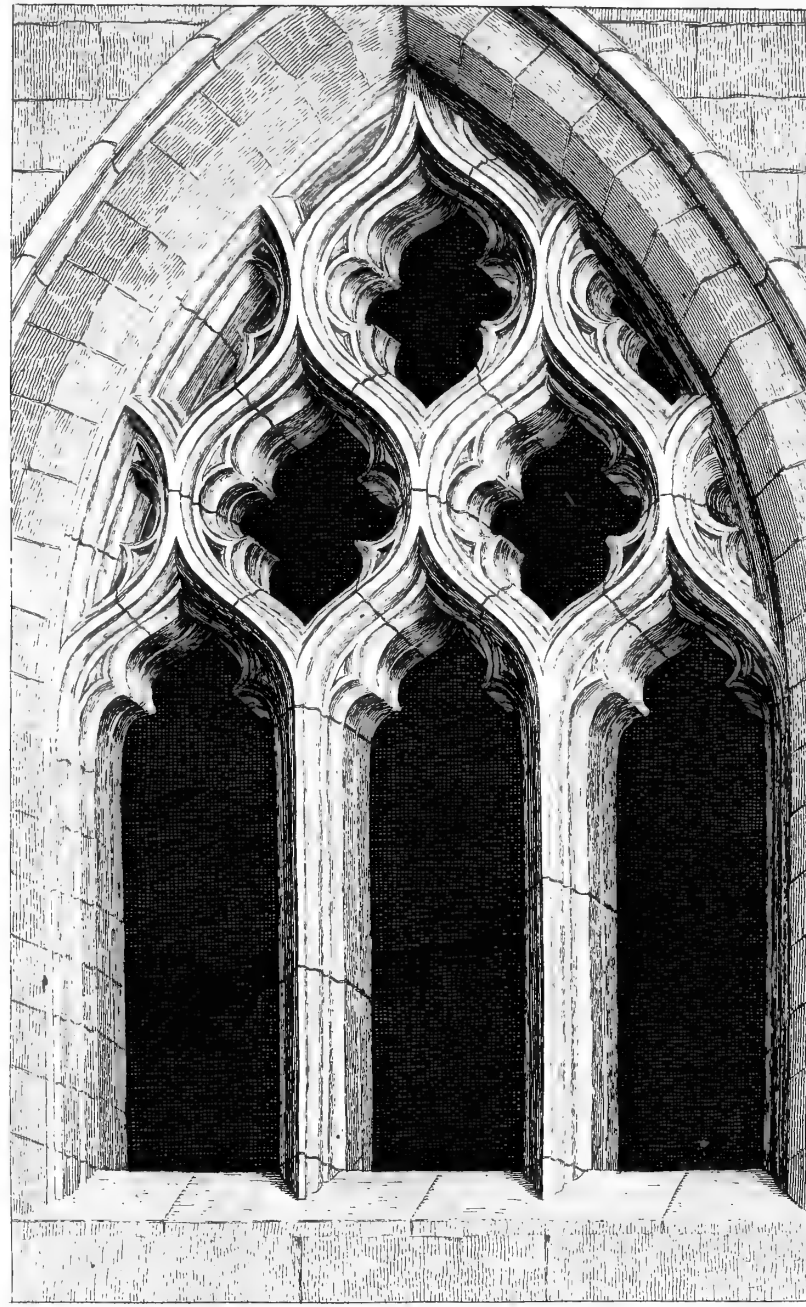

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I.Beugo sc

II. *M. CHEVALIER'S* TABLEAU de la PLAINE de TROYE *illustrated and confirmed, from the* OBSERVATIONS *of subsequent* TRAVELLERS, *and others. By ANDREW DALZEL,* M. A. F. R. S. EDIN. *Professor of Greek, and Secretary and Librarian in the University of Edinburgh.*

[*Read Sept.* 4. 1797.]

AS the Members of this Society afforded to M. CHEVALIER an early and warm encouragement and patronage, and readily gave his *Tableau de la Plaine de Troye* a place in their Transactions*, as well as admitted the author to a seat among their number; and as that paper, since the time of its publication, has excited a good deal of interest and speculation, they will, no doubt, hear with pleasure, that it has now received, at least in all its material circumstances, a most ample and satisfactory confirmation.

THE author, previous to his departure from England, in May 1796, had expressed an anxious desire that a second edition of the English version of his Essay should be published, improved from some materials I had collected, and by such amendments as he should communicate. But as this could not be done, without

* See Vol. III. Lit. Cl. p. 1, &c.

without a new arrangement with the bookſellers, and as an obſtacle occurred which rendered a delay neceſſary, I have thought that it would, in the mean time, be agreeable to the Society to have a ſhort Abſtract of the moſt material contents of the Eſſay, as now confirmed by ſubſequent travellers, laid before them, preceded by an account of the manner of its firſt reception, of the communications of thoſe travellers, and of certain objections that have been made to it; and followed by an Appendix, containing the papers and letters referred to in the foregoing detail.

Account of the Reception which the Deſcription of the Plain of Troy at firſt met with.

M. CHEVALIER, after his return from the Eaſt, and before he came to Edinburgh, viſited Paris, where he found the late M. l'Abbé BARTHELEMY, author of the *Travels of the Young Anacharſis*, to whom he gave ſome account of his excurſions into the Troad. That celebrated and reſpectable ſcholar was ſo much pleaſed with the light he received, on this occaſion, concerning that famous claſſical region, that he introduced M. CHEVALIER to a party of his friends by the title of *le Reſtaurateur de la Troade:* and it is probable that, if he had been favoured with M. CHEVALIER's information previous to the publication of his great work, he would have embelliſhed his book with a more ſatisfactory deſcription of the Troad, than he found himſelf able to do from the imperfect and inaccurate accounts formerly given of it.

IN the year 1792, when the Diſſertation in queſtion, which the author had read in French before this Society, was publiſhed in the Engliſh tranſlation of it, which, at his own deſire, and with the approbation of the Council of the Society, I had made, it ſeemed to give great ſatisfaction to claſſical readers in general.

ral. In Germany, even before it was publiſhed, it had found a warm ſupporter in the celebrated Profeſſor HEYNE of Gottingen, with whom the author became acquainted, in a tour he made in that country, ſoon after he had read the original of his paper in the meetings of this Society. Having no copy along with him, when he went into Germany, he endeavoured to give Mr HEYNE an idea of his reſearches in the Troad, as diſtinctly as he could from recollection, aided by ſome travelling journals which he had retained in his cuſtody. He found the ſubject extremely intereſting to Mr HEYNE, whoſe attention had been for ſome time particularly turned to the poems of HOMER, of which he had projected a new edition upon the plan of his Virgil, ſo favourably received by the Public. At the united deſire of the author and Mr HEYNE, with the approbation of the Council of this Society, I firſt tranſmitted a printed copy of the tranſlation, with notes, to Gottingen, before the work could be publiſhed here, and afterwards a copy of the maps, immediately upon their being finiſhed by the engraver.

MR HEYNE was highly gratified with M. CHEVALIER's diſcoveries, and pleaſed with what he conſidered as the very liberal manner in which they had been conveyed to him. That his countrymen might partake of the ſatisfaction he had received, he employed Mr DORNEDDAN, a young promiſing ſcholar, to tranſlate into German the *Deſcription of the Plain of Troy* from the Engliſh verſion. The greateſt part of the notes, which I had ſubjoined, were alſo tranſlated by the ſame ingenious ſcholar; a preface and further illuſtrations by Mr HEYNE himſelf, with an Eſſay on the Topography of the Iliad, and a Diſſertation by Mr KAESTNER on the Height and Shadow of Mount Athos, were added; and the whole publiſhed in Germany in an octavo volume, almoſt as ſoon as the Engliſh verſion, with notes, appeared in England*.

It

* See Appendix, No. I.

It had been perufed alfo, before publication, by feveral gentlemen of learning and tafte in this place, who had defired to fee it; fome of whom expreffed their fatisfaction in converfation, and others in writing: and, after publication, I received letters from feveral eminent claffical fcholars in England, by whom M. Chevalier's labours were highly approved of. Some of thefe teftimonies I have happened to preferve*.

But though M. Chevalier's refearches, thus given to the public in Englifh and in German, and afterwards in the French original in the third volume of the Tranfactions of this Society, were received in the moft favourable manner by claffical fcholars in general; yet fome, who had long before acquiefced in the account of the prefent appearance of this claffical region given by the late Mr Wood, could not conceive how that ingenious obferver fhould have gone fo completely aftray on the ground as had been alleged; and were difpofed to think, that an enthufiaftic admiration of Homer, common to M. Chevalier with many perfons of fenfibility and tafte, might have prefented to his fancy circumftances, and fcenes and appearances, of which a cool and unbiaffed examiner might not have perceived the reality.

Of the Communications of fubfequent Travellers, and of certain Objections that have been made.

I had reafon, therefore, to confider it as a fortunate circumftance, that, towards the end of the year 1793, Mr Robert Liston, my own moft intimate friend ever fince a very early period

* In a card from Mr Home, author of *Douglas*, &c. (who ftill takes great delight in ftudying his favourite poet Homer, particularly the Odyffey), I find the following expreffion: "I have read over your tranflation of M. Chevalier's Difcourfe, "which is the moft fatisfactory inveftigation and criticifm I ever read." See Appendix, No. IV.

period of life, was, after being employed in various honourable public miſſions, appointed by his Majeſty Ambaſſador to the Sublime Porte. Having the pleaſure of meeting with him previous to his departure for Conſtantinople, I requeſted that he would endeavour to find an opportunity of paying a viſit to the Troad, with M. CHEVALIER's book in his hand. This I found to be already his own inclination, as he ſtill retained a fondneſs for claſſical learning, in which he had greatly diſtinguiſhed himſelf, when a ſtudent formerly at this Univerſity. I only regretted that my own ſituation rendered it impracticable for me to accept of a moſt kind and tempting invitation to be the companion of his voyage. In the courſe of our correſpondence, after he had been ſome time at Conſtantinople, I had the ſatisfaction to receive from him a ſhort letter, incloſing two others from Dr SIBTHORPE and Mr HAWKINS, written immediately after an excurſion they had made to the plain of Troy, and confirming the principal circumſtances of M. CHEVALIER's diſcoveries. He afterwards tranſmitted extracts from another letter of Mr HAWKINS relative to the ſame ſubject, to all of which I ſhall have occaſion to refer*.

IN the beginning of laſt year Mr BRYANT publiſhed his *Obſervations upon a Treatiſe entitled, A Deſcription of the Plain of Troy, by* M. CHEVALIER, of which he did me the honour to ſend me a copy, accompanied with a letter. It appeared that this learned gentleman had, antecedently to the publication of M. CHEVALIER's Eſſay, been engaged in the compoſition of a *Diſſertation concerning the War of Troy, and the Expedition of the Grecians, as deſcribed by* HOMER, *ſhewing that no ſuch Expedition was ever undertaken, and that no ſuch City of Phrygia exiſted:* but finding that the new *Deſcription of the Plain of Troy*, by gaining credit in the world, might be likely to prevent the ſucceſs of his learned labours, he deemed it adviſable to employ his talents

* See Appendix, No. V.

lents in an attempt to invalidate and remove this obſtruction, in order to pave the way for his *Diſſertation;* which now at length has likewiſe made its appearance, and of which I have alſo received a copy from the learned author.

I AM now ready to admit (as, in a ſhort correſpondence with Mr BRYANT, on the firſt glance of the former of theſe productions, I promiſed to do, if afterwards, upon a careful peruſal of that pamphlet, I ſhould ſee good cauſe), that he has diſcovered what now appear to me to be inaccuracies and inadvertencies in ſeveral parts of M. CHEVALIER's performance, and ſome errors in the notes which I had written. For, upon topics and inveſtigations, where hypotheſis muſt ſometimes take place, and where arguments may not always be concluſive, it is not to be wondered at if a perſon of Mr BRYANT's learning and ſagacity ſhould have detected a few improprieties and inaccuracies. But after a careful peruſal, which I have now given both to his *Obſervations*, and his *Diſſertation*, I cannot bring myſelf to go along with him in his views of this ſubject; nor can I be perſuaded, by any thing Mr BRYANT has written, to give up the pleaſure received from remarking the ſtriking ſimilarity between thoſe ſcenes, which ſtill exiſt, and the deſcriptions which occur in the poems of HOMER. This ſimilarity has been traced by Mr HEYNE, in a moſt convincing manner, in his *Eſſay on the Topography of the Iliad;* a valuable piece of inveſtigation, which of itſelf appears to me completely to refute all Mr BRYANT's radical objections to M. CHEVALIER's Eſſay*. I ſhall therefore decline following the learned gentleman through the minute parts of his elaborate performances, which indeed I want time as well as inclination to do: but ſhall content myſelf with introducing a few remarks upon his *Obſervations*. I moſt readily reſign every attempt at framing an anſwer to his *Diſſertation;* as I find he has met with two antagoniſts much better qualified to enter the liſts with him

* See Appendix, No. III.

him than I am, the acute and ingenious Mr WAKEFIELD *, and a learned anonymous reviewer in the *Britiſh Critic* †.

MR LISTON being to return from his embaſſy at the Porte, towards the concluſion of the year 1795, I was glad to find, by a ſhort letter, that he himſelf had made an excurſion to the Troad; and underſtanding that a new edition of M. CHEVALIER's Eſſay was projected, he deſired it might be deferred till he ſhould come home, as he had ſome obſervations to communicate which would render the work more perfect. When I met with him at Edinburgh he was very much hurried, owing to his being under the neceſſity of ſetting off ſoon for America, as his Majeſty's Plenipotentiary to the United States. He nevertheleſs devoted a few hours to the reviſal of M. CHEVALIER's Eſſay, whilſt I ſat by him and took notes of his remarks. As a great many of theſe conſiſted of ſmall alterations of various parts of M. CHEVALIER's deſcriptions, with a view to condenſe them where they ſeemed too diffuſe, and to correct them where they ſeemed inaccurate, it would be tedious at preſent to enter into a particular detail. But, in the caſe of a new edition of the Eſſay, I am perſuaded that they would be extremely uſeful. It may be ſufficient, here in this Introduction, to ſay in general, that Mr LISTON confirmed, from his own inſpection, all the great points of M. CHEVALIER's reſearches and diſcoveries, after ſpending many hours in walking over the ground. He ſaw the ſuppoſed ſite of Ancient Troy, the ſources of the Scamander, and the place where that river is now diverted into its new channel. In ſhort, I found that Mr LISTON, along with a great deſire to render every thing as exact and accurate as poſſible, had alſo caught that ſort of intereſt in the ſubject, which is ſo

 natural

* See "A Letter to JACOB BRYANT, Eſq; concerning his Diſſertation on the "War of Troy: by GILBERT WAKEFIELD, B. A. Lond. 1797. 26 pp. 4to.

† For May and June 1797, vol. ix.

natural to a claſſical mind, when engaged in ſurveying or deſcribing ſuch pleaſing ſcenes.

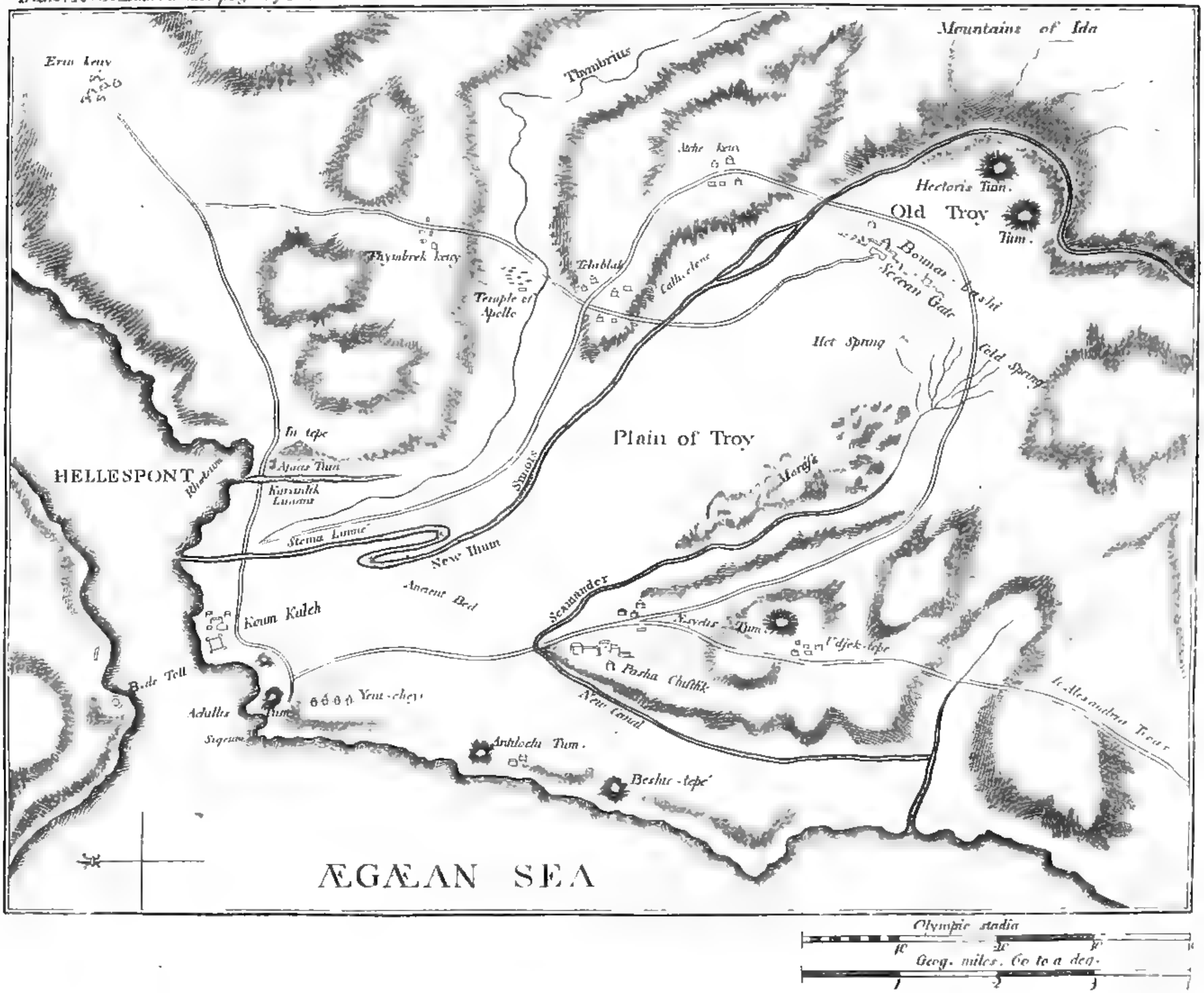
In ſome parts of M. Chevalier's map, alſo, he found ſome inaccuracies, which he was enabled to rectify, both from his own obſervation, and from another map with which he had been furniſhed. This laſt he expected to be ſent after him from Conſtantinople, and intended it ſhould contribute to the improvement of M. Chevalier's in the new edition of the Eſſay*. Of all this I apprized M. Chevalier, in a letter directed to him in London, which found him about to ſet off for the Continent. Previous to his departure, I received from him two letters in anſwer; extracts from which will be found in the Appendix †.

But one of the chief inducements for bringing the ſubject before the Society at this time, is the recent publication of a very ingenious work, entitled, *Conſtantinople, Ancient and Modern, with Excurſions to the Shores and Iſlands of the Archipelago, and to the Troad. By* James Dallaway, M. B. F. S. A. *late Chaplain and Phyſician of the Britiſh Embaſſy to the Porte.* This learned author has been at great pains in aſcertaining the topography of the Troad; and the reſult of his inveſtigations there has produced the fulleſt confirmation of all the material parts of M. Chevalier's Eſſay, and a total but reſpectful diſſent on the part of the author from Mr Bryant's ſcepticiſm on this ſubject. To this book, therefore, I ſhall, in the enſuing paper, have frequent occaſion to appeal.

ABSTRACT

* This map I have never received, owing to ſome omiſſion which I cannot explain. In the mean time, this paper is accompanied with a ſmall one, ſomewhat amended, chiefly from that given by Dr Dallaway, the author of the book preſently to be mentioned.

† No. VI.



TOPOGRAPHICAL SKETCH of the PLAIN of TROY.

ABSTRACT of the moſt material Parts of M. CHEVALIER's *Eſſay, with the Confirmation of ſubſequent Travellers.*

IN giving a ſhort Abſtract of M. CHEVALIER's inveſtigations, I ſhall not follow the order in which he himſelf proceeded, but that which ſeems to convey the cleareſt idea of his diſcoveries and obſervations, now that they have been made. For the caſe is quite different with a perſon, who gives a detail of the manner in which he himſelf advanced in the courſe of inveſtigating objects, of which he had at firſt but an imperfect notion, where the direct path leading to them was yet obſcure and unknown, and where he had to form conjectures that were ſometimes erroneous; and with one who points out or elucidates ſuch objects after they have been diſcovered, and their relative ſituations aſcertained.

AFTER M. CHEVALIER had formed the reſolution of exploring the Aſiatic coaſt, where the Helleſpont unites with the Ægean Sea, with a view to aſcertain the true topography of the Iliad, he happened to land firſt at *Cape Baba*, the ancient promontory of Lectos. Thence he proceeded to Alexandria Troas, the ruins of which he examined, and has given an account of; and this account Mr LISTON in converſation, and Dr DALLAWAY in his book, (p. 326.), have agreed in confirming; but of which a particular detail would be here unneceſſary*.

The

* THE Turkiſh name *Eſki Stamboul;* the warm baths called *Lidga Hamam;* the hill on whoſe declivity theſe are ſituated, and which is covered with tombs, whoſe ſarcophagi of white marble the Turks break down and make bullets of, for ſupply-ing

The Plain.

In advancing from Alexandria Troas, along the coaſt, M. Chevalier's attention was particularly attracted by a *tumulus*, or barrow of immenſe ſize, at a conſiderable diſtance*. This is now called *Udjek Tepè*, from *Udjek*, the name of the adjacent village. From the top of this at noon, (Ch. III.), he took a retroſpect of the ruins of Alexandria, now at the diſtance of more than four leagues; towards the north he ſaw a large plain, encompaſſed with delightful hills; to the eaſt the foot of the mountains of Ida; and to the weſt the Ægean Sea, the iſlands of Tenedos, Imbros, Samothrace, Lemnos, and all the way to the ſummit of Mount Athos.

Dr Dallaway remarks, that "from the high ground near "Alexandria Troas, the view of Tenedos, and of the ſea, with "*Udjek Tepeè*, a vaſt tumulus above the plain of Troy, on the "right under the horizontal line, is particularly pleaſing." (p. 326.). And that "in the progreſs the country ſoon be-"comes leſs woody, and ſpreads into a wide heath, from whence "the whole plain of Troy is ſeen."

When M. Chevalier, in the courſe of his inveſtigation, arrived at the eaſtern extremity of this extenſive plain, on the eminence above the modern Turkiſh village called *Bounar-baſhi*, and where he at laſt concluded the citadel of ancient Troy to have been placed, he obtained a view of the whole extent of it; and it ſeemed to him of a ſemicircular ſhape†. "Of the two chains "of

ing the Caſtles of the *Dardanelles;* the aqueduct of Herodes Atticus; the circuit of the wall ſtill almoſt entire; the thickets of Valonea trees; are all likewiſe remarked by Dr Dallaway, or were mentioned to me by Mr Liston. The former obſerves, that "the whole ſite is now a thick foreſt of Valonea, or dwarf oak, "peculiar to the Levant." Of this ſhrub the latter brought away ſome ſeeds.

* See the Map. † Mr Liston adds, "on each ſide."

" of hills which embrace it, one appeared to run in a direction " towards the promontory of *Yeni-cheyhr*," (or Sigeum), " and " the other towards the point of *Jn-Tepé-Gheulu*," (or Rhœteum). The part of the hills to the right, reaching between the villages of *Atché* and *Tchiblac*, appeared more cheerful than the rest, and which he had no doubt composed the Callicoloné of HOMER. From this station he descried " the islands of Te- " nedos and Imbros, Samothrace and Lemnos, the high top of " Mount Athos, and the Thracian Chersonesus beyond the Hel- " lespont." (Ch. IV.). As to the soil of the plain, he observed it to be " of a rich and blackish colour, and of great fertility." The village of *Bounar-bashi* he reckoned to be " at the distance " of four leagues from the sea." (Ch. XVII.).

MR HAWKINS and DR SIBTHORPE took horses at *Koum-kaleh* on the coast, and crossed the plain to the village of *Bounar-bashi*, in three hours, " an extent," says DR SIBTHORPE, " of nine " miles *." MR HAWKINS, in his second letter to MR LISTON, assures him that Tenedos is to be seen from the hill of Troy, and that even " the whole coast of the island is visible, from the " northern to the southern point."

DR DALLAWAY remarks, that " the whole plain of Troy, " from the height said to have been the citadel, is of uninter- " rupted extent." (p. 346.). From the promontory also of *Yeni-cheyhr*, or Sigeum, at its lower extremity, the same intelligent traveller looked over the plain, the whole scope of which he commanded. " Its broadest diameter," says he " may be five " or six, and its longest twelve miles to *Atché-keuy*. It is natu- " rally verdant and fertile, and now very generally cultivated, " excepting near the marsh, which occupies a fifth part." (p. 347.). This I take to be the marsh at the mouth of the Simois, of which afterwards.

The

* See their Letters, Appendix, No. V.

The Site of Ancient Troy.

NEAR the eaſtern extremity of the plain, upon a gentle acclivity, is ſituated, as has been ſaid, the Turkiſh village of *Bounar-baſhi.* While M. CHEVALIER advanced upwards to this village, by a pleaſant and eaſy aſcent, riſing gradually from the plain, he paſſed through a ſpacious cemetery, where each of the tombs is adorned with a fragment of marble or of granite. Paſſing the village he continued to aſcend for near a mile, till he arrived at the borders of a precipice of great height. (Ch. IV.). Beneath this precipice a torrent, coming down from the mountains above the plain, (but whoſe bed in the ſummer is commonly dry), runs in a curve direction toward the north; and, bending its courſe along the northern ſide of the plain, flows down through the whole length of it, and diſcharges itſelf into the Helleſpont, betwixt the modern Turkiſh fort called *Koum-kaleh* on the ſouth, and a ſort of haven called *Karanlik-limani* on the north, near Rhœteum. This river is undoubtedly the Simois. And upon the riſing ground extending upwards from the village of *Bounar-baſhi* to the abrupt precipice encompaſſed by rocks above and the river below, on every ſide, except that which opens upon the village, and where the Scæan Gate may be ſuppoſed to have been, M. CHEVALIER concludes, that the ancient city of Troy was placed. From the ſummit of this high ground, where he ſuppoſes the citadel to have been, and which the Turks now call *Ballidahi, mountain of honey*, he had a view, as has been ſaid, of the whole extent of the plain. This being an airy ſituation, juſtifies, in his opinion, HOMER's epithet of ἠνεμόεσσα, ſo often applied to Troy. (Ch. XVII.). The precipices which ſkirt this eminence, and the Simois which runs at the foot of them, render the place impracticable to be aſſailed from any other quarter than from the ſide towards the village. *(Ibid.).*

Mr

M. Chevalier further remarked, on this high ſituation, four barrows or *tumuli*, three of which are ſimilar to thoſe on the ſhore of the Helleſpont, (which ſhall be afterwards mentioned), and the fourth conſiſts of an enormous maſs of ſtones. This he conjectured to be the monument of Hector; and thought it the remains of a demoliſhed ſtructure. (Ch. XVII.).

Mr Hawkins and Dr Sibthorpe "ſpent a day in viſiting the "hill ſuppoſed by M. Chevalier to have been the ſite of "Troy; and the ſprings of water, which he conſiders as the "fountains of the Scamander*." Mr Hawkins thought, that "the place pitched upon for the ſite of the city has much natu-"ral ſtrength to recommend it, particularly the eaſtermoſt angle "of the hill, which, from its height above the Simois, and its "perpendicular form, muſt have been conſidered as a very "ſtrong natural faſtneſs in thoſe times of warfare, and could "have been eaſily rendered an impregnable citadel; for it is not "large enough for the ſite of the whole city."—"Some *tumuli*," adds he, "near the ſpot, are certainly ſtrong indices." Dr Sibthorpe obſerved, that "the ſituation, where the citadel is ſup-"poſed to have been, is particularly ſteep and rocky:" and that "it is covered with prickly barnet, and a few thorny ſhrubs. "The almond tree," adds he, "which grows wild, is not with-"out its thorns. It has even more pleaſing plants, the yellow "jaſmine and the wild olive."

Mr Liston took particular notice of a contiguous place, where the ſtones of what is called the tomb of Hector ſeemed to have been dug; and he remarked a ſort of hollow all around the city, except ſome part, which is rocky.

Dr Dallaway, who advanced towards the village from the northern ſide, thus deſcribes his approach: "As the ſetting ſun "was more brilliant than for many days paſt, the village of

* See their Letters, Appendix, No. V.

" *Bounar-bashi* opened upon us very pleasantly from the ford of " the Simois, which we passed within a furlong of the chiftlik " of HADGÌ MEHMÈT Agha, the present proprietor of a do-" main producing near L. 5000 Sterling *per annum*, and inclu-" ding little less space, and the identical ground of the kingdom " of old PRIAM*. His house is mean, but many columns were " dispersed about it, which had been collected from the sites of " adjacent cities. From the village," adds he, " the hill rises " rapidly, and soon becomes an insulated mountain. The lofty " wall of Troy, and the Scæan Gate, intersected the modern " village of *Bounar-bashi*. Ascending the hill, thickly strewn " with loose stones for the space of a mile, the first object on the " brow is a stony hillock, which CHEVALIER, with no apparent " reason, calls the tomb of HECTOR. It has been opened and " examined, but we could not learn the result. There are others " covered with grass, appropriated likewise to Trojan heroes." Dr DALLAWAY has given a beautiful design and engraving of the *tumulus* said to be HECTOR's. This learned traveller is of opinion, that " upon the area and the intermediate ground " from the village of *Bounar-bashi*, there is undoubtedly space " enough for such a city as Troy is described to have been." (p. 345.). And he observes, that " the level falls abruptly on " the south, with a precipitate cliff, into a deep ravine, forming " a mural rock, now almost covered at its base by the stream " and sands of the Simois, for the length of forty or fifty yards, " and completing a fortification rendered impregnable by na-ture;

* M. CHEVALIER had said, (Ch. XVII.) that " near the hill were situate the " gardens of PRIAM, where LYCAON, when cutting wood, was surprised by ACHIL-" LES; and on that spot are still situate the gardens of the Agha of Bounar-bashi, " who, after *forty* centuries, succeeds to the king of the Trojans, &c. (*Forty*, among the *Errata*, is corrected *thirty*: which Dr DALLAWAY, not observing, has supposed the author guilty of a mistake). Mr LISTON told me that he ate grapes in this very place.

" ture; and that the face of the ground exhibits nothing worthy " of remark; bushes and huge unhewn ſtones only being to be " ſeen."

The Sources of the Scamander.

BUT the chief circumſtance which aſcertains the poſition of the city is the ſources of the Scamander. Theſe M. CHEVALIER was ſo fortunate as to diſcover, and deſcribes as ſtill to be ſeen, a little below the village to the ſouth, and as conſiſting: 1. Of a ſolitary copious ſpring, riſing from the bottom of a baſon, bordered with pillars of marble and granite; of which ſpring, in the month of September, he felt the water to be tepid; but was aſſured that it is much warmer about the middle of winter; 2dly, Several ſmall ſprings of cold and limpid water guſhing forth from crevices in the rock, at the bottom of the low hills at the head of the plain, and which uniting into one ſtream, a little below, receive alſo the firſt mentioned fountain, and thus form the Scamander*. (Ch. IV. xix.).

" WE ſlept," ſays Dr SIBTHORPE, " at *Bounar-baſhi*, a little be-" low which riſes the Scamander, fed by numerous ſprings of a " pure cryſtalline water. One of theſe is ſaid to be warm in " winter; it communicated to us no ſenſation of heat." This was about the middle of September. Dr DALLAWAY, who was there in November 1795, ſpeaking of the hot ſpring, expreſsly ſays: " It " is at leaſt tepid; and the Agha (in the front of whoſe houſe " it is to be ſeen, at a little diſtance) told us, that, in the winter " months, eſpecially during froſt, it is hot and ſmokes."—" HOMER," adds he, " muſt be allowed the privilege of a hot " ſpring, and a river full to the brink, if they happen once with-

f 2 " in

* Compare Iliad, xxii. 147.

" in the year." (p. 344.). M. CHEVALIER found the Turkiſh women of the village of *Bounar-baſhi* waſhing their garments at the ſources of the Scamander, as the wives and daughters of the Trojans were wont to do when they enjoyed the ſweets of peace, before the arrival of the Greeks *. I repeat this circumſtance, becauſe Mr LISTON aſſured me that, when he was there, he made the very ſame remark.

The Courſe of the Scamander.

M. CHEVALIER examined the two rivers, the Simois and the Scamander, by tracing them upwards; the latter from the place where it now diſcharges itſelf into the Archipelago, by a new canal; and the former from its mouth upon the Helleſpont, a little to the north of *Koum-kaleh*. The new canal of the Scamander had been firſt obſerved by him, on his way from Alexandria Troas, as he came down from *Udjék-Tepé*, or monument of ÆSYETES. About a mile to the northward of this monument, as you paſs the village of *Erkeſſighi*, and near an elegant Kioſk, or repoſing place, conſtructed by HASSAN, the Turkiſh Captain Paſcha, a conſiderable ſtream flowing down upon the ſouth ſide of the plain, and then bending towards the Simois, takes a ſudden direction to the ſouth, being plainly diverted into an artificial canal, which carries it a conſiderable way, in a ſloping courſe through a valley, and conveys its waters into the Ægean Sea. (Ch. III.). This new canal made a ſtrong impreſſion on M. CHEVALIER's mind; and induced him afterwards to ſearch for the ancient bed of this beautiful ſtream, which he at length found, and traced, as marked on his map. (Ch. IV.). This was a moſt important diſcovery; and when, in the inveſtigation,

* See Iliad, xxii. 154.

gation, he came again to the ſtream, where it turns into the new canal, and traced it up to its ſources already mentioned, near *Bounar-baſhi*, no doubt any longer remained on his mind, that this was the true Scamander, which had formerly united its water with the Simois.

SUCCEEDING travellers have, in the moſt liberal and decided manner, confirmed the genuineneſs of theſe inveſtigations, and acceded to M. CHEVALIER's concluſions.

"WE ſaw the place," ſays Mr HAWKINS, in his firſt letter to Mr LISTON, "where the courſe of this river was diverted by "an artificial canal to the Archipelago." And he adds, more explicitly in his ſecond letter: "The moſt eſſential point in "ſubſtantiating the evidence of CHEVALIER is that of the canal, "made to divert the waters of the Scamander from their origi-"nal courſe towards the Simois. This canal we can bear teſti-"mony to. The errors of WOOD ſeem to ariſe from the over-"looking this circumſtance. As for STRABO, he had never "viſited the ſpot in all probability, and relied on the authority "of DEMETRIUS of Scepſis *." Mr LISTON himſelf afterwards examined the river with the greateſt care, and particularly the new canal, and the old bed. This laſt he croſſed on bridges in different places, and was convinced, that when, occaſionally, the ſtream of the Scamander is more copious, part of it ſtill flows into the Simois by this ancient channel. For he differed in opinion from M. CHEVALIER in the idea, that the Scamander is never ſubject to any increaſe or diminution; (Ch. IV. xi.); and ſaw no reaſon why it ſhould not occaſionally ſwell in the caſe of long continued and heavy rains; though by no means to ſuch a degree as the Simois, which is ſometimes dried up, and ſometimes comes down with the utmoſt magnitude and impetuoſity.

* See Appendix, No. V.

impetuofity *. Moreover, Mr LISTON affured me, that from M. CHEVALIER's defcription, the Scamander feems to be a more diminutive water than it really is †.

" FOR feveral hours," fays Dr DALLAWAY, " we traced, with " the utmoft attention the courfe of the Scamander from the " cold or fecond fource, which is a collection of fmall fprings, " through the morafs, where for fome miles it is pofitively hid, " till we reached the new canal, and faw plainly the ancient bed. " The banks of this river, where expofed, are verdant and beau- " tiful, and watered to the brink. M. CHEVALIER's topography " and general idea, after a fair inveftigation, we acknowledged " to be ingenious and plaufible." (p. 347.).

IN characterifing the Scamander, M. CHEVALIER mentions particularly " the tranfparency of the water, which runs upon " a bottom of fand and round pebbles, betwixt two verdant " banks "

DR DALLAWAY fays of the two rivers : " Simois has broad " fands, with a fudden and rapid current ; Scamander is tran- " fparent and regularly full, within a narrow channel, and fo " they continue to be till their junction, before they reach the " fea." (p. 348.).

M. CHEVALIER further defcribes his having paffed the Scamander upon an old willow ftretched acrofs, near a mill. Mr LISTON alfo mentioned to me this mill, and his having croffed the current in a fimilar manner.

The

* IF this hypothefis of Mr LISTON be well founded, perhaps it may be inferred that the Scamander remains in the fame ftate in which it was in the days of HOMER, occafionally flowing into the Simois, but commonly, by what is thought a new canal, into the Ægean Sea. And if this is admitted, it may affift Mr HEYNE in obviating a difficulty which occurs to him in his Effay on the Topography of the Iliad. See Appendix, No. III.

† PERHAPS I may be partly to blame for this, by calling it, in the tranflation, *a rivulet*, (p. 13. 15.), and once *a rill*, (p. 25.). The original is *ruiffeau*, which might have been rendered *a ftream*.

The Course of the Simois.

From *Yeni-cheyr*, which is the Sigean promontory, and which commands an extensive view of the plain, M. Chevalier particularly observed the Simois, which intersects the plain along the north side. " Its waters were then dried up; but the width " and irregularity of its channel sufficiently demonstrated the " nature of its devastations, and its rapidity." (Ch. III.). The Turks call it *Menderé*. An extensive marsh occupies the ground at the place of its discharge on both sides, and reaches almost to the fortress called *Koum-kaleh*. This marsh is taken notice of by Strabo by the name of Στομαλίμνη, *the mouth lake*. On his way from this place, M. Chevalier passed the Simois near its mouth, and found it to be more than 300 feet broad. In the marsh, on its banks, he observed certain small lakes of fresh and of salt water, and was struck with the prodigious quantity of reeds and tamarisks he met with, as he proceeded along the coast. (Ch. IV.). He travelled onwards for half an hour, and saw a large barrow, the monument of Ajax, which he examined, as we shall by and by mention. Having then proceeded as far as *It-Guelmes* or *Erin-keu*, he returned, and resolved to ascend towards the source of the Simois; and had not proceeded far, when he was so fortunate as to discover, to the right, the bed of a smaller river, at that time dry, and covered with plants and turf. This proved, on a nearer investigation, to be the old bed of the Scamander. If Mr Wood had adverted to this, instead of still searching higher up for the confluence of the two rivers, he probably would have given a more rational account than he has done of the present state of the scene of the Iliad.

Afterwards, when M. Chevalier had examined the Scamander, its sources, and the situation of ancient Troy, as already mentioned, he resumed the design of tracing the Simois still higher;

higher; and went down to its banks, from the village of *Arabler*, about half a mile to the ſouth-eaſt of *Bounar-baſhi*. The torrent being then dried up, he reſolved to aſcend within its channel, ſcrambling over trunks of trees and rocks borne down by the impetuoſity of the current. (Ch. IV.). He walked for five hours between two chains of abrupt rocks, which border the valley, and came into a plain, with a village at its entry, called *Iné* or *Ené*. Here he found that a river diſcharges itſelf into the Simois, and that it takes its riſe near a village called *Baharlar*, to which he proceeded in five hours journey to the ſouthward, through a rugged and mountainous country. This ſtream he found to be the ſuppoſed Scamander of Mr WOOD. Returning to *Ené* he continued to trace the Simois, now the *Menderé*, up to the high mountain, whence he was aſſured it iſſued. This proved to be Mount Cotylus, now called *Cas-dahi, the mountain of the gooſe*, from which, miſled by DEMETRIUS of Scepſis, STRABO makes the Scamander to flow down, confounding it with the Simois. M. CHEVALIER reſolved to aſcend to the ſummit of the mountain, which, after being hindered from doing for ſome days, in conſequence of a great fall of rain, he at laſt effected; of which expedition he gives an intereſting deſcription, particularly of the ſublime proſpects he obtained.

IT does not appear that any of the ſubſequent travellers I have mentioned, went to the ſource of the Simois, or the ſummit of Mount Cotylus, as M. CHEVALIER did: but Dr SIBTHORPE remarks, that the ſituation, where they ſuppoſed the citadel of Troy to have been, is particularly ſteep and rocky, and is girt by the Simois, " which is now," ſays he, " entirely " dry: but perhaps the winter torrents may raiſe it into a con- " ſiderable river. Its banks are fringed with plants, agnus ca- " ſtus, and tamariſk *."

DR

* See his Letter, Appendix, No. V.

Dr Dallaway croffed the Simois three times: 1. On his way from *Udjek-tepé*, or the monument of Æsyetes; and after he had refted during a tempeftuous night at the *Chiftlik*, built by the famous Hassan Pafha, formerly mentioned, on the 5th of November he croffed both the Scamander and the Simois, the latter of which the rains had increafed to a confiderable river; the bed being from forty to fifty yards wide; though it is frequently almoft dry, efpecially in the midft of fummer. This was on his way to the village of *Thimbrek-keuy*, and the temple of Apollo Thymbræus; which he paffed and defcended to the fhore, and proceeded as far as Cape *Berbier;* and after exploring the fhores of the Hellefpont, he returned by fea to *Koum-kaleh.* Here having landed, he again croffed the Simois over a wooden bridge, near its *embouchure;* (p. 338.); and advancing upwards on the northern fide of that river, he repaffed it within a furlong of the *Chiftlik* of Hadgi Mehmèt Agha, at *Bounar-bafhi.* (p. 343.). In viewing the fituation of the citadel, where the Simois runs under the rock, he fays, "That the divifion of the rifted rock "from the groupe of foreft mountains, does not exceed 150 "yards, and is fcarcely farther afunder at the top, finking as "perpendicularly as an artificial channel."

The Monument of Æsyetes.

M. Chevalier, as has been faid, began his refearches in Afia at Cape *Baba*, the ancient promontory of Lectos. From thence he proceeded to the ruins of Alexandria Troas; his account of which has been minutely confirmed by Dr Dallaway. But though the narrative of both travellers be very agreeable and interefting, we did not before, nor do we now, think it neceffary to detail the particulars. On advancing, his notice was particularly attracted by *Udjek-tepé*, a barrow of an extraordinary ſize, which already has been mentioned *. He had no notion at firſt that this was the ſame with the monument of ÆSYETES. He contented himſelf with meaſuring its dimenſions, and enjoying the magnificent proſpect from the top of it. Its height he found to be not leſs than 100 feet, and its outline to be 400 paces. He remarked it to be of a conic ſhape, and quite regular. After his third journey to the Troad, he had no heſitation in concluding it to be the monument of ÆSYETES. (Ch. III. XII.).

DR DALLAWAY ſays, that " the tomb of ÆSYETES, according " to POCOCKE, or, as it is now called, from the adjacent village, " *Udjek-Tepee*, is a barrow of extraordinary height and ſmooth " ſurface, and was the ſituation from whence POLITES, the ſon of " PRIAM, reconnoitred the Grecian camp, and the oppoſite iſland " of Tenedos, with its harbour and promontory †."

Five other Tumuli.

AFTER M. CHEVALIER had examined the new canal of the Scamander, he proceeded, from the place of its diſcharge into the Ægean Sea, along the coaſt, towards the village of *Yeni-cheyr*, in order to have a nearer view of ſeveral high mounds of earth, which had attracted his attention from the top of *Udjek-tepé*, or monument of ÆSYETES. The firſt he arrived at, called *Beſhik-tepè*, is not by any means ſo high as that laſt mentioned. He next came to that, which, upon the map, he has called *Antilochi tumulus*, not finding any Turkiſh name for it, and which ſeemed to be of the ſame dimenſion with *Beſhik-tepé*. He then proceeded to the village called *Yeni-cheyr*, ſtill inhabited by Greeks, and ſituate upon the extremity of the famous Sigean promontory,

* See above. p. 38.

† Iliad, II. 792, ſeq.

promontory, where, juſt as he was entering the Church, he ſaw the Sigean inſcription, ſo well known to the learned; and oppoſite to it the bas relief of marble, of the fineſt workmanſhip, of which Dr CHANDLER has given an exact account; and there is an elegant engraving of it in *Ionian Antiquities*.

DR DALLAWAY, too, ſaw this bas relief, as well as the Sigean inſcription; which laſt, he obſerves, is now placed at the door of a low hut, conſecrated as a chapel: and the letters are nearly worn out, the marble having been ſo long uſed as a bench to ſit on. Mr LISTON told me, that the effacing ſeems to be promoted by a drop which falls from the eaves of the chapel.

FROM the top of the promontory M. CHEVALIER had another extenſive view of the plain of Troy, and ſaw particularly the mouth of the Simois, as already mentioned; alſo the Turkiſh caſtle of *Koum-kaleh*, mentioned by all the ſubſequent travellers. At the foot of the promontory he remarked two other *tumuli*, of which the neareſt is underſtood to be the monument of ACHILLES; and the more diſtant one M. CHEVALIER ſuppoſed to be that of PATROCLUS. Others take it for that of PENELEUS; the aſhes of PATROCLUS having been depoſited in the ſame monument with thoſe of ACHILLES.

"ADVANCING ſome furlongs over the promontory," ſays Dr DALLAWAY, "we ſaw the barrow *(beſhik-tepè)* called the "tomb of ANTILOCHUS by STRABO. On the other ſide of the "village, under the brow of the hill, crowned by half a dozen "windmills, near the ſea, are two ſmaller *tumuli*, generally ſup"poſed to be thoſe, one of which is attributed, by the ancient "geographers, to the illuſtrious friends ACHILLES and PATRO"CLUS, and the other to PENELEUS the Bœotian." (p. 350.).

AFTER remaining ſome days near *Koum-kaleh*, M. CHEVALIER paſſed the Simois; and, travelling for half an hour, came to a fifth *tumulus* of the ſame kind with the reſt, having a large aperture in its ſide, which he entered. The monument being demolifhed from top to bottom, its whole interior ftructure was to be difcerned. This is fuppofed to be the monument of AJAX, and is called by the Turks *In-tepé-Gheuleu, the monument of the marfh*. It is fituated at Rhœteum, a promontory or tongue of land advancing into the plain oppofite to the Sigean promontory. (Ch. IV. XIV.).

DR DALLAWAY, after croffing the Simois the fecond time, paffed over an extenfive level of ploughed fields, and *Goulu-fui*, a brook, which empties itfelf into the fea near *Jn-tepè*, or the tomb of AJAX Telamonius. "This *tumulus*," fays he, "is now irre-"gularly fhaped. Near the top is a fmall arched way almoft "choked up with earth, which was the entrance into the vault, "and over it a broken wall, where was once a fmall fepulchral "fane called *Aiantéum*." He thinks the whole to be of a much more modern date than the death of AJAX.

DR SIBTHORPE, in his letter to Mr LISTON, writes thus: "I "write to your Excellency in hafte, our veffel toffing about op-"pofite the tomb of AJAX, where it has been juft drove by a "hard gale of wind *."

THESE monuments, with the others formerly mentioned upon the hill of Troy, appear to have made a ftrong impreffion on M. CHEVALIER's mind; and many of the Members of this Society will recollect, that, in converfation, he ufed to lay great ftrefs on them. They are objects very confpicuous and ftriking to thofe who fail along the coaft, near the entrance to the Hellefpont, as Mr LISTON particularly informed me. They feem to have made a ftrong impreffion likewife on Dr DALLAWAY, who, on viewing them from *Halileli*, near the village of *Thimbrek-keuy*, (p. 340.), remarks, that the fucceffion of the five *tumuli*, under the diftant horizon, tend more than any other proof to afcertain the Trojan war. He fays afterwards, (p. 349.): "Of all the "proofs advanced by M. CHEVALIER, the *tumuli*, fo connected "with

* See Appendix, No. V.

" with the Sigean and Rhœtean promontories, and the outpoſts " of the Grecian camp, are the moſt ſatisfactory. The ſite is " likewiſe confirmed by four others, which, to whatever heroes " they may be conjecturally attributed, with no additional " weight to the argument, give a certain degree of internal evi- " dence, and aſcertain the ſcene of great military tranſactions, " or vicinity to a large city."

The Valley of Thymbra.

On quitting the monument of Ajax at the Rhœtean promontory, and after taking a view of a ſmall adjacent harbour called *Karanlik-limani, the ſhut haven*, M. Chevalier continued his journey to the village of *It-Guelmes* or *Erin-keuy*. It appeared to be of no conſequence to the end in view to proceed in that direction any farther, and he returned, in order to trace the circumference of the great plain. On his way back, he ſoon deſcended into a delightful valley, called *Thimbrek-deré, the valley of Thimbrek*, or *Thymbra*. On beginning to aſcend towards the ſource of a rivulet, which runs through it, he was ſtopped on its left bank, oppoſite to the village of *Halileli*, by a heap of ruins, among which were ſome bas reliefs, columns, capitals, entablatures, and inſcriptions. He took them for the ruins of the temple of Apollo Thymbræus, and copied ſome of the inſcriptions, which are now publiſhed in the third volume of our Tranſactions.

Mr Liston ſaw theſe ruins, and told me that they are very conſiderable; ſome fragments of marble ones ſtill remaining. Every year the inhabitants carry pieces of theſe to place over the dead in the adjoining cemetery, near the ruins of an old moſque; ſo that ſoon nothing will remain but the large pieces. M. Chevalier, in his map, has, in Mr Liston's opinion, placed

ced them too far up. They are at leaſt half a mile from the village of *Halileli*, on the oppoſite ſide of the rivulet. Dr Dallaway has given an elegant engraving of them, and ſays, that he " paſſed the village of *Thimbrek-keuy*, and a dilapidated moſque, " with a cemetery full of parts of fluted columns and cornices, " ſet up as memorials, the probable ſite of the temple and city " ſacred to Apollo Thymbræus." (p. 331.).

The Promontories.

M. Chevalier agrees with all preceding travellers, in holding the promontory of Sigeum to be at the modern village of *Yeni-cheyr*. That of Rhœteum he has no doubt in fixing at *In-tepè-Gheuleu*, near the harbour called *Karanlik-limani*, where the barrow, ſuppoſed to be the monument of Ajax, is ſtill to be ſeen. He concludes, with the greateſt reaſon, that M. d'Anville and Mr Wood are miſtaken in placing the Rhœtean promontory at Cape *Berbier*, which, according to the latter, lies about 12 miles from the Cape of *Yeni-cheyr* or Sigean promontory. (Ch. XIII.). He was at the pains to meaſure the diſtance betwixt what he thinks the two promontories, and found it to be 3000 fathoms, which agrees with Pliny's account, who ſays it is 30 ſtadia. M. Chevalier thinks Strabo miſtaken when he reckons it at 60 ſtadia.

Dr Dallaway obſerves, that " the entrance into the great " plain is formed by the Sigean promontory, and that called " Rhœteum, about four Engliſh miles aſunder, through which " the two rivers Simois and Scamander at length took an united " courſe. Between theſe promontories the Grecian fleet was " drawn up on dry ground, and probably remained ſo during " the whole war." (p. 336, note.). " Wood," adds he, " miſtakes Cape *Berbier* for the Rhœtean promontory, which

" Strabo

" STRABO makes to be 60 ſtadia, SOLINUS, 26, and PLINY, 30, " from the Sigean; the latter is the true diſtance. (p. 337. note.). " The city of Sigeum covered the ſhore between the *tumulus* and " a bay, in which I anchored for a week, (Nov. 1795), and re- " ſurveyed the whole with attention."

Some Miſtakes admitted, and corrected.

AFTER what has been ſtated, and thus confirmed by ſuch reſpectable authorities as have been adduced, no reaſonable perſon can now doubt that M. CHEVALIER has given a true and diſtinct account of the preſent ſtate of the Troad. But as he has had occaſion to offer various hypotheſes, and to make various obſervations and inferences, during the courſe of his Eſſay, it is not to be wondered at that a few miſtakes ſhould have been committed, and ſome unneceſſary animadverſions introduced. The author was himſelf ſenſible of this, as appears from the late letters I received from him *. In the notes, too, which accompany the Engliſh verſion, I now perceive there are ſome errors, which I wiſh to take the firſt opportunity of correcting.

The Map.

M. CHEVALIER, upon information being communicated to him that Mr LISTON, as well as Mr HAWKINS *, had found ſome inaccuracies in his map, anſwered as follows: " There is " nothing I deſire ſo much as to have any miſtakes, that have " been committed in my map, rectified; and I moſt cordially " give my aid to every improvement of which that performance " is

* See his firſt Letter, Appendix, No. VI.

" is ſuſceptible. But I will venture to aſſure you before hand, " that the alterations which may be made will not extend to the " monuments eſſential to the underſtanding of the Iliad; ſuch " as the ſite of ancient Troy, the ſources of the Scamander, " the tombs of the warriors, the promontories, &c. All theſe " points are fixed relatively to one another, with a degree of " preciſion ſufficient to prevent any change that may be made " upon them from materially affecting my work. As to mo- " dern monuments, ſuch as Alexandria Troas, &c. I own that I " did not think it neceſſary to pay ſuch a ſcrupulous attention " to them. The line of the coaſt was done with the greateſt " exactneſs, as well as the mouth of the Helleſpont and the " iſland of Tenedos; and therefore I ſuſpect that upon this the " new map will make no alteration*."

Dr Dallaway obſerves, that M. Chevalier has deſcribed the artifical canal in his map of the Troad as having much too ſtraight a direction. It is conducted round the hill upon which the *Chiftlik* of Hassan Paſha is built. (p. 347.).

The Monument of Ilus.

About an hundred paces up the Simois, from the place where it is joined by the old bed of the Scamander, and near the place where the city called *New Ilium* is ſuppoſed to have been ſituated, M. Chevalier had obſerved the ruins of a bridge, which had been built of hewn ſtone, and of exquiſite workmanſhip. Fronting theſe remains, on the right of the river, he ſaw a ſort of riſing ground, which he took to be a demoliſhed barrow. This he afterwards fancied to be the monument of Ilus, and probably the ſame with Homer's θρωσμὸς πεδίοιο. In theſe conjectures,

* See Appendix, No. VI.

jectures, however, he was, after a converſation with Profeſſor HEYNE, convinced he was miſtaken; and readily admitted, that his whole XVIth chapter, which is upon this ſubject, is good for nothing*. After that converſation, alſo, he was diſpoſed to think that this barrow might probably be that mentioned by HOMER, (Iliad, VII. 337.), which was to be deſtined as a common one for the warriors who had fallen in battle; ἄκριτον ἐν πεδίῳ.

Situation of the Grecian Camp.

CHAPTER XIII, where the author treats of the ſituation of the Grecian camp, now appears to me to require much amendment. That the camp was ſituated ſomewhere betwixt the Sigean and Rhœtean promontories is generally agreed; but that it occupied the whole ſpace or line of coaſt in that interval, as M. CHEVALIER has ſuppoſed, cannot be admitted. This would have made it neceſſary for the camp, which conſiſted of the tents, with the ſhips drawn out upon the dry land, as was the ancient cuſtom, to occupy the place on both ſides of the mouth of the Simois, which M. CHEVALIER, and the other travellers, as well as STRABO, deſcribe as being an extenſive marſh. M. CHEVALIER was evidently aware of this inconvenience; and therefore ſuppoſes that the Greeks, in the courſe of the war, frequently ſhifted their ſtation; and that, at laſt, in the tenth year, during the ſummer ſeaſon, they encamped, in full force, at the mouth of the Scamander, or Simois, for, at the mouth, they were united.

I REGRET that, in the note, I have endeavoured to ſupport this idea, by ſuppoſing, that " the Scamander, even in the ſum-

* See his Letters, Appendix, No. VI.

" mer, when the Simois was dry, continued to convey its pure " and perennial, though lefs copious, ftream through the midft " of the camp, in the fame channel through which the Simois, " after having joined it, difcharged its winter torrents." (p. 104.). Ever fince I read Mr HEYNE's Effay, I have given up this hypothefis, and willingly accede to his idea, which fuppofes, that the camp only ftretched on both fides *towards* the promontories Rhœteum and Sigeum ; and that on the north-eaft it extended no farther than the Simois *. In this way the whole is rendered clear, and free from every objection. This, however, makes nothing againft M. CHEVALIER, but that he was not fo fortunate in his hypothefis as Mr HEYNE, on this occafion, which I am fure he himfelf would have been the firft to admit.

MR HEYNE's notion of the fituation of the camp is confirmed by Dr DALLAWAY ; and the more ftrongly, as the latter does not appear to have feen the former's Effay on the Topography of the Iliad, or to have known any thing of the coincidence of Mr HEYNE's opinion with his own. In a very diftinct note on this fubject, (p. 336.), he obferves, that " between thefe promontories the Grecian fleet was drawn up on dry ground, " and probably remained fo during the whole war." And he concludes the note thus : " The purfuit of the Trojans by " ACHILLES, fixes the fituation of the Grecian camp between " the confluence of the rivers and Sigeum, for they retreated " over the Scamander to gain Troy, and he kills many of them " in the river."

Of fome other Miftakes, and erroneous Criticifms.

THE author, in fpeaking of the two *tumuli* near the Sigean promontory, (Ch. IV. XXI.), fays, that " he was informed by " a Greek inhabitant of the place, that the name given to the " more

* See Appendix, No. III.

" more conſiderable of the two was *Dios-tapé*, which he interprets *the divine Tomb*." Mr LISTON obſerved, that the inhabitants ſpoke of both monuments by the appellation of *dtheo tepé*, which, in their language, has no other meaning than *the two tombs*. He therefore concluded, that M. CHEVALIER had been deceived by the ſimilarity of the ſound. This is alſo noted in Dr DALLAWAY's book, with an aſſertion, (but not of Dr DALLAWAY himſelf), that the miſtake proceeded from M. CHEVALIER's ignorance of modern Greek; which I have the greateſt reaſon to believe to be without foundation.

IN examining carefully the ſurface of the rock of *Balli-dahi*, M. CHEVALIER thought he " diſtinguiſhed foundations of ancient buildings, the maſonry of which had aſſumed the conſiſtence of the rock itſelf." Mr LISTON, on a narrow inſpection, was convinced that nothing could be diſcerned but the real ſubſtance of the rock, which is indeed rough, of a chalky appearance, and, at firſt ſight, ſeems as if there was mortar adhering to it. He brought away a fragment of it, which I have here in my cuſtody; and the gentlemen preſent may judge.

IT ſeems ſurpriſing that there ſhould be a total diſappearance of every ruin or veſtige of a building, to mark the ſite of ſo famous a city. STRABO, however, gives a good reaſon for this, as follows: Ὅτε γὰρ ἐκπεπορθημένων τῶν κύκλῳ πόλεων, οὐ τελέως δὲ κατεσπασμένων, ταύτης δ᾽ἐκ βάθρων ἀνατετραμμένης, οἱ λίθοι πάντες εἰς τὴν ἐκείνων ἀνάληψιν μετενέχθησαν. Αρχαιάνακτα γοῦν φασὶ τὸν Μιτυληναῖον ἐκ τῶν ἐκεῖθεν λίθων τὸ Σίγειον ἐκτειχίσαι. (L. XIII. p. 895.). *For when all the cities around were laid waſte, but not entirely demoliſhed; and while this one was totally overturned, all the ſtones were carried off from it to rebuild thoſe others. Accordingly, they ſay, that* ARCHÆANAX *of Mitylené with the ſtones taken from thence fortified Sigeum.* Dr DALLAWAY, ſpeaking of the city of Ilium, once ſituated near the junction of the Scamander and Simois, and which owed its origin to ALEXANDER and LYSIMACHUS, ſays,

(p. 338.), " It excites no wonder, that, after ſo long poſſeſſion of " it by the Turks, not a ſtone ſhould remain; yet ſome con- " tend againſt the exiſtence of Troy, becauſe no veſtiges were " diſcoverable when ALEXANDER founded the ſecond city, " whilſt they admit the latter fact equally unauthoriſed by pre- " ſent appearances *."

IN a paſſage quoted from HERODOTUS, in which an account is given of the march of XERXES's army from Sardes to Abydos, the expreſſion—*τὴν Ἴδην δὲ λαβὼν ἐς ἀριστερὴν χέρα*, is tranſlated *advancing towards the left branch of Mount Ida*, different from the common way of rendering it, *having Ida on the left*. As this interpretation is diſapproved of both by Mr HEYNE and Mr BRYANT, I have no inclination to diſpute the point with ſuch learned antagoniſts, provided they can make it appear, that XERXES could and did proceed, with Ida on his left. " Ida," ſays Mr HEYNE, " has many branches and ridges. The army " may have gone round one of theſe outſkirts of the mountain " approaching towards the ſea, in ſuch a manner as to leave it " on the left †."

FROM M. CHEVALIER's letters, it appears that he was ſenſible that he had at times introduced unneceſſary or inaccurate reflections; of which kind are thoſe in Chap. VI. reſpecting travellers

* SEE, in Mr WAKEFIELD's letter to Mr BRYANT, (p. 11, 12.), a remarkable fact reſpecting the total diſappearance of *Flaxford* Church, about five miles from Nottingham.

† I OBSERVE, too, that this notion is ſupported in a paper in the ſixth volume of *Commentt. Soc. Reg. Scient. Gotting.* Ann. 1783, 1784; entitled, HERODOTI *ac* THUCYDIDIS *Thracia*, JOS. CHRISTOPH. GATTERERI: with a map, where XERXES's march is traced accordingly. Mr BRYANT enters into a long diſcuſſion upon the ſubject, through which I have no inclination to follow him now, nor ſhall I afterwards, I ſuppoſe, when I come to take more particular notice of his *Obſervations;* but will freely confeſs myſelf reſponſible for the whole blame of this miſtake, having ſuggeſted the culpable interpretation to M. CHEVALIER, on my firſt reading his paper; and I am anxious that he ſhould here be cenſured only for paying ſo much deference to my judgment as to introduce an equivalent expreſſion into the French original.

travellers of high diſtinction, and the prieſts in the early ages of Chriſtianity: both of which he deſires may be ſtruck out in a new edition. The former, I obſerve, has already been omitted in the German tranſlation; and the latter, which begins thus: "But why did not the prieſts of the lower empire demoliſh "thoſe monuments?"—has given great offence to, and has been cenſured and reprobated with uncommon aſperity by, Mr BRYANT, in his *Obſervations*. (p. 42. 43.).

Of the Notice that has been taken of STRABO.

IN giving a deſcription of the Troad, it was neceſſary to advert particularly to what a geographer ſo reſpectable as STRABO has ſaid upon that ſubject. This M. CHEVALIER has done in his VIIth and VIIIth chapters. STRABO derived the greateſt part of his information, relating to the Troad, from DEMETRIUS of Scepſis, who, though he had his reſidence in thoſe parts, was evidently deceived reſpecting the true ſource of the Scamander, and has led STRABO into the ſame error. They ſuppoſe that this river takes its riſe in Mount Cotylus, far beyond the place where ancient Troy was ſituated. M. CHEVALIER has ſhewn this to be a groſs miſtake; and it is evident that it was likewiſe the chief cauſe of Mr WOOD's errors. STRABO ſaw and frankly admitted the difficulty of reconciling this with HOMER's account in the XXIId book of the Iliad, where the two ſources are explicitly mentioned, the one a hot and the other a cold ſpring, and both as being in the vicinity of the Scæan Gate; but STRABO has not been ſucceſsful in his attempt to obviate this difficulty *.

M.

* MR HEYNE, in a note on the German verſion, (p. 85.), as well as in the preface to the ſame work, (See App. No. I.), thinks it evident that DEMETRIUS ſet out on a wrong hypotheſis, in conſequence of miſunderſtanding a paſſage of the Iliad, (XII. 19.). This paſſage I had quoted and explained in a note. (p. 59. of the Engliſh Tranſlation.).

M. Chevalier being clearly convinced of this error of Demetrius and Strabo, and ſtruck with the confuſion to which it has given riſe, has perhaps ſhewn too great a degree of ſuſpicion of the latter, in reſpect to ſome other paſſages of his account of the Troad; and may have cenſured him ſomewhat too keenly. Wherever this ſeems to be the caſe, Mr Heyne, in his notes on the German verſion, has taken the part of the ancient geographer, to whom ſcholars have been ſo long accuſtomed to look up with the greateſt reſpect: and if I were to publiſh a ſecond edition of the Engliſh, I ſhould certainly, in conſequence of *carte blanche* given by the author *, avail myſelf of Mr Heyne's aſſiſtance to obviate, as far as poſſible, every objection made to Strabo, except upon the great and fundamental error reſpecting the ſource of the Scamander. For this I take to be altogether untenable. "In general," ſays Mr Heyne, in one of his notes, "nothing can be objected againſt Strabo, but in "the ſingle caſe where he has allowed himſelf to be ſeduced by "Demetrius, and changed the ſources of the Simois and the "Scamander." M. Chevalier perhaps ſhould have been ſatisfied with gaining this point.

But though it ſhould appear, that the author or his editor had, in one or two inſtances, miſconceived or miſinterpreted Strabo, where the text is acknowledged to be obſcure, not yet having been properly elucidated by any able editor or commentator, this ſurely would furniſh no argument for ſetting aſide M. Chevalier's account of the Troad, founded on the author's actual obſervation, ſupported by ſo many ſubſequent reſpectable travellers. In the VIIIth chapter he has, with due reſpect, taken occaſion to quote and comment upon ſome paſſages of Strabo; from which it is clear, that the plain of Troy has not changed its appearance ſince the days of that learned writer.

The

* See his Letters, Appendix, No. VI.

The opening of ACHILLES's *Monument.*

THE XXIst chapter contains a number of pleaſing remarks on the ſubject of the *tumuli* to be ſeen on the ſhores of the Helleſpont; and any perſon of ſenſibility muſt, on the peruſal, feel his mind affected with a ſoothing, though ſolemn, ſenſation; and be ready to confeſs, that M. CHEVALIER has there expreſſed himſelf in a moſt elegant and intereſting manner. Inaccuracies, however, and redundancies, may now and then be perceived, ſome of which were pointed out to me by Mr LISTON, and they ought to be corrected in a new edition.

IT appears, in particular, that M. CHEVALIER had not received very accurate information reſpecting what was found in the tomb of ACHILLES, in conſequence of the operation of digging into it, which had been performed after his departure from Conſtantinople, by the direction of Count DE CHOISEUL GOUFFIER, the French Ambaſſador. He had been told, that towards the centre of the pile were found "two large ſtones leaning at an "angle the one againſt the other, and forming a ſort of tent, "under which was diſcovered a ſmall ſtatue of MINERVA, ſeat"ed in a chariot with four horſes; and an urn of metal filled "with aſhes, charcoal, and human bones; which urn was encir"cled in ſculpture, with a vine branch, from which were ſuſ"pended bunches of grapes done with exquiſite art."

THERE does not appear to have been any foundation for the figure of a chariot. There were however ſome curious reliques found there. Mr LISTON ſaw at Conſtantinople the very perſon who had been employed to conduct the operation of digging; and who had retained ſome of the fragments in his own cuſtody, which he offered to diſpoſe of. It appears from a letter, publiſhed in a note by Dr DALLAWAY, and giving a very particular account of this affair, that this perſon was the Signior

SOLOMON

Solomon Ghormezano, ſon of the late French Conſul. After immenſe labour, he at laſt diſcovered the place where the reliques were depoſited. When collected, they filled a large cheſt. He delivered them to his employer M. Choiseul, who repaid his trouble with thanks only: but he reſerved ſeveral ſpecimens, which he afterwards ſhewed and explained, when the Count was no longer formidable. Of theſe a liſt is given in the letter; ſuch as, pieces of burnt bones; pieces of a metal vaſe; charcoal of vine branches; a piece of mortar and ſtone; a piece of metal of a triangular ſhape; pieces of very fine pottery, well painted with wreaths of flowers of a dark olive colour, &c. An account is then given of the ſtrata of earth dug through. Dr Dallaway, in the text, ſays, that "extreme age, and the "preſſure of the ground, had crumbled into atoms of ruſt all "the metallic ſubſtances. The *urn* or *vaſe*, M. Fauval, an "ingenious artiſt, now reſiding at Athens, received from M. "Choiseul in its decayed form, and made a model from it, "which has been exhibited to ſeveral conoiſſeurs, as much to "their ſurpriſe as ſatisfaction." Dr Dallaway adds: "And "*the goddeſs, with her chariot and four horſes*, ſeems to prove that "the Troad continues to be the land of invention." Yet it is very remarkable that Mr Hawkins, who ſaw M. Fauval at Athens, expreſsly ſays, that this laſt mentioned gentleman denied the exiſtence of an urn, but ſpoke of a ſmall bronze image of Minerva, of which he ſhewed them a caſt. "At Athens," ſays Mr Hawkins in his ſecond letter to Mr Liston, "we fell "in with M. Fauval, a very ingenious artiſt, long in the ſer- "vice of M. de Choiseul, who aſſured us, that M. Cheva- "lier's account of the goblet, diſcovered in the tomb of Achil- "les, is perfectly fabulous. It originated, it ſeems, from the "fragment of a ſmall bronze figure, which, when he had clean- "ſed, and put together, proved to be a very curious image of "Minerva. He ſhewed us a caſt which he had made of it in

"plaſter,

" plaster of Paris *." According to M. CHEVALIER, then, there were both an urn and a figure of MINERVA; according to Dr DALLAWAY an urn, but no figure or statue; and according to Mr HAWKINS a small statue, but no goblet or urn. It should seem, therefore, that this affair still stands in need of further elucidation †.

BUT whatever may be thought of these barrows; " suppo-" sing," says Mr HEYNE, " that M. CHEVALIER was mistaken, " and that the eminences were not at all tombs, the main point " remains what it was. The sources of the Scamander are near " *Bounar-bashi*, and in that neighbourhood is the site of Troy ‡."

Of the Objections made by Mr BRYANT.

MR BRYANT, whose name has been long so well known in the learned world, has, in the warfare he has thought fit to wage with M. CHEVALIER, been, no doubt, pretty successful in several assaults, where the latter has laid himself somewhat open; (as we have admitted to be sometimes the case); but he has totally failed in obtaining any thing like a decisive victory.

THIS learned gentleman having, thirty years ago, embraced an opinion, not a new one indeed, but, I believe, almost generally esteemed very extravagant and paradoxical, that no Trojan war, such as forms the foundation of the poems of HOMER, was

* Appendix, No. V.

† IN the above-mentioned letter, quoted by Dr DALLAWAY, an instance of a very strange pitch of arrogance is recorded. It is there said, that " when the bar-" rows were closed up, Count CHOISEUL caused a sheet of lead to be placed on the " bottom, inscribed, *Ouvrage fait par le Comte* DE CHOISEUL GOUFFIER, *l'an* 1787.

‡ CONCLUSION of his preface to the German version. See Appendix, No. I.

ever carried on *, and that even no ſuch city as Troy ever exiſted, had employed himſelf occaſionally, during that long period, in an attempt to eſtabliſh the truth of this odd opinion. The ſubject had grown a favourite one; and the author ſeemed to himſelf to be upon the point of achieving his great undertaking; when M. CHEVALIER's performance appeared. This obliged him to ſtop ſhort for a little, and to pauſe. He took his reſolution. Encouraged, by obſerving ſome ſlips committed by an author, as yet raw in the art of ſyſtematizing, it ſeemed more eligible to him to endeavour to reduce the obſtructing fabric to a heap of ruins, than to demoliſh and ſuppreſs his own occaſional labour of thirty years. The avowed object, then, of Mr BRYANT's pamphlet, is to ſet aſide M. CHEVALIER's *Deſcription*, as unſound and fanciful. I once indeed heard, that, after the *Obſervations* had come out, the author met with ſome travellers, who aſſured him, that M. CHEVALIER's account of the preſent ſtate of the Troad was a fair and true one; in conſequence of which, it was reported, that he had renounced his heretical opinion upon the ſubject, and was to ſuppreſs his *Diſſertation*. This I was very glad to hear, as I thought the ſo doing would have redounded very much to Mr BRYANT's honour. But I was ſoon convinced that this information was premature, by my receiving a printed copy of the *Diſſertation*, in a preſent, from the learned author himſelf; in the peruſal of which, one, every now and then, regrets (at leaſt this was the caſe with me) that Mr BRYANT had ever undertaken ſuch a toilſome inveſtigation, employed ſo much learning, and waſted ſo much ingenuity, which the appearance of M. CHEVALIER's work, thirty years ſooner, might have prevented; and perhaps might have engaged thoſe very talents to aſſiſt in ſupporting and illuminating a ſyſtem, which

* SEE Mr MACLAURIN's Diſſertation, to prove that Troy was not taken by the Greeks. Vol. I. p. 43, &c. Lit. Cl. of Tranſactions of this Society.

which they have now been employed to puzzle, perplex, and obſcure. After all, if the learned veteran had ſeen Mr HEYNE's Eſſay on the Topography of the Iliad*, and Dr DALLAWAY's late publication, in both of which M. CHEVALIER is ſo ably ſupported, I imagine he would have been deterred from publiſhing his grand ſceptical work, notwithſtanding the great labour it had coſt him.

MR BRYANT, in the introduction to his *Obſervations*, charges the author and his editor with indulging in ſevere critical cenſure againſt Dr POCOCKE, Mr WOOD, Dr CHANDLER, and STRABO. But I can't help thinking that the accuſation is too ſtrongly ſtated. I hope it was not with an intention to create an early prejudice in the mind of the reader againſt the perſons animadverted upon, and in favour of what was to follow.

WITH reſpect to the firſt of the above-mentioned authors, M. CHEVALIER had ſaid, that " his account of Troas, though full " of errors, and in every reſpect obſcure, yet proved to him a " very uſeful guide in his reſearches." (Ch. VI.). He, no doubt, found conſiderable obſcurity, and a number of errors, in Dr POCOCKE's account; and where was the harm in ſaying ſo? But Mr BRYANT, in his complaint that Dr POCOCKE has been unjuſtly accuſed, does not ſubjoin the qualifying clauſe of the ſentence, viz. that " notwithſtanding theſe defects, the work pro- " ved a very uſeful guide ;" but he reſerves this latter part of the expreſſion, till he find an opportunity of introducing it with more effect, and more fitly for his own purpoſe afterwards. I am not ſure if this way of diſmembering expreſſions, and expoſing them in disjointed morſels, ſhould be conſidered as a very fair mode of attack. If M. CHEVALIER was convinced that Dr POCOCKE was miſled by STRABO, and regrets that he did not rather " truſt to his own obſervation, which probably would

i 2 " have

* See Appendix, No. III.

"have brought him to agree with HOMER," I cannot perceive any very ſevere cenſure in this: On the contrary, M. CHEVALIER finds out, and adds a very good excuſe for POCOCKE, which is, that he could not, at that time, have the aſſiſtance of a geometrical apparatus in his obſervations, as it was then hazardous to produce any ſuch to the view of the Turks. On other occaſions, M. CHEVALIER pays compliments to Dr POCOCKE, calling him, in one place, "that excellent traveller," inſomuch, that he appeared to me to have even over-rated his merit. In a note, therefore, (p. 100.), I have ventured to ſay as much, in as far as related to the art of compoſition. For, on reading POCOCKE's travels, I certainly thought him very deficient in point of arrangement, and very confuſed in the communication of his ideas. This, however, was expreſſed with all due deference to his veracity, which I believed to be quite unimpeachable. But, if it will give any ſatisfaction to Mr BRYANT, I am ready to admit, that I may have been miſtaken in thinking Dr POCOCKE a confuſed and inelegant writer. And yet the late Mr GIBBON, whoſe acuteneſs nobody will deny, when he pays a compliment to Dr POCOCKE's plan of the ſeven hills of Conſtantinople, adds, "that this traveller is ſeldom ſo "ſatisfactory."

As to the manner in which Mr WOOD is treated, it will no doubt ſeem very diſreſpectful in the eyes of thoſe who are diſpoſed to believe in his doctrine concerning the ſource of the Scamander; but to M. CHEVALIER this appeared ſo palpably untenable and abſurd, and he was ſo conſcious of his victory, that he has, no doubt, purſued his triumph with a great deal of vivacity and pleaſantry. Where Mr WOOD appeared to have merit, it has been allowed him; but becauſe he viewed the Troad erroneouſly, Mr BRYANT thinks it inconſiſtent to admit that his deſcription of the coaſt is exact; and ſmartly ſays, (with what

what reaſon I leave others to judge), " a man ſo erroneous, and " ſo exact, was never before ſeen."

Dr Chandler, in one paſſage, is blamed for giving his readers too much credit; but a good reaſon for this is aſſigned in the note. In another place, he is noted as having once inadvertently ſpoken of the rivers, repugnantly to his own right notion of them. I have not had time to examine what foundation M. Chevalier had for this remark. Perhaps it might as well have been ſpared. I find it is omitted in the German edition: very probably at the author's own deſire. Of Dr Chandler, M. Chevalier ſpeaks elſewhere with the greateſt deference and reſpect; and I queſtion, if Dr Chandler will thank Mr Bryant for coming forward as his champion, where he had not himſelf obſerved any antagoniſt on the field.

It is ſurpriſing that Mr Bryant, in his zeal for the reputation of Strabo, did not perceive that he himſelf is as guilty of rejecting the teſtimony of that admired geographer as M. Chevalier, when it happens to diſagree with his own ideas. An inſtance of which we find in his *Diſſertation.* (p. 44.). " Of " Troy," ſays he, " there is no ſign: no remainder: nor was " there ever any upon record."—" Strabo endeavours to give a " reaſon for this: but I believe that it will not be deemed ſatis- " factory." And ſo he produces the paſſage which we had occaſion to quote above. (p. 59.).

Mr Bryant employs the firſt three pages immediately ſucceeding his introduction, in endeavouring to prove that the city of Troy, as deſcribed by Homer, muſt have been much nearer the ſea than the ſituation aſſigned to it by M. Chevalier, which is aſſerted to be contrary to the very evidence of the poet himſelf.

I am glad I have it in my power to give a very ſhort, and, I think, a very ſatisfactory anſwer to this objection; and I feel the more ſo, becauſe Mr Bryant's arguments have, in this particular,

ticular, brought over to his ſide a very learned and intelligent Reviewer in the *Britiſh Critic*, (May and June 1797); inſomuch that, after combating Mr BRYANT ſucceſsfully in the other parts of *the Obſervations*, he at laſt feels himſelf under the neceſſity of ſeeking for the ſite of Troy farther down the plain, in which I am ſorry I cannot go along with him. The anſwer alluded to is furniſhed in a few words by Dr DALLAWAY; and coming from one who has been upon the ground, muſt have more weight than any thing which could be ſaid on the ſubject by a perſon who has not had that advantage. "The diſtance "from the Grecian camp to the ſite of Troy," ſays this accurate obſerver, "has ſupplied thoſe who contend againſt its exiſtence "with many plauſible objections. It is, however, certain, that "the preſent village of *Koum-kaleh* is ſituate on a ſand-bank "more than a mile in extent, which will reduce the diſtance, "ſuppoſing it to be an accretion from the Helleſpont, to leſs "than eight Engliſh miles from *Bounar-baſhi*, where the Scæan "Gate once ſtood. The advanced works, both of the Greeks "and Trojans, leſſened the intermediate ſpace. The diſtance of "the moſt advanced rank of ſhips from the ſea is not mentioned; perhaps we might not be far from the truth in ſuppoſing "it half a mile, and a quarter of a mile farther from thence to "the ſea. Allowing the firſt circumſtance of the accretion at "*Koum-kaleh*, and the Grecian camp having been advanced into the plain, the diſtance of Troy is perfectly reconcileable "with every incident mentioned by HOMER. It is likewiſe evident from the circumſtances of the war. Had the city been "very near, the firſt work of the Grecians muſt have been a "ſtrong fortification to prevent ſudden attacks; without it, "their deſtruction muſt be inevitable. Beſides, there had not "been a theatre large enough for the actions of the war." (p. 336, 337.)

Mr Bryant afterwards, (p. 14.), argues from a paſſage of Homer, (Iliad, XX. 216.),—*ἐπεὶ ἔπω Ιλιος ἱρὴ Εν πεδίῳ πεπόλιϛο*,—that Troy muſt have been ſituated in the plain, much nearer the ſhips than M. Chevalier imagines. To this Dr Dallaway alſo gives the following ſatisfactory anſwer: "The moſt eleva-"ted ground on the edge of a precipice was the Acropolis, other-"wiſe called Pergamus, (Iliad, IV. 507. V. 460. and XXIV. "700.). Ilion was lofty enough to be called *windy*, (*paſſim*), yet "it was lower than Pergamus, (XXIV. 700.); ſo that it is once "ſaid to be in the plain, ἐν πεδίῳ, (XX. 216.), as ſtanding at the "head of the plain on an eaſier acclivity, and being lower than "the mountains of Ida. It is, notwithſtanding, incontrovertible, "that Troy ſtood on the aſcent, (VI. 74. XXIV. 390.); and the "ἐρινεὸς, which was without the town, has the ſame epithet *win-*"*dy*, (XXII. 145.), from its unſheltered ſituation. The wall ex-"tended only in the front of the plain, the natural fortification "of cliffs above the Simois rendering its continuance unneceſ-"ſary. Mr Bryant lays much ſtreſs on the expreſſion ἐν πεδίῳ, "which might have been uſed comparatively, and in contradi-"ſtinction to higher acclivities, and not poſitively." (p. 349.).

What Mr Bryant ſays of the diſtance between the promontories, the ſituation of the Grecian camp, and of the θρωσμὸς πεδίοιο; (p. 4. to p. 13.); alſo his criticiſms relating to Strabo, and upon a paſſage of Herodotus, (p. 15.—28.), do not here require a particular anſwer or diſcuſſion, after the conceſſions already made, and the amendments which have been propoſed. In the caſe of a new edition of M. Chevalier's *Treatiſe*, it is admitted that ſeveral of Mr Bryant's remarks might furniſh aſſiſtance in the correction of ſome errors and inaccuracies, and would merit a tribute of praiſe to the learned author's acuteneſs; but they can have no effect in ſubverting the great and eſſential articles of M. Chevalier's inveſtigations and diſcoveries.

Nor

Nor will I enter any further into what is objected to the account of the Scamander, taken from the diminutive ſize of the river; enough having been already ſaid upon that ſubject to convince any unprejudiced perſon that the ſtream, which has its ſources at *Bounar-baſhi*, and which has been explored and deſcribed by other reſpectable travellers, as well as M. Chevalier, anſwers perfectly to all the deſcriptions and hints to be found in the Iliad; allowance being always to be made for the poetic way of repreſenting ſuch things *. Enough too has been already ſaid concerning the tombs.

The paſſage in the deſcription, where M. Chevalier has expoſed himſelf moſt to the power of Mr Bryant, is contained in two paragraphs in the VIth chapter, where Clemens Alexandrinus is referred to, and where the prieſts of the lower empire are mentioned. The obſervations there made are evidently ill digeſted, and raſhly thrown out. This the author has frankly admitted, by directing them to be totally rejected in the caſe of his book's being reprinted †. But ſtill this does not in the leaſt affect the material parts of the *Treatiſe;* and ſuch diminutive or partial victories as this will ſcarcely entitle Mr Bryant to the honour of an ovation, far leſs to the glory of a triumph.

Mr Bryant, I find, willingly allows the author and the editor ſome praiſe for exploding the idle notion of Hector's flight three times round the city of Troy; and ſupports them in their endeavour to ſhow the abſurdity of ſuch a ſuppoſition. At firſt I was afraid there might be ſome ſort of decoy in this, ſome contrivance, like that of the wooden horſe, for deſtroying us; eſpecially as this was a quarter (—*ἔνθα μάλιςα Αμβατός ἐςι πόλις, καὶ ἐπίδρομον ἔπλετο τεῖχος*—) where I never had felt very bold, having ſtill had my doubts about the poet's acceptation of *περί*.

But

* See Mr Heyne's Preface, Appendix, No. I.

† See Appendix, No. VI.

But I was ſoon convinced that Mr BRYANT had no treacherous deſign in making this conceſſion; and the hypotheſis having alſo the ſtrong ſupport of Mr HEYNE *, there is now good reaſon to be confident that it is well founded.

M. CHEVALIER, in the beginning of his XIIth chapter, had remarked, that Mr BRYANT has endeavoured to prove " that " the Greeks were miſtaken in ſuppoſing thoſe to be the tombs " of heroes, which were in reality conſecrated mounds." This obſervation, it ſeems, was of too general a nature. Mr BRYANT meant what he ſaid to be taken in a limited, not a general, ſenſe; and thinks himſelf much injured by this miſrepreſentation. He wiſhes, therefore, that M. CHEVALIER had paſſed him by unregarded; and in this wiſh I heartily concur: for I am ſure M. CHEVALIER will ſincerely regret that he ſhould have written any thing that could be conſtrued into a deſign to injure Mr BRYANT's reputation; which I am as much convinced he never intended, as I am conſcious that I never meant, by the long unfortunate note ſubjoined on the ſubject of barrows, to ſupport him in any ſuch deſign.

BUT in following Mr BRYANT any further, I am afraid I ſhould treſpaſs on the indulgence of the Society. I did formerly, and do now, entertain a high reſpect for that gentleman's talents, learning, and character: at the ſame time, I cannot help lamenting, that he ſhould ever have miſemployed thoſe talents, and that learning, in a laborious attempt which can never enlighten the mind with any cheerful rays of conviction; nor ever reach beyond a dreary and diſguſtful ſtate of obſcurity and doubt, tending to blunt or extinguiſh thoſe pleaſing ſenſations which the poems of HOMER excite in every breaſt qualified to feel their genuine ſpirit; and for a diminution of which, the efforts of a frigid and phlegmatic erudition, even if ſucceſsful in proving them to have been derived entirely from fiction, would ſcarcely be able to compenſate. But that " the war on which

* See his Note, Appendix, No. II.

" HOMER founded his famous poems was never carried on, and " that, if the city called Troy ever exifted, it muft have been in " Egypt, and not in Phrygia ;—nay, that HOMER himfelf, un- " der the name of ULYSSES, was the hero of his own Odyffey," are paradoxes, I fhould think, too whimfical, too violent, and too repugnant to the beft authorities of antiquity, ever to admit of any thing like a proof.

ON the other hand, that the fcene of the Iliad has derived great light from the laudable refearches and fortunate difcoveries of M. CHEVALIER muft be allowed; and therefore he deferves the thanks of every admirer of the works of the great poet. This is the decided opinion of many; and particularly of one, whom the world allows to be qualified in an eminent degree to judge of this fubject, the learned and fagacious Profeffor HEYNE; to whofe Effay on the Topography of the Iliad, which is annexed in the Appendix *, I beg leave to direct your attention.

APPEN-

* No. III.

APPENDIX, containing Papers and Letters referred to in the foregoing Detail.

No. I. (p. 31.).

From Professor HEYNE's *Preface to the German Translation of* M. CHEVALIER's *Treatise* *.

TO penetrate, at least with the mind's eye, beyond the narrow circle to which life is bounded, and to study nature on a large scale, is a propensity in the constitution of man. From this principle arises the pleasure which we receive from the description of foreign lands, and in the representation of natural scenes and prospects. In the case of celebrated places, this pleasure is enhanced, when, in countries well known to fame, the remembrance of illustrious actions is before us. The interest rises still higher, if the spot be what is termed classic ground, the mention of which in ancient authors is connected with important events; or where the topography is doubtful, and has become a subject of controversy.

THIS is the case with the Troad. HOMER furnishes us with so much accurate observation, that we are ready to imagine our-

 selves

* I AM indebted for the translation of the following Extracts, from the German of Mr HEYNE's Preface and Notes, and of the Essay on the Topography of the Iliad, to a very ingenious young gentleman, now the Reverend ALEXANDER BRUNTON, minister of Bolton in East Lothian; formerly educated at this University, and who resided some time at Berlin, as private secretary to the late JOSEPH EWART, Esq; British minister at that court. My learned friend, Mr JAMES BONAR of the Excise, took the trouble of revising and preparing it for the press. D.

ſelves able to make a viſible repreſentation of the country. But if we try to complete the picture in all its parts, we ſhall meet with gaps and with places which do not coincide with the reſt of the deſign. Accurate deſcriptions of this diſtrict have not been obtained.

STRABO is the only author who has furniſhed us with a minute account of the Troad, compoſed not from the perſonal obſervations of this great geographer, but borrowed from DEMETRIUS of Scepſis. DEMETRIUS ſeems indeed to have a juſt title to belief and reſpect, as he was born in the neighbourhood of the Troad, and had in all probability ſurveyed it himſelf. Our good opinion of him is confirmed by the accuracy with which particular places are laid down, and by their coincidence with the deſcriptions of the ancient poets.

THIS author, however, gives riſe to a ſtill greater embarraſſment, not ſo much reſpecting the ſituation of Troy, for it is aſſigned to what, in all probability, is its exact place, as in regard to the river Scamander and its ſources, which are thrown far back in the mountainous region behind Troy.

SUCCEEDING travellers have thrown little light on the Troad. WOOD, alone, made it a ſerious object to explore this claſſic ground, and to form an accurate idea of it. He was prepared for the inveſtigation by claſſical erudition. He travelled, he ſays, with his *Homer* in his hand, but he ſeems to have had STRABO alone in his eye. Without attending to ſo many other circumſtances, which might have directed his view, the ſources of the Scamander were his only point, from which he ſurveyed every thing elſe; and as he was miſtaken in the ſituation of theſe, every thing elſe muſt have received from him a falſe poſition and appearance *.

To

* AN ingenious criticiſm on WOOD's *Eſſay on* HOMER, which appears in the original of this preface, is here omitted, as not immediately connected with the preſent ſubject. D.

To the edition in 1775 of Wood's *Eſſay on the Original Genius and Writings of* Homer, was added his *Comparative View of the ancient and preſent State of the Troad.* Some years afterwards, I read in the Society a paper attempting to explain the military tranſactions in the Iliad, according to the topography of the country*. Had I kept by Homer I ſhould have fallen into fewer miſtakes: but, unfortunately, from confidence in ſuch a man as Wood, who had viſited the country with his *Homer* in his hand, I took him and his chart of the Troad for my guides, and thus allowed myſelf to be entangled in ſuch a labyrinth of errors, that I ſtrove in vain to extricate myſelf.

The main blunder in Wood is the alteration of the ſources of the Scamander, and the conſequent placing of ancient Troy deep in the mountainous region of Ida. Every thing elſe was now confounded. Wood did not perceive that Demetrius of Scepſis, whom Strabo follows, builds, in this inſtance, on a mere hypotheſis. Demetrius, I imagine, founded it on an erroneous interpretation of Iliad, XII. 18, &c. †, which he underſtood geographically, without conſidering that he had before him a poet, not a geographer. Wood, indeed, traced the courſe of a ſtream, till at laſt he found another that flowed into it: he then ſought the ſources of this new ſtream, and diſcovered them. Thus far, all is accurately obſerved, and coincides with Demetrius's aſſertion. But was this ſtream of courſe the Scamander? and was Troy to be immediately transferred to that ſpot? Had not Strabo preceded him with a multitude of doubts? Wood helped himſelf out with changes of nature, which muſt have taken place here, and have altered of conſequence the face of the country. But ſuch changes hiſtory knows of only upon the coaſt, or when occaſioned by the overflow of rivers:

* This paper is publiſhed in *Commentat. Soc. Reg. Scientiarum Gottingenſis*, tom. VI. under the title of *De acie Homerica, et de oppugnatione caſtrorum a Trojanis facta*.

† See above, p. 61.

rivers: and ſuch Homer himſelf deſcribes, Iliad, VII. 459, &c. XII. 13—33.

The transference of Rhœteum to Cape *Berbier* is an error not peculiar to Wood: but the Grecian camp derives from thence an extent which again does not accord with Homer's deſcription. The poet is not indeed to be a geographer; but he muſt not feign any thing which contradicts the firſt glance at nature, or claſhes with the known accounts of the topography of the country. The epic poet muſt repreſent nature as certain leading circumſtances require. The main circumſtance here is the general chart of the face of the country, and an eſtabliſhment of certain principal ſpots. As to the reſt of the ſcene, fancy muſt have full play in ſuggeſting its greatneſs and extent. The epic poet's chief engine is the marvellous. By an accurate determination of every particular, the illuſion would quickly vaniſh. Much muſt appear only in great maſſes. Some things muſt be and muſt remain in obſcurity, that the fancy of the hearers or readers may have room to work, to form to itſelf an idea of greatneſs and power. Homer therefore does not give an accurate determination of the Grecian camp, or of the field of battle. Here the fancy of the reader has room to operate, as that of the poet himſelf has been engaged in working up every thing into the great and wonderful. Every thing appears to him many degrees higher than it is in real nature. Muſt he not raiſe the reader to the ſame pitch? "I ſee gods ariſing" is the language of the poet; and when he is read as a poet ought to be, it will be the language of the reader alſo. If we are at any time to figure to ourſelves the Scamander as a tremendous torrent, which, as a god, fights with Achilles, and threatens to bury him in its waves, Homer muſt not inform us how diminutive its real ſize is. He muſt leave us, by aſſociation with the greatneſs of the effect, to give it all the bulk our fancy can graſp. He in no place gives the exact dimenſions of the town and fortreſs of Troy. This is quite

quite natural; for ſuch accuracy could in no reſpect have had an advantageous effect. The combat of ACHILLES and HECTOR is filled with the *wonderful*. The race of both heroes is traced by means of points, which the fancy of the reader may extend as far as it can; the walls, the wild fig tree, the watch-tower, the ſources of the Scamander. But it may be premiſed, that to a perſon who knew the topography of the country in the days of HOMER, nothing would be repreſented, which he would have recogniſed and declared to be falſe and erroneous, elſe the effect of the poem would have been loſt.

WHEN we ſpeak of the Troad, it may be viewed in various lights. What is the preſent appearance of that country? What was it formerly, at different times, particularly in the days of HOMER? and how can its preſent appearance be reconciled with the deſcriptions of that poet? Or, again; in HOMER there is a certain appearance of the country deſcribed. How far does this actually accord with nature? Each of theſe views and queſtions it is rather the province of the geographer and hiſtorical critic to anſwer. There is ſtill another view of the ſubject. As the poet cannot be read with pleaſure, without a ſenſible repreſentation, what is the repreſentation he gives of the face of the country? To what extent does he give it? and how much of this kind of knowledge muſt accompany or precede the reading of the Iliad?

THE explainer of HOMER is properly bound to diſcharge only the laſt taſk. With this view I had entirely new modelled the above mentioned Memoir, according to HOMER, and had taken no further aſſiſtance from STRABO than coincided with and illuſtrated HOMER's account. So much the more lively was my pleaſure, when I perceived, in the paper of M. CHEVALIER, a greater coincidence with my ideas than I had found in WOOD, or in any other work. This induced me to annex to this

this publication my Memoir in a new dreſs, in order, at leaſt, to remedy the errors it may have formerly occaſioned.

THAT the ſources of the Scamander are ſtill found near *Bounar-baſhi*;—that of its junction with the Simois the ancient channel ſtill remains, as the ſtream is now diverted into a canal, which falls into the ſea below Sigeum;—that the ſtream which comes down from the hills is the Simois, and not the Scamander;—and, alſo, that the other ſtream, which the former receives, is no Scamander;—that *Bounar-baſhi* exhibits the ſite and veſtiges of ancient Troy;—that even the citadel is ſtill diſtinguiſhed by its abrupt precipice:—all theſe are leading remarks and obſervations which we owe to M. CHEVALIER. The coaſt, the promontories, the tombs, the temple of APOLLO at *Thymbra*, *Callicoloné*, and other places, receive from him all the diſtinctneſs that readers of HOMER can wiſh.

M. CHEVALIER viſited the country about the year 1787. He was at that time attached to the embaſſy of M. DE CHOISEUL GOUFFIER at Conſtantinople. The occaſion both of his drawing up the paper, of its being read before the Royal Society of Edinburgh, and afterwards publiſhed by Mr DALZEL, are detailed in the preface of this laſt gentleman *.

I HAD the pleaſure of M. CHEVALIER'S acquaintance during his ſhort reſidence at Göttingen. The peruſal of parts of his travelling journals made me deſirous to communicate to my countrymen the whole work. This propoſal, however, was attended with ſeveral difficulties, particularly, that the paper was the property of the Royal Society of Edinburgh, and that it was aſſigned to a place in the third Volume of their *Tranſactions*, which was not to be publiſhed for a twelvemonth.

IN the mean time, upon ſignifying my wiſhes, I experienced a complaiſance and readineſs to oblige, which calls for the warmeſt

* See the Preface to the Engliſh Tranſlation.

warmeſt and moſt grateful acknowledgment on my part. Not only M. CHEVALIER gave me every aſſiſtance, but, on the part of the Royal Society of Edinburgh, I was anticipated with aſſurances which ſhew the liberal ſentiments of thoſe *Literati*, who are far ſuperior to any little ſelfiſh vanity. I had even immediate acceſs to a tranſlation of the Paper before it had appeared in the Society's *Tranſactions*. A copy of this tranſlation was ſent to me before its publication, and the earlieſt impreſſions of the maps were communicated to me. If ever the occupations of learned men merited the title of the ſtudies of humanity, it was in the preſent inſtance. To the exertions of Profeſſor DALZEL, I am particularly indebted. He preſerved, on this occaſion, his character, already high in my eſtimation, by ſhewing himſelf in no ways actuated by envy, or by any little jealouſy, towards a profeſſor in his own line.

I COMMITTED the German tranſlation to a young promiſing ſcholar, Mr CHARLES FREDERIC DORNEDDEN. According to the permiſſion which I received from Edinburgh, and from the author, I have added ſome remarks, which are chiefly critical, or relate to the interpretation, particularly of STRABO, or refer to a compariſon of paſſages in HOMER. On different points I have received from the author written explanations, and have, by his permiſſion, made ſome changes and additions. The particular ſtate of literature in Germany would perhaps have required other changes, omiſſions, and abbreviations; but the work was not my property.

THE author ſets out always from tombs, and ſeems to lay the greateſt ſtreſs on the obſervations he has made reſpecting theſe. There may have been particular reaſons for this. For us they decide little. Suppoſing that M. CHEVALIER was miſtaken, and that the eminences were not at all tombs, the main point remains what it was; the ſources of the Scamander are near *Bounar-baſhi*; and in that neighbourhood is the ſite of Troy.

No. II. (p. 73.).

Mr Heyne's *Note, additional to Mr* Dalzel's, *on* Achilles's *Purſuit of* Hector. (Iliad, XXII. 165.).

LONG as this note has been *, I find it neceſſary ſtill to ſubjoin another. We ought, I think, to take up the ſubject in this way. Here, as frequently happens in regard to Homer, two diſtinct queſtions occur: 1. How the Ancients underſtood Homer? 2. How he *may* and *ſhould* be underſtood?

Unquestionably the ancients often underſtood their *Homer* ſurpriſingly ill; and in the inſtance before us it may very well have happened that they miſtook his meaning. His commentators have conſtantly been deficient in point of acquaintance with the topography of the Troad. Seldom was this rugged coaſt viſited by travellers, as no great road either led to or run through it. Over the precipices of Mount Ida it was hardly poſſible that there ſhould lie any much frequented path. To the preſent hour this coaſt continues to be but rarely viſited. Thoſe tracts only are known to us through which caravans travel. Even where an accurate acquaintance with the topography of the country might have been moſt confidently looked for, in Strabo for inſtance, we find nothing more than an abridgment of the accounts of Demetrius of Scepſis; and that this laſt mentioned author, in his examination of the ground, carried throughout in his mind a preconceived hypotheſis, is evident in what relates to the fountains of the Simois and Scamander. This may perhaps have been the caſe too, when he aſſerted

* See the Engliſh Tranſlation of M. Chevalier's Eſſay, p. 135, &c.; and the German, p. 206, &c. D.

ed, as follows, of the place which he had rightly marked out as the ſite of ancient Troy, " HECTOR could not poſſibly have " been purſued round about New Ilium, but he might very " well have been ſo round ancient Troy,"—ἡ δὲ παλαιὰ ἔχει περιδρομήν. (STRABO, p. 895. A.). In QUINTUS of Smyrna, who, as well as DEMETRIUS, reſided juſt upon the weſtern coaſt of Aſia, we find a ſimilar deficiency in point of local knowledge. No wonder, then, that even he makes HECTOR be dragged around the walls, ἀμφὶ πόληα. (I. III. XIV. 132.)

VIRGIL's imitation of this incident, in the combat between ÆNEAS and TURNUS before Laurentum, (quoted and referred to in the Eſſay), can prove nothing more than that VIRGIL either adopted in his narrative a different plan from HOMER, or endeavoured to give ſomewhat more probability to his ſtory; juſt as in another paſſage we find him ſubſtituting, for the triple chace of the combatants, the more probable incident of dragging the dead body of HECTOR round the city;

Ter circum Iliacos raptaverat HECTORA *muros.*

He obſerved, in this, the ſame rule by which he conducted himſelf on other occaſions, not always to be anxious to tread in the very ſteps of HOMER, but, where a different delineation ſhould offer more poetical beauties, to carry his imitation at large through the whole circle of poets, epic or dramatic. In this particular, of the dragging of HECTOR's body, he followed ſome other poet, probably EURIPIDES. (See Excurſ. XVIII. ad Æn. I.).

IF it is to be maintained, that the paſſage in HOMER, reſpecting this purſuit of the combatants, cannot mean that it was actually round about the city, and that ſuch a purſuit could not poſſibly have taken place, the main proof muſt be drawn from the topographical ſituation of the country. Ancient Troy was acceſſible only on the ſide next the ſea. On the quarter of the

Acropolis it was ſurrounded by abrupt precipices, and deep ravines; and at the bottom lay the rocky bed of the Simois, as M. CHEVALIER, an eye witneſs, aſſures us. His teſtimony, by the by, affords a ſolution why the Greeks, numerous as they were, never completely inveſted the city, though this would have been a natural and effectual plan of operation. It explains, too, why they did not cut off all approach to the place; for we find freſh ſupplies and proviſions received without interruption from Phrygia; allies and auxiliaries arriving conſtantly at Troy. On the ſide next the mountains there muſt therefore have been a free acceſs to the town. Hence, too, it is no leſs evident, that HOMER, intimately acquainted as he was with the ground, never could have ſaid what has been aſcribed to him, that ACHILLES chaſed HECTOR thrice *round* the walls. Still leſs can this be ſuppoſed, when what the poet is thus made to ſay is palpably abſurd in itſelf, that two combatants ſhould run three times round the walls of a city. For either, if we ſhould reckon the thing poſſible, our idea of the city muſt be diminutive and contemptible; or, ſhould we ſuppoſe the city to be large, the improbability becomes obvious, and we are ſtruck with the abſurdity of the army's ſtanding idle, waiting for the re-appearance of the runners from the oppoſite ſide of the walls. Add to this, that ſuch an abſurdity is by no means neceſſarily implied in the words; nor would it at all occur, were the paſſage read without prejudice, and with proper attention to its meaning. All the combats take place before the Scæan Gate. Thus far had PATROCLUS, the preceding day, driven back the flying Trojans. (XVIII. 453. XVI. 712.). No battle, no tranſaction, is mentioned, as happening in any other quarter, or on the oppoſite ſide of the town. It is on the Scæan Gate that PRIAM and his Trojans ſtand, to be ſpectators of the fight. (Iliad, III. 145—154. XXII. 25. 462.). Even during the flight of HECTOR, we do not find PRIAM running from one gate to another, from one ſide

ſide of the walls to the other; he continues ſtanding on the Scæan Gate.—The whole narrative of the tranſaction in queſtion is as follows:—

HECTOR at firſt takes his ſtation before the Scæan Gate, waiting on foot the approach of ACHILLES, (XXII. 96.); but as ACHILLES draws near, he is ſeized with a panic. To eſcape from him, he takes his flight along the foot of the wall, (*τεῖχος ὑπὸ Τρώων*. XXII. 144.), partly with the view of being protected from the walls, partly, perhaps, in order to get away towards the mountains. ACHILLES gets between him and the wall, and drives him to the oppoſite ſide againſt the Grecian army. This track brings HECTOR to the watch-tower, the wild fig-tree, and the ſources of the Scamander. Here he finds an opportunity to wheel round, and again approach the walls. ACHILLES, once more, interpoſes betwixt him and the city, and drives him back towards the ſources of the Scamander; and this is repeated four times, (v. 157. 165. 188. 194. *Ὁσσάκι*—). On this ſpot, at a diſtance from the walls, near the ſources of the Scamander, HECTOR at length makes a ſtand, and the laſt combat, with his death, enſues.

WHEN the ſubject is taken up in this point of view, the word *περὶ*, in the phraſes *περὶ πόλιν, περὶ ἄστυ, περὶ τεῖχος*, can be underſtood in no other ſenſe, than "*about—before* the city," without any idea of its meaning "*round about* the city itſelf." Even the 165th line, *Ὣς τὼ τρὶς Πριάμοιο πόλιν περιδινηθήτην*, (or rather *περὶ δινηθήτην*); proceeds expreſsly upon the notion, that the flight was directed away from the city towards the ſources of the Scamander; ſo that no idea of a *round about* can be admitted. The matter is completely cleared up by verſes 194—208. The circle of the flight is there accurately marked out, as extending merely from the walls towards the ſources of the Scamander; conſequently verſes 230, and 251, cannot be underſtood in any other ſenſe.

As

As ACHILLES flew HECTOR before the Scæan Gate, fo it was decreed that he himfelf fhould one day fall before the fame gate, (Iliad, XXII. 359. and 360.), ἐνὶ Σκαιῃσι πύλῃσι. This is expreffed by QUINTUS, III. 82. Σκαιῇς ἀμφὶ πύλῃσι.

AFTER HECTOR is killed, ACHILLES expreffes the idea,—worthy of a warrior; but which would have embarraffed the poet in the execution, by giving the Iliad at once an inconvenient termination,—the idea of hazarding immediately, while the panic of the Trojans was frefh, an affault upon the city; v. 381. Ειδ' ἄγετ', ἀμφὶ πόλιν σὺν τεύχεσι πειρηθῶμεν. Here, alfo, it is not neceffary to fuppofe, that the troops were to advance towards the wall round about on every fide. The expreffion' implies only fomething indeterminate in regard to the place, provided other circumftances do not more accurately mark it out. In QUINTUS, (IV. 86. and 87.), DIOMEDE fays,

> 'Αλλ' ἄγε, συν τεύχεσι κ̀ ἅρμασιν, ἠδὲ κ̀ ἵπποις
> Ιομεν ἀμφὶ πόληα.

Let us affault the city itfelf,—On *one* fide, is underftood,—in *one* place, where an affault is practicable. On the contrary, when ACHILLES drags the body of HECTOR round the tomb of ACHILLES, Τρὶς δ' ἐρύσας περὶ σῆμα,—(Iliad, XXIV. 16.), it feems clear, from the nature of the thing, that, in this paffage, the expreffion may fignify *round about*.

UPON the whole, one muft here call to mind the remark, which I have elfewhere introduced,—What other poets do by art, in throwing into the fhade certain parts of their ftory, that the effect of the whole may be more forcible, HOMER does here, certainly not from theoretical notions, but by the guidance of true feeling, and in the glow of imagination. The poet was now arrived at the great, the decifive moment, when his hero ought to appear with the higheft luftre. The combat itfelf is raifed to the marvellous; even deities muft take a part in it, and contribute

contribute to the wonders of the ſcene. So terrible is the look of ACHILLES, that HECTOR, prepared as he was to ſtand the conflict, loſes courage at his approach. The race of the two heroes goes far beyond human force; but how far,—over that the poet throws a vail. Fancy has now room to work, and may repreſent every thing as far beyond what is common and natural as ſhe will or can. They run three times round at the city, —the ſpace, the diſtance, may be conceived as great as we chooſe; but the poet neither does nor ought to determine them. Such determination would fall either into the gigantic or the diminutive. The caſe is different, when, by means of a compariſon, an idea and image can be enlarged or extended. The poet then makes uſe of what is defined, to render the undefined object more diſtinct, and to throw light on what is obſcure. That however is not the caſe here.

No. III. (p. 34. 67. 74.).

ESSAY on the Topography of the Iliad. By Profeſſor* HEYNE *of Gottingen, Aulic Counſellor to His Britannic Majeſty, &c.*

FOR nine years had the war between the Greeks and Trojans been carried on. The former now lay encamped in the neighbourhood of Troy, when the quarrel between ACHILLES and AGAMEMNON, occaſioned a diviſion in the army.

AGAMEMNON,

* THE preſent Eſſay follows out the train of ideas, ſuggeſted in a Paper read before the Royal Society of Sciences at Gottingen, *De acie Homerica, et oppugnatione a Trojanis facta*, in the year 1783, publiſhed in the ſixth volume of their Tranſactions. All the diſquiſitions, there introduced, reſpecting the origin of military tactics, the manner of drawing up an army, and giving battle, and the art of fortifying and attacking a poſt, as deſcribed in the Iliad, are here omitted; many topics, on the other hand, are now corrected and enlarged. That Eſſay was my firſt on the Topography of the Iliad; a ſubject involved in ſo much difficulty. I allowed myſelf

Agamemnon, to convince Achilles that, even without his aſſiſtance, victory might be obtained, cauſes the army to march out of the camp, and advance towards the city. Hitherto the Trojans had kept cloſe within their walls, following the advice of their old men*, who ſaw plainly, that, if a ſiege ſhould actually take place, the Greeks could make little impreſſion on the town: for the firſt rudiments of the arts of attack were then hardly known. Encouraged, however, it ſhould ſeem, by intelligence of the diviſion in the Grecian army, the Trojans quitted the city, and met the Greeks in the field;—a new gratification to the proud ſpirit of Achilles, that now, for the firſt time, when it was known he was not with the army, the Trojans ſhould venture out into the plain †.

The two armies met. Four principal battles are deſcribed in the Iliad. The firſt, (the ſubject of our preſent inveſtigation), on the

ſelf then to be miſled by reſpect for Pope and Wood, ſo far as to renounce my own ideas, and to mould, according to the repreſentations of theſe gentlemen, the views I had drawn from Homer himſelf. I ſoon found, however, that I had truſted to bad guides, and at once reſolved, laying aſide all ſecondary aids, to attempt, from the deſcriptions given in the poem itſelf, a ſketch of the Topography of the Iliad, ſuch as Homer exhibits it. This Eſſay I now preſent to the public. I had for a long time thrown it aſide, when its coincidence with the information collected by M. Chevalier on the ſubject, induced me to reviſe it, and now inclines me to ſubmit it, for further inveſtigation, to the friends of the poet. Amendment after this will be an eaſy taſk. H.

* Iliad, XV. 721, &c. The ſage Polydamas, afterwards, likewiſe, when the deſign of an attack upon the camp ſeemed likely to miſgive, gave his advice rather to retire again within the city, and take refuge, as formerly, behind the walls. But the raſh Hector would not conſent, (XVIII. 266. &c.). Unqueſtionably the long ſiege muſt have proved extremely harraſſing. The proviſions, as well as the treaſure, of Priam were exhauſted, as Hector himſelf urges. (Ibid. 288.). H.

† Once only Hector had ventured beyond the Scæan Gate, as far as the beech tree; but on that occaſion he with difficulty eſcaped from Achilles. (Il. IX. 352, &c.). H.

the plain between the camp and the city, (Il. IV. 422. VI. 306.); —the fecond, when the Greeks were driven back to their camp, (Iliad, VIII. 55—213.);—the third, which extends not only to the flight of the Grecians into their camp, but likewife to the ftorming of the camp itfelf by the Trojans, who break in and fet fire to a fhip, till at length they are repulfed, and purfued almoft to the city by PATROCLUS. Here PATROCLUS falls; and the Greeks, put to flight, are once more driven back to their camp. (Iliad, XI—XVIII.). In the fourth battle, ACHILLES beats back the Trojans again to the city, and crowns his victory by the fall of HECTOR.

No lively idea can be formed, either of thefe battles, or of the ftorming of the camp, without fome general conception of the environs of Troy.

FROM Mount Ida, run two hilly ridges from the eaft down to the fea, where two promontories bound a jutting beach. The promontory on the north is Rhœteum; that on the fouth Sigeum. Within thefe two ridges lies a plain, floping down to the fhore, and inclofed within their femicircular compafs. (STRABO, XVIII. p. 892. B.). In this plain run two rivers: on the north fide the Simois; on the fouth the Scamander, called alfo the Xanthus. The latter now difcharges itfelf into the fea to the fouth, below Sigeum, but formerly, before approaching the fhore, it muft have united with the Simois, fo that both rivers had a common outlet into the fea, above or to the north of Sigeum. This *embouchure* was furrounded with many marfhes, and hence was called *Stomalimné*; a name which occurs but once in HOMER, in an interpolated paffage. (Iliad, VI. 4.). The exact fituation is laid down by STRABO, (XIII. p. 890. A. PLINY, V. 20. 33*.).

* OF all thefe places, the charts of POPE and WOOD give very different views; that of M. CHEVALIER, however, accords exactly with what is faid by STRABO and PLINY.

The Grecian fleet was drawn on ſhore at a place between the two promontories. The diſtance betwixt the two, according to Strabo, (p. 890. B. 891. A.), was 60 ſtadia, (about two German or nine Engliſh miles), in a direct courſe by ſea. The curvature of the land, however, would increaſe the diſtance in keeping along the ſhore *.

It is generally ſuppoſed, that the Grecian camp extended from cape to cape. This notion involves very conſiderable difficulty. Had it done ſo, the camp muſt have reached beyond the Simois, and the marſhes on both ſides of it; a circumſtance by no means probable, particularly as the ſtream is ſo apt to overflow; and not the ſmalleſt trace occurs in Homer, either of the river running through the camp, or of the left wing being ſtationed beyond the river. When Homer, therefore, ſays, that the ſhips occupied the whole ſhore † between the two promontories, he probably ſpeaks in a poetical ſtyle, to convey a magnificent idea; and it is more likely that the camp only ſtretched on both ſides *towards* the promontories Rhœteum and Sigeum, and that on the north-eaſt it extended to the Simois ‡.

Within this ſpace were the ſhips of the Greeks hawled up on the land, at a conſiderable diſtance from the ſhore, with their ſterns towards the land, and arranged in ſeveral rows ‖. The rows,

* D'Anville, in his deſcription of the Helleſpont, (*Memoires de l'Academie des Inſcriptions*, tom. XXIV. p. 329.), allows only half the diſtance; M. Chevalier does the ſame, (Ch. VIII.), on the authority of the paſſage in Pliny, (V. 33.), where the diſtance is reckoned from Æanteum. Still, however, it is a conteſted point, what part of the coaſt muſt properly be regarded as Rhœteum.

† Iliad, XIV. 35. ——————— καὶ πλῆσαν ἁπάσης
Ηϊόνος στόμα μακρὸν, ὅσον συνεέργεθον ἄκραι.

He does not expreſsly name either Sigeum or Rhœteum; on the contrary, he always places the camp on the Helleſpont, in the more extenſive ſignification of that term, as meaning the northern part of the Ægean Sea.

‡ See above, p. 57, 58. D.

‖ The ſhips are therefore ſaid to have ſtood προκρόσσαι, (XIV. 35.), parallel and behind one another, like the ſteps of a ladder. That this is the meaning we learn from Herodotus, (VII. 188.).

rows, however, muſt have been drawn backwards, according to the oblique direction of the whole camp, from the north towards Sigeum. Behind the foremoſt row of the ſhips the troops were encamped, ſo that the ſhips themſelves muſt have ſerved for a kind of rampart, as is plain from a compariſon of different paſſages *. In the rear of the left wing muſt have been the marſhes called *Stomalimné*. STRABO aſſigns particular names to ſeveral parts of the coaſt, though he has not put them down in geographical order †. As only one part of the coaſt bears the name of *Station of the fleet*, it may perhaps be inferred from this, that the Grecian camp occupied only a part of the beach.

THE ſhips ſtood in the order in which they had been drawn aſhore. The veſſels of PROTESILAUS, accordingly, occupied the foremoſt place; and next to them were the ſhips of AJAX, the ſon of TELAMON. (Iliad, XIII. 681. XV. 706, &c.). AJAX was ſtationed towards Rhœteum, conſequently on the left wing of the camp; ACHILLES, with his Myrmidons, on the right towards Sigeum ‡. In regard to the two extremities there is no doubt; but the arrangement in the intermediate ſpace cannot be ſo exactly aſcertained; unleſs, perhaps, thus far: Near to AJAX, and farther to the right, lay IDOMENEUS, with the Cretans,

* ILIAD, XV. 653, &c. 408. 426. XIV. 34.

† STRABO, (XIII. 890. A.). "After Rhœteum follows Sigeum, a town in "ruins, then the ſtation of the fleet, (το Ναυσταθμον), and the harbour of the Greeks, "(ὁ Ἀχαιῶν λιμὴν), and the Grecian camp, (το Ἀχαϊκὸν στρατόπεδον), and *Stomalimné*, "and the mouth of the Scamander, (viz. of the Scamander united with the Simois), "then the promontory of Sigeum." Compare MELA, I. 19. PLINY, V. 30. 33.

‡ ILIAD, XI. ad init. It is true that in XVII. 432. it is ſaid, that the horſes of ACHILLES would not return without PATROCLUS to the Helleſpont, ἄψ ἐπὶ νῆας ἐπὶ πλατὺν Ἑλλήσποντον. But this whole northern arm of the Ægean Sea, before the entrance of the ſtrait, is more than once called the Helleſpont. (Iliad, XVIII. 150.

(Iliad, X. 112.); beſide him NESTOR, with his Pylians; then followed MENESTHEUS, with the Athenians; next to him was ULYSSES; near to whom were ſtationed the Argives, Myceneans, and Lacedæmonians; after theſe came ſeveral other corps; and, laſtly, on the right wing were the Myrmidons, with whom, it ſhould ſeem, the other Theſſalian tribes (the troops of PROTESILAUS excepted) were united.

BY this arrangement, the following paſſages appear both to be cleared up themſelves, and to throw light on others in their turn. The poſt of AJAX is all along the moſt important. Towards this wing the main aſſault upon the camp takes place. To that ſide alſo the battles tend. When NESTOR conducts the wounded MACHAON into his own tent, ACHILLES is at ſuch a diſtance that he ſees only his back, and cannot diſtinctly recogniſe his perſon, (XI. 596. 610. et ſeq.). PATROCLUS, diſpatched by ACHILLES to make inquiry, in returning from NESTOR paſſes the place where the ſhips of ULYSSES are lying. (XI. 805.). Juſt at this ſpot he finds EURYPYLUS, who was coming back from the engagement at the left wing wounded, and was going, it would appear, to the right wing, where probably his Theſſalians were ſtationed. MACHAON, though a Theſſalian, was conducted by NESTOR into *his* tent, probably becauſe he was too much exhauſted to be able to reach the right wing. The ſhips of ULYSSES lay in the centre, ſo that, from thence, the ſhout, which called the troops to arms, could be heard on both wings *. To this the form of the camp, which, from its poſition, extended more in depth than in length, probably contributed. Hard by

150. XXIV. 346. Odyſſ. XXIV. 82. alſo Iliad, VII. 86. XII. 30. XV. 233. XXIII. 2.). And hence muſt be derived the explanation of the epithets πλατὺς and ἀπείρων, which do not ſeem well applied to the proper Helleſpont; though, indeed, *broad* and *narrow* are relative terms.

* ILIAD, XI. 5. Theſe verſes are likewiſe inſerted, though rather awkwardly; lib. VIII. 222. et ſeq.

by theſe ſhips of ULYSSES, and conſequently behind the foremoſt row, was the place for holding the public aſſemblies, and for the altars for the ſacrifices. (Iliad, XI. 806-7.). One of theſe, it ſhould ſeem, was the altar of JUPITER Panomphæus *.

THE order of the ſhips in the catalogue, (Iliad, II.), appears to have ſome connection with this arrangement in the camp, ſo that the Bœotians, and thoſe after them, as far on as the Salaminians, under AJAX, belonged to the left wing. The Argives, and thoſe next in order, as far as the Cretans, Rhodians, and other Iſlanders, compoſed the centre. The Theſſalians, with the Myrmidons, formed the right wing.

THE ſucceſſion and order of the troops, when afterwards drawn up in the field of battle, is ſomewhat different. AGAMEMNON runs through the midſt of the battle; and after paſſing ſome, who are not named, he comes to IDOMENEUS with the Cretans, to AJAX and the Salaminians, to NESTOR with his Pylians, to the Athenians under MENESTHEUS, to ULYSSES, and laſtly to DIOMEDE †.

AGAMEMNON, it appears, went from the left to the right wing. ULYSSES was at ſuch a diſtance from the ſpot where the Trojans were preſſing on to the aſſault, that he as yet knew nothing of their approach. (IV. 331.). In the battle itſelf all order

* ILIAD, VIII. 249. 250. OVID. Met. XI. 197. APOLLO ſtands on the Trojan ſhore,

Dextera Sigeï, Rhœteï læva profundi
Ara Panomphæo vetus eſt ſacrata Tonanti.

What notion the editors have had of this paſſage, it is not eaſy to divine. At all events, a point muſt be put after *profundi*, and that line muſt be underſtood as a complete ſentence.

† ILIAD, IV. 231, &c. The leaders and the corps are by no means all particulariſed by name. Thus, it appears from lib. XI. 808. II. 736. that the Theſſalians, commanded by EURYPYLUS, were there.

der is loſt; and the combatants, individuals as well as ſquadrons, are confuſedly mixed with one another. (IV. 457, &c.).

THE ground in this neighbourhood muſt have experienced alterations by the overflowing of the rivers, as well as by the operation of the Simois at its mouth. HOMER himſelf intimates this, when he takes notice, that not a trace of the wall of the Grecian camp was remaining. (Iliad, XII. ad init.). HERODOTUS alſo quotes the ſhore of Troy as an inſtance of ſuch changes. (lib. II. 10.). And ſhould we even incline to reject the teſtimony of STRABO, (lib. XIII. p. 890. A.), the fact may be regarded as certain. Whether the alterations of the ground, however, have been ſo great as WOOD ſuppoſes, is a different queſtion *.

BEFORE the camp, as already mentioned, a plain, gradually riſing, ſtretched towards Troy, diverſified, it ſhould ſeem, with ſeveral little eminences †. That the two rivers Simois and Scamander incloſed this plain, and that farther down they united with each other, HOMER expreſsly teſtifies ‡; but he furniſhes us with no further or more accurate information ||. The field of battle lies in the neighbourhood of the Scamander §, and is called likewiſe the Scamandrian Plain ¶, though it alſo receives,

* M. CHEVALIER anſwers this queſtion.

† OF this kind was one immediately in front of the camp, the θρωσμὸς πεδίοιο. (Iliad, X. 160. XI. 56.). It lay juſt before the place for croſſing the Scamander, in going from the camp, on the road towards Troy; for in the laſt battle the Trojans had taken poſt ἐπὶ θρωσμῷ πεδίοιο, (XX. 3.), and from thence they came, in the courſe of their flight, to the paſſage of the Xanthus, πόρον Ξάνθου. (XXI. 2.). In ſo far the delineation, on M. CHEVALIER's map, is erroneous. H. See above, p. 56, 57. D.

‡ ILIAD, V. 713. et ſeq. Vid. STRABO, XIII. p. 890. A. 892. C.

|| STRABO ſays: "A little way before New Ilium the ſtreams unite." It is doubtful, however, whether by this expreſſion he means between Ilium and the ſea, or on the inland ſide of the town.

§ ILIAD V. 36. VII. 329. XI. 498-9.

¶ Iliad, II. 465. 467.

ceives, at leaſt in the more immediate vicinity of the city, the epithet of Trojan*. More preciſely ſtill it is ſaid, (Iliad, VI. 1, &c.), "the battle raged between Simois and Xanthus." The latter muſt have been neareſt the Grecian camp; for when the Trojans had advanced very nigh the rampart, and lay a night in the field before it, they are ſaid to be between the camp and the Scamander. (Iliad, VIII. 556.). At the Scamander † HECTOR holds a council of war; and when the Trojans are compelled to retire from before the camp, the wounded HECTOR is laid down at the ſide of the Scamander. (Iliad, XIV. 433.). When, again, PATROCLUS drives the Trojans finally from the camp, he cuts off the retreat of a part of the fugitives to the city, forces them back towards the camp, and falls on them betwixt the ſtation of the ſhips, the river and the city ‡. ACHILLES, in advancing from the camp to the Xanthus, drives a part of the flying enemy into the river; the reſt eſcape to the town. (Iliad, XXI. 1. et ſeq.). Here it ſeems to be plainly intimated, that, on the way between the camp and the city, the river muſt be paſſed. And this is confirmed by ſeveral paſſages in the laſt book, where PRIAM, in going from the city to the Grecian camp, after paſſing the tomb of ILUS, arrives at the river,—undoubtedly the Scamander. Here he waters his horſes. (Iliad, XXIV. 349.). In returning, he comes again to the ſame ſpot, (v. 692.); and here there

* ILIAD, X. 11. XXIII. 464. STRABO, p. 892. C.

† FOR this muſt be the ποταμῷ ἐπὶ δινήεντι of Iliad, VIII. 490.

‡ ——————— Μεσηγὺ
Νηῶν καὶ ποταμοῦ καὶ τείχεος ὑψηλοῖο. Iliad, XVI. 397.

Here it is difficult to form a diſtinct idea of the topographical ſituation, unleſs we underſtand it thus: Firſt, between the ſhips and the river; and farther on, between the river and the town.

there was a place for crossing the river *. HOMER guides us no farther.

I FORMERLY thought it probable that HOMER meant only a near approach of the two rivers, not an entire confluence of their streams; but this opinion I have long since abandoned. The Scholiasts, and even EUSTATHIUS, give us no aid here; they rather mislead; they themselves had probably no ocular knowledge of the place. The Scholia, however, on Iliad, II. 465. say, "the Scamander comes from Ida, divides in the "midst the plain that stretches to the shore, and discharges it-"self, on the left hand, into the sea." But how is this to be understood? If the left hand *from Troy* is spoken of, the present mouth, to the southward of Sigeum, must be intended; and on that supposition this mouth would be of considerable antiquity. If the commentator, however, means on the left hand going *from the shore* to Mount Ida, it is then the united stream of the Scamander and Simois, that is said to fall into the sea at this place †.

EVEN

* Ἀλλ' ὅτε δὴ πόρον ἶξον ἐϋῤῥεῖος ποταμοῖο. ——692.

It is here that M. CHEVALIER's observations on the spot, and his delineation upon the map, give us so much light. The Scamander, as it came near the shore, directing its course obliquely over the plain, approached the Simois, and run into it, exactly as described in STRABO. At present the Scamander is conducted into a canal, and discharges itself into the sea below Sigeum. This is one important observation made by M. CHEVALIER. There is another, also, relating to the sources of the Scamander. Still it is a perplexing circumstance, that, neither in the advancing, nor in the retreat, of the armies, is any express mention made of so important a circumstance as crossing the river. Almost all the passages, except perhaps the last, rather imply that the rivers run on each side. H. See above, p. 46. Note *. D.

† I DOUBT whether any of the poets, QUINTUS of Smyrna, TRYPHIODORUS, or COLUTHUS, had an accurate knowledge of this neighbourhood. TRYPHIODORUS, for instance, says, (lin. 316.),

Ἴαχε καὶ Ξάνθε ποταμε̃ κυκλούμενον ὕδωρ
Καὶ στόμα κεκλήγει Σιμοείσιον.

"Loud

Even in Strabo's time the ſite of Old Ilium was unknown, and was a ſubject of diſpute; but he marks out diſtinctly a *new* Ilium. Alexandria Troas was a different place from both, and lay more to the ſouthward. New Ilium was twelve ſtadia (three-eighths of a German mile, ſomewhat leſs than two Engliſh miles) from the Grecian harbour. Thirty ſtadia (almoſt a German mile, or about four Engliſh miles and an half) higher up, eaſtward from New Ilium, and nearer Mount Ida, was ſituate Old Ilium, on a ſpot where then ſtood a village named Ilium *.

The road from the city of Troy to the ſea ſhore ran from the Scæan Gate, paſt a beech tree, to the tomb of Ilus, on which ſtood a pillar †. Another monument was called Batieia, or the tomb of the Amazon Myrinna, an inſulated hillock, where the Trojans took poſt in the firſt battle. (Iliad, II. 811—15.). Upon another tomb, that of Æsyetes, ſat Polites, as a ſcout on behalf of the Trojans. (Iliad, II. 793.). The Scamander

" Loud roar'd the Xanthus, and the mouth of the Simois;" ſo they were not then united at the mouth. A little after, (lin. 319.), " They were dragging the wooden " horſe, but were retarded, the way being interſected by rivers, and very uneven."

Ὁδὸς δ' ἐβαρύνετο μακρή,
Σχιζομένη ποταμοῖσι, καὶ οὐ πεδίοισιν ὁμοιή.

* Strabo, XIII. p. 889. Ὀυ γὰρ (Ilus) ἐνταῦθα ἵδρυσε τὴν πόλιν οὗ νῦν ἐστιν (New Ilium), ἀλλὰ σχεδόν τί τριάκοντα ἀνωτέρω πρὸς ἕω καὶ πρὸς τὴν Ἴδην, καὶ τὴν Δαρδανίαν, (as this old habitation of Dardanus lay ſtill deeper in the mountains Il. XX. 216, 217. northward from Old Ilium, Strabo, XIII. p. 891. D.) κατὰ τὴν νῦν καλουμένην Ἰλιέων κώμην. Compare p. 891. A. 892. D. When Homer ſays of Ilium ἐν πεδίῳ πεπόλιστο, this is ſaid in reſpect to Dardania, which lay among the mountains. Troy, however, actually ſtood at the *foot of the hill*, at the entrance of the valley or the plain.

† Iliad XI. 166. 371. Here Hector had his poſt, on the night when he encamped before the Grecian camp. (X. 415.). Here Paris ſtood behind the pillar, when he wounded Diomede with an arrow. (XI. 372.). Juſt by the beech Apollo ſtood near the city, and the place muſt likewiſe have commanded a view of the country. (XXI. 549.).

mander could not be far from the hillock where the tomb of Ilus was. (XXIV. 349. 350. Compare 692, 693.). Nearer the city, on the ſouth-weſt ſide, and juſt under the walls, the Watch-tower muſt have ſtood, where the deities reſorted*. Next to it was the wild fig-tree †, and the ſources of the Scamander; and then the place where clothes were commonly waſhed ‡. Before the city, on the north ſide, was Callicoloné (καλὴ κολώνη), a pleaſant hill upon the Simois, five ſtadia in circumference, and ten ſtadia from the village Ilium ||.

That it ſhould ſtill be poſſible, after ſuch a lapſe of time, to recogniſe all theſe places, is not to be expected; but there is one of them which we ſhould think could even yet be traced, and which, if diſcovered, would furniſh at once the moſt certain direction for all the reſt, and even for the ſite of ancient Troy itſelf;—that is, the ſources of the Scamander, ſo accurately and circumſtantially deſcribed by Homer, (XXII. 147. et ſeq.), the one of them a warm and ſmoking fountain, the other, even in

* Σκοπιά. (XX. 136.).

† Ερινεός. (XXII. 146. XI. 167.). Quite cloſe upon the walls, and at the place where they were ſo low that the Greeks had once attempted to force their way into the city from that quarter. (VI. 433—9.).

‡ See above, p. 44. D.

|| According to Strabo, (p. 802. D.), who borrowed this information from Demetrius of Scepſis. The Venetian Scholiaſt A, upon Iliad, XX. 3, quotes the paſſage reſpecting Callicoloné, as if taken from the latter; but he miſtakes this hillock for the θρωσμὸς πεδίοιο on the Scamander. He adds alſo, "Here it was that "Paris ſaw the three goddeſſes." At v. 53. the obſervation is repeated, more juſtly indeed, but in a mutilated form. In all other reſpects, the places hitherto mentioned are determined by M. Chevalier with great plauſibility and diſtinctneſs. I find upon the map, which I had not an opportunity of ſeeing till too late, the hill Callicoloné more rightly laid down, than, from the words of the Memoir, I had ſuppoſed; (ſee p. 94.); and I retract what I there advanced. The paſſages reſpecting Callicoloné (XX. 53. 151.) are not, as I imagined, contradictory.

in the middle of ſummer, of an icy coldneſs. Yet even here there is a very great chaſm in our topographical knowledge. At the place, where (according to DEMETRIUS of Scepſis, whom STRABO follows), the Scamander had its riſe, one ſpring only was to be met with; and WOOD, with STRABO in his hand, ſought and found this ſpring, and this alone*.

AFTER this preliminary ſketch of the Topography of the Troad, let us now try whether it be poſſible to get a clear idea of the battles of the Greeks and Trojans.

THE firſt battle took place on the plain between Troy and the Grecian camp. The Greeks were drawn out in the Scamandrian plain. (Iliad, II. 467.). The Trojans, on the other hand, had taken poſt on the hill Batieia. (Iliad, II. 811. The engagement commences. PARIS and MENELAUS ſoon deſcry each other. HECTOR negociates a combat between them, which is not attended with any deciſive conſequences. The armies muſt have been poſted at no great diſtance from the city, for PRIAM, with his old men, ſees from the walls the Grecian chiefs, and learns their names from HELEN †. The treacherous PANDARUS,

n 2 by

* STRABO, p. 898 9. WOOD, p. 323-4. (98. of the German tranſlation). And yet Mr WOOD did meet with a hot ſpring, but in a place where he was not looking for the Scamander. (p. 329.). M. CHEVALIER was more fortunate in this reſpect. He ſearched for and diſcovered the ſources of the Scamander preciſely at the hot ſpring; and thus cleared up the whole matter in doubt.

† THE diſtance, formerly ſtated, of the city from the ſhore, or more accurately from the harbour of the Greeks, making in all forty-two ſtadia, (one and one-fourth German, nearly five and one-half Engliſh miles), and the high commanding ſituation of the town, render this circumſtance by no means improbable.

by discharging an arrow, brings on a general action. The Trojans attack the Greeks, (IV. 221.), and at length the armies close. (446.). The poet describes, as a poet must, individual combats only. (457, &c.). These however must have taken place in the neighbourhood of the city; for APOLLO surveys the combatants from Pergamos, and animates them by his shout. (IV. 507. V. 460. VII. 20.). For a long time the two armies alternately advance and retreat between the Simois and Scamander, (VI. 2, 3.), till AJAX at last makes the Trojans give way.* When near the gate of the city, and not till then, they are rallied by the exertions of ÆNEAS and HECTOR, and again make a stand. (VI. 73, &c.). HECTOR, by the advice of HELENUS, and on account of the impending danger, as may be conjectured, has recourse to religious rites. He goes into the city, and gives directions for a female procession to the temple of MINERVA. In the mean time, a single combat between GLAUCUS and DIOMEDE terminates in a friendly parley. Upon the return of HECTOR, the battle is renewed. At length a single combat between HECTOR and AJAX is proposed. With this the narrative of the day closes. (VII. 1—306.). Both parties retire, the one into the city, the other to their camp. (VII. 310, &c.).

THE following day an armistice is agreed upon for burying the dead. The Greeks avail themselves of this interval, and rear in haste a rampart round their camp. (VII. 325, &c.). Of this more will be said by and by.

NEXT morning, by break of day, a new battle ensues; the second, on the plain between the city and the camp. (VIII. 60, &c.). Towards noon a panic spreads among the Greeks. They flee, and retreat in disorder to the very camp. (VIII. 68. &c. 139, &c. 213, &c.). At one time, indeed, they again advance to the charge; but still they are forced to give way; and at last shut themselves up in their camp. (336—343.). Fortunately for them night intervenes. (485, &c.).

HECTOR,

Hector, on this occafion, does not draw off his troops into the city, but makes them pafs the night at the river, in the open air, at fome diftance from the camp*, and orders them to kindle watch-fires. By the advice of Nestor, the Greeks likewife fet a watch †. The fame night a deputation is fent by the Greeks to Achilles, and Ulysses and Diomede fet out on a fcouting party. The fituation of the Trojan encampment, at this juncture, is accurately delineated. (X. 415. 428.). Hector had affembled the chiefs at the tomb of Ilus. The watch-fires, like the foldiers, were fcattered over the field without any order. The troops extended themfelves down to the fea, (probably the right wing of the Trojans pointed on the north towards Rhœteum, beyond the Simois), and fome of their pofts reached as far as Thymbra. At the outermoft extremity lay the new arrived Thracians and Rhesus. (434.). This muft have been towards the fea or the mouth of the Simois, and farther out before the Trojan army towards the Grecian camp; for Ulysses and Diomede, who furprifed them, went along the ftream of the Simois ‡. The diftance cannot have been great, for they fet off a good while after midnight, and had returned to the camp by day-break.

Next

* Νόσφι νηῶν ἀγαγὼν ποταμῷ ἐπὶ δινήεντι. (VIII. 490.).

What river now could this be? The Scamander is termed δινήεις, *eddying*. The Simois, however, was ftill more fo. Yet if the Scamander had its courfe obliquely thro' the plain, it muft be the river here intended.

† IX. 67. Out at the tomb, λέξασθαι παρὰ τάφρον ὀρυκτὴν τείχεος ἐκτός. It is more diftinctly faid afterwards, (v. 87.), between the tomb and the wall, καδδὲ μέσον τάφρου καὶ τείχεος. Compare 180. 194. 198.

‡ Hence we find mention made of the heron, (Iliad, X. 274.); of the tamarifks, (μυρίκη), and of the fedges, (466-7.). Homer does not take notice of their paffing the river. This, however, they muft have done.

NEXT day the Trojans aſſault the Grecian camp. And here it becomes neceſſary to have ſome idea of the newly conſtructed fortification of the camp.

THE ſituation has been generally deſcribed already. The camp, according to my ſuppoſition, did not occupy the whole intermediate ſpace, but only a part of the ground, between the two promontories Sigeum on the ſouth, and Rhœteum to the north. Perhaps on this ſide it went no farther than to the Simois. By all appearances the camp muſt have had an oblique front, the right wing receding towards Sigeum, the left bending forwards, and hence more expoſed to the enemy's attacks *.

AS the Greeks in the firſt battle had not been ſucceſsful, NESTOR propoſes, during the truce agreed upon for burying the dead, to fortify the open camp. Such a precaution was before unneceſſary; the Trojans having till now kept themſelves ſhut up within their walls. NESTOR muſt now have been terrified at the ſuperiority of the Trojans, and the valour of HECTOR particularly, when there was no ACHILLES to oppoſe him †. The idea of fortifying

* THIS repreſentation ſeems to be corroborated by M. CHEVALIER's map.

† To give a hiſtorical probability to the circumſtance of the Greeks having now, for the firſt time, thought of fortifying the camp, we muſt ſuppoſe, with THUCYDIDES, (I. 11.), that immediately upon their firſt landing they had beat back the Trojans, or, at leaſt, that the latter ſought their ſafety by remaining within their walls, while the Greeks were unacquainted with any means for carrying on a ſiege. In the above quoted paſſage of THUCYDIDES, I may obſerve, in paſſing, there is ſomething which ſeems to contradict this explanation, ἐπειδὴ δὲ ἀφικόμενοι μάχῃ ἐκράτησαν, (δῆλον δὲ τὸ γὰρ ἔρυμα τῷ στρατοπέδῳ 'ουκ ἂν ἐτειχίσαντο), &c. One ſhould think the 'ουκ muſt be eraſed. Should it be ſaid, THUCYDIDES may have underſtood the matter in a different light; the Greeks would not have been able to fortify their camp, had they not remained maſters of the field. This is contradicted, firſt, by the time of their fortifying the camp, which took place in the tenth year; and, next, by the occaſion of its being done: for it was when they were defeated that they firſt thought of fortification. The Scholiaſt ſays: This is to be underſtood of a former ſlight fortification. But that is a creature of his own fancy, which only ſerves to prove, that, even then, when he wrote, the 'ουκ was to be found in the MS.

tifying the camp was then entirely new, and the plan for accomplifhing it was fingular enough. Nestor advifes to rear, for burning the dead, a common pile on the outfide of the fhips, and upon and round this pile to throw up a hillock, from which a wall and ditch fhould be drawn in front of the camp. The propofal is agreed to, (Iliad, VII. 327—343. 434, &c.), the pile is erected, the mound thrown up, and befide it a rampart conftructed, (Iliad, XII. 29. 255, &c.), which the poet terms a wall, (τεῖχος and πύργυς). (VII. 338. 436. et al.). It had battlements and breaftworks, and was provided with gates, baftions, and turrets *. That all this was a very flight piece of work, may be fuppofed from the fhortnefs of the time in which it was conftructed. No wonder, then, if, in a fhort time, no trace of it remained. Homer, by an ingenious and highly epic turn, afcribes its annihilation to Neptune and Apollo. (XII. 1, &c. 459, &c.). It was, however, the firft attempt we know of to fortify a camp; and, in fo far, is fufficiently remarkable to merit fome attention.

A few elucidations refpecting the work of this fortification may be added. That the mound was raifed to the north-eaft, in front of the camp, can fcarcely be doubted. Its pofition muft therefore have been on the left wing, to which it muft have ferved for a protection; and it may be fuppofed, that Nestor, in propofing it, had this very end in view. But, as the river Simois ran on the fame fide, it is not clear what was the pofition of the mound in relation to the river, and what was the fituation of the left wing, and particularly what was the pofition of the fhips and of the poft of Ajax with refpect to both. In the affault on the camp, which took place on this wing, no mention is made either of the river or the mound. We only fee that the rampart muft have been conftructed at a confiderable diftance before the fhips; for here, between the fhips and

* Στῆλαι προβλῆτες. (XII. 259.). Compare Lycophron, 291. and the Scholiaft.

and the rampart, a ſevere engagement enſued. (XIII. 136, &c. XIV. 30, &c.)*.

THE mound terminated in the rampart, properly a fence of earth, upon which turrets were erected, compoſed of beams and ſtones. (XII. 29.). That the rampart was low is clear, from the circumſtance of SARPEDON's being able to catch hold, with his hand, of the battlements of the breaſt-work. The ſide on which the ſhips of AJAX were placed, is deſcribed as the loweſt. (XIII. 682-3.). What QUINTUS ſays, (VII. 474.), has a reference to this circumſtance.

THROUGH the rampart gates led into the plain †. Among theſe, it ſhould ſeem, there was one principal gate, at the extremity of the left wing of the camp. Through it the Greeks marched out to battle. (XII. 118. Compare XIII. 326.).

ON the outſide of the rampart, towards the plain, a ditch was drawn (VII. 341.) to break the firſt onſet of the Trojans. In the ditch paliſades were fixed ‡.

THE fortification ſeems not to have extended along the whole front of the camp. We do not find, at leaſt, that it reached to the

* THE poet indeed ſays, The mound was thrown up in the field, not far before the ſhips. (VII. 334. 433, &c.), τυτθὸν ἄπο πρὸ νεῶν,—τύμβον ἀμφὶ πυρὴν,—ἐν πεδίῳ ποτὶ δ' αὐτὸν,—πύργυς ὑψηλὺς εἶλαρ νηῶν τε κ̀ αὐτῶν.

THE mound muſt have been thrown up *upon* and *round* the ſpot where the burning took place. Compare XXIII. 255, &c. and VIRGIL, *ſepulchrum imponit*, VI. 292. in like manner upon the ſpot where the funeral pile had been erected; which is preciſely what HOMER means by ἀμφὶ πυρήν. In QUINTUS of Smyrna we find, in like manner, πυρκαΐην κ̀ τάφρον, (read τάφον). XII. 163, 164.

† Πύλαι. (VII. 339, 340. 438.). The Scholiaſt on v. 339. ſeems to be in the right, when he ſays, "On the left hand of the ſhip-ſtation (ναύσταθμος) was a large "gate, beſides which ſeveral other gates were conſtructed."

‡ VII. 441. XII. 54. 63, &c. Between the ditch and the wall no intermediate ſpace was left, as may be inferred from VIII. 2, 3.; τάφρος πύργῳ muſt be united.

the quarter where ACHILLES was ſtationed. The oblique poſition of the camp muſt have been the cauſe of this. To the ſame circumſtance we muſt have recourſe to explain how, from the ſpot where the Trojans made a breach in the rampart, and at length ſet fire to a ſhip, the diſtance could be ſo great to the tents of AGAMEMNON, and the quarter where the remaining veſſels were hauled up on the land *.

WE now come back to the aſſault of the camp. At day break the Greeks, leaving their chariots behind them, (XI. 48.), marched out from the camp. The Trojans had taken poſt on the field of battle, which had an acclivity towards Troy †. Till about noon the fate of the day was equivocal; but then the Greeks made the Trojans give way. The Trojans fled, paſt the tomb of ILUS, (XI. 166, &c.), through the midſt of the plain, towards the wild fig-tree, (XI. 167.), and never ſtopped their flight till they had reached the beech tree and the Scæan Gate. (XI. 170.). Here the battle is renewed. (211, &c.). During all this day AGAMEMNON diſtinguiſhes himſelf, till he is wounded. On this the Trojans take freſh courage, repulſe the Greeks, drive them back again paſt the tomb of ILUS, where PARIS lies in ambuſh, and wounds DIOMEDE with an arrow. (XI. 369, &c.). The combat ſpreads to a great diſtance over the plain, for HECTOR fought on the left wing, towards the Scamander, (XI. 498, &c.), againſt NESTOR and IDOMENEUS, and knew nothing of the defeat which DIOMEDE, ULYSSES and AJAX had given the Trojans towards the Simois. HECTOR flies to that quarter, and AJAX himſelf is now forced to fall back. (521, &c.). The Greeks flee to their camp, and ſhut themſelves up in it. HECTOR purſues, and reſolves to attack them in the camp, to

 break

* SEE Iliad, XIV. 30, &c.; a paſſage which I know not how to explain.

† Επὶ θρωσμῷ πεδίοιο. (XI. 56.); of which we have ſpoken already.

break in, ſet the ſhips on fire, and annihilate the whole Grecian army.

THIS operation was ſo new to the Trojans, that they did not know how to conduct the attack, ſo as to make themſelves maſters of the camp. At length, by the advice of POLYDAMAS, (Iliad, XII. 75.), the chiefs diſmount from their chariots, and bring the infantry in five columns over the ditch. ASIUS alone remains in his chariot. He obſerves, upon the left wing of the ſhips *, the gate open, through which the Greeks had paſſed to and from the field. He makes an attack here, but with an unfortunate iſſue. (XII. 110, &c.). The other diviſions aſſault at different points the rampart and the entrances. (175, &c.). As there were five columns of the Trojans, it is commonly ſuppoſed that the gates of the fortification muſt have alſo been five in number. HECTOR's diviſion exert themſelves to the utmoſt to demoliſh the rampart, (251.), particularly around and near one of the gates. (291.). SARPEDON aſſaults the rampart at the quarter defended by MENESTHEUS, leader of the Athenians. (331.). MENESTHEUS finds himſelf worſted, and calls for aſſiſtance to AJAX and TEUCER, who were engaged with HECTOR. By the abſence of theſe two, HECTOR is left at liberty to act. He burſts the gate with a piece of rock, and forces his way into the camp. (437. et ſeq.).

THE terrified Greeks retreat towards their ſhips. Here the two AJAXES had joined. They rally the fugitives, and lead them on again againſt the enemy. This column of the Greeks appears to have ſome reſemblance to a phalanx, the firſt outlines of which it is believed may be found here; for the braveſt troops, we are told, drew up in thick cloſed ranks, and waited for the approaching foe. (XIII. 126, &c.). The enemy, by this manœuvre, is quickly repulſed.

WHILE

* Νηῶν ἐπ' ἀριστερά. (XII. 119.).

WHILE the battle rages here among the ſhips *, IDOMENEUS, accompanied by MERION, repairs to the left wing †, and there, with the veſſels in his rear, makes head againſt the troops of ASIUS. The diviſion commanded by ÆNEAS muſt have joined the column of ASIUS, and the troops of PARIS united with theſe two. At leaſt, all the three detachments, as well as ſeveral others after them, muſt have formed a junction to oppoſe IDOMENEUS, in the place mentioned above. (XIII. 490.).

THE Trojans, in the mean time, began to crowd in on all ſides round the place where HECTOR was engaged. By the advice of POLYDAMAS, (Ib. 726. et ſeq.), HECTOR calls the chiefs together to a council. He himſelf goes off, (Ib. 674. et ſeq. ‡. 754. et ſeq.), collects the braveſt of the chiefs, with their battalions, and advances with them againſt AJAX. (789.).

* XIII. 312. Εν μέσσησι νηυσί.

† IBID. 326. Επ' ἀριστερὰ στρατȣ̃. AJAX, as afterwards appears, fought in front of his own ſhips. The left wing of the camp, therefore, muſt have extended beyond the ſtation of AJAX. Compare 679, &c. At that quarter, too, there were ſhips lying; for IDOMENEUS fought ἐπὶ πρύμνῃσι νέεσσι. (Ibid. 333.).

‡ A PASSAGE of conſiderable difficulty, in reſpect of the topography, occurs here. It is ſaid, (XIII. 675.): "HECTOR knew not yet that, on the *left* hand of the ſhips, "νηῶν επ' ἀριστερὰ, his Trojans were ſuffering ſo much; but he ſtill kept the place "where he had firſt penetrated into the camp, beſide the quarter where the ſhips of "AJAX and PROTESILAUS were hauled up." (679—682.) The rampart, in front of the ſhips, was loweſt at this ſpot. Here the action was ſharpeſt. (v. 684.).

ἔνθα μάλιστα
Ζαχρηεῖς γίνοντο μάχη ἀυτοί τε καὶ ἵπποι.

This laſt expreſſion embarraſſes me. How could chariots be of any uſe in the narrow ſpace between the ſhips and the rampart? HOMER ſays further: "Here fought "the Bœotians, the Ionians, (Athenians), the Locrians, the Phthians," not thoſe ſubject to ACHILLES, but thoſe who had come with PROTESILAUS, out of Phylace in Theſſaly, (II. 695.), but at this time fought under the command of PODARCES, (XIII. 693.), "the Epeans." I hardly think the ſhips of theſe people lay there, Matters had now advanced fo far, that Hector thought the completion of his wifhes at hand, when the Grecian chiefs, after getting their wounds dreffed, return to the combat. (XIV. 128. 365—387.). Hector is wounded, and the Trojans driven from the rampart to the outfide of the ditch. (XVI. 1.).

Hector recovers again, rallies the Trojans, affaults the rampart once more, fills up the ditch, (Ibid. 355. et feq.), and renews the battle between the fhips and the tents. (367. 384. et feq.). The Greeks beaten back take fhelter behind and between the foremoft row of the fhips on the beach, and with their fhip-poles ward off the Trojans as they prefs on. (Ib. 653. et feq.). Ajax boldly encounters Hector. At length Hector catches hold of the ftern of a fhip, belonging to the fquadron of Protesilaus, and fets it on fire. (Ib. 704. et feq. XVI. 124. et feq.).

Here the fuccefs of the Trojans ftopped. Patroclus came forward to the combat. The Myrmidons, to the number of 2500, advanced in five divifions, drawn up in clofe columns *. The Trojans are defeated, and forced to retreat to the outfide of the ditch. (XVI. 366. et feq.). There a complete flight enfues. Patroclus cuts off one part from the city, and deftroys them betwixt the fhips, the river, and the town †. Intoxicated with fuccefs, he purfues the fugitives, contrary to the orders of Achilles, to the very walls, and even attempts an affault upon the

but that the troops happened to come together in that place. Befides, fo far as I can find, throughout this whole paffage, even where Hector is fpoken of, the *left* fide muft be underftood as referring to the Grecian camp. It is fo, where mention is made of Paris, (v. 765.), as well as, in apreceding paffage (v. 326.), of Idomeneus.

* XVI. 212. Achilles and his foldiers, we find, evidently excelled the reft of the Greeks in military fkill. Writers on the art of war, Puysegur for example, difcover, in this arrangement of the troops led on by Patroclus, the firft rudiments of cohorts.

† Here occurs the remarkable expreffion formerly adverted to, Μεσσηγὺ νηῶν καὶ ποταμοῦ καὶ τείχεος ὑψηλοῖο. (XVI. 396. et feq.).

the city. (698—710.). Hector, having halted at the Scæan Gate, rushes again upon the Greeks and slays Patroclus. He pursues the flying Greeks to their camp; they bring off with them, however, the body of Patroclus. (XVII. 736.). The sight of Achilles, though unarmed, deters the Trojans from advancing farther.

This time too the Trojans pass the night in the open plain before the camp. (XVIII. 243. et seq.). Hector opposes the sage advice of Polydamas, to retire into the city, and defend themselves behind the walls. (Ib. 274. et seq.). At day-break Achilles, clothed in new armour, comes out from the camp. (XX. 1. et seq.). The Trojans draw up on the rising ground* before the camp. This is the fourth and last battle. At first both armies display equal valour; but at length the Trojans give way, and fall back upon the Scamander. (Ib. 494. et seq.). Here Achilles separates the flying army. (XXI. 1. et seq.). One part are fortunate enough to effect their escape across the plain to the city. The remaining part he drives into the river, which, being choked in its course, swells and overflows its banks. Achilles now comes close up to the city, (Ib. 520.), which the flying Trojans had already entered by the Scæan Gate. (Ib. 526.). Hector alone remains before the town; and then ensues the single combat, in which Hector is slain by Achilles.

No. IV.

* Επὶ θρωσμῷ πεδίοιο; before the camp. (XX. 3.).

No. IV. (p. 32.).

The Reverend Dr Jackson, *Dean of Christ Church, Oxford, to Mr* Dalzel *.

I cannot permit myself to leave Oxford for the summer, without paying you my very sincere thanks for the obliging manner in which you transmitted to me the present of M. Chevalier's Essay; and I beg you, when you have an opportunity, to present my acknowledgments to M. Chevalier himself: accompanied, however, with a little reproach, for his having forgotten the promise he made me, of calling at Oxford whenever he came to the south of England.

I have had a very particular pleasure from the perusal of the work itself. No reader of Homer could possibly be satisfied with the accounts we had before of the Troad; and Mr Wood's book, in particular, was idle and childish in the extreme.

It was impossible, also, for the reader of Homer to doubt of the situation of Troy, and the adjacent country, as described in the Iliad; and I had always, therefore, heard, from the few men who understood Homer, one and the same language;—a language which I thoroughly adopted, that we were misinformed and mistaken as to the Scamander. And when I had the pleasure of meeting a set of friends, a few weeks ago, at Lord Stormont's in London, I was not surprised to find that we all agreed in the same

* At M. Chevalier's desire, Mr Dalzel sent a copy of the Essay to the learned and respectable Dean of Christ Church, (to whom M. Chevalier was known), and received the above answer.

ſame opinion, that M. CHEVALIER had cleared up our difficulties, and brought every thing into its right place, by diſcovering the true Scamander.—I have the honour to be, with perfect eſteem and regard, &c.

CYR. JACKSON.

CHRIST CHURCH,
July 7. 1792.

The late Earl of MANSFIELD, *(formerly Lord* STORMONT), *to Mr* DALZEL.

I MUST not omit repeating my thanks for the Diſſertation you were ſo good as to ſend me, which is upon a ſubject that has always intereſted my curioſity, and which I read twice in the courſe of laſt ſummer. [After a compliment to the Tranſlation and Notes, his Lordſhip adds]:—I underſtand that you may ſoon expect an anſwer from a very ingenious gentleman *, but one who doubts even of the exiſtence of the Trojan war. I can venture to foretel that he will not ſhake my faith, which is, and long has been, that HOMER reſted upon hiſtorical tradition, not only for the principal facts, but alſo for the leading differences in the characters of his heroes; and that they know little of his real excellence, who aſcribe to him that ſort of invention, which is the paltry merit of a modern writer of romance.—I am, with great eſteem, &c.

MANSFIELD.

PORTLAND-PLACE,
June 17. 1793.

No. V.

* THIS proved to be the learned Mr BRYANT.

No. V. (p. 33. 39. 41. 45. 48. 52. 65.).

ROBERT LISTON, *Efq; His Britannic Majefty's Ambaffador at Conftantinople, to Mr* DALZEL, *Greek Profeffor in the Univerfity of Edinburgh.*

MY DEAR FRIEND, *Conftantinople, Sept.* 25. 1794.

To day I have not time to fay a fingle word with regard to myfelf: but I cannot avoid the temptation of fending you copies of letters from gentlemen who lately left me, and at my requeft promifed to infpect the Troad with attention. They are both ingenious men. Dr SIBTHORPE is Profeffor of Botany in Oxford: The other, noted for his knowledge in mineralogy, and his geographical refearches, a brother of Sir CHRISTOPHER HAWKINS.

YOU will be glad to fee their obfervations tend to confirm M. CHEVALIER's fyftem. I ever am moft cordially yours,

ROBERT LISTON.

J. HAWKINS, *Efq; to his Excellency* ROBERT LISTON, *His Britannic Majefty's Ambaffador at Conftantinople.*

At Anchor, oppofite Karanlik-limani,
Sept. 15. 1794. *Monday Eve.*

I SEIZE the firft oportunity of giving your Excellency fome account of our expedition to the Troad, but the time will not permit to enter into particulars.

WE

We caſt anchor at *Koum-kaleh*, about mid-day, on Saturday, engaged horſes, and croſſed the plain in three hours to the village of *Bounar-baſhi*, where we ſlept. We ſpent the whole of the next day in viſiting the hill, which M. Chevalier ſuppoſes to have been the ſite of Troy, and the ſprings of water, which he conſiders as the fountains of the Scamander. A day, I think, is fully ſufficient for this purpoſe, unleſs the traveller means to make topographical obſervations, which was the caſe with me.

We were well lodged and entertained in a *Chiftlik* at *Bounar-baſhi*, belonging to Hadgi Mehemet Bey, a perſon of ſome conſequence, who actually reſides at the Dardanelles, but is now on a pilgrimage to Mecca. His ſubſtitute or ſteward received us in a manner which left us nothing to wiſh for; and our arrival there ſeemed to cauſe no ſurpriſe, as they were accuſtomed to *frank* viſitors. We returned by a different rout this day, viſiting the tomb of Æsyetes, (ſee Chevalier's map), and thoſe near Cape *Jenitcheri*, ſuppoſed to be of Achilles and Patroclus.

Your Excellency naturally wiſhes to hear our preſent ſentiments reſpecting the hypotheſis of M. Chevalier. We ſtill think it a very plauſible one; and although his map is incorrect in the detail, it gives a pretty good idea of the Troad in general. He has certainly pitched upon a place for the ſite of old Troy, which has much natural ſtrength to recommend it, particularly the eaſternmoſt angle of the hill, which, from its height above the Simois, and its peninſular form, muſt have been conſidered as a very ſtrong natural faſtneſs in thoſe times of warfare, and could have been eaſily rendered an impregnable citadel; for it is not large enough for the ſite of the whole city. Some *tumuli* near this ſpot are certainly ſtrong indices.

There are two places diſtant from each other about two hundred yards, in which the ſuppoſed Scamander iſſues out of the earth; in each, however, by many mouths. The water proved equally cold in them all: neverthelefs in winter one is faid to be warm.

WE faw the place where the courfe of this river is diverted by an artificial canal to the Archipelago. We are now about to fhape our courfe for *Samothraki.* The bearer, our janiffary, fets out alfo on his return to the Dardanelles, where he will confign this to the care of our Conful, to whofe great attention and civilities, as well as to thofe of his uncle Mr KAIM, we are much indebted.

I BEG leave to add, how much I am flattered by the civilities paid me at Conftantinople, and with what truth I have the honour to be, &c.

J. HAWKINS.

Dr JOHN SIBTHORPE, *Profeffor of Botany in the Univerfity of Oxford, to his Excellency* ROBERT LISTON, *His Britannic Majefty's Ambaffador at Conftantinople.*

DEAR SIR, *Troy, Sept.* 15. 1794.

I AM juft returned from Troy, as perfuaded as a faithful Muffulman who has made his pilgrimage to Mecca, or as a pious crufader who has been at Jerufalem, that my eyes have beheld the tombs of thofe mighty heroes HOMER has fung near two thoufand years fince. It was the "*Campus ubi Troja fuit.*" The piety of former ages raifed tombs more lafting than marble or brafs, which time has not deftroyed. Troy and its temples have been fo completely rafed, that not a column, or even a ftone that has been ufed in architecture, remains to tell its fite; and it is from the *tumuli* only, with their relative fituation to the Simois and Scamander, that we are to learn where it once

ftood.

ſtood. The ſituation where we ſuppoſe the citadel to be, is particularly ſteep and rocky. It is girt by the Simois, the bed of which is now entirely dry. Perhaps the winter torrents might raiſe it into a conſiderable river. Its banks are fringed with planes, agnus caſtus, and tamariſk. We ſlept at *Bounar-baſhi*, a little below which riſes the Scamander, fed by numerous ſprings of a pure cryſtalline water. One of thoſe is ſaid to be warm in winter. At preſent it communicated to us no ſenſation of heat. The courſe of the Scamander is often interrupted and choked up. It had overflowed the adjacent lands, which were become reedy, and offered a favourable ſituation to wild ducks, ſnipes, and coots. The plain of Troy is rich and fertile. We traverſed it from *Koum-kaleh* to *Bounar-baſhi*, an extent of nine miles, and ſlept at the houſe of the Aga. He was himſelf gone to Mecca, but his *homme-d'affaires*, or ſteward, received us with much hoſpitality. Your Excellency will find it the beſt ſituation to ſleep at, when you viſit the Troad. Troy ſeems to have been built on a moſt rocky ſpot. We could not find on it even a ſpring of water. It is covered with prickly barnet, and a few thorny ſhrubs. The almond tree, which grows wild, is not without its thorns. It has even more pleaſing plants, the yellow jaſmine and the wild olive.

I WRITE to your Excellency in haſte, our veſſel toſſing about at anchor oppoſite the tomb of AJAX, where it has been juſt drove by a hard gale of wind. The janiſſary, who accompanied us from the Dardanelles, is waiting for my letter. He was recommended to us by our Conſul, and has done credit to the recommendation. In appointing Signior TARAGANO, your Excellency has nominated a Conſul very deſirous to oblige and render every ſervice to his countrymen. &c.

JOHN SIBTHORPE.

A ſecond Letter on the Subject of the Troad, from his Excellency ROBERT LISTON, LL. D. F. R. S. EDIN. *His Britannic Majeſty's Ambaſſador at Conſtantinople, to Mr* DALZEL, *Profeſſor of Greek in the Univerſity of Edinburgh.*

MY DEAR FRIEND, *Conſtantinople, April* 25. 1795.

YOUR letter of the 28th of December reached me after a long delay, occaſioned by the interruption of the communication through Holland.

IT gives me pleaſure to obſerve, that the circumſtances I tranſcribed for you, on the ſubject of the Troad, appeared intereſting. I have ſince had another letter from Mr HAWKINS, which confirms ſtill more perfectly the topography of CHEVALIER, by removing the only difficulty that could poſſibly cauſe heſitation; a difficulty which had been propoſed to me in ſo poſitive a manner, as to make an impreſſion on my mind, deeper (it ſeems) than it ought to have done. As I have not as yet any near proſpect of viſiting the ſpot myſelf, I will once more copy from Mr HAWKINS.

" I AM extremely happy" (ſays he) " that our communications " reſpecting the Troad proved ſo ſatisfactory; and I am happy " that it is in my power to remove the only remaining doubt " expreſſed in your letter, by aſſuring your Excellency, that Te- " nedos is really to be ſeen from the hill of Troy; even the whole " coaſt of the iſland is viſible from the northern to the ſouthern " point.

" THE moſt eſſential point, in ſubſtantiating the evidence of " CHEVALIER, is that of the canal made to divert the waters of " the Scamander from their original courſe towards the Simois.

" This

" This canal we can bear teſtimony to. The errors of Wood " ſeem to ariſe from the overlooking this circumſtance. As for " Strabo, he had never viſited the ſpot in all probability, and " relied on the authority of Demetrius of Scepſis.

" At Athens we fell in with Mr Fauval, a very ingenious " artiſt, long in the ſervice of M. de Choiseul, who aſſured us, " that M. Chevalier's account of the goblet, diſcovered in the " tomb of Achilles, is perfectly fabulous. It originated, it " ſeems, from the fragments of a ſmall bronze figure, which, " when he had cleaned, and put together, proved to be a very " curious image of Minerva. He ſhewed us a caſt which he " had made of it in plaſter of Paris.

" This gentleman ſhewed us ſome *genuine* Etruſcan vaſes, " diſcovered in *tumuli* he had opened in Attica. This will throw " new light on the hiſtory of art. For my own part, I conſider " the Etruſcan as nothing elſe than the early Greek ſtyle."

I have copied more than I intended when I took Mr Hawkins's letter into my hand; but you will think probably that the whole is intereſting. Ever moſt truly and cordially yours,

Robert Liston.

No. VI. (36. 55, 56, 57. 62. 72.).

M. Chevalier *to* Mr Dalzel.

Monsieur et cher Ami, *Londres, ce* 11 *Avril* 1796.

J'ai reçu votre reponſe du 2, et j'ai été enchanté d'apprendre que M. l'Ambaſſadeur Liston avoit prit la peine d'aller verifier lui-

lui-même mes obſervations ſur la plaine de Troye. Son temoignage ſera du plus grand poids dans la diſpute qui s'éleve entre le Dr BRYANT et nous. Quant aux fautes qu'il a trouvées dans la Carte, je ne demande pas mieux qu'on les corrige, et je prête de tout mon cœur les mains à toutes les ameliorations dont cet ouvrage eſt ſuſceptible; mais je ne crains pas de vous aſſurer d'avance, que les changemens qu'on pourra faire ne ſauroient tomber ſur des monumens eſſentiels à l'intelligence de l'Iliade, tels que la ſituation de l'ancienne Troye, les ſources du Scamandre, les tombeaux des guerriers, les caps, &c. Tous ces points ſont fixés relativement les uns aux autres, avec aſſez de preciſion pour que les changemens qu'on y fera ne puiſſent pas affecter ſenſiblement mon ouvrage. Quant aux monumens modernes, tels qu'Alexandria Troas, &c. j'avoue que je n'ai pas cru qu'il fut neceſſaire de les traiter avec une auſſi ſcrupuleuſe attention. La ligne de la côte a été faite avec la plus grande exactitude; ainſi que l'embouchure de l'Helleſpont et l'ile de Tenédos. Je doute, en conſequence, que la nouvelle carte y faſſe aucun alteration.

AU reſte: encore une fois je vous donne carte blanche, et de tout mon cœur. Vous pouvez couper, tailler, rogner à votre fantaiſie.

LORSQUE vous publiez la ſeconde edition, mon ami, vous m'obligerez beaucoup de vous ſouvenir du petit nombre d'obſervations que je vais vous faire; ou plutôt, que je crois déjà vous avoir faites.

JE deſire, d'abord, que vous ſupprimiez ma tirade contre les princes et les femmes voyageurs. Je deſire, en ſeconde lieu, que l'autre tirade contre les prêtres des premiers Chretiens ſoit auſſi ſupprimée; et Mr BRYANT vous en a dit la raiſon. 3°, Tout le chapitre du *throſmos*, et du tombeau d'ILUS, ne vaut rien. Mr HEYNE m'a ſuggeré autrefois une très excellent idée ſur ce *barrow* qu'on voit ſur les bords du Simois, en avant le

camp

camp des Grecs. Ce monument eſt certainement le *tombeau commun* que les Grecs éleverent à leur ſoldats tués dans le combat. Vous voudrez bien profiter de cette idée, et l'arranger à votre façon. Un tombeau ſi voiſin du camp des Grecs ne pouvoit pas être un tombeau Troyen.——

ADIEU, mon ami, vous aurez encore une fois des mes nouvelles avant mon depart.

LE CHEVALIER.

M. CHEVALIER *to* Mr DALZEL.

MONSIEUR ET CHER AMI, *Londres, ce* 5 *Mai* 1796.

* * * * * JE joins ici les corrections que vous m'avez demandées, et qui ſont beaucoup trop longues pour être écrites à la marge d'un de nos livres, comme vous aviez paru le deſirer.

1MO, J'inſiſte ſurtout ſur la ſuppreſſion totale du Chapitre 16. page 112. de la traduction Angloiſe, qui traite du tombeau d'ILUS. Il eſt évident que je me ſuis groſſièrement trompé ; premièrement, en confondant le θρωσμὸς avec le tombeau d'ILUS ; et ſecondement, le tombeau d'ILUS avec le monument que j'ai decouvert près des ruines du pont, à peu de diſtance de l'embouchure du Simois. Mr HEYNE, qui ſait beaucoup mieux l'Iliade que moi, avoit ſoupçonné que ce monument pouvoit bien être le *tombeau qu'on éleva en commun* aux ſoldats Grecs après le premier combat, et dont il eſt queſtion dans le 7e livre, verſ. 334, &c. Il me fit part de ſes idées, que j'adoptai ſur le champ, et c'eſt ce qui lui a fait dire, page 168. de ſa traduction Allemande, dans une des notes, *que M.* LE CHEVALIER, *n'étoit pas éloigné de croire que ce tombeau, au lieu d'être celui d'*ILUS, *étoit vraiſemblablement*

blablement le tombeau commun. En effet ce *tombeau commun* n'étoit pas loin des vaiſſeaux, puiſqu' Homere le place,

Τυτθὸν ἀπὸ πρὸ νεῶν,——Iliad, VII. 334.

et que le retranchement fut bati tout près de lui. Ces circonſtances s'accordent fort bien avec la ſituation du monument decouvert près des ruines du pont.

2DO, Je deſirerois auſſi que vous ſupprimaſſiez tout-à-fait le paſſage qui a rapport aux princes voyageurs; vous n'imagineriez jamais qu'il y a eu des perſonnes aſſez malveillants pour m'accuſer d'avoir voulu faire des applications auxquelles vous ſavez que je n'ai jamais ſongé.

3TIO, J'ai dit, à la page 12, que du ſommet d'*Udjek-tepè* j'avois apperçu à l'oueſt la mer Égée, les iles de Tenédos, d'Imbros, de Samothrace, et de Lemnos; j'ai dit, de plus, à la page 36. qu'en arrivant à *Koum-kalè* avec M. Casas, j'avois encore remarqué les mêmes pics d'Imbros et de Samothrace, &c. Lorſque je faiſois cette obſervation, j'ignoroit entièrement qu'Homere l'avoit juſtifier dans le 13e livre de l'Iliade, verſ. 11, &c. où il repreſente Neptune obſervant les combats du haut du pic de Samothrace; *Car de là,* dit il, *on apperçoit toute la chaine de l'Ida*:

Καὶ γὰρ ὁ θαυμάζων ἧστο πτόλεμόν τε μάχην τε
Ὑψȣ̃ ἐπ' ἀκροτάτης κορυφῆς Σάμȣ ὑλήεσσης
Θρηϊκίης· ἔνθεν γὰρ ἐφαίνετο πᾶσα μὲν Ἴδη,—

La marche de Neptune, quand il quitte Samothrace pour ſe rendre au camp des Grecs, s'accorde auſſi très bien avec mon obſervation; car il laiſſe ſes chevaux à moitié chemin, entre Imbros et Tenédos:

Μεσσηγὺς Τενέδοιο καὶ Ἴμβρȣ παιπαλοέσσης· Ibid. 33.

4TO,

4TO, Du moment où nous ſupprimons entièrement le chapitre qui traite du tombeau d'ILUS, je n'ai pas beſoin de vous avertir qu'il faut ſupprimer le même tombeau, encore mentionné à la page 63. comme faiſant encore aujourd'hui partie des monumens cités par STRABON.

VOILÀ, mon ami, tout ce que je puis vous dire en poſte pour le moment. Recevez, pour la dernière fois, mes ſinceres remercimens pour toutes les marques d'amitié que vous m'avez données ; et comptez ſur la mienne à la vie à la mort. J'attends de jour en jour mon paſſeport ; auſſitôt qu'il arrive je me mets en route. Mes complimens à tous nos amis. Adieu.

LE CHEVALIER.

END OF THE FOURTH VOLUME.

ERRATA.

HISTORY.

Page 17. *line* 12. for *flots*, read *floats*.
30. line laſt, *for* laſt Article, Part II. *read* laſt Art. Phyſ. Cl. Part II.

PART II. PHYS. PAPERS.

Page 111. *line* 4. from the bottom, *for* M, *read* N.
12. from the bottom, *for* Join AH, *read* Join EH.
119. 4. from the bottom, *for* APPOLLONIUS *read* APOLLONIUS.
120. 11. from the bottom, *for* hence the quadrilateral, *read* hence, if AG, GK be joined, the quadrilateral, &c.
132. 6. from the top, *for* fig. 20. Pl. IV. *read* fig. 13. Pl. II.
N. B. In Pl. IV. fig. 18. the points B and K muſt be joined by a ſtraight line.
135. This Paper is by miſtake numbered V. inſtead of VI. and the ſame error is continued in numbering the remaining Papers of the Phyſ. Cl.
138. line laſt. *for* the latitude here given, viz. 57°. 9′. 1″, *read* 57°. 8′ 59½″, the ſun's ſemidiameter, uſed in the reduction of the obſervations, having been 1½″ too great.
178. 6. *inſtead of the term* $\frac{1^2}{2^2}. e$, *read* $\frac{1^2}{2^2}. e^2$.
193. 4. from the bottom, *for* quilt-like *read* quill-like

PART III. LIT. PAPERS.

Page 86. *line* 21. *for* ACHILLES, *read* PATROCLUS,
101. 5. from the bottom; Notes, *for* tomb *read* trench

DIRECTIONS FOR THE BINDER.

THE Binder is deſired to obſerve, that this VOL. conſiſts of Four Sets of Pages, to be arranged, after the TABLE OF CONTENTS, in the following Order, viz.: PART I. containing the HISTORY OF THE SOCIETY, with the Pages regularly numbered as far as 40; and afterwards going on with the numbers included between parentheſis, thus (1), &c. to the end of PART I. Then follows PART II. conſiſting, 1ſt, Of PAPERS OF THE PHYSICAL CLASS, with the Pages numbered in one Series; and, 2dly, PAPERS OF THE LITERARY CLASS, with the Pages numbered in another Series. The Binder will alſo obſerve, that there are in all 13 PLATES, 6 for the PHYSICAL CLASS, and 7 for the LITERARY, which are to be placed exactly according to the references marked on the margin of each.

18/8.P.

ERRATA.

[illegible]

[illegible] c. Pl. IV. read fig. 13. Pl. II.

[illegible] g. 18. the points B and K must be joined by a [illegible] line.

[illegible] among the remaining Papers [illegible]

[illegible] Jun's lamidimeter, used in the reduction of the observations, having been [illegible] too great.

[illegible]

[illegible] A. from the bo[illegible] the word quill-like [illegible]

[illegible]

5. from the bottom; Notes, for tomb read trench [illegible]

DIRECTIONS FOR THE BINDER.

[illegible] &c. to the end of Part I. Then follows Part II. consisting, 1st, Of Papers [illegible] for the Literary, which are to be placed exactly according to the reference [illegible]