XXXIV. *Experiments and Obſervations made in* Britain, *in order to obtain a Rule for meaſuring Heights with the Barometer.* *By* Colonel William Roy. *F. R. S.*

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INTRODUCTION.

IN philoſophical inquiries of every kind, where any point is to be aſcertained by experiments, theſe cannot be repeated too often, nor varied too much, in order to obtain the truth: for even when the utmoſt precaution hath been uſed, and the greateſt pains have been taken, it rarely happens, that they agree ſo exactly, as to leave no room for doubt. Were it poſſible at all times, to have experiments made in circumſtances perfectly ſimilar, a conſiderable degree of conſiſtency might naturally be expected among the reſults, whereof the mean would determine the point in queſtion; but different men, making uſe of different inſtruments, have different modes of conducting their operations, each purſuing the tract that ſeems to him the moſt likely to inſure ſucceſs. Hence it is that a variety of of refults arife, and that things fometimes appear contradictory, or at leaft prefent themfelves under new forms, difficult at firft fight to be accounted for, and therefore apt to miflead, till by a farther inveftigation of the matter, the true caufes are difcovered. Even irregularities of this fort are worthy of being communicated, that others may know what hath happened before, and what, in like cafes, they may expect to meet with, in the courfe of their future inquiries. Improvements of every kind advance by flow degrees; and it is not until things have been viewed in every poffible light, that the errors, even of our own experiments, are difcovered, the points in queftion ultimately afcertained, and the branch of philofophy depending upon them, gradually brought nearer to perfection.

Ever fince the difcovery made by TORRICELLI, the barometer hath been applied, by different perfons, in different countries, to the meafurement of vertical heights, with more or lefs fuccefs, according to the more or lefs perfect ftate of the inftruments ufed, and the particular modes of calculation adopted, by the obfervers. But of all thofe who have hitherto employed themfelves in this way, none hath beftowed fo much time and pains, or fucceeded fo well, as Mr. DE LUC, of Geneva, F. R. S. In two quarto volumes, publifhed fome years fince, that gentleman

gentleman hath given us the hiſtory of the barometer and thermometer, with a very curious and elaborate detail of many years experiments, made by him, chiefly on the mountain Saleve. It would be totally ſuperfluous here to enter into any circumſtantial account of the method he makes uſe of, ſince that hath already been ſo fully illuſtrated by two Fellows of the Royal Society, who have at the ſame time given formulæ and tables, adapted to the meaſures of this country, (Phil. Tranſ. for 1774, vol. LXV. N° xx. and xxx.) that nothing farther can be deſired on that head.

It may nevertheleſs be neceſſary juſt to call to remembrance that the rule, deduced from the obſervations on Saleve, conſiſts of three parts. 1ſt, The equation for the expanſion of the quickſilver in the tube, from the effect of heat, whereby the heights of the columns, in the inferior and ſuperior barometers, are conſtantly reduced to what they would have been in the fixed temperature of $54°\frac{1}{4}$ of FAHRENHEIT, independant of the preſſure they reſpectively ſuſtained. 2d, When the mean temperature of the column of air to be meaſured, is 69°.32, as indicated by thermometers expoſed to the Sun's rays at its extremities; then the difference of the common logarithms, of the equated heights of quickſilver in the two

two barometers, gives the altitude intercepted between them, in toiſes and thouſandth parts, reckoning the three figures to the right hand decimals, and the others integers, the index being neglected. This temperature of 69°.32, when the logarithmic differences give the real height without any equation, is reduced to 39°.74, the new zero of Mr. DE LUC's ſcale, when his formula is adapted to Engliſh fathoms and thouſandth parts, inſtead of French toiſes. And laſtly, when the mean temperature of the air is above or below 39°.74, an equation, amounting to $\frac{21}{10000}$ parts of the logarithmic height for each degree of difference, is, in the firſt caſe to be added to, and in the laſt ſubtracted from, that reſult, in order to obtain the real altitude.

In Mr. DE LUC's book, the experiments for aſcertaining the expanſion of the quickſilver, are not given in detail; neither are the particular temperatures of the barometers ſpecified. The winter ſeaſon was however choſen for the purpoſe; one being left in a cold room, and the other in a cloſet, heated as high as could conveniently be ſuffered. The operation having been repeated ſeveral times without any eſſential difference in the reſults, this general concluſion is drawn, that between the temperatures of melting ice and boiling water, the expanſion of

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the quickfilver is exactly fix French lines, or .532875 decimal parts of an English inch. But it is to be obferved, that the barometer ftood then at 28.77525; whereas, if it had ftood at 30 inches, it would have been .555556, becaufe the expanfion is in proportion to the length of the column. Farther, the interval between the freezing and boiling points in all thermometers, varies with the height of the barometer, or weight of the atmofphere; and it is the cuftom in England to make thermometers when the barometer ftands at 30 inches; that is to fay, 1.225 or 13.8 French lines, higher than when Mr. DE LUC's boiling point was fixed: and fince from his experiments it appears, that each line of additional height in the barometer, raifes the boiling point $\frac{1}{1134}$th part of the interval between that and freezing, it follows that $\frac{180}{1134} = 0.158 \times 13.8 = 2^{\circ}.2$, will denote the number of degrees, that Mr. DE LUC's boiling point is lower than that of English thermometers, which reduces it to 209.8 of FAHRENHEIT, and makes the interval between freezing and boiling only 177.8 degrees. Hence the expanfion .555556, formerly found, muft be increafed in the proportion of 177.8 to 180, which gives for the total .5624297 or .56243, on a difference of temperature of 180°. Thus the expanfion for each degree, fuppofing it

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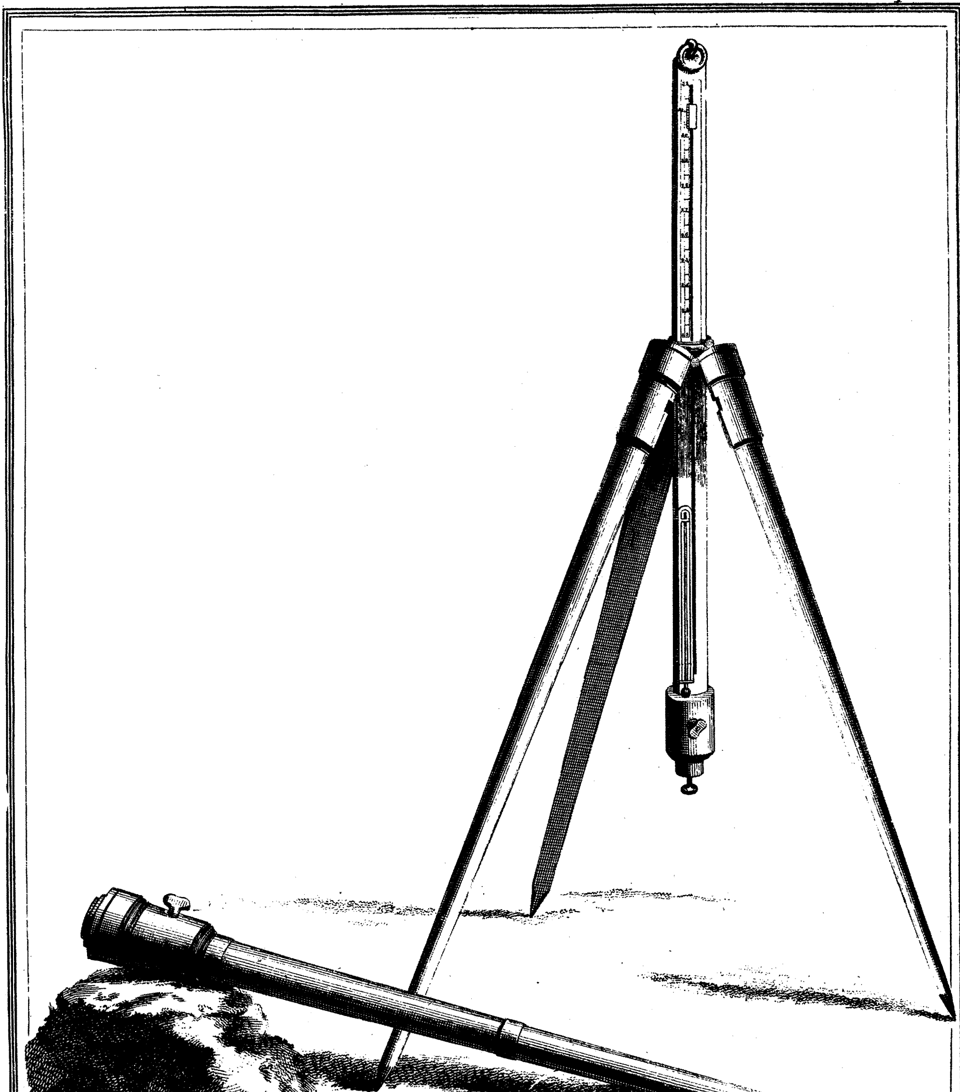
to be arithmetical, or uniformly the ſame in all parts of the ſcale, will be .00312461 [(a)].

Having now ſhewn the expanſion of quickſilver in the tubes of barometers reſulting from the Geneva obſervations, I ſhall next proceed to give ſome account of thoſe I made for that purpoſe. They derive their origin from my having very accidentally obſerved, that a ſmall degree of heat, and of ſhort duration, ſenſibly affected the length of the column in Mr. RAMSDEN'S portable barometer, whereof a view is given in plate XVI. The principal parts of this inſtrument are a ſimple ſtraight tube, fixed into a wooden ciſtern, which, for the conveniency of carrying, is ſhut with an ivory ſcrew, and, that being removed, is open when in uſe. Fronting this aperture is diſtinctly ſeen, the coincidence of the gage-mark, with a line on the rod of an ivory float, ſwimming on the ſurface of the quickſilver, which is raiſed or depreſſed by a braſs ſcrew at the bottom of the ciſtern. From this, as a fixed point, the height of the column is readily meaſured on the ſcale attached to the frame, always to $\frac{1}{500}$

(a) This paper having lately been communicated to Mr. DE LUC, he hath informed me, that the difference of temperature in his experiments, amounted to about 31° of REAUMUR, or 72° of FAHRENHEIT, above freezing: wherefore, .00312461 × 72 = .225 nearly, will denote the rate of expanſion from which he deduced that for 180°; and within theſe limits, it will hereafter be oundt o differ very little from the reſult of the preſent experiments.



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part of an inch, by means of a nonius moved with rack-work. A thermometer is placed near the ciitern, whofe ball heretofore, was ufually inclofed within the wood work, a defect that hath been fince remedied. The three-legged ftand, fupporting the inftrument when in ufe, ferves as a cafe for it, when inverted and carried from place to place. Two of thefe barometers, after the quick-filver in them hath been carefully boiled, being fuffered to remain long enough in the fame fituation, to acquire the fame temperature, ufually agree in height, or rarely differ from each other more than a few thoufandth parts of an inch, which were conftantly allowed for in calculating altitudes, as well as in eftimating the rate of expanfion, in the courfe of the following experiments.

S E C T I O N I.

Experiments on the expanfion of quickfilver.

THE experiments made for this purpofe were numerous as well as various, and were therefore fubdivided into feveral claffes. To give a minute detail of them all, would be extremely tedious, and now wholly ufelefs, fince it was from thofe of the third clafs alone, that the rate as well as maximum of expanſion was aſcertained: wherefore thoſe of the two preceding claſſes need only be mentioned in a general way.

The firſt ſet of the firſt claſs comprehended ſuch as were made with one barometer in a cold room, or in the open air, and the other in a room on the ſame level with the former, where there was conſtantly a fire, which was occaſionally increaſed, in order to augment the difference of temperature. When the heated barometer had remained ſeveral hours in an angle of the room, the difference of temperature of its quickſilver above that of the coldeſt, as indicated by their reſpective attached thermometers, rarely exceeded 10 or 12°, which, from a mean of many obſervations, gave an expanſion of .0333 decimals of an inch, for the 10° comprehended between 32 and 42° of FAHRENHEIT's thermometer. So far the reſult ariſing in this way, from ſmall differences of temperature, will be found to agree with the third claſs of experiments.

But when, in the ſecond ſet of this firſt claſs, the difference of temperature was augmented to 20 or 30°, by expoſing the barometer within doors to a greater heat, or placing the ſuperior one on the leads, whereby it received the direct and reflected rays of the Sun throughout the greateſt part of the day, while the other was kept in the cold area underneath, the rate of expanſion for the firſt 10° exceeded that formerly found nearly in the proportion of three to two, while that for the ſecond and third terms, of 10° each, diminiſhed progreſſively.

The chief, though not the only cauſe of this great difference, as will appear hereafter, aroſe from the poſition of the ball of the thermometer, originally incloſed within the wood-work of the frame, which prevented it from receiving the heat ſo readily as the quickſilver in the tube; at the ſame time that it retained it longer, and conſequently produced reſults in ſome degree fallacious.

Finding, from the firſt claſs of experiments, that much uncertainty remained with regard to the rate of expanſion of quickſilver affected by theſe ſmaller degrees of heat, and that it was utterly impoſſible, from them, to determine its maximum for the 180° between freezing and boiling; I reſolved to try, how much a column of 30 inches of quickſilver, carefully boiled in a tube, would lengthen, the ſame being placed with the open end upwards in a tin veſſel, occaſionally filled with pounded ice and water, and afterwards brought to boil, by means of a charcoal fire placed underneath? In this ſecond claſs, it was eaſy to ſee, that the expanſion of the tube containing the quickſilver, was neceſſarily to be taken into the account, and added to that apparently found by experi-

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ment. This was of courſe to be done, either by ſuch differences as I could diſcern and meaſure, or by thoſe that had reſulted from the experience of others.

The nature of the apparatus, employed in this claſs of experiments, will be eaſily underſtood from plate XVII. where it is repreſented, as it was uſed in thoſe of the third claſs. In its firſt ſtate it was not quite ſo long, and a chafing-diſh with a charcoal fire, occupied the place of the ciſtern holding the quickſilver below. By means of a circular bit of tin, ſoldered edgeways in the center of the bottom, and an aperture in the middle of the lid, the tube was kept ſteadily in the axis of the veſſel. Other openings in the lid, ſerved for the admiſſion of the thermometer, and the application of a deal rod cloſe to the ſide of the tube, when its height was to be meaſured. The longitudinal expanſion of the glaſs was marked by a ſcratch thereon with a fine edged file at the top of the deal rod, when reſpectively at the temperatures of freezing and boiling. The apparent dilatation of the quickſilver was in like manner marked, by the coincidence of its ſurface with the lower edge of a braſs ring embracing the tube.

It having been found impoſſible to procure tubes whoſe bores were truly cylindrical, or of any uniform figure, the experiment was repeated, as often as poſſible,

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in both ends of the same tube, that the mean might be taken. But it frequently happened that the tube, which had undergone one or more experiments in one end, broke before any could be made with it in the other. In this case, the rate of expansion in the last end was taken from that given by such another tube, where it had succeeded in both. The mean of five results with the best tubes, taken in this way, gave .4901 for the apparent expansion of 30 inches of quicksilver, on 180° of FAHRENHEIT, between freezing and boiling, which being augmented by the apparent longitudinal dilatation of the glass $.0356 \times 3 = .1068$, the real expansion is .5969; exceeding Mr. DE LUC's by more than $\frac{3}{100}$ths of an inch. If, however, Mr. SMEATON's dilatation of glass, $(.025 \times 3 = .075)$ be substituted, instead of that resulting from these experiments, the real expansion of 30 inches of quicksilver will be .5651, which does not exceed it quite $\frac{3}{1000}$ parts of an inch.

In this class of experiments, having attended as diligently as possible to all the circumstances, it seemed to me, that tubes with a small bore, and whose glass was thick, lengthened more than those, which had a larger bore and whose glass was thin: whence I was led to suppose, that solid glass rods would dilate more in proportion, and consequently, shew a still more perceptible difference.

difference. With the view of afcertaining this point, I procured four glafs rods near three feet long each, and of different diameters, the largeft being of the fize of the little finger, and the fmalleft about the thicknefs of a quill. One end of each, was fomewhat larger than the other, and was made perfectly fmooth, as that on which they were to reft when feverally meafured with the deal rod. They were then all placed in the tin veffel, in fuch a manner, as to admit pounded ice rammed very clofe around them, and the interftices to be filled with water. Having remained in that ftate a full half hour, they were feverally meafured with the deal rod, whofe length of $32\frac{1}{2}$ inches was fcratched on each with the fharp edge of the file. This being done, the ice thrown out, and the veffel carefully wafhed, all the rods were replaced in it, immerfed in water, which afterwards was brought to boil. The fire being kept up, and the ebullition rendered as violent as poffible for half an hour, the glafs rods were then feverally meafured, by applying them one after another to the deal rod, ftanding with them in the boiling water. The experiment was repeated three times, on as many different days, without its being poffible to difcern, that any of the glafs rods had dilated more than that of deal, from a difference of temperature of 180°. In all of them, the freezing mark feemed accurately to coincide with the top of of the deal rod; whereas the dilatation of the tubes, by the ſame degree of heat, was always very viſible[(b)].

Finding from the ſecond claſs of experiments, whereof the general reſult hath now been given, that glaſs rods ſeemed not to lengthen more than deal; and that tubes of different bores, and probably too of different ſorts of glaſs, were ſuſceptible of different degrees of extenſion, which rendered it impoſſible, by this means, to aſcertain the longitudinal expanſion of the quickſilver they contained; I thought it neceſſary to recur once more to the barometer, and to try whether it could not be ſo contrived as to act in water of different temperatures, from freezing to boiling. This led me to the experiments of the third claſs: and in order to comprehend them thoroughly, it ſeems neceſſary to point out ſome few alterations which the apparatus underwent.

The center of the bottom being pierced on purpoſe, a braſs ſocket was prepared for it, wherein a hole was bored conically, to receive the ground-end of a barometer tube, of the ordinary length of $33\frac{1}{2}$ inches; the tube having been firſt ground in a ſeparate piece of braſs, and ulti-

(*b*) Since theſe experiments were made, the relative expanſion of 18 inches of one of the tubes and one of the rods that had been formerly employed, was found to be, by Mr. CUMMING's pyrometer, nearly as 4 to 1, from a heat approaching to that of boiling oil.

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mately in the ſocket itſelf, fitted it ſo exactly, as to ſuffer no water to paſs. The ſocket being inſerted into the aperture at the bottom of the veſſel, was firmly ſoldered to it for the reception of the tube, which was ſo ground as to reach a full inch and a half below the ſurface of the braſs. It could not deſcend farther, the ground parts in both being of the figure of the fruſtum of an inverted cone. From the view in the plate it will appear, that underneath the veſſel, a ſeparate ſtand was placed, in order to ſupport the iron ciſtern containing the quickſilver. The diameter of the ciſtern was ſuch, that its ſtand being occaſionally moved, ſo as to bring one ſide of it cloſe to the ground part of the tube, the other ſide projected beyond the bottom of the veſſel; and conſequently permitted the rod of a float, reſting on the ſurface of the quickſilver, to riſe freely and parallel to the axis of the tube. The rod was of deal, $\frac{1}{10}$th of an inch ſquare, carrying on its top a ſcale, whoſe zero lay in the lower ſurface of the float, and whereof the ſix uppermoſt inches, from 28 to 34, were divided into 20ths.

That the whole column of quickſilver might alternately be covered with the freezing mixture and water of different temperatures, and yet permit its ſurface to be ſeen, two eyes of plate glaſs were ſcrewed into ſockets, ſoldered for that purpoſe oppoſite to each other, near the

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top of the veſſel, which, in the firſt ſet of the third claſs of experiments, was little more than 29 inches high. The top of the tube paſſing through the aperture in the lid, one and a half or two inches of the vacuum generally roſe above the veſſel. That the expanſion of the column might be meaſured as nearly as poſſible in that part of the tube fronting the center of the eyes, more or leſs quickſilver, according to the ſtate of the atmoſphere, was occaſionally put into the ciſtern, to raiſe or depreſs the ſurface of the column to the proper height. A thin braſs ring, whoſe lower parts were made to ſpring, embraced with ſufficient force the upper part of the tube, permitting it at the ſame time to be moved freely with the hand. It carried along with it a nonius index, projecting as far as the center of the rod, and conſequently applying itſelf to the diviſions of the ſcale, which was kept in its proper poſition by paſſing through a ſlit fitted for it in an arm attached to the lid. The diviſions on the nonius being the ſame with thoſe of the barometer formerly deſcribed, the height of the quickſilver could always be read off to $\frac{1}{500}$th part of an inch.

The quickſilver having been carefully boiled, as on former occaſions, in the tube; and that being filled completely, and held with its open end upwards; the tin veſſel was inverted over it, and lowered gradually, till the ground end could be inserted into the socket with such a degree of force as to prevent it from being too easily removed. The finger being then applied closely to the open end of the tube, the whole apparatus was turned up, and placed over the cistern into which the quicksilver had previously been put, great care being taken not to remove the finger till the lower extremity of the tube was fairly immersed into the quicksilver; when that in the tube was permitted to descend into an equilibrium with the atmosphere. In the first experiment it was found that the water issued by the eyes, and running down the side of the vessel, fell into the cistern. In order to remedy this inconveniency, a circular piece of tin was soldered round the upper part of it, immediately below the eyes; and a flat spout, projecting from it, served as a gutter to throw off the water from the cistern, and from the lamps made use of to bring that in the vessel to boil. Six lamps, each with a double light, were suspended around the trunk of the vessel, to heat the water as equally as possible; though any irregularity of this kind was sufficiently guarded against, by constantly mixing it during the operation. Another lamp of the same kind stood under the cistern, whereby the quicksilver there was kept at the temperature of the water in the vessel, each having its proper thermometer: this last lamp was placed and difplaced frequently, during the courfe of every experiment; for the heat was very expeditioufly communicated to the iron ciftern, and thence to the quickfilver it contained; and both were found to cool very faft, after the lamp was removed. Such was the ftate of the apparatus, when the firft fet of this third clafs of experiments was made. In thofe of the fecond fet, its height was farther augmented by tin foldered to the top, that a tube of the ordinary length might be wholly immerfed in boiling water. The third and laft alteration confifted in the occafional application of a detached tin cafe, equal in diameter to the upper part of the veffel, having a hole in its bottom to admit the top of a long tube to pafs. This cafe was fo contrived, that its bottom ftood two inches and a half higher than the lid of the veffel, thereby allowing room for the hand to move the index up or down. In this ftate the apparatus is reprefented in the view; and its various ufes will be beft underftood from the account of the experiments, which were fubdivided into four fets.

Thofe of the firft fet were made with tubes of a large bore, upwards of three-tenths of an inch in diameter, of the ordinary length, with a vacuum over the quickfilver of two inches and a half or three inches, part of which reached above the top of the veffel. The mean of three experi-

experiments gave .5258, for the total dilatation of 30 inches of quickfilver, on 180° between freezing and boiling; that, anfwering to the firft 20°, between 32° and 52°, was .0688; that, for the 20° in the middle of the fcale, between 112° and 132°, was .058; and the rate for the laft 20°, between 192° and 212°, was only .041. From this firft fet of the third clafs of experiments, it appeared evident, that the expanfion of 30 inches of quickfilver in the barometer, fuffering a heat equal to 180° of FAHRENHEIT, inftead of exceeding Mr. DE LUC's, as appeared to be the cafe from the refults of the open tube, really fell fhort of it: and inftead of being arithmetical or uniformly the fame, for equal changes of temperature, was actually progreffive; the expanfion anfwering to the lower part of the fcale, being greater than that correfponding to the middle; which again exceeded that for high temperatures. In thefe experiments, when the water had acquired a heat 20 or 30 degrees greater than that of the open air, a certain duftinefs was perceived in the vacuum of the tube. At 100° of FAHRENHEIT, or thereabout, this appearance had fo far increafed, as to fhew clearly, that it could proceed from no other caufe than a vapour arifing from the furface of the heated quickfilver, quite invifible, till, by its condenfation in the cold part of the tube, it was formed into balls, every where adhering to

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its sides and summit. These globules were very small near the surface of the water, augmenting gradually as they approached the top of the tube, where they were greatest: their bulk increased with the heat; and when the water was at or near boiling, they would sometimes unite, and descend by their own gravity, along the sides of the tube, into the general mass. Hence the progressive diminution of the rate of expansion of the column of quicksilver in the barometer, perceptible even in the first class of experiments, is easily accounted for by the resistance of the elastic vapour[(c)], acting against the top of the tube, which was here colder than the rest.

But in the application of the barometer to the measurement of heights, the whole instrument is of the same temperature; wherefore, in the second set of this third class of experiments, the tin vessel was heightened, that tubes of the ordinary length, placed in it, might be wholly immersed in boiling water. The mean of four experiments, which agreed very nearly among themselves, gave .5117 for the total expansion between freezing and boiling; for the 20°, between 112° and 132°.059; and for the last 20°, between 192° and 212°.046. In these

(*c*) Having mentioned the circumstances to Mr. RAMSDEN, it first occurred to him, that the resistance of the elastic vapour was the cause of the diminution in the rate of expansion.

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experiments; the tube being wholly covered with boiling water, no condenſation of vapour took place in the vacuum; and therefore no particles of quickſilver were ſeen adhering to the upper part of the tube. When the water boiled, the reſiſtance of the vapour was greater than in the preceding ſet, and the total expanſion leſs. Theſe two reſults ſerve ſtrongly to confirm each other: it is, however, the laſt that furniſhes the data for conſtructing the table of equation depending upon the heat of the quickſilver in the barometer, of which table we ſhall give an account hereafter.

Finding, from the compariſon of theſe two ſets of experiments with each other, that the maximum and rate of expanſion ſeemed to vary with the length of the vacuum above the quickſilver, I was adviſed to try[(d)] what might be the reſult, when the vacuum was much longer than in the common barometer.

The third ſet of experiments of this claſs was therefore made with a tube ſomewhat narrower in the bore than the former, and whoſe vacuum was 14½ inches in length, whereof 11½ reached above the top of the veſſel. The mean of three obſervations gave .5443 for the total expanſion on 180°; that for the firſt 20° was .067; for the

(*d*) Dr. BLAGDEN, who afterwards aſſiſted in ſome of the firſt experiments with the manometer, propoſed that with the long tube.

the 20° in the middle of the scale .058; and for the uppermost 20°.065: whence the mean rate for every 20°, is nearly .0605[(e)]. In this set, the condensation in the vacuum of the tube was particularly attended to: it began, as in those of the first set, immediately above the surface of the boiling water, which was always kept an inch or two above the top of the column: the lowermost globules were very small, increasing gradually till they got without the lid of the vessel, where they were the largest; thence they diminished uniformly upwards, and disappeared entirely three or four inches below the top of the tube. Though the rate for the middlemost 20°, in these last experiments, be below the mean, probably from some inaccuracy in observation; yet, being compared with the former sets, they still serve to corroborate each other: for in these with the long tube, the vacuum seems to have been either completely maintained, or nearly so; and we accordingly find the maximum of expansion increased, and its rate rendered nearly uniform, as will be farther confirmed from what follows.

(*e*) Mr. CAVENDISH, who assisted in the first part of the experiments with the open tube, informed me, that, in those made by his father Lord CHARLES, the difference between the expansion of quicksilver and glass, from 180° of heat, was .469. If to this we add Mr. SMEATON's dilatation of glass, the total expansion of 30 inches of quicksilver will be .544, which agrees with the experiments in the long tube, and gives a rate of only .003022 for each degree.

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I have already had occaſion to mention that a detached tin caſe was ſometimes applied above the veſſel, in which ſtate it is repreſented in the view. This method was thought of during the operations with the long tube, in order to try whether the vacuum was completely maintained by the temperature of the open air? For this purpoſe the caſe was placed on the ſtones of the yard, with a ſmall tube inſerted in it, to preſerve an open paſſage in the middle: it was then rammed full of a compoſition of ſalt and ice; and afterwards fixed on the top of the long tube. The degree of cold thus applied round the greateſt part of the vacuum, muſt have been very great, probably near the zero of FAHRENHEIT; yet it produced no viſible alteration in the height of the column of quickſilver, which ſtill remained in boiling water below, and ſhould have riſen, if the vacuum had been formerly incompleat. As it would have occaſioned much trouble to have lengthened the ſeveral parts of the apparatus ſo as to have kept the long tube wholly in boiling water, the counterpart of this laſt experiment was not made in the accurate manner it ought: nevertheleſs, the tin caſe, being emptied of its cold compoſition, was placed on the tube as before, and filled with boiling water; which, joining with the intermediate ſteam ariſing from that in the veſſel below, muſt have kept the whole nearly in the

ſame

ſame temperature. The conſequence of this application was, that the column ſhortened about $\frac{2}{100}$ths of an inch; which ſeems to prove, that the quickſilver vapour now reached the ſummit of the tube, and, acting againſt it, overcame, by ſo much, the preſſure of the atmoſphere.

I ſhould now proceed to give ſome account of the fourth ſet of this laſt claſs of experiments, made on the condenſation of the quickſilver, by means of artificial cold, below the temperature of the air. Previouſly however to this, it may not be improper to take notice, in a more general way, of ſome others that were made on expanſion; as tending, with certain circumſtances yet to be mentioned, not only to confirm thoſe already deſcribed, but likewiſe to account for many irregularities that occur in operating with barometers.

In the courſe of the preceding experiments, from accidents of various kinds, it was often neceſſary to reboil the quickſilver; and in that operation, many tubes were broken. The frequent removal of the ſocket from the bottom of the veſſel, in order to get others ground for it, became at laſt very troubleſome; and made more caution neceſſary, in boiling ſuch as were ground, eſpecially in froſty weather, which happened to be the caſe in the laſt days of March, 1775: wherefore it was thought beſt in the interim to try, what might be the expanſion of a column of quickſilver, carefully put into the tube, but not boiled therein?

With this view, the ſtandard barometer and apparatus were left out during the night of the 29th, that they might acquire the ſame temperature, which was found next morning to be $34^{\circ}\frac{1}{2}$; the unboiled quickſilver ſtanding $\frac{1}{100}$th of an inch higher than that which had been boiled. The lamps being applied to the veſſel, the lengthening of the unboiled column was perceived, on the whole, to be more irregular, and the progreſſive diminution quicker, than in former experiments; ſo as to give, for the maximum of expanſion, only .443 for 180°.

On the morning of the 31ſt, the unboiled column, which on the preceding day had been the higheſt, was lower than the other by near $\frac{2}{100}$ths of an inch, the temperature of both being $31^{\circ}\frac{1}{2}$. As the water acquired heat from the application of the lamps, the rate of expanſion diminiſhed; and, at boiling, was only .405 for 180°. The operation of the 30th ſeems to point out, in a manner ſufficiently concluſive, that the air contained in the unboiled quickſilver, rendered its ſpecific gravity leſs, than that which had been boiled even a great while before; ſince it required a longer column of the firſt, to counterbalance the weight of the atmoſphere. And though the vacua might poſſibly, at the beginning, have been equally

compleat

compleat in both; yet they could not continue long ſo: for the air eſcaping gradually from the unboiled quickſilver, its elaſticity increaſing with the heat, and uniting with the quickſilver vapour, muſt have reſiſted the dilatation of the column, and rendered it leſs than on former occaſions; which actually appeared from experiment. This is farther confirmed by the obſervations of the ſubſequent day; for now the unboiled column was become the ſhorteſt, owing no doubt to more air having aſcended, and rendered the vacuum ſtill more incompleat. Thus, the cauſes of reſiſtance increaſing, the dilatation is leſſened in a ſuperior degree.

The other circumſtances to be mentioned, occurred on the 12th of April. After finiſhing one of the experiments of the ſecond claſs, and when the water had cooled to 192°, the veſſel, by accident, received a ſudden jolt, whereby the mouth of the tube muſt have been raiſed, for a moment, out of the quickſilver in the ciſtern. In a few minutes after this, intending to obſerve how far the column had ſhortened from the decreaſing heat, I was ſurprized to find, that the quickſilver had wholly diſappeared in the tube, and was ſunk ſo low as not to be ſeen by looking obliquely down at the eye of the veſſel. It was then certain that air, and probably a particle of moiſture along with it, had aſcended into the upper part of the tube,

whereby

whereby the vacuum was deſtroyed in ſo remarkable a degree. Since this accident made it neceſſary to reboil the quickſilver, the water (then between 180° and 190°) was let out by the cock fixed for that purpoſe at the bottom of the veſſel; but before it could be intirely drawn off, the tube and its contents, had ſo ſenſibly felt the condenſing force of the ſurrounding atmoſphere, then about 48°, that the quickſilver had riſen again, and preſented itſelf oppoſite to the eye of the veſſel, ſomething lower indeed than where it formerly ſtood. On this diſcovery, and as ſoon as water could be boiled for the purpoſe, the veſſel was filled again, when the quickſilver ſubſided, as before, quite out of ſight; and on drawing off the water a ſecond time, it roſe anew, ſeemingly to its former height.

The appearance, which this accidental circumſtance produced, was ſuch, as naturally ſuggeſted that farther experiments might have been made, varied as much as poſſible from each other, by the admiſſion of different quantities of air, or of air and moiſture intermixed. But the nature of the veſſel rendering it impoſſible to ſee, and conſequently to meaſure, the motion of the quickſilver, occaſioned by the alternate expanſion and condenſation of the elaſtic vapour contained in the upper part of the tube, and which could not have been accom-

pliſhed

pliſhed without many troubleſome alterations in the apparatus, therefore nothing of the kind was attempted. From the circumſtances juſt now mentioned, it will be readily conceived, how much care is neceſſary in operating with barometers for the meaſurement of heights, that the vacua be as nearly as poſſible compleat; and particularly, that no moiſture get up into the tube. I now proceed to the fourth and laſt ſet of experiments.

Having found, from the two firſt ſets of this claſs, the rate of expanſion of a column of quickſilver, in the tube of a barometer of the ordinary length, to be progreſſive and not arithmetical; and that its maximum, for the 180° comprehended between feeezing and boiling, was leſs than had been ſuppoſed; I thought it proper to try, by means of artificial cold, whether the condenſation, for the 32° below freezing, followed nearly the ſame law?

For this purpoſe the tin veſſel, containing the ground tube, was rammed quite full of pounded ice and ſalt, as well as the tin ſtand holding the iron ciſtern below. In this operation, twelve pounds of ice and four pounds of ſalt were employed, whereby the mean temperature of the mixture was reduced to +4° of FAHRENHEIT. But before the eyes of the veſſel could be ſufficiently freed from the compoſition, ſo as to permit the ſurface of the column to be diſtinctly ſeen and read off; it had riſen to

+14°; the temperature of the air, and alfo of the ftandard barometer, being at the fame moment $49°\frac{1}{2}$. The obferved condenfation, arifing from this difference of $35°\frac{1}{2}$, was $\frac{12}{100}$ths of an inch; or .1189, when reduced for the height of the barometer, which then ftood at 30.296. Hence the condenfation for 32° is .1072, or .00335 for each degree. In this day's experiment, when the temperature of the mixture had rifen to 32°, that of the air and ftandard barometer was $52°\frac{1}{4}$; whence the reduced difference, for the 20° between 32° and 52°, was found to be .0664, anfwerable to former experiments.

The fame experiment was repeated two days after, with great care, the veffel being filled no higher than the furface of the quickfilver. The mean temperature of the mixture was now +4°, and that of the ftandard barometer $49°\frac{1}{4}$. The obferved condenfation, arifing from this difference of $45°\frac{1}{4}$, was $\frac{162}{1000}$; or .1594, when reduced for the height of the barometer, then ftanding at 30,416: hence the rate for 32° is .1127, or .003,522 for each degree. When the temperature of the mixture had rifen to 32°, that of the air was 51°: whence the augmented rate for the 20°, between 32° and 52°, was found to be .0662.

From the mean of thefe two experiments it appears, that the condenfation of a column of 30 inches of quickfilver

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quickfilver in the barometer, affected by the 32° of cold below freezing, is .1099: and that the expanfion from 20° of heat, between 32° and 52°, is .0663, a number agreeing perfectly well with former refults. If the condenfation .1099 thus found, be added to the expanfion .5117 arifing from the fecond clafs of experiments, we fhall have .6216 for the total difference of height of the columns of quickfilver in two barometers, fuftaining the fame preffure, but differing from each other in their temperatures 212° of FAHRENHEIT's thermometer.

The feries of numbers expreffed in the annexed table, agreeing in all effential refpects with the expanfions found by experiment, will therefore fhew that which correfponds to any intermediate temperature, for every 10° of the fcale.

Rate of expanfion of a column of quickfilver in the tube of a barometer.

	Temperature.	Expanfions.	Differences.	2d Differences.
Expanfion above 32° of FAHRENHEIT; equation to be fubtracted from the height of the column of quickfilver of 30 inches.	212	.5117		
	202	.4888	.0229	
	192	.4652	.0236	
	182	.4409	.0243	.0007
	172	.4159	.0250	
	162	.3902	.0257	
	152	.3638	.0264	
	142	.3367	.0271	
	132	.3090	.0277	
	122	.2807	.0283	
	112	.2518	.0289	.0006
	102	.2223	.0295	
	92	.1922	.0301	
	82	.1615	.0307	
	72	.1302	.0313	
	62	.0984	.0318	
	52	.0661	.0323	
	42	.0333	.0328	
	32	.0000	.0333	.0005
Condenfation below 32° of FAHRENHEIT; equation to be added.	22	.0338	.0338	
	12	.0681	.0343	
	2	.1029	.0348	
	0	.1099	.0070	

Con-

Construction and application of the table of equation, for the expansion of the quicksilver in the tubes of barometers.

In the introduction to this paper there was occasion to remark, that in the application of the barometer to the measurement of heights, various modes of calculation had been adopted. The easiest and best method seems however to be, by means of the tables of common logarithms, which were first thought of by Mr. MARIOTTE, and afterwards applied by Dr. HALLEY, Mr. BOUGUER, Mr. DE LUC, and others. They have all proceeded on the supposition, that air is a truly homogeneous and elastic fluid, whose condensations being proportionable to the weights with which it is loaded, its dilatations are in the inverse of the weights; and in consequence of this law, that the heights of the atmosphere ascended, are in geometrical progression, while the corresponding successive descents of the quicksilver in the tube of the barometer, are in arithmetical progression.

Mr. DE LUC makes use of an arithmetical or uniform equation for the heat of the quicksilver in his barometers, whereby their relative heights are reduced to what they would have been in the fixed temperature of $54^{\circ}\frac{1}{4}$

 of

of FAHRENHEIT. In the formulæ adapting his rule to English measures (Phil. Transf. vol. LXVII. N° xx. and xxx.) hath been fhewn, that the eafieft and fimpleft method is, to make the difference of temperature of the two barometers the argument for the equation; and that it is fufficient to reduce either column to what would have been its height in the temperature of the other. But whatever may heretofore have been the method of ufing the equation for the heat of the quickfilver, while it was confidered as arithmetical; now that it hath been fhewn, from the preceding experiments, to be progreffive, there feems at leaft to be propriety in applying to each barometer the equation anfwering to its particular temperature. And though, for this purpofe, any fixed temperature might have been affumed at pleafure, as that to which both barometers were to be reduced; yet, the freezing point being fundamental in all thermometers, and that being likewife the zero of the fcale for the equation depending on the heat of the air, as will be fhewn hereafter, it hath been preferred to any other.

From the experiments it appears, that a column of quickfilver of the temperature of 32°, fuftained, by the weight of the atmofphere, to the height of 30 inches in the barometer, when gradually affected by different degrees of heat, fuffers a progreffive expanfion; and that,

having

having acquired the heat of boiling water, it is lengthened $\frac{5117}{10000}$ parts of an inch: alſo, that the ſame column, ſuffering a condenſation by 32° of cold, extending to the zero of FAHRENHEIT, is ſhortened $\frac{1099}{10000}$ parts, the weight of the atmoſphere remaining in both caſes unaltered; but that, in the application of the barometer to the meaſurement of altitudes, ſince the preſſure and length of the column change with every alteration of vertical height, the equation, depending on the difference of temperature of the quickſilver, will neceſſarily augment or diminiſh by a proportionable part of the whole. Thus, if the weight of the atmoſphere ſhould at any time be ſo great as to ſuſtain 31 inches of quickſilver, the equation for difference of temperature will be juſt $\frac{1}{30}$th part more than that for 30 inches; at 25 inches it will be $\frac{5}{6}$ths; at 20 inches $\frac{2}{3}$ds; at 15 inches $\frac{1}{2}$; and at 10 inches only $\frac{1}{3}$d of that deduced from experiment.

It is upon theſe principles that the annexed table of equation hath been conſtructed, for differences of temperature extending to 102° of the thermometer, and for heights of the barometer from 15 to 31 inches; beyond which limits, it is not probable, that many barometrical obſervations will be made. The firſt or left-hand column, ſhews the height of the barometer for every half inch, from 31 to 25; thence for every inch downwards

to

to 20; the 15th inch being half of the obferved expanfion. The five next columns towards the right, comprehend the additive equation for condenfations, anfwering to 0°, 12°, and 22°, with their intermediate differences; thofe that are progreffive, as arifing from difference of temperature, being ranged horizontally; and thofe that are arithmetical, as depending on the height of the barometer, being placed vertically. The temperature of 32° requires no equation, and the thirteen columns from thence towards the right hand, contain the fubtractive equations for expanfion, correfponding to every 10° as far as 102°, with their progreffive and arithmetical differences ranged as before. By means of thefe differences, the equation for intermediate temperatures may readily be taken out by infpection. Hence is deduced the firft part of the rule for meafuring heights by the barometer. When the temperature of the quickfilver is below 32° of FAHRENHEIT, add the correfponding equation for condenfation to the obferved heights of the columns refpectively; when above 32°, fubtract the equation for expanfion from the obferved heights of the columns refpectively; with which equated heights of quickfilver, expreffed in 1000th parts of an inch, the tables of logarithms are to be entered.

Table

Table, ſhewing the equation to be applied to the obſerved height of quickſilv
temperature extending to 102° of FAHRENHEIT: whereby the column is redu

Obſerved height of quickſil-ver in the Barom.	Condenſation below 32°; Equation to be added to the height of the quickſilver in the barometer.									32°	Expanſion above 32°; I					
	0°		Diff.	12°		Diff.	22°				42°		Diff.	52°		Diff.
31	.1136	.00183	.0432	.0704	.00114	.0355	.0349	.000563		When the temperature of the quickſilver in the barometer is 32° of FAHRENHEIT, no equation is neceſſary.	.0344	.000555	.0339	.0683	.001102	.0334
30½	.1118		.0425	.0693		.0349	.0344				.0339		.0333	.0672		.0328
30	.1099		.0418	.0681		.0343	.0338				.0333		.0328	.0661		.0323
29½	.1081		.0411	.0670		.0338	.0332				.0327		.0323	.0650		.0318
29	.1063		.0405	.0658		.0331	.0327				.0322		.0317	.0639		.0312
28½	.1045		.0398	.0647		.0326	.0321				.0316		.0312	.0628		.0307
28	.1026		.0390	.0636		.0321	.0315				.0311		.0306	.0617		.0301
27½	.1008		.0384	.0624		.0314	.0310				.0305		.0301	.0606		.0296
27	.0990		.0377	.0613		.0309	.0304				.0300		.0295	.0595		.0291
26½	.0971		.0370	.0601		.0302	.0299				.0294		.0290	.0584		.0285
26	.0953		.0363	.0590		.0297	.0293				.0289		.0284	.0573		.0280
25½	.0935		.0356	.0579		.0292	.0287				.0283		.0279	.0562		.0275
25	.0916		.0349	.0567		.0285	.0282				.0278		.0273	.0551		.0269
24	.0880	.00366	.0336	.0544	.00228	.0273	.0271	.001126			.0266	.001110	.0263	.0529	.002204	.0258
23	.0843		.0321	.0522		.0263	.0259				.0255		.0252	.0507		.0248
22	.0807		.0408	.0399		.0251	.0248				.0244		.0241	.0485		.0237
21	.0770		.0294	.0476		.0239	.0237				.0233		.0230	.0463		.0226
20	.0733	.0183	.0280	.0453	.0114	.0228	.0225	.00563			.0221	.00555	.0220	.0441	.01102	.0215
15	.0550		.0211	.0339		.0170	.0169				.0166		.0165	.0331		.0161

ickſilver in the barometer, from 15 to 31 inches; and for differences of
s reduced to the height it would have ſtood at in the temperature of 32°.

'e 32°; Equation to be ſubtracted from the height of the quickſilver in the Barometer.

Diff.	62°		Diff.	72°		Diff.	82°		Diff.	92°		Diff.	102°	
.0334	.1017		.0328	.1345		.0324	.1669		.0317	.1986		.0311	.2297	
.0328	.1000		.0323	.1323		.0319	.1642		.0312	.1954		.0306	.2260	
.0323	.0984		.0318	.1302		.0314	.1616		.0306	.1922		.0301	.2223	
.0318	.0968		.0312	.1280		.0309	.1589		.0301	.1890		.0296	.2186	
.0312	.0951		.0307	.1258		.0304	.1562		.0296	.1858		.0291	.2149	
.0307	.0935		.0302	.1237		.0298	.1535		.0291	.1826		.0286	.2112	
.0301	.0918	.00164	.0297	.1215	.00217	.0293	.1508	.002692	.0286	.1794	.003203	.0281	.2075	.003705
.0296	.0902		.0291	.1193		.0288	.1481		.0281	.1762		.0276	.2038	
.0291	.0886		.0285	.1171		.0283	.1454		.0276	.1730		.0271	.2001	
.0285	.0869		.0281	.1150		.0277	.1427		.0271	.1698		.0266	.1964	
.0280	.0853		.0275	.1128		.0272	.1400		.0266	.1666		.0261	.1927	
.0275	.0837		.0269	.1106		.0267	.1373		.0261	.1634		.0256	.1890	
.0269	.0820		.0265	.1085		.0261	.1346		.0256	.1602		.0251	1853	
.0258	.0787		.0254	.1041		.0252	.1293		.0245	.1538		.0240	.1778	
.0248	.0755	.00328	.0243	.0998	.00434	.0241	.1239	.005384	.0235	.1474	.006406	.0230	.1704	.007410
.0237	.0722		.0232	.0954		.0231	.1185		.0225	.1410		.0220	.1630	
.0226	.0689		.0222	.0911		.0220	.1131		.0215	.1346		.0210	.1556	
.0215	.0656	.0164	.0211	.0867	.0217	.0210	.1077	.02692	.0204	.1281	.03203	.0201	.1482	.03705
.0161	.0492		.0158	.0650		.0158	.0808		.0153	.0961		.0150	.1111	

SECTION

SECTION II.

Experiments on the expansion of air in the Manometer.

WITH respect to order of time, the manometrical experiments were made subsequently to the chief part of the barometrical observations, from which alone an approximate rule had previously been deduced for the measurement of heights: nevertheless, in this paper it seemed to me best, that what related to the expansion of air in one instrument, should immediately succeed the expansion of quicksilver in the other.

The thermometer made use of in these experiments is above four feet long. Its scale extends from $-4°$ to $+224°$ of FAHRENHEIT, each degree being more than $\frac{2}{10}$ths of an inch: when the barometer stood at 30 inches, its boiling point was fixed in the tin vessel formerly described. Mr. RAMSDEN's thermometers generally rise in the same vessel $213°\frac{1}{2}$; and the long thermometer, being placed in the vessel he makes use of to fix his boiling points, rises only to $210°$.

The manometers were of various lengths, from four to upwards of eight feet: they consisted of straight tubes,

 whose

whofe bores were commonly from $\frac{1}{15}$th to $\frac{1}{25}$th of an inch in diameter. The capacity of the tube was carefully meafured, by making a column of quickfilver, about three or four inches in length, move along it from one end to the other. Thefe fpaces were feverally marked, with a fine edged file, on the tubes; and transferred from them to long flips of pafte-board, for the fubfequent conftruction of the fcales refpectively belonging to each. The bulb, attached to one end of the manometer at the glafs houfe, was of the form of a pear, whofe point being occafionally opened, dry or moift air could be readily admitted, and the bulb fealed again, without any fenfible alteration in its capacity.

The air was confined by means of a column of quickfilver, long or fhort, and with the bulb downwards or upwards, according to the nature of the propofed experiment. Here it muft be obferved that, from the adhefion of the quickfilver to the tube, the inftrument will not act truly, except it be in a vertical pofition; and even then, it is neceffary to give it a fmall degree of motion, to bring the quickfilver into its true place; where it will remain in equilibrio, between the exterior preffure of the atmofphere on one fide, and the interior elaftic force of the confined air on the other.

All

All the experiments were made when the barometer was at, or near, 30 inches. When the bulb was downwards, the height of the barometer at the time of obfervation, augmented, and when upwards, diminifhed by the number of inches of quickfilver in the tube of the manometer, expreffed the denfity of the confined air.

Pounded ice and water were ufed to fix a freezing point on the tube; and by means of falt and ice, the air was farther condenfed, generally four, and fometimes five or fix degrees below zero. The thermometer and manometer were then placed in the tin veffel, among water which was brought into violent ebullition; where having remained a fufficient time, and motion being given to the manometer, a boiling point was marked thereon. After this the fire was removed, and the gradual defcents of the piece of quickfilver, correfponding to every 20 degrees of change of temperature in the thermometer, were fucceffively marked on a deal rod applied to the manometer. It is to be obferved, that both inftruments, while in the water, were in circumftances perfectly fimilar; that is to fay, the ball and bulb were at the bottom of the veffel.

In order to be certain that no air had efcaped by the fide of the quickfilver during the operation, the manometer was frequently placed a fecond time in melting

 ice.

ice. If the barometer had not altered between the beginning and end of the experiment, the quickfilver always became ftationary at or near the firft mark. If any fudden change had taken place in the weight of the atmofphere during that interval, the fame was noted, and allowance made for it in afterwards proportioning the fpaces.

Long tubes, with bores truly cylindrical or of any uniform figure, are fcarcely ever met with. Such however as were ufed in thefe experiments, generally tapered in a pretty regular manner from one end to the other. When the bulb was downwards, and the tube narrowed that way, the column of quickfilver confining the air lengthened in the lower half of the fcale, and augmented the preffure above the mean. In the upper half, the column being fhortened, the preffure was diminifhed below the mean. In this cafe, the obferved fpaces both ways from the center, were diminifhed in the inverfe ratio of the heights of the barometer at each fpace, compared with its mean height. If the bore widened towards the bulb when downwards, the obferved fpaces, each way from the center, were augmented in the fame inverfe ratio; but in the experiments on air lefs denfe than the atmofphere, the bulb being upwards, the fame equation was applied with contrary figns: and if any

 extra-

extraordinary irregularity took place in the tube, the corresponding ſpaces were proportioned both ways from that point, whether high or low, that anſwered to the mean.

The obſerved and equated manometrical ſpaces being thus laid down on the paſte-board containing the meaſures of the tube; the 212° of the thermometer, in exact proportion to the ſections of the bore, were conſtructed along-ſide of them: hence the coincidences with each other were eaſily ſeen; and the number of thermometrical degrees anſwering to each manometrical ſpace, readily transferred into a table prepared for the purpoſe.

I have already had occaſion to remark that, from the operations of the barometer alone, an approximate rule, or mean equation, had been obtained for the meaſurement of heights; but as, among the reſults, irregularities were now and then met with, doubts naturally aroſe, whether the equation, inſtead of being conſidered as uniform, might not follow an increaſing or diminiſhing progreſſion? Without an infinite number of obſervations, in very different temperatures above and below the zero of the ſcale, this point could not poſſibly be determined by the barometer: wherefore the firſt and chief thing propoſed to be diſcovered by the manometrical experiments was, whether common air, occaſionally rendered more or lefs denfe, by the addition or fubtraction of weight, expanded equally with quickfilver, when affected with the fame degrees of heat? According to the ratio that took place between the expanfion of quickfilver and air, above and below zero, I intended to regulate the barometrical equation already found, without regarding the proportion of the bulb to the bore of the manometer; or in other words, without paying any attention to the actual expanfion of the air confined in that inftrument.

But after a great number of thefe firft experiments had been made, it was judged proper to compute the actual expanfion of 1000 equal parts of air in the manometer, from a heat of 212°; wherefore, in the laft, the accurate capacity of the bulb, with refpect to the bore, was determined; at the fame time that the original mode of comparing the thermometrical with the manometrical fpaces, was ftill adhered to.

It is eafy to conceive in experiments of this very delicate nature, part of which, namely thofe on air lefs denfe than the atmofphere, were extremely difficult and even laborious, that mathematical exactnefs was not to be looked for; and that, notwithftanding every poffible precaution was taken, irregularities would occur. Thefe, however, were not fo numerous as might have been expected, nor any way so great as to render the research fruitless: for a few of that kind being thrown out of the total number, the mean of the others, which were very consistent among themselves, served to prove beyond the possibility of doubt, that the expansions of common air did not keep pace with the dilatations of quicksilver. The manometrical space, answering to the 20° of the thermometer between 52° and 72°, was always found to be greater than any other 20° of the scale. Here it is to be understood, that I do not pretend to have ascertained the exact point in that space where the maximum falls: the mean corresponds to the 62d degree, and yet I am inclined to think that it is somewhat lower, perhaps it may be about the 57th: from this point, the condensations of air downwards, and its expansions upwards, follow a diminishing progression, compared with the condensations and dilatations of quicksilver. The manometrical are equal to the thermometrical spaces, in two points of the scale; namely, at or near the freezing temperature on one side, and between the 112° and 132d degrees of the scale on the other. At the zero and boiling point they are less than the thermometrical spaces. Whether this maximum of expansion of air, compared with that of quicksilver, be owing to moisture, or any

thing

thing elſe mixed with the former, which is brought into its greateſt degree of action, about the temperature of 57° of FAHRENHEIT, muſt be left to the inveſtigations of future experimenters: I only relate things as I found them after many repetitions, without being able to diſcover any material difference in the reſults, even when the air was rendered more or leſs denſe by an addition to, or ſubtraction from, the weight wherewith it was loaded. The thermometrical, compared with the manometrical ſpaces, will therefore appear as in the following table.

Spaces of the quickſilver thermometer, FAHRENHEIT's ſcale.	Spaces of the manometer, meaſured in degrees of FAHRENHEIT.
212°	212°
20	17.6
192	194.4
20	18.2
172	176.2
20	18.8
152	157.4
20	19.4
132	138.0
20	20.0
112	118.0
20	20.8
92	97.2
20	21.6
72	75.6
20	22.6
52	53.0
20	21.6
32	31.4
20	20.0
12	11.4
0	0

Expe.

Experiments, for determining the actual expansion of common air, in the manometer, affected by the heat of 212°.

For this purpose it became necessary to ascertain, in every manometer, the exact proportion between the capacity of the tube and that of its bulb. This was done, by weighing the quicksilver that filled them respectively, in a balance that was sensible to a very small fraction of a grain. The contents of the bulb, and that part of the tube between it and zero, expressed in grains, was called the air in experiment. The apparent expansion of that air was measured, by the grains that filled the several sections of the tube between zero and the boiling point; the sum being the total expansion or increase of volume, from a heat of 212°. The apparent expansion, thus found, was again augmented for the dilatation of the tube, on the following principles.

In the first part of this paper I have shewn, that solid glass rods dilate much less than barometer tubes. The mean between Mr. SMEATON's and my experiments, gives $\frac{14}{1000}$ of an inch for the longitudinal extension of every foot of these tubes, by 212°. From the rate of going of a clock, for near a year, whose pendulum rod is solid glass, its dilatation seems to be one-third part of a steel rod,

or

or $\frac{58}{10000}$ on a foot, by 212°. Now, as the manometers resemble solid rods much more than they do barometer tubes, it is probable their dilatation, even allowing for the greater extension of the bulb, would not exceed $\frac{6}{1000}$ths of an inch on a foot, or $\frac{1}{1000}$th part on every two inches. In this ratio I have therefore augmented the apparent, to obtain the true, capacity of each manometer. The equation, amounting to about $\frac{1}{220}$th part of the whole, being less than the common error of such complicated observations, might in fact have been entirely omitted, without producing any material alteration in the results.

Having, in this manner, computed the total increased volume of any number of equal parts of air (according to the capacity of the bulb and tube in grains)/and very often likewise the partial expansions for intermediate temperatures, expressed by the contents of the corresponding sections of the tube, I then found the ratio answering to 1000 equal parts, which, being divided by the degrees of difference of temperature, gave the mean rate for the whole scale, or the particular rate for any intermediate section of it.

The experiments, considered in this way, are distributed into four classes, whereof the results are comprehended in the four following tables. The first shews the expansion of air, whose density was much greater than that of the common

common atmofphere. The fecond, which is divided into two fets, contains thofe on air that fuftained a preffure lefs than the atmofphere. In the third clafs, a very fhort column of quickfilver being employed to confine the air, its denfity differed little from that we commonly breathe in: this clafs is likewife fubdivided into two fets, and it will hereafter be made ufe of to regulate the equation depending on the temperature of the air, in the application of the barometer. The fourth and laft clafs of experiments, were made on air of the common denfity, artificially moiftened by the admiffion, fometimes of fteam, and at others of water, into the bulb; it is accordingly diftinguifhed into two fets.

TABLE I. Refults of experiments on the expanfion of air, whofe mean denfity was equal to $2\frac{1}{2}$ atmofpheres.

N°	Height of the barometer.	Inches of quickfilver confining the air.	Denfity in inches.	Total expanfion of 1000 equal parts of air by 212°.	Mean rate for each degree.
1	29.7	+72.	101.7	451.54	2.12991
2	29.7	+62.6	92.3	423.23	1.99637
3	29.62	+50.84	80.46	412.09	1.94382
4	29.66	+24.88	54.54	439.87	2.07486
5	29.66	+20.05	49.71	443.24	2.09075
		Mean,	75.74	434.00	2.04717

TABLE

TABLE II. Refults of experiments on the expanfion of air of the denfity of five-fix[ths of the] common atmofphere; and of others on air that was extremely rare, being only p[ressed with] about one-fifth of an atmofphere.

Set	N°	Height of the barom.	Inches of quick-filver.	Denfity in inches.	Total expanfion of 1000 equal parts of air by 212°.	Mean rate for each degree.	Expanfion for intermediate temperatures. From 0 to 32°.	32° to 52°.	52° to 72°	72° to 92°	92° to 132°	13[2°] to 1[…]
Firft fet.	1	29.85	—5.44	24.41	495.455	2.33705	——	——	Not obferved.		——	——
	2	29.76	—3.05	26.71	504.340	2.37896	2.27190	2.41666	2.64060	2.55200	2.46040	2.31
	3	29.79	—0.53	29.26	470.32	2.21849	1.90437	2.48150	2.63150	2.59650	2.15050	2.12
	4	30.09	—5.43	24.66	469.07	2.21259	2.32688	2.53450	2.66250	2.24800	2.25425	2.05
	5	29.93	—9.63	20.30	479.20	2.26038	2.14750	2.49500	2.59850	2.24700	2.25950	2.21
		Mean,		25.17	483.677	2.28140	2.16266	2.48191	2.63327	2.41087	2.28116	2.1

Set	N°		Difference of temperature.			Tota[l ex]panf[ion]
Firft fet.	6	Experiment in a heated room in Philpot lane, February 25, barometer 30.°03 — 4.82 = 25.21 the denfity of the air, —	on 113½°	from 48½°	to 162°	244
			51½	48½	100	126
			62	100	162	118
Second fet.	7	In Philpot lane; tube with a fmall bore; barometer 30.03 — 23.2 = 6.77 the denfity. The air had been heated red-hot in the bulb before it was fealed, — — —	on 113½	from 48½	to 162	138
			51	48½	101½	71
			60½	101½	162	66
		The expanfion for 212°, at the mean rate, would be —	—	—	—	259
	8	In Pulteney ftreet, February 28th; with the fame manometer that had been ufed in the fame experiment in Philpot lane, barometer 30.08 — 23.2 = 6.88 the denfity of the air, — —	on 212	—	—	33
			32 above zero.			4
			20	from 32	to 52	3
			80	52	132	13
			60	132	192	9
			20	192	212	1
	9	In Pulteney ftreet, April 19th; tube with a large bore, barometer 29.8 — 24.08 = 5.72 the denfity of the air, which had been heated red-hot in the bulb before it was fealed, — —	on 180	from 32	to 212	14
			20	32	52	1
			20	52	72	2
			20	72	92	2
			20	92	112	1
			20	112	132	1
			20	132	152	1
			20	152	172	1
			20	172	192	1
			20	192	212	

ive-fixths of the

nly preffed with

...ratures.		
...°	132° to 172°	172° to 212°
40	2.31850	2.20748
50	2.12000	2.10925
25	2.05325	1.83525
50	2.21375	2.11850
16	2.17637	2.06762

...e.	Total expanfion.	Mean rate.
	244.604	2.15510
	126.311	2.45264
	118.293	1.90800
	138.75	1.22247
½	71.93	1.41039
	66.82	1.10446
	259.164	
	330.487	1.55890
	44.574	1.39294
2	37.771	1.88855
2	139.784	1.74730
2	94.804	1.58007
2	13.554	0.67770
2	141.504	0.78613
2	17.845	0.89225
2	25.943	1.29715
2	20.911	1.04550
2	14.937	0.74685
2	14.228	0.71140
2	14.151	0.70755
2	14.150	0.70750
2	12.264	0.61320
2	7.075	0.35375

	20	152	172	1
	20	172	192	1
	20	192	212	
The Expansion for 212° at the mean rate would be, —	—	—	—	16
Mean of the three means; density 6.46, expansion for 212°,	—	—	—	2

2	14.150	0.70750
2	12.264	0.61320
2	7.075	0.35375
	166.660	
	252.104	1.18917

TABLE

TABLE III. Results of experiments on the expansion of air of the density of the common atmosphere.

	N°	Height of the barom.	Inches of quicksilver confining the air.	Density in inches.	Total expansion of 1000 equal parts of air by 212°.	Mean rate for each degree.
First set; common air.	1	29.95	+1.57	31.52	483.89	2.28250
	2	30.07	+0.70	30.77	482.10	2.27406
	3	29.48	+0.42	29.90	480.74	2.26764
	4	29.90	+0.83	30.73	485.86	2.29182
	5	29.96	+0.96	30.92	489 45	2.30870
	6	29.90	+0.65	30 55	476 04	2.24547
	7	29.95	+0.65	30.60	487.55	2.29976
Second set; common air heated red-hot	8	30.07	+0 53	30 60	482 80	2.27736
	9	29 48	+0 52	30.00	489.47	2.30871
			Mean	30.62	484.21	2.28401

The total expansion 484.21 being divided into parts proportionable to the manometrical spaces, measured in degrees of the quicksilver thermometer, as already given; we have the following expansions for intermediate temperatures, the rates for every 10° below 92° being found by interpolation.

Ther-

Thermometrical ſpaces.	Manometrical ſpaces.	Total Expanſions for degrees above zero, 1000 parts.	Difference of expanſions, 1000 parts.	Rate for each degree, 1000 parts.
212.°	212.°	484.210	40.199	2.00995
192.	194.4	444.011	41.559	2.07795
172.	176.2	402.452	42.949	2.14745
152.	157.4	359 503	44.310	2.21550
132.	138.	315.193	45.680	2.28400
112.	118.	269.513	47.507	2.37535
92.	97.2	222.006	24.211	2.42110
82.	86.6	197.795	25.124	2.51240
72.	75.6	172.671	25.581	2.55810*
62.	64.4	147.090	26.037	2.60370
52.	53.	121.053	25.124	2.51240
42.	42.	95.929	24.211	2.42110
32.	31.4	71.718	23.297	2.32970
22.	21.2	48.421	22.383	2.23830
12.	11.4	26.038	26.038	2.16983
0.	——	——		

Hence $222.006 - 26.038 = 195.968 = 2.4496$, or 2.45, is the mean rate of expanſion for the 80° comprehended between 12° and 92° of FAHRENHEIT.

TABLE

TABLE IV. Refults of experiments on the expanfion of air, artificially moiftened,
of the manometer.

	N°	Height of the barom.	Inches of quickfiver confining the air.	Denfity in inches.	Total expanfion of 1000 equal parts of air by 212°.	Mean rate for each degree.	from zero to 32°.	32° to 52°	52° to 72°
Firft fet: fteam admitted into the bulb before it was fealed.	1	30.16	+ 1.6	31.76	——	——	2.059375	2.60700	3.0265
	2	29.97	+ 2.2	32.17	1409.04	6.64642	2.20250	2.59250	2.9095
	3	30.00	+ 2.2	32.20	1350.10	6.36840	2.26875	2.59100	3.0490
	4	30.43	+ 1.92	32.35	——	——	2.20875	2.51450	2.7470
	5	30.2	+ 1.6	31.80	1999.71	9.43259	2.361875	2.51300	2.9640
	6	30.32	+ 2.37	32.69	2576.16	12.15169	2.16250	2.55350	3.1160
Second fet: a drop of cold water admitted into the bulb before it was fealed.	7	30.2	+ 1.3	31.50	1135.48	5.35604	2.22594	2.74450	2.9050
	8	30.06	+ 3.2	33.26	——	——	2.54062	2.63350	2.8085
	9	30 32	+ 1.6	31.92	1538.31	7.25618	2.02156	2.54250	3.2250
Mean,				32.18	1668.13	7.86854	2.22799	2.58800	2.9722
Mean of the fecond, third, and feventh,				31.96	1298.20	6.12362	2.23239	2.64267	2.9545
Mean of the fifth, fixth, and ninth,				32.14	2038.06	9.61349	2.18198	2.53633	3.1016

By N° 1. the total expanfion for 192° is 1208.72, when

4. — — 192° 1367.05,

8. — — 112° 358.03,

tened, by the admiſſion of ſteam, and ſometimes water, into the bulb meter.

Expanſion for intermediate temperatures.							
52° to 72°	72° to 92°.	92° to 112°.	112° to 132°	132° to 152°.	152° to 172°	172° to 192°	192° to 212°
3.02650	3.38050	4.18300	6.48000	8.67750	11.93600	16.85050	———
2.90950	3.67650	5.16700	6.93300	10.17500	10.64200	16.57850	8.25400
3.04900	3.77550	4 36900	7.60500	8 94400	10.42950	11.92200	11.69000
2.74700	3.25500	3.73700	5.91350	9 18950	11.57550	25.88650	———
2.96400	3.84750	5.76100	7.19450	12.29850	16.69750	19.29500	25.23550
3.11600	3.72300	5 53600	7.83900	12.74100	16 74600	27.84350	45.25000
2.90500	3 47750	5.41900	6.16650	7.98850	8.58950	10.93600	4.98600
2.80850	3.78700	4.60750	———	Tube broken.		———	———
3.22500	3.76500	5 41700	6.79250	9.14350	9.71100	13.75550	19 93270
2.97228	3.63194	4.91072	6.86550	9.89494	12.04087	17.88344	19.22470
2 95450	3.64317	4.98500	6.90150	9.03583	9.88700	13.14550	8.31000
3.10167	3.77850	5.57133	7.27533	11.39500	14.38483	20.29800	30.13940

2, whence the mean rate is 6.29542.
5, — — 7.12005.
3, — — 3.19669.

From

From the experiments of the firſt claſs it appears, that 1000 equal parts of common air, loaded with two atmoſpheres and a half, being affected with a heat of 212°, expands 434 of thoſe parts; that is to ſay, in its dilated ſtate, it occupies a ſpace bearing, to that which it originally filled, the proportion of 1434 to 1000: hence the mean rate of expanſion of air of that extraordinary denſity is 2.04717 for each degree.

From the firſt ſet of the ſecond claſs of experiments it appears, that 1000 equal parts of air, preſſed only with $\frac{5}{6}$ths of an atmoſphere, and ſuffering a heat of 212°, expands nearly 484 of thoſe parts, whereof the mean rate for each degree is 2.28140. The maximum correſponds to that ſection of the ſcale between 52° and 72°; and the rate for the extremes is leſs than the mean.

But in the ſecond ſet of this claſs, when the confined air was rendered ſo extremely rare as to be preſſed with only one-fifth of an atmoſphere, in which caſe there was a neceſſity for heating it red-hot before it was poſſible to make the quickſilver hang in any tube of a moderate length, the expanſion of 1000 equal parts of air is, by the ſeventh and eighth experiments, diminiſhed to about two-thirds of the uſual quantity; and by the ninth, it is conſiderably leſs, amounting only to 141.5 for the 180°

 com-

comprehended between freezing and boiling, or 0.78613 for each degree. The maximum ſtill correſponds to the ſpace between 52° and 72°; and the minimum is conſtantly at the boiling point.

From theſe three laſt experiments it would ſeem, that the particles of air may be ſo far removed from each other, by the diminution of preſſure, as to loſe a very great part of their elaſtic force; ſince, in the ninth experiment, the heat of boiling water applied for an hour together, could only make it occupy a ſpace which, compared with what it filled at freezing, bears the proportion of 1141.5 to 1000.

From the third claſs of experiments it appears, that common air, preſſed with a ſingle atmoſphere, whether taken into the manometer in its natural ſtate, or heated red-hot therein, has the ſame expanſion with air of only five-ſixths of that denſity: for 1000 equal parts of this air expanded 484.21 from 212° of heat, whereof the mean rate is 2.28401 for each degree. By comparing this reſult with that of the firſt claſs, and again with that deduced from the ſecond ſet of the ſecond claſs, it would ſeem, that the elaſtic force of common air is greater than when its denſity is conſiderably augmented or diminiſhed by an addition to, or ſubtraction from, the weight with which it is loaded[(f)]; for, in the first case, it bears the proportion of 484 to 434; and in the last, it is (from the

(f) This difference between the elastic force of common air, and that which is artificially rendered more or less dense, by the addition or subtraction of weight, particularly the latter, is truly remarkable, and contradicts the experience of BOYLE, MARRIOTTE, &c. It could not arise from the adhesion of the quicksilver to the tube, though in the dense experiments a column of 72 inches was once made use of; because the constant motion given to the manometer before the spaces were marked, must either have prevented any irregularity whatever, or made the apparent expansion sometimes too great, and at others too little. But the rare experiments serve to put this matter out of doubt; for if the adhesion of the quicksilver to the tube had tended to lessen the apparent expansion of the air, beneath the truth in one case, it must have had a direct contrary effect in the other, and augmented it above the truth, which it evidently doth not.

These experiments on the expansion of air less dense than the atmosphere, were extremely difficult and troublesome; and it was not till after several fruitless attempts that, with the assistance of Dr. LIND, an apparatus was prepared for making them with sufficient accuracy. The vessel employed for this purpose was made of the brass tube of a large telescope, near four inches in diameter; it was divided into four pieces, which, when screwed together, made a pot of six feet in height. This was mounted on a platform laid over the area rails, for the reception of the manometer, which was placed therein, with the bulb uppermost, the lower extremity of the tube passing through a socket at the bottom of the vessel, and then through a collar composed of many thicknesses of flannel. By means of a brass plate and three long screws, the collar was made to embrace the tube so closely, as to suffer very little water to pass: such as did issue, oozed off along the sides of a paper funnel, bound round the end of the tube, without entering into the bore. In this position, it required some degree of force to push the manometer up, or draw it down, till the top of the quicksilver confining the air, just appeared without the collar, so as to admit the spaces to be measured, from a fixed point marked on the tube. The vessel being filled with boiling water, was kept to that temperature by means of lamps suspended the mean of three experiments) as 484 to 252, when preſſed with only one-fifth of an atmoſphere.

The

pended around it. Two thermometers were made uſe of; the long one, whoſe ball ſtood at the bottom; and a ſhort one at the top, that deſcended no lower than juſt to be immerſed in the water. By ſome of the firſt of theſe experiments, the lamps not being placed directly at the bottom, water was perceived to be a very bad conductor of heat; for it would boil violently at the top, and the ſhort thermometer there would mark 212°, while the long one would only mark 185° or 190° at the bottom. By ſlow degrees the heat would nevertheleſs deſcend, and in the ſpace of fifteen or twenty minutes the whole column would become of the ſame uniform temperature. But when the apparatus was adapted for experiments on air denſer than the atmoſphere, in which caſe a plate of tin was ſoldered over the hole at the bottom, that it might be placed on a ſtrong fire, the heat was then greateſt below, and the long thermometer would mark upwards of 215°, while the ſhort one ſtood at 209° or 210°. By deſiſting from blowing the fire, or removing a part of it, the particles of water ſuffering the greateſt heat would aſcend, mix with the reſt, and for ſome little time make the whole column of an uniform temperature. But the fire being totally removed, the top of the column in cooling was always hotteſt; wherefore, in all theſe experiments, whether on denſe or rare air, great care was taken to mix the water thoroughly.

From Mr. DE LUC's book it appears, that M. AMONTONS found the effect of heat on the air confined in his thermometer, which ſeems to have been the ſame ſort of inſtrument with the manometer, proportionable to the weight with which it was loaded. By this he could not mean that, being of a double denſity, it had twice the expanſion. I apprehend it muſt here be underſtood, that the ſpaces the air occupied, were inverſely as the weights. That being preſſed with a double weight, it only filled half the ſpace; or with half the weight, a double ſpace. This is no doubt nearly, though not accurately, the law that it follows. From theſe experiments it appears, that there is little difference in the actual expanſion or elaſtic force of air, preſſed with an atmoſphere + or — one-third part: yet, when it is rendered extremely rare, its elaſticity is wonderfully diminiſhed. There ſeems likewiſe to be a viſible diminution in its expanſion, when loaded with two atmoſpheres and a half. Some of the tubes that I uſed were near nine

feet

The total expansion 484.21 resulting from the third class of experiments, which are very consistent among themselves, being divided into parts proportionable to the manometrical spaces, as measured in degrees of the quicksilver thermometer, we have the expansions for intermediate temperatures, expressed at the bottom of the third table, where, it is to be observed, the rates for every 10° below 92° were found by interpolation.

Now as barometrical observations will probably never be made in a temperature higher than 92° in the shade, nor in one lower than 12°, if we subtract 26.038, the expansion answering to 12°, from 222.006, that which corresponds to 92°, we shall have 195.968 for the 80 intermediate degrees; or 2.45 for the mean rate on each. This equation, compared with Mr. DE LUC's, bears the proportion of 245 to 210, which is a difference of $\frac{35}{100000}$ on every degree, or one-seventh part of the whole: and though this rate will be found hereafter to

feet long. Had it been possible to have managed them of double or triple that length, so as to have admitted the air to be pressed with a column of 18 or 20 feet of quicksilver, I am persuaded the diminution in the expansion of air of that extraordinary density would have been much more perceptible.

Mr. AMONTONS found, that the condensation of air in his thermometers kept pace with that of spirit of wine, which we are told follows a decreasing progression with respect to quicksilver: wherefore his experiments agree with these, in making the condensation of air below 57° follow a decreasing progression, when compared with that of quicksilver.

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exceed that deduced from the operations of the barometer in extreme temperatures; yet they agree exceedingly well with each other for the mean heat of the air, when the barometer will come moſt frequently into uſe.

The fourth claſs of experiments are all that now remain to be mentioned. The bare inſpection of TABLE IV. will ſhew, how greatly ſuperior the elaſtic force of moiſt is to that of dry air. It is true indeed, that two kinds of irregularities preſent themſelves among the reſults: firſt, with regard to the total expanſion for 212°; and ſecondly, as to the greateſt exertion of the elaſtic force, which ſometimes ſeems to have taken place before the air has acquired the heat of boiling water. The firſt is eaſily accounted for: it muſt have ariſen from different proportions of moiſture being admitted into the ſame quantity of air, which there was no poſſibility of aſcertaining, the bulbs and their apertures being of very different dimenſions. With regard to the ſecond irregularity, I am rather inclined to think that it may have proceeded from error of obſervation, it being difficult to determine the accurate temperature near boiling; eſpecially when any part of the air roſe above the top of the veſſel, which was ſometimes the caſe, notwithſtanding its extraordinary height. Be that as it may, a very uniform encreaſing progreſſion will be perceived to take place,

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from the zero of FAHRENHEIT, as far as 152° or 172°; and even to the boiling point, in those which I esteem the best experiments. By adhering to the mean result it will appear that air, however moist, having that moisture condensed or separated from it by cold, its expansion differs not sensibly from that of dry air. Thus the rate for 32° below freezing 2.22799, is nearly the same as in dry air; but no sooner doth the moisture begin to dissolve and mix with the air, by the addition of 20° of heat, than the difference is perceptible: for instead of 2.46675, the rate for 20° above 32° in dry air, we have 2.588 for that which is moist. In the next step of 20°, the rate for dry air is 2.5809; whereas that for moist is 2.97. In this manner the progression goes on continually encreasing, so as to give 7.86854 for the mean rate on each degree of the 212°, which is near three times and a half the expansion of dry air. And lastly, the rate for the 20° between 192° and 212°, is twice and one-half the mean rate, and about nine times that which corresponds to the zero of the scale: but if the comparison is drawn from the mean of the fifth, sixth, and ninth experiments, as being probably nearest the truth, the total expansion of moist, will be more than four times that of dry air; and the rate for the temperature at boiling, will be nearly fifteen times that which correſponds to the zero of FAHRENHEIT.

I am aware it will be alledged, that the proportion of moiſture admitted into the manometer in theſe experiments, is greater than what can ever take place in nature; and therefore, in order to be able to judge of the degrees of expanſion the medium ſuffers in its more or leſs denſe, and more or leſs moiſt ſtates, that not only air near the ſurface of the earth, but likewiſe that found at the top of ſome very high mountain, ſhould have been made uſe of. I grant all this: but on the other hand it muſt be remembered, that theſe experiments are very recently finiſhed; that a good hygrometer (if ſuch can ever be obtained) a great deal of leiſure time, and the vicinity of high mountains, were all neceſſary for the carrying of ſuch a ſcheme into execution.

It is for theſe reaſons, and in hopes that other people will, ſooner or later, inveſtigate this matter ſtill farther, not only by experiments made on the expanſion of air, taken at different heights above the level of the ſea in middle latitudes, but likewiſe on that appertaining to the humid and dry regions of the atmoſphere towards the equator and poles, that I have been induced to haſten the communication of this paper. In the mean time having proved, beyond the poſſibility of doubt, that a wonderful

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difference doth exist between the elastic force of dry and moist air, I may be allowed hereafter to reason by analogy, on the probable effects this will produce, in measuring heights with the barometer; leaving it to others, much better qualified, to consider how far it will affect astronomical refractions. In the following section I shall therefore give an account of the barometrical observations made in Britain, and compare them with some others made in distant countries.

SECTION III.

An account of the barometrical observations made in Britain, *wherein they are compared with some others of the same kind made in distant countries.*

THE revival of the inquiries into that curious and useful branch of philosophy, whereby vertical heights are determined to a great degree of exactness, by the pressure of the atmosphere alone, we owe to Mr. DE LUC; who hath undoubtedly removed many of the difficulties that formerly occurred in the application of the barometer, and thereby encouraged others to attempt to overcome, some part at least, of such as remain.

If the rule deduced from the obfervations on Saleve had been abfolutely free from exceptions, and if there had not been particular points in the theory concerning which the ingenious author himfelf feems to have entertained doubts, it would probably have been univerfally adopted, without undergoing any very fcrupulous inveftigation; but the obfervations made at Sun-rifing on Saleve, gave refults that were defective, or lefs than the real height. In certain cafes, the equation for high temperatures, remote from the zero of the fcale, appeared to follow a diminifhing, and in others an increafing progreffion. Hence arofe fome caufes of uncertainty, with refpect to the fpecific gravities of quickfilver and air, and the relative expanfion of one compared with the other; efpecially when the atmofphere happened to have more or lefs moifture diffolved in it. It was doubtlefs from confiderations of this fort, that Mr. DE LUC, in his book, fo ftrongly recommends the making of numerous fets of obfervations, in different countries; that, by the united labours of all, this interefting part of natural philofophy, might be brought ftill nearer to perfection.

With this general object in view, I am now to give an account of the principal barometrical obfervations that have been made in Britain, on heights determined geometrically with great care. Thefe heights are claffed in the

the following liſt in ſix ſets, according to the diſtricts of the country wherein they are ſituated, and nearly in the order of time in which the obſervations were made.

		Height in feet.
N° I. Heights in and near London.	St. Paul's Church-yard *(g)*, North-ſide, and iron gallery over the dome, — — —	281
	Top of Paul's-ſtairs, and the ſaid gallery, —	324
	Top of Scotland-yard wharf, and the dining-room of the Spaniard on Hampſtead-heath, —	422
	Great Pulteney-ſtreet, and the ſaid dining-room, —	352
	Pagoda in Kew gardens, — — —	116½
	Gun wharf in Woolwich Warren, and uppermoſt ſtory of Shooter's-hill inn *(h)*, — — —	444

(g) Mr. BANKS, aſſiſted by other gentlemen, meaſured very accurately with a line the height of the ball of St. Paul's above the floor of the church, which was found to agree, exceedingly near, with that taken from the engraved ſection of the building. The diſtance of the ball from the dining-room of the Spaniard, was found by a baſe meaſured on Hampſtead-heath; and their relative heights by the angle of depreſſion of the ball, taken with the aſtronomical quadrant from the ſaid dining-room. The heights of Paul's ſtairs and Scotland-yard wharf, with reſpect to each other, were found by meaſuring from them ſeverally to the ſurface of high water in the Thames. And the elative heights of the church-yard and floor of the church with reſpect to the ſtairs, and of Pulteney-ſtreet with regard to the wharf, were obtained by levelling to them reſpectively.

(h) The height of Shooter's-hill inn, above Woolwich, was found by a baſe meaſured in the meadows from the Warren eaſtward. Lord MULGRAVE, Mr. BANKS, and Dr. SOLANDER, aſſiſted in the geometrical operations; as did Dr. BLAGDEN, Meſſ. DE LUC and LLOYD, in the barometrical obſervations.

		Feet.
N° 2. near Tay-bridge in Perthshire.	Station at the East-gate of Castle Menzie's gardens near the village of Weem, and top of Weem Craig,	700¼
	The said station, and top of Bolfracks Cairn, —	1076½
	The said station, and top of Dull Craig, —	1244½
	The said station, and top of Knock Farle, —	1364½
	The said station, and that at the rivulet of Glenmore, below the South observatory on Schihallien, —	1279¼
	The said station, and South observatory, — —	2098
	The said station, and Western summit of Schihallien,	3281
	Station at the rivulet of Glenmore, and the South observatory, — — — —	818¾
N° 3. near Lanark.	Level of the Clyde at Lanark-bridge, and station in the garden at Lanark, — —	362½
	Ditto level, and top of Stonebyre-hill, — —	654
	Robinhood's well, before Carmichael-house, and top of Tinto, four feet below the summit of the Cairn,	1642½
	Ditto well, and West end of Carmichael-hill, —	451½
N° 4. near Edinburgh.	Leith pier-head, and top of the Calton-hill, —	344
	Leith pier, and summit of Arthur's Seat, — —	803
	Leith pier, and Kirk-yetton Cairn, on the East-end of the Pentland hills, — — —	1544
	Calton hill, and ditto Cairn, — — —	1200
	Level of Hawk-hill study, and top of Arthur Seat,	702½
	Hawk-hill observatory, and bottom of the little rock on Arthur Seat, 7¼ feet below the summit, —	684
	Hawk-hill garden-door, and ditto little rock, —	730¾
N° 5. near Linhouse.	Linhouse, and East Cairn-hill, 5 feet below the summit,	1176½
	Ditto, 18 feet below the top, — —	1165½
	Linhouse, and West Cairn-hill, 11 feet below the top,	1178½
	Ditto, and Corstown-hill, 4 feet below the top, —	386½
	Corstown-hill, and West Cairn-hill, — —	792
	Ditto, and East Cairn-hill, — — —	776½
N° 6. near Carnarvon in North Wales.	Carnarvon Quay, and Snowdon Peak, — —	3555
	Ditto, and summit of Moel Eilio, — —	2371

To enter into a minute detail of the geometrical operations, whereby the whole of these vertical heights were

were determined, would be extremely tedious and uninteresting. That some idea may however be formed of the degree of accuracy with which they were ascertained, it will be sufficient to observe, that the requisite angles were taken with an astronomical quadrant of a foot radius, made by Mr. SISSON, and curiously adapted for the measurement of horizontal or base angles; which, as well as those of the vertical kind, might always be determined thereby to within ten seconds of the truth. The bases were measured with care; and, in order to ascertain the distances, the three angles of each triangle were, as often as possible, actually observed with the quadrant. That the variation of the line of collimation of the instrument, which was found to alter in carrying, might occasion no error, one or more of the angles of elevation, at each station, were taken on the arc of excess, as well as on the quadrantal arc. In all cases, the usual [(i)] allowances were made for curvature and refraction: and for the correction of the last, sometimes the angles of de-

(*i*) If the square of the distance be divided by the diameter of the earth, the quotient will give the curvature of the globe on that distance, or the excess of the apparent above the true level: and, by Mr. MASKELYNE's rule, the square of the distance being divided by the diameter of the earth, augmented by one-fourth part, we have the allowance for curvature and refraction; which last is supposed to raise the object, by an angle equal to that of a great circle subtended by one-tenth part of the distance.

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preffion as well as of elevation were taken. When time would permit, the geometrical operations were repeated at the firft ftations; or the angles of elevation were obferved from fome new point connected with the firft, and whofe relative height, with refpect to the others, was known. Small altitudes were occafionally determined by levelling from one ftation to the other.

To prove that the vertical heights, affigned to the places in the preceding lift, are exceedingly near the truth, I need only mention the following inftances, by way of confirmation. In 1771, with the affiftance of Dr. LIND and his friend Mr. HOY, I meafured a bafe from the obfervatory of Hawk-hill weftward, whereby the height of the fummit of Arthur's Seat, above the telefcope of the Hawk-hill quadrant, in its horizontal pofition, was found to be 685.66 feet. In 1775, thefe gentlemen levelled, three feveral times, from the fummit downwards to the faid telefcope; and found the vertical diftance to be, by the firft operation, 686.47 feet; by the fecond, 684.43; and by the third, 685.25. This laft, which, from the great care that was ufed, they confidered as the beft, differs only three-tenths of a foot from the geometrical refult. They afterwards continued the operation of levelling from Hawk-hill to the pier of Leith, and having repeated it twice, with a difference of only two inches

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between the results, they found the mean descent to be 117.38 feet: hence Arthur's Seat is above Leith pier, by the mode of levelling, 802.66; and by the mixed method 803 feet.

In 1774, when the astronomer-royal was carrying on the Society's experiments for ascertaining the attraction of Schihallien, I found, from my own geometrical operations, depending on a base measured in the plain near Taybridge, the Western summit of the mountain to be 1183 feet above the South observatory.

Of this height, the effect of curvature and refraction amounted to 28.86 feet, on the distance of Bolfracks Cairn from the observatory; and to 38 feet, on the distance of the said Cairn from the summit of Schihallien. The result of these operations I communicated to Mr. MASKELYNE, before his trigonometrical operations were begun. From the data which he hath since been so obliging as to furnish me with, depending on the base in Glenmore at the bottom of Schihallien, and the angles of elevation taken from the Southern extremity of that base, the Western summit of the mountain is 1186.6 feet above the South observatory. But if the triangle that served to connect the station of the barometer in that valley with the others, and the angles of elevation taken from the same station are made use of, the dif-

 ference

ference of height will be 1183.33 feet. Laſtly, Mr. MASKELYNE's reſult, from the triangles on the North-ſide of the mountain, makes it 1180. The mean of theſe three 1183.31 feet, is the height of the Weſtern ſummit of the mountain above the South obſervatory, which only exceeds my height by one-third of a foot. Here it is to be obſerved, that from the vicinity of theſe triangles to the mountain, and the ſhortneſs of the ſides, the greateſt curvature amounted only to 16 or 17 inches, which conſequently made the effect of refraction next to nothing. This near agreement between the reſults ſeems therefore to prove, that the mode of computation for curvature and refraction, made uſe of in the Taybridge obſervations, is juſt.

By the firſt angles of elevation, taken from the ſtation of the barometer in Glenmore, the Weſtern ſummit of Schihallien is 2001.88 feet above it; from which, if we deduct 1183.33, there remains 815.55 for the height of the South obſervatory above the ſaid ſtation: but if the laſt angles of elevation at the ſtation of the barometer are made uſe of, the height between it and the obſervatory comes out 818.97, whereof the mean is 818.76 feet. Though theſe inſtances are of themſelves ſufficient to prove, that the geometrical heights may be ſafely depended upon; yet, as an example of the method that

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was always made ufe of, I fhall annex to this paper, a plan of the triangles and detail of the operations for obtaining the height of Snowdon; becaufe that mountain, at the fame time that it is the higheft I have meafured, is, from its fituation, more likely to be vifited, and to have experiments repeated upon it, than the remote hills of the North. I now proceed to give fome account of the barometrical obfervations.

The heights in and near London being fo very inconfiderable, it was eafily forefeen, that nothing conclufive could be drawn from obfervations made on them alone. It was, however, natural enough to try, even on thefe, whether the rule we had been furnifhed with would anfwer? A fmall height of 41 feet 4 inches, which, without inconveniency, could be recurred to at all times of the day, and all feafons of the year, was the firft that was made ufe of. St. Paul's, Hampftead, Kew pagoda, and Shooter's-hill, were the next. The mean refults of many obfervations on the three firft, and of feveral on Shooter's-hill, were found to be defective. In general the coldeft obfervations, made in the morning and evening, when the temperatures at the two ftations differed leaft from each other, anfwered beft. In the hotteft part of the day, when that difference was the greateft, the refults were moft defective.

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Some months ſpent in Scotland in the ſummer of 1774, afforded opportunities of making barometrical obſervations on hills of various heights, from three or four hundred, to upwards of three thouſand feet, as hath been exhibited in the preceding liſt. That ſeaſon was remarkably cold and wet; wherefore, in theſe obſervations, the mean temperature of the air in the ſhade was commonly about 55°. The hotteſt never exceeded 63° in the plain; and the coldeſt, namely thoſe on the higheſt mountains, were generally from 43° to 48°.

From the defect found in the reſults of theſe obſervations, which, with reſpect to temperature, correſpond to the mean and hotteſt of thoſe made at Sun-riſing on Saleve, and without any exception whatever, I could eaſily diſcover, either that a much greater equation than what the rule directed, muſt be applied for each degree of heat above the zero of the ſcale; or, that the zero itſelf would fall conſiderably lower than 39°74, where Mr. DE LUC's formula, adapted to Engliſh meaſures, hath fixed it. This firſt ſtep towards a correction of the rule, naturally pointed out the ſecond thing to be aimed at, namely, the obtaining of a ſufficient number of cold obſervations, near the zero, and as far as poſſible below it, that the equation might diſappear entirely, and even come to be applied with the contrary ſign. Of this kind the winter

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seasons of 1774 and 1775 afforded a few on the small heights in and near the metropolis; but the best I have been furnished with are those which Dr. LIND, assisted by Mr. HOY, was so obliging as to make on Arthur's Seat near Edinburgh; and those which Captain CALDERWOOD has since favoured me with on the Cairn-hills, being a part of the Pentland range to the South-west of that city.

By comparing these sets of observations together, it appeared from all of them, that when the air was at or near the freezing temperature, the logarithmic differences gave the real height in English fathoms and thousandth parts, without any equation; and when considerably below that point, the equation was to be subtracted, or applied with the sign − instead of +. It was farther perceived, that the same general conclusion might be drawn from the coldest, not only of the Sun-rising, but even of the ordinary observations on Saleve; some reduction of the temperature being in certain cases made, on account of the exposure of the thermometer to the Sun's rays: hence I was led to suppose, that the morning observations, instead of being made exceptions from the rule, were those, which, it might be presumed, would form the best basis for deducing the equation depending on the heat of the air; because the mean temperature of the column was then found to differ least from that of its extre-

extremities; whereas in the hotteſt time of the day, that difference was generally the greateſt.

Having been enabled, by means of the cold obſervations, to form ſome judgement whereabout the zero of the ſcale would fall, below which the equation was negative, and above it affirmative; it followed of courſe, that the next principal thing to be ſought for, was the maximum of equation, or that correſponding to the higheſt temperatures the climate of our iſland would afford. It was partly with the view of obtaining theſe that I went, in July 1775, to Snowdon in North Wales. On this expedition Captain CALDERWOOD was ſo obliging as to accompany me, and lend me his aſſiſtance in the operations for determining the geometrical height of that remarkable mountain. At that particular period, the weather proved unfavourable for obtaining hot barometrical obſervations; but, in other reſpects, they were very ſatisfactory, as being in general conſiſtent among themſelves, and agreeing ſufficiently near with thoſe of the preceding year in Scotland; at the ſame time that they were made on a height, as formerly mentioned, greater than any other hitherto meaſured, with equal care, in Britain. During the ſummer of 1776, Dr. LIND obtained ſome more hot obſervations on Arthur's Seat; and in the beginning of the following winter, Captain CALDERWOOD made others of the cold kind, on the Cairn-hills in his neighbourhood. From the combination of the whole of these observations taken together, and a comparison of them with Mr. DE LUC's, as far as they are similar, I mean to shew the agreement or otherwise, between the equation for the heat of the air, as deduced from the barometer and manometer; but since the British observations, in certain cases, differ considerably in their circumstances from those on Saleve, it is necessary, in the first place, to point out wherein this difference chiefly consists.

In the observations in Britain, the barometers and detached thermometers have been, almost constantly, placed in the open air in the shade, and suffered to remain there generally half an hour, and sometimes a great deal longer, before the corresponding observations were begun, that the quicksilver might have time to take the temperatures of the situations respectively. They were then observed four times, usually at intervals of ten minutes, the mean of the four being that which is calculated, and called a single observation. If the time did not admit of so long an interval, the same number of observations were taken at distances of five minutes from each other. In either case, the extremes never differed above a few thousandth parts of an inch from the mean, so as to

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render the computations of them ſeparately wholly unneceſſary.

Except in very ſmall heights, and chiefly in London, where it was impoſſible to ſcreen the upper barometer ſo effectually from the Sun during the time of obſervation as that below, which generally ſtood in the ſhade of ſome building, the temperature of the quickſilver in the ſuperior (k) hath been colder than that in the inferior barometer. The difference was commonly found to be two or three degrees; ſometimes it would amount to ſix or ſeven; rarely, in heights that were conſiderable, to nine or ten; and in one inſtance only to thirteen, where the vertical diſtance of the inſtruments was great.

Whether in the plain or on the tops of the higheſt mountains, the detached thermometers, indicating the temperature of the air, have generally ſtood ſomething

(*k*) I have ſometimes found, particularly in froſty weather, that a thermometer placed on the pavement of the North-ſide of St. Paul's Church-yard, cloſe to the wall of the building, would ſtand two degrees lower than that which was expoſed on the North-ſide of the iron gallery over the dome. The firſt, no doubt, felt the cold produced by the evaporation from the ſtones, while that above might be affected by the aſcending ſmoke. But the moſt remarkable inſtance of this kind occurs in one of Dr. LIND's obſervations, on the breaking up of the hard froſt January 31, 1776: at Hawk-hill, at $10^h\ 45''$ A.M. the temperature of the open air was 14°, while that at the ſummit of Arthur's Seat was 20°. The froſt that remained in the ground kept the air extremely cold below, though it had already felt the effects of the thaw at the top of the mountain.

lower

lower than thoſe attached to their reſpective barometers, until they had remained a conſiderable time in the ſame ſituation, equally ſhaded from the Sun, when they always agreed: whence it followed, that in theſe obſervations, the mean temperature of the air, and equation depending upon it, might always have been determined very near the truth, from the temperature of the quickſilver in the tubes, as ſhewn by the attached thermometers, without ever conſulting the detached ones. Let us now ſee what were the circumſtances attending the obſervations on Saleve.

Mr. DE LUC's lowermoſt barometer ſtood in the ground-ſtory of a houſe near Geneva, where it remained unaltered during the whole of his experiments; while the detached thermometer, indicating the temperature of the air, was expoſed on a ſmall eminence, at a little diſtance, directly to the Sun's rays: hence we find that, in the obſervations of high temperatures, the bottom of the column of air is often 12° or 15°, and in one caſe 18°, hotter than the quickſilver in the tube. And even in the loweſt temperatures, the bottom of the column of air is generally hotter than the quickſilver within doors, contrary to common experience in this country: for in England, in winter, the exterior air in the ſhade is always colder than the interior air. This circumſtance gives reaſon to apprehend, that the thermometer ſuffered not only direct but reflected heat.

The ſuperior barometer was ſhaded with a paraſol from the Sun, while its correſponding detached thermometer was expoſed to his rays: wherefore, in the obſervations of high temperatures, the top of the column of air is uſually four or five degrees hotter than the quickſilver in the barometer ſtanding in the ſame air; and the mean heat of the column often exceeds very conſiderably the mean heat of the quickſilver in the tubes.

In many of the coldeſt of Mr. DE LUC's obſervations, as well as in thoſe of mean temperatures of about 50° or 55°, the ſuperior barometer is often the hotteſt of the two, even when the ſurrounding atmoſphere at the top is colder than at the bottom. This circumſtance is eaſily accounted for: wood is known to be a bad conductor of heat, to receive it ſlowly, and retain it long: that barometer, which was moved about from place to place upon the mountain, with a very ſhort interval between the obſervations (as is ſufficiently evident from the great number of ſtations it paſſed through in a limited time) muſt have acquired and retained heat ſuperior to that of the atmoſphere, and communicated it to the tube with which it was in contact. Some difference would no doubt ariſe from this cauſe, if the temperatures of the quickſilver

quickſilver in the tube and attached thermometer did not keep exactly pace with each other.

The laſt point to be mentioned is ſtill more remarkable than the reſt; it is briefly this: in the obſervations at Sun-riſing on Saleve, though the ſuperior quickſilver is the coldeſt; yet the top of the column of air is commonly five or ſix, and ſometimes eight or nine degrees, warmer than the bottom.

Having thus ſhewn the ſteps that were taken, for obtaining the coldeſt and hotteſt barometrical obſervations that the climate of this iſland would afford, the mode of obſerving, and wherein the circumſtances attending them differed from thoſe on Saleve, I ſhall now point out the general reſult. In order to avoid repetitions as much as poſſible, it is neceſſary, once for all, to remark, that the computations of the Britiſh obſervations, by the rule hereafter to be given, are ſubdivided into their reſpective claſſes. Each table contains 15 columns, which their titles ſufficiently explain, that the principles from which the rule was deduced, the reſult and error, might all appear in one view. The laſt column towards the right-hand ſhews the ratio of the weight of quickſilver to air, the columns of the firſt in the barometers being ſeverally reduced to the mean temperature of the laſt.

By comparing the tables it will be found, that the obſervations for extreme temperatures belong to the Edinburgh claſs of obſervations (N° 4.) it being thought beſt, in this caſe, to omit the few hot ones obtained on the inconſiderable heights near London: the mean of the coldeſt, anſwering to the temperature of 21°.75, make the logarithmic exceſs $\frac{29}{1000}$; and the mean of the hotteſt, correſponding to the temperature of 69°.6, give a defect of $\frac{81}{1000}$. Now the ſum of the two equations $\frac{110}{1000}$, being divided by the difference of temperature 47°.85, we have nearly 2.3 for the mean rate of the equation on each degree, which is leſs than that reſulting from the operations of the manometer. Again, from the mean of the very beſt obſervations, as being made on the greateſt heights, when the temperature of the air is 52°, it appears, that the defect is from $\frac{49 \text{ to } 50}{1000}$, or 2.5 for each degree nearly, which agrees perfectly well with the manometrical expanſion. In this caſe, the ratio of the weight of quickſilver to air is as 11377 to 1; greater very conſiderably than 11232 to 1, aſſigned to them by Mr. DE LUC, when the temperature is 69°.32, anſwering to the zero of his ſcale, without any allowance for the diminution of preſſure on his columns, which ſhould have rendered air ſtill comparatively lighter. From the Britiſh obſervations, made on the moſt conſiderable heights, it appears, that when the temperature of the air is 28°.2, the ratio of its weight, with respect to that of quickfilver, is as 1 to 10552: hence the increase of the weight of air, on every degree of difference of temperature between 28°.2 and 52°.5, amounts to 34.4; and hence we have 52°.5−4°.2=48°.3 for the temperature of the air in Britain, when its weight would be $\frac{1}{11232}$ of that of quickfilver; and consequently agree with Mr. DE LUC's, though the heat would differ from his 21°. It will no doubt be remarked, that the equation for the air, resulting from the operations of the barometer, falls short of that given by the manometer. Part of the difference, I apprehend, may arise from the small number of barometrical observations obtained in extreme temperatures. I shall, nevertheless, adduce reasons hereafter for supposing, that it really should diminish, because of the drier and less elastic state of the superior air, compared with that taken into the manometer at the earth's surface. In the mean time, since both instruments agree in the equation for 52°, which is a heat that the barometer will very frequently be used in, it seems best to adhere to the mean manometrical result 2.45, in fixing the zero of the scale, which is obtained in the following manner.

Divide the excess or defect, expressed in 1000th parts of the logarithmic result, by 2.45, the mean expansion of air

air for each degree of the thermometer; the quotient will give the number of degrees, in the firſt caſe, to be added to, and in the laſt ſubtracted from, the temperature of the air in the obſervation; the ſum or difference anſwers to the zero of the ſcale, or that temperature when the logarithmic reſult gives the real height in Engliſh fathoms and 1000th parts.

According to this mode of computation, we have, from the aggregate of the ſeveral claſſes of Britiſh obſervations, the place of the zero as follows:

					Zero.
By the 1ſt claſs of obſervations in and near London, between the temperatures of — —	25°.5	and	71°.2	at	32°.2
2d, near Taybridge, — —	46.1	—	62.9	-	31.1
3d, near Lanark, — —	44.	—	62.	-	32.8
4th, near Edinburgh, — —	17.	—	70.7	-	31.3
5th, near Linhouſe, — —	26.1	—	46.5	-	29.9
6th, near Carnarvon, — —	49.1	—	62.3	-	32 9
Mean place of the zero at — —					31.7

The number 31°.7 differing ſo very little from 32°, we may hereafter conſider that remarkable point of FAHRENHEIT's thermometer, as the zero of the ſcale depending on the temperature of the air; and hence is deduced the ſecond part, of the rule for meaſuring heights with the barometer. When the mean temperature of the column of air to be meaſured is at 32° of FAHRENHEIT, the difference

difference of the common logarithms of the equated heights of quickſilver in the inferior and ſuperior barometers, expreſſed in 1000th parts of an inch, gives the real height in fathoms and 1000th parts, the three figures towards the right-hand being decimals, and the reſt integers; which, being multiplied by ſix, gives the reſult in feet.

Let us next conſider, in a general way, how far this will correſpond, or otherwiſe, with Mr. DE LUC's obſervations in extreme temperatures.

I have already had occaſion to remark, that when the temperature of the air was at 69°.32, as indicated by thermometers expoſed to the Sun's rays, Mr. DE LUC found that the differences of the common logarithms of the heights of the barometers at the two ſtations, gave the altitude between them, in French toiſes and 1000th parts: in which caſe the ſpecific gravity of quickſilver to air was as 11232 to 1. When his formula is adapted to Engliſh meaſures, the zero of the ſcale neceſſarily deſcends to 39.74, where the Engliſh fathom bears the ſame proportion to the modulus of the common logarithms, as, in the former caſe, the French toiſe did to that modulus, the equation for the intermediate temperature being now applied with the contrary ſign. As it hath been ſhewn, that the Britiſh obſervations differ in their circumſtances from thoſe on Saleve, and require a greater equation, it is unneceſſary to enter into any minute compariſon of the two ſets: nevertheleſs, that ſome idea may be formed of the cauſe, of part at leaſt, of the difference that takes place between them, I have collected into one view, the computations of ſuch as were made in extreme temperatures; namely, the coldeſt of thoſe at Sun-riſing (though the whole of that claſs were conſidered as exceptions from the rule); the coldeſt and hotteſt of the ordinary obſervations; alſo thoſe on the Dole(*l*), at Genoa, and at Turin, whereby the heights of the lake of Geneva and of Turin, above the ſea at Genoa, were obtained. In the table it will be obſerved, that there is a column for the reduced temperature of the air, on account of the expoſition of the thermometer to the Sun's

(*l*) Having recomputed the whole of Mr. DE LUC's obſervations on Saleve, and claſſed them according to the months in which they were made, I intended, at one time, to have given a general table, comprehending the mean reſults of all of them: however, this is now become unneceſſary, ſince a very reſpectable and ingenious member of this Society hath had opportunities of making many curious and intereſting obſervations on thoſe very heights, which cannot fail of being perfectly ſatisfactory; and who, at my requeſt, was ſo obliging as to determine the height of the Dole geometrically. On this mountain Mr. DE LUC had made barometrical obſervations, whoſe reſults differing conſiderably from the altitude, 4182 feet above the lake of Geneva, as taken by Mr. FATIO DE DUILLIER, made me ſuſpect there was an error. In fact it appears, from the laſt meaſurement, that the ſummit of the Dole is 4293 feet above the ſurface of the lake, which gives for the vertical diſtance of Mr. DE LUC's barometer 4210 feet.

rays:

rays: I apprehend that I have not exceeded, but rather fallen ſhort, in the reduction, to what would have been indicated by thermometers in the ſhade, perfectly free from direct and reflected heat, and with ſufficient time allowed between the obſervations. Be this as it may, it is of no importance, as no other concluſion is drawn from theſe obſervations, than that of ſhewing what, in my apprehenſion, might probably have been the caſe, if another mode had been adopted.

From the table it appears, that when the temperature of the air is at 29°.5, the logarithmic exceſs is $\frac{9}{1000}$; and at 75°.5 reduced temperature, the defect is $\frac{96}{1000}$. The ſum of the two equations $\frac{105}{1000}$ being divided by the difference of temperature 46°, we have, as in the Britiſh obſervations, nearly 2.3 for each degree, which is greater than that applied by Mr. DE LUC's rule, in the proportion of 23 to 21. That too ſmall an equation hath been made uſe of in theſe hotteſt obſervations, ſuppoſing the original zero and temperature to remain, is ſufficiently evident: for $\frac{96}{1000}$ being divided by 42° the difference of temperature, we have, as before, 2.3 very nearly for the equation anſwering to each degree.

Farther, if we conſider the ratio of the weight of quickſilver to air, actually reſulting from the obſervations themſelves, the ſame kind of error (for I cannot ſee

 it

it in any other light) ſtill exiſts. Thus, in the coldeſt of the morning, as well as in the ordinary obſervations, when the temperature is at or near freezing, the mean ratio of the weight of quickſilver to air, is about 10850 to 1. When the obſerved and reduced temperatures are reſpectively 41° and 35°, the ratio between them is that of 11295 to 1, anſwering nearly to what hath been aſſigned to them when the heat is 69°.32. Again, in the hotteſt obſervations of the 14th and 15th of July 1759, and 20th of July 1760, on the higheſt, and conſequently the beſt ſtations, when the obſerved and reduced temperatures are reſpectively 81°.7 and 75°.6, quickſilver is to air as 12650 to 1. Now if we reduce this number 12650 by a proportionable part, for the degrees of difference between Mr. DE LUC's zero 69°.32, and the obſerved and reduced temperatures reſpectively, we ſhall have, in the firſt caſe, 12200; and in the laſt, 12390 to 1, for the ratio of the weight of quickſilver to air; either of which exceeds very conſiderably 11232, which hath been aſſigned to them.

With regard to the obſervations on the Dole, the defect is $\frac{81.4}{1000}$, anſwering to the obſerved temperature of 66°.6, and which is only reduced to 65°.2. On this great height, the ratio of the weight of quickſilver to air[m] is that of 12595 to 1. Mr. DE LA CAILLE's observations at the Cape of Good Hope, annexed to the table containing Mr. DE LUC's, give a defect of $\frac{58.7}{1000}$, when the temperature seems to have been about 58°, in which case quicksilver was 11687 times heavier than air.

Now if, from the aggregate of these observations, the same method be adopted, as was made use of in the British, for finding the zero of the scale, we shall have it as follows:

	By Mr. DE LUC's equation for the air and observed temperature.			By the manometrical equation and reduced temperature.		
	°	°	°	°	°	°
Coldest of the morning observations, from —	25.2	to 30.5	at 33.7	from 25.2	to 30.5	at 33.12
Coldest of the ordinary observations,	27.1	- 41.9	- 38.7	— 26.	- 35.	- 32.97
Hottest of the ordinary observations,	76.	- 84.5	- 36.2	— 73.5	- 77.	- 36.32
On the Dole, —	59.2	- 71.5	- 27.6	— 58.	- 70.	- 32.
Light house of Genoa,	75.	- 79.	- 26.	— 75.	- 79.	- 33.40
DE LA CAILLE's,	—	58.	- 30.	— —	58.	- 33.35
Zero at	—	—	32.03	Zero at		33.52

(*m*) It will even be found, though the calculations are not inserted in the table, that the hottest of Mr. DE LUC's morning observations, June 8th, 1758, at the 15th station, answering to the mean temperature of 57°.5, and which I consider as the best, because no reduction is necessary for the exposition of the thermometer, agree with the manometrical experiments, in requiring a greater equation than is wanted in extreme temperatures: for in this case, the mean of two observations gives a defect of $\frac{65.5}{1000}$ for 25°.5 above freezing, which is 2.57 for each degree; the ratio of the weight of quicksilver to air being that of 12196 to 1.

From

From the mean of theſe obſervations, though the reſults are irregular among themſelves, it appears ſufficiently evident, that if the morning obſervations on Saleve had been retained, inſtead of being made exceptions from the rule, the zero of the ſcale would have deſcended about 8°; *viz.* from 69°.3 to 61°.4 of FAHRENHEIT, ſuppoſing always the equation 2.1 for each degree of temperature, and the French toiſe, as the ſtandard meaſure, to have been adhered to: for the French toiſe bears to the Engliſh fathom, the proportion of 106575 to 100000; wherefore $\frac{6575}{106575} = \frac{61.69}{2.1} = 29°.4 + 32° = 69°.4$, denotes the relative poſitions of the two zeros, the intermediate equation $\frac{61.69}{1000}$ being to be ſubtracted, when the toiſe is made uſe of. But it hath been ſhewn, that the mean expanſion of air is really greater, for ſuch temperatures at leaſt as the barometer can be applied in, than what Mr. DE LUC ſuppoſed it, in the proportion of 245 to 210; whence it follows, that $\frac{61.69}{2.45} = 25°.18 + 32° = 57°.18$, will denote the relative poſitions of the two zeros; which, inſtead of almoſt 30°, are only diſtant from each other a little more than 25°.

From what hath been ſaid it is eaſy to ſee, that in calculating heights according to Mr. DE LUC'S rule, when the temperature of the air is below his zero, which we may

may take at 40°, the English measure being used, the common error in the result will be equal to the sum of the two equations, $2.1+2.45=4.55$ for each degree; which amounts to $\frac{36.4}{1000}$ parts for the 8° that the zero is too high. Above 40°, the former error $\frac{36.4}{1000}$ will be augmented by the difference of the equations for each degree that the temperature is above his zero, *viz.* $2.45-2.1=\frac{0.35}{1000}$. In either case it is to be observed, that the progressive rate of equation for the heat of the quicksilver is not here taken into the account; because it will not produce any material difference, unless one barometer is much hotter than the other, at the same time that their vertical distance is very great. Thus the 32d degree of FAHRENHEIT, or freezing temperature, which is fundamental in all thermometers, happens, somewhat remarkably, to be the zero of the scale, when the English fathom bears such proportion to the modulus of the common logarithms, as that their difference, in computing heights by the barometer, brings out the result in fathoms. No other proportion of a measure will do it: for if we suppose twenty-four of different lengths, between ours and the French toise, each surpassing the other by $\frac{2.63}{100000}$ of that toise, the zero of the scale, in computing heights by these measures respectively, will ascend a single degree on each; and the French toiſe being the 25th, will have its zero nearly at the 57th degree: about which temperature the expanſion of air appears, from the experiments, to be at its maximum. From that point, therefore, the equation will diminiſh both ways, though by a quicker progreſſion for condenſation, than it doth for dilatation.

Having thus compared, in a general way, the reſults of the Britiſh obſervations with thoſe of Mr. DE LUC, pointed out what ſeem to be the chief cauſes of the conſtant defect found in his rule, and thereby obtained, it is hoped, ſome corrections tending to improve the theory of the barometer, when applied to the meaſurement of heights in middle latitudes; it remains to ſhew the principles, whereon the table for the equation of the air hath been conſtructed. Previouſly however to this, it may be proper to compare, with as much brevity as poſſible, theſe obſervations, with others that have been made towards the Pole and at the Equator: from which it will appear probable, that the rule which anſwers in middle latitudes, will not in the frigid and torrid zones.

In 1773, Captain PHIPPS, now Lord MULGRAVE, commanding two of his Majeſty's ſhips then ſent on diſcoveries towards the North Pole, meaſured geometrically, with great care, the height of a mountain in Hakluyt's Iſland near

near Spitzbergen, and found it to be 1503 feet above the level of the sea. On the morning of the 18th of August, the following observations, at the sea-shore and top of the mountain, were made with a single barometer, wherein the quickfilver had not been boiled.

At 6 h. A.M.	Barometer at the shore, — —	30.040	therm.	50°
7 h. 45′ A.M.	Ditto at the top of the mountain,	28.266	——	42
8 h. 45′ A.M.	Ditto at the top of ditto, —	28.258	——	42
11 h. 45′ A.M.	Ditto at the sea-shore, —	30.032	——	44

Whence we have the following computations, equated for the times corresponding to the two observations at the top.

7 h. 45′ A.M.	30.038	46° — 046 = 29.992	= 1573	+ 70.	43°	42°
	28.266	42 — 031 = 28.235		= 44.5	41	
8 h. 45′ A.M.	30.036	45° — 043 = 29.993	= 1581.3	+ 78.3	43	42
	28.258	42 — 031 = 28.227		= 49.5	41	
		Mean	1577.1	$= +\frac{47}{1000}$		

Quickfilver to air as 10224 to 1.

From these observations it appears that, instead of the usual equation $\frac{24.5}{1000}$, to be added to the logarithmic result, in order to obtain the true height in Britain, when the temperature is 42°, there is an excess of $\frac{47}{1000}$: and, instead of the usual ratio of the weight of quickfilver to columns of air, of equal altitude and temperature in Britain, namely about 11200, we have that of 10224 to 1.

Thus air at Spitzbergen feems to be fpecifically heavier, than that affected with the fame heat and preffure in the middle latitudes: whence it follows that, inftead of 32° which is found to be the zero of the fcale about the middle of the temperate zone, we fhall have $\frac{47}{245} = 19°.2 + 42° = 61°.2$ for the zero at Spitzbergen, within 10° of the North Pole.

It is much to be regretted, that the French academicians, when employed in meafuring the degrees of the meridian in Peru, were not fupplied with better barometers, and that they made not obfervations at correfponding times; fince the fcene of their operations was undoubtedly preferable to any other on the furface of the globe, for determining many curious points with refpect to the modifications of the atmofphere in the torrid zone: neverthelefs, by attending diligently to what Mr. BOUGUER [(n)] hath told us, of the fteadinefs of the barometer

(*n*) He fays, that at the South Sea, REAUMUR's thermometer, in the morning before Sun-rifing, ftood at 19°, 20°, or 21°; and in the afternoon at 26°, 27°, or 28°. The refpective means correfpond to 76°½ and 92°½ of FAHRENHEIT, and make the mean heat of the day 84°½. At Quito the temperature continued at 14° or 15°, anfwering to 65°½ of FAHRENHEIT. At the fummits of Coraçon and Pichincha, the thermometer ftood in the morning feveral degrees below freezing, and varied 17° in the heat of the afternoon; whence the mean temperature at thefe higheft ftations, would probably be about 43°½ of FAHRENHEIT. He farther fays, that in the torrid zone, whatever may be the mean meter throughout the year; the uniformity of the mean temperature in every aſſigned ſtation; and his mode of computing, by means of the tables of common logarithms, the altitudes of the Cordillero mountains above the valley that extends itſelf between them; it will be no difficult matter to diſcover, nearly at leaſt, what ſort of equation became neceſſary; and what were the relative weights of quickſilver and air of the mean temperature, not only in that high region of the atmoſphere, but alſo at the level of the ſea.

Thus, by inſpecting the table of computations, it will appear, that columns of air, whoſe baſes were removed ſix or eight thouſand feet from the level of the ſea, and whoſe heights equalled that diſtance, when the temperature was 55° of FAHRENHEIT, as determined from the mean between the coldeſt of the morning and hotteſt of the afternoon, the mean logarithmic defect was only $\frac{56.3}{1000}$: whereas, in meaſuring heights near the level of the ſea, in middle latitudes, the common equation for that temperature is about $\frac{57}{1000}$. The mean ratio of the weight of quickſilver to air, on theſe long columns comprehended reſpectively between Carabourou and Quito, and the

mean heat in any aſſigned ſtation, it continues uniformly the ſame throughout the year. In this rough eſtimation of the temperature in Peru, it ſeemed unneceſſary to examine, whether the true thermometer of REAUMUR was uſed or not; as it could produce no material difference, except at the very hotteſt ſtations.

 ſummits

ſummits of Pichincha and Coraçon, is that of 16793 to 1. On the altitude of 1534 feet, intercepted between Carabourou and Quito, which ſhort ſection of the column is about half-way between the level of the ſea, and the ſummits of the Cordilleros, the mean temperature being 66°, the ratio is that of 15089 to 1: hence it ſeems probable, that quickſilver would have to the different ſections of the general column of air, comprehended between the ſea and the top of Coraçon, nearly the following ratios:

	Temp.	
At the level of the South Sea,	84½	13100 to 1
Half-way from thence to Carabourou,	75½	14100
At Carabourou, — —	66½	15100
Half-way from thence to Coraçon,	55	16100
At the ſummit of Coraçon, —	43½	17100
Whereof the mean is, —	65	15100

Mr. BOUGUER tells us, that the barometer in the torrid zone varies not at the ſea-ſhore above two and a half, or at moſt three lines throughout the whole year. At Popayan, its variation is only a line and a half; and at Quito a ſingle line. Now let us ſuppoſe, that an altitude had been meaſured with the barometer at the level of the

the South-sea, where the descent of quicksilver at the upper station was exactly an inch in the mean heat of the day, answering to $84°\frac{1}{2}$. On the former supposition of the weight of quicksilver to air, the height would be 13100 inches or 1091.7 feet.

$$\text{Hence} \left\{ \begin{matrix} 29.930 & 84\frac{1}{2} - 169 = 29.761 \\ 28.930 & 84\frac{1}{2} - 169 = 28.761 \end{matrix} \right\} = 890.6 \text{ feet};$$

the logarithmic result, which is defective 201.1, or nearly $\frac{226}{1000}$ parts. Now this equation being divided by 2.45 the mean expansion of air, we have nearly 92° for the difference between $84°\frac{1}{2}$, the temperature of the observation, and the zero of the scale, which reduces it to $-7°\frac{1}{2}$ of FAHRENHEIT. If it should be thought that I have supposed the air to be too light at the level of the sea under the equator, let it be taken to quicksilver only, at a mean between 13100 and 12672, which seems to have been the ratio of their weights at Genoa, when Mr. DE LUC's temperature was 79°, and we shall have 12881 inches, or 1073.4 feet of air, for the counterpoise to the inch of quicksilver in the barometer: hence $1073.4 - 890.6 = \frac{182.8}{890.6} = \frac{205}{2.45} = 83°.7$, will denote the number of degrees that the zero of the scale would, in that case, be below the temperature of the air, which brings it to within less than a degree of the cypher of FAHRENHEIT. But in middle latitudes the zero of the scale is at 32°, and the

 equation

equation, applicable at the level of the ſea for the heat of $84^{\circ}\frac{1}{2}$, is at moſt only $\frac{132}{1000}$ inſtead of $\frac{205}{1000}$.

Mr. BOUGUER found, that the rule which his experience had furniſhed him with, for computing heights with the barometer between the ranges of the Cordilleros, namely, that of deducting $\frac{1}{30}$th part from the number of toiſes expreſſed by the logarithmic differences, which agrees nearly with the equation $\frac{36.3}{1000}$ which I have made uſe of in the table of computations, would not anſwer when he came to apply it at the level of the ſea. He tells us, indeed, that the elaſticities of the air, above and below, are there, as well as in Europe, exactly proportionable to its condenſations; and even, that the intenſity of the elaſtic force, or ſpring of the air, is every where equal in all places of the torrid zone that are conſiderably elevated. The real condenſations in each place are proportionable to the weights of the ſuperior columns cauſing the compreſſion; theſe condenſations being in geometrical, the heights are in arithmetical progreſſion. But below the ſame law doth not take place; becauſe the intenſity of the elaſtic force is really conſiderably leſs at the level of the ſea, than it is at one or two hundred toiſes above it, notwithſtanding the effect of the heat, which ſhould render it greater. It is to be obſerved, that Mr. BOUGUER hath not given us the obſervations whereon

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he founded this laſt deduction; and his note on the text, which I apprehend, nevertheleſs, conveys his true meaning, is contradictory to it: for there he ſays, that the dilatation occaſioned by the heat throughout the day, changed the diſtribution of the weight with regard to all the places ſituated within the Cordilleros, as well as on other mountains, and made the lower ſections of the columns contain leſs and the upper ſections more air, than they ſhould have done, had it been a perfectly elaſtic fluid.

Having now mentioned all the barometrical obſervations that have come to my knowledge, tending any way to throw light on this very intricate ſubject, it remains to ſum up, from the whole, the general principles whereon I have proceeded in conſtructing the table of equation for the heat of the air.

It will be remembered, that I have more than once remarked, that in the Britiſh obſervations, when the temperature was 52°, the defect was $\frac{49 \text{ or } 50}{1000}$, the lowermoſt barometer ſtanding at or near the level of the ſea; but in the obſervations on Tinto, a conſiderable hill appertaining to the third claſs, whoſe baſe is elevated 700 feet above the level of the Clyde at Glaſgow, when the temperature was 52°, I found the equation to be little more than $\frac{45}{1000}$. Again, theſe two facts being compared with

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the aggregate refult of Mr. DE LUC's obfervations, where the lowermoft barometer ftood about 1300 feet above the fea, the equation for the fame temperature feemed not to exceed $\frac{42}{1000}$. Laftly, thefe circumftances being confronted with the refults of Mr. BOUGUER's obfervations, where the lowermoft barometer ftood from 6000 to 8000 feet above the fea, the mean equation for 55° was only $\frac{36.3}{1000}$, which gives $\frac{34}{1000}$ for the heat of 52°. Now thefe Peruvian obfervations, which I believe to be exceedingly good from the fteadinefs of the barometer in that part of the world, being fubftituted in lieu of thofe not yet obtained in our own quarter of the globe, there feemed to me to be a neceffity for concluding, that the equation for middle latitudes, with any affigned temperature above or below the zero of the fcale, diminifhed as the height of the place above the fea increafed; which confequently implied, that the magnitude of the logarithmic terms increafed fafter than the dilatations of the air. But when the comparifon was carried yet farther, and the obfervations in Peru and at Spitzbergen were fairly brought into one view, there appeared to be fufficient grounds for fufpecting, if not abfolutely for concluding, that there could be no fixed zero for the fcale depending on the temperature of the air; but that it would change with the denfity of the atmofphere appertaining to the latitudes,

latitudes, climates, or zones of the earth, where the observations were made. On this ſuppoſition it was natural for the mind to form to itſelf ſome general hypotheſis, which might ſerve to account for the appearances; and the firſt that preſented itſelf was the following: that the atmoſphere ſurrounding our globe might poſſibly be compoſed of particles, whoſe ſpecific gravities were really different; that the lighteſt were placed at the equator; and that the denſity of the others gradually increaſed from thence towards the poles, where the heavieſt of all had their poſition (o).

It is a well known and eſtabliſhed fact, that in the middle latitudes, a North or North-eaſt wind conſtantly raiſes the barometer, and generally higher as its continuance is longer. The contrary happens when a South or South-weſt wind blows; for I believe it is commonly loweſt when the duration and ſtrength of the wind from

(o) It was ſuggeſted by Dr. GEORGE FORDYCE, that equatorial and Greenland air might be brought bottled up, and weighed in this country in air of the reſpective temperatures, by means of a curious balance whereof he is poſſeſſed, in order to ſee whether any difference could be diſcovered in their ſpecific gravities. A thought of the ſame kind, but more eaſily put to experiment, occurred to Lieutenant GLENIE, of the Royal Artillery, namely, that of weighing equatorial and polar ſea-water. To this gentleman I am obliged for his aſſiſtance in part of the manometrical experiments, as well as in ſeveral of the computations.

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that quarter have been the greateſt. Thus the North-eaſt wind, by blowing for any length of time, brings into the middle latitudes a maſs of air heavier than that which naturally appertains to the region, and raiſes the barometer above its mean height. The continuance of a South-weſter carries off the heavy air, depoſits a much lighter body in its ſtead, and never fails to ſink the barometer below its mean height: hence, in the middle parts of Europe, there is a difference of about two inches and a quarter between the higheſt and loweſt ſtates of the barometer. But ſuppoſing it to be only two inches, the difference of preſſure ſtill amounts to $\frac{1}{15}$th part of the whole weight of the atmoſphere. Now it is evident from the Peruvian obſervations, that the greateſt fluctuation of the barometer, which is at the level of the ſea, doth not exceed 0.226 of an inch, or $\frac{1}{133}$d part of the whole preſſure; and if the change ſhould be no greater at the poles, which I think not improbable, it follows, that the meaſurement of heights by means of the barometer, in middle latitudes, will be more precarious and uncertain than in the torrid and frigid zones.

Such in general were the firſt ideas which the compariſon of the operations of the barometer with the effects of of the North-eaſt and South-weſt wind [(p)] on that inſtrument, ſuggeſted with regard to the different denſities of the atmoſphere in the different zones of the earth.

But ſince the experiments on the expanſion of moiſt air have ſhewn its elaſticity to be ſo much greater than that which is dry, I apprehend, that the ſimple principle of heat and moiſture may ſuffice to account for all the phenomena. Thus it is univerſally admitted, that there is a greater degree of humidity and heat in the air, near the earth's ſurface, than there is in the higher regions of the atmoſphere. The elaſticity or expanſion of the lowermoſt ſection [(q)] of every column of air, whether long

(*p*) I have been well informed, that in China the North-weſt wind raiſes the barometer moſt, and is highly electrical; it is at the ſame time the drieſt and the coldeſt; and at Canton, under the Northern tropic, there is frequently ice. On the Eaſt-coaſts of North America the ſeverity of the North-weſt wind is univerſally remarked; and there can ſcarcely be a doubt, that the inhabitants of California, and other parts on the Weſt-ſide of that great Continent, will, like thoſe on the Weſt of Europe, feel the ſtrong effects of a North-eaſt wind. The extraordinary dryneſs and denſity of the wind from the North pole, ſeems therefore to be occaſioned by its paſſing over the Continent of Europe and Aſia on one ſide, and that of North America on the other. Thoſe who live on the Eaſt and Weſt-coaſts of South America, will find the drieſt and coldeſt winds come to them reſpectively from the South-weſt and South-eaſt. As the winds ſeem to be colder, drier, and denſer, in proportion to the extent of land they paſs over from the poles towards the equator, ſo they appear to be more moiſt, warm, and light, in proportion to the extent of Ocean they paſs over from the equator towards the poles. Hence the humidity, warmth, and lightneſs, of the Atlantic wind to the inhabitants of Europe.

(*q*) Mr. DE LUC ſeems to have ſuſpected ſomething of this kind towards the end long or ſhort, will conſequently be greater than the uppermoſt ſection of it; for the heat, by diſſolving the moiſture, produces a vapour lighter than air, which mixing with its particles, removes them farther from each other, increaſes the elaſticity of the general maſs, and diminiſhes its ſpecific gravity comparatively more than it doth that of the ſection immediately above it, where there is leſs heat and leſs moiſture. Hence I infer, that the equation for the air, in any aſſigned vertical, will gradually diminiſh as the elevation of the place above the ſea increaſes, and that it will vaniſh at the top of the atmoſphere. This is in ſome reſpect confirmed by the experiments on the expanſion of rare air; for from them it appears, when the particles are very far removed from each other, by a great diminution of preſſure, as is undoubtedly the caſe in the higher regions of the atmoſphere, they loſe a great part of their elaſtic force. Thus the equation, anſwering to any particular temperature, above or below the zero of the ſcale, at different heights above the ſurface, will, I apprehend, be expreſſed by the ordinates to a curve of the hyperbolic order, whoſe cur-

end of his 8th chap. *ſur les difficultés à vaincre*: and in that which follows, he gives proofs of the lightneſs of vapours with regard to air, ſaying, that they point out fire to be their vehicle. He afterwards quotes NEWTON with reſpect to the lightneſs of a humid atmoſphere compared with one that is dry.

vature may be suppofed to change faft near the furface of the earth, and differ infenfibly from a ftraight line at great heights above it.

With regard to the latitudinal equation, the fame principle of heat and moifture feems to make it probable, that fuch will become neceffary in operating with the barometer; for it is well known, that there is a great degree of humidity in the air between the tropics; and, on the contrary, that the polar atmofpheres are very dry. The heat and moifture being greateft at the equator, there the elafticity or equation will likewife be the greateft at the level of the fea; and the zero of the fcale will neceffarily defcend to a lower point of the thermometer, than that to which it correfponds in middle latitudes. As the elafticity of the air at the level of the fea, or equal heights above it, with the fame degree of heat, will always be proportionable to the quantity of moifture diffolved in it, therefore it will gradually diminifh from the equator towards the poles; that is to fay, the zero of the fcale will afcend in the thermometer, coincide with the 32d degree in the middle latitudes, and, in its motion upwards, will give the equation to be applied with the contrary fign in high latitudes. Hence I infer, that every latitude, climate, or zone, will not only have its particular zero, but alfo its particular curve, whofe ordinates

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will always meaſure the equations applicable in the reſpective ſituations. The equatorial curve will probably change the faſteſt, and the others become gradually flatter, as they approach towards the poles, where the greater, but more uniform, denſity of the atmoſphere may occaſion it to differ little from a ſtraight line. I apprehend, however, that even at the pole ſome ſmall diminution might be found to take place in the equation, was it poſſible, in that region, to prove it by experiments at a ſufficient height above the level of the ſea.

The table of the equation, depending on the heat of the air, annexed to this paper, is conſtructed for middle latitudes. It extends to temperatures from 12° to 92° of FAHRENHEIT; and for ſituations ſo greatly elevated above the ſea, as to make the mean barometer between the two ſtations ſtand no higher than 19 inches. As the equation correſponding to the lower parts of the atmoſphere, contained in the right-hand columns, will come more frequently into uſe than that appertaining to the higher regions, comprehended in thoſe on the left; therefore, in the firſt, it is given for every half; and in the laſt only, for every whole inch of deſcent of quickſilver in the tube.

The equation found in the column of 29 inches, correſponds exactly with the expanſion of air reſulting from the manometrical experiments; and the ratio of diminution, in the temperature of 52°, hath been taken from the Peruvian obſervations, ſuppoſing it to decreaſe uniformly $\frac{2}{1000}$ on each inch, or $\frac{16}{1000}$ on the eight inches between 29 and 21. For the ſake of ſimplicity, as well as from the want of ſufficient data for aſcertaining the lengths of the ordinates of the curve, the arithmetical hath been preferred to any progreſſive diminution that might have been adopted, though by this mode the reſults would have agreed better with ſome of my own, as well as Mr. DE LUC's obſervations. In each of the columns the equations for particular temperatures, compared with that for 12° or 92°, are reciprocally proportionable, ſo that the maximum of the rate always correſponds to the ſpace between 52° and 72°, as indicated by the manometer. It will be obſerved, that though the equation in the table is only given for every 10° of difference of temperature, yet, by the intermediate rates for ſingle degrees in the columns reſpectively, and the ratio of diminution for the height of the mean barometer above the ſea, expreſſed in that towards the right-hand, the equation for any particular temperature may be readily obtained. The application of this table makes the third part of the rule, for meaſuring heights with the barometer. When the mean temperature of the column

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of air is above 32° of FAHRENHEIT'S thermometer in the ſhade, add the equation correſponding to the temperature and height of quickſilver in the mean barometer to the logarithmic altitude; when below 32°, ſubtract the equation from the logarithmic altitude; the ſum in the firſt caſe, and difference in the laſt, gives the real height.

Beſides the table of equation for the air, adapted to the meaſurement of the greateſt acceſſible heights the barometer can poſſibly be applied to in middle latitudes, I have annexed, for the uſe of thoſe who may prefer ſimplicity, and ſtill doubt of the vertical diminution, a thermometrical ſcale of the equation, ſuited to Engliſh and French meaſures, with their reſpective thermometers. It will readily be conceived, that the diviſions, expreſſing the 1000th parts in this ſcale (r), are unequal, ſince they follow the inverſe ratio of the thermometrical compared with the manometrical degrees. Where theſe laſt are the greateſt, as between 52° and 72°, the diviſions expreſſing the equation are the ſmalleſt, becauſe a greater

(r) Any ſcale of this kind, unleſs it had been mechanically divided by a mathematical inſtrument-maker, could not be rendered very exact; and it may be expected, that the imperfections in the original will be augmented in copying by the engraver, notwithſtanding the utmoſt care on his part: wherefore, on the left-hand ſide of the plate, I have annexed the number of degrees and decimal parts of FAHRENHEIT, below the temperature of 91°.88, correſponding to every $\frac{10}{1000}$th parts of the equation, by which means the unequal ſcale may, at any time, be divided with ſufficient accuracy.

number

number of them correfpond to the fame thermometrical fpace. When the height is required in fathoms, the zero of FAHRENHEIT correfponds to −71.72, and the boiling point to +412.49: the fum of the two equations 484.21 is the actual expanfion of common air from the heat of 212°. When the French toife is made ufe of as the meafure, the zero of the fcale hath been fhewn to coincide with 57°.18 of FAHRENHEIT, or $+11°\frac{1}{4}$ of REAUMUR. The negative equation 134°.72 anfwering to $-14°\frac{1}{4}$ of REAUMUR, and the pofitive 349°.49 correfponding to +80°, or the boiling point, being added together, make again 484.21.

In order to convey a more diftinct idea of the effect which heat produces in the dilatation of different kinds of air, compared with quickfilver, along with the fcale for the equation I have placed another, expreffing the actual and relative expanfions, refulting from the mean of the experiments, for every 20° of difference of temperature. This fcale is intended to give a comparative view of the manometrical with the thermometrical fpaces, mentioned in the fecond fection.

I fhall now clofe this paper, which hath already greatly exceeded the limits I wifhed to have been able to prefcribe to it, with a few remarks on the error of the rule, perceivable in the tables of computation, and the meafures that fhould, in my opinion, be taken to bring the theory of the barometer to a ftill greater degree of perfection, fuch as I believe it to be really capable of.

By infpection of the tables containing the computations of the Britifh obfervations, it will be feen, that the error of the rule is in general very fmall. In the London clafs it is greateft on Shooter's-hill, making the height five feet too little. In thofe at Taybridge, one of the obfervations on Schihallien gives a defective refult of $29\frac{1}{2}$ feet; but this is eafily accounted for, as it certainly arofe from the fhort time given to the barometer to lofe the heat it had acquired in carrying upwards, thofe deftined to obferve at the fummit arriving there too late, that is to fay, towards the expiration of the whole hour which the inferior barometer had been obferved in. One of the obfervations on Carmichael-hill, though a fmall height, is defective eight feet, which I afcribe to the South-weft wind and humidity of the air. From the fame caufe I would account for the uniform defect in the firft part of the Edinburgh obfervations: in the laft part of thefe, the circumftances having changed, the error hath the contrary fign. In the Linhoufe clafs of obfervations, the fame caufe of defect appears on the 1ft of December, 1775, and on the 20th of November, and 17th of December, 1776. The only refult which I confider consider as very irregular, and do not pretend to account for, is that for the height of Moel Eilio, a hill situated between Carnarvon and Snowdon: the real altitude 2371 feet, is exceeded by the barometrical result 21 feet, though the circumstances were such as, in other cases, generally make it fall short.

At the bottom of the tables of computations I have occasionally substituted Mr. DE LUC's equation for the air, in calculating one or more of the greatest heights, that the difference between the two methods might become more obvious. Thus the first observation on Schihallien is defective $67\frac{1}{2}$ feet; the mean of those on Tinto 29 feet; Moel Eilio 41 feet; and Snowdon 81 feet.

With respect to the results that the rule produces on Mr. DE LUC's heights it will be observed, that it answers very well in the cold observations, which, with his rule, were often defective 60 or 70 feet; but gives too much in those that are hot. If, however, the whole of these hot observations had been included, the apparent error would have been less; for the mean defect was taken at $\frac{96}{1000}$ for the hottest temperature, whereas it sometimes amounts to $\frac{110}{1000}$. On the height of the Dole the rule errs in defect; and on the mean of Mr. DE LA CAILLE's observations, at the Cape of Good Hope, it exceeds the truth. By substituting Mr. DE LUC's equation for the air,

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in the computations of the Dole and Table-hill, the refpective refults are defective 96 and 62.6 feet.

To the Britifh obfervations a table is annexed, containing the barometrical computations of altitudes not yet determined geometrically. In the chief part of thefe the inferior barometer ftood at Belmont-caftle, the feat of the lord privy-feal for Scotland, by whofe directions the correfponding obfervations were made. This table likewife comprehends Mr. BANKS's obfervations in 1772, for the height of the South-pap of Jura, above Freeport in the ifland of Ifla, and thofe he made the fame year, to obtain the height of Mount Hecla, above Hafniford in Iceland.

Laftly, it is to be obferved, that in the application of the table, the equation found in the columns $29\frac{1}{2}$, 30, and $30\frac{1}{2}$, will never come into ufe, except in the meafurement of fhort columns of air, whofe bafes ftand at, or not much above, the level of the fea[(s)]. In an ifland, whofe

(s) Having been accuftomed, from the beginning, to call the ftation of the inferior barometer the place of obfervation, and to fuppofe the mean height of its quickfilver to denote the elevation of the place above the fea, for the fake of fimplicity I adapted the formula to the height of quickfilver in that barometer, and made all the computations in the tables accordingly. But it having been fuggefted to me, firft by Sir GEORGE SHUCKBURGH, and afterwards by Mr. DE LUC, that this mode, though the eafieft, was not ftrictly accurate, nor confiftent with the principles whereon a vertical diminution of the equation for the whose climate is so very variable as that of Britain, settled weather should be chosen as the best time for observations. With any sudden fall of the barometer, in any assigned station below its mean height, it is apprehended that the rule will have a tendency to give defective results; and the contrary should happen when, from the increased weight of the atmosphere, it rises much above the mean height.

From what hath been said in the course of this paper, it will be perceived, that though the error of the rule is in general very small, yet now and then such irregularities do occur as plainly shew, that something still remains to be done, in order to perfect the theory of the barometer.

The existence, or otherwise, of a latitudinal equation being a point of the greatest consequence, should be determined with so much care as to leave no doubt remaining on that head. And as this can only be effected by differences that are extremely obvious, the observations for that purpose should be made at the equator, and as near as possible to the poles[(t)]. Peru is no doubt the best situation

the heat of the air was founded, I have since changed it to the mean barometer, or middle of the column of air intercepted between the two stations. In this way all the great heights have been re-computed: the smaller altitudes, not being sensibly affected by the alteration, continue as at first.

(t) Some idea may be formed what altitudes on the surface of the globe are accessible ſituation on the globe for concluſive equatorial obſervations; but as it would be found very difficult to carry any ſcheme of that kind into execution, ſuch as may be more eaſily obtained in our Weſt India iſlands, which have the higheſt mountains, would be very ſatisfactory with reſpect to the expanſion and weight of moiſt air, at different heights above the ſurface. At the tops of the mountains in the torrid zone, the obſervations would always be ſufficiently cold; but it would be of uſe likewiſe, to have the coldeſt poſſible at the level of the ſea, under or near one of the tropics, when the Sun was in the other.

With regard to obſervations in the frigid zones, Spitzbergen ſeems to be as proper a ſituation as any; though others may no doubt be found in the Northern parts of the Ruſſian empire: and it is preſumed, that the Peterſburg academy would direct the experiments to be made.

acceſſible to man, by conſidering the height above the ſea of the inferior line of perpetual ſnow. In the middle of the torrid zone it appears, from Mr. BOUGUER's obſervations, to be elevated 5201 yards, and 4476 about the tropics. In middle latitudes there is everlaſting ſnow on the mountains at the height of 3300 yards. In the latitude of 80° North, Lord MULGRAVE found the inferior line of ſnow to be only about 400 yards above the ſea: whence we may conclude, that the ſurface of the earth, at the pole itſelf, is for ever covered with ſnow.

The Peak of Teneriffe, Ætna, the mountains of Auvergne and Rouſſillon, as well as Hecla in Iceland, are all very proper for obſervations in intermediate latitudes.

Within the iſland of Great Britain, Ben Nevis ſeems to be the beſt mountain for barometrical obſervations, becauſe of its great height, its vicinity to the ſea, and that there is very good ground cloſe to its foot (which is rarely the caſe in the Highlands) for the meaſurement of the baſe that would be made uſe of in the geometrical operations.

One of the chief cauſes of error in barometrical computations, I apprehend, proceeds from the mode (though ſimplicity is in its favour) of eſtimating the temperature of the column of air from that of its extremities, which muſt be faulty [(u)] in proportion as the height and difference of temperature are great. Where very accurate concluſions are expected, ſimultaneous obſervations, at different times of the day, and different ſeaſons of the year, ſhould be made with ſeveral barometers, placed at different heights, each accompanied with a thermometer and manometer. By this method, the progreſſion of temperature, as well as the law of diminution of the equation, from the poſition of the inferior barometer above the ſea (if ſuch diminution doth really take place)

(*u*) This is taken notice of by Mr. DE LUC.

would

would be obtained with certainty. Suppofing, for inftance, Ben Nevis was divided into four fections, five barometers, with as many obfervers, would be neceffary. This number may feem great, but the expence of people employed in that way would be inconfiderable. And if it fhould be judged proper, there could not furely be any great difficulty in providing reafonable accommodation for an obferver, who fhould live a whole year at the top of the mountain, while another made correfponding obfervations below.

But the perfecting of the theory of the barometer is not the only advantage that would accrue from a combination of thefe obfervations; for, while they were carrying on in different climates, or zones of the earth, good opportunities would offer of determining the refractions, as well as the force of gravity and figure of the globe, from the vibrations of the pendulum.

The mean expanfion of common air is already found to be greater than what was formerly fuppofed; wherefore the mean refraction will be altered proportionably. And fince the expanfion of moift air is found to be fo much greater than that of common air, a larger field for inquiry and inveftigation is now laid open.

With refpect to the experiments with the pendulum, Mr. BOUGUER feems to have been the only perfon, fo far

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as I know, who hath taken the denſity of the medium in which it performed its vibrations into the account, and given us its length at the equator in vacuo. But if we are to judge of the denſity of the air in the frigid zone from the barometrical obſervations at Spitzbergen, the pendulum there muſt have loſt ſo much of its weight, as to have leſſened conſiderably the number of vibrations below what they would have been in vacuo, in the ſame temperature. Having conſidered the effect that this would produce, I collected the beſt experiments that have hitherto been made with the pendulum into one view, and having applied the equation that the denſity of the air, in which they ſeverally vibrated, ſeemed to require; I found from computation, that the ratio of the diameters of the earth is (as Mr. BOUGUER ſuppoſed it) nearly that of 178 to 179, inſtead of 229 to 230, as eſtimated by Sir ISAAC NEWTON, and which agrees very nearly with the mean reſult from the meaſurement of the degrees of the meridian. The experiments with the pendulum are ſo ſimple and eaſy, may be repeated ſo often in all ſituations, and are ſo much more conſiſtent with each other, than the meaſured lengths of degrees of latitude, that it appears to be incomparably the beſt method for determining the figure of the earth. And if it ſhould really be found ſo flat a ſpheroid as the pendu-

 lum

lum ſeems to make it, both parallaxes and refractions, will require correction.

Upon the whole, though I wiſhed to be conciſe in the recital of the experiments and obſervations contained in this paper, yet I found it neceſſary at the ſame time to be explicit. Some of them were either entirely new, or managed in a different manner from what they had formerly been. This forced me into a compariſon of many minute circumſtances attending the operations, and to a tedious, though neceſſary, combination of the various reſults. Without taking a comprehenſive view of the whole matter, and ſtating every thing with fairneſs and candour, I could not convey to others the ideas I entertained of it myſelf; nor enable them to judge, how far I had been juſt in the concluſions already drawn, or conſiſtent in my ſuppoſitions concerning ſuch points as are yet left doubtful. If I have been obliged to differ from Mr. DE LUC, it is becauſe the Britiſh obſervations, as well as his own (conſidered by their extremes) ſeem to authorize it: he is himſelf too candid to ſuppoſe, that I have had criticiſm in view, or indeed any other object, than that of contributing my mite towards the diſcovery of the truth, from the very good foundation which he hath already laid for it. I am aware it may be alledged, that I have rendered the theory of meaſuring heights by the barometer ſo much more complicate and difficult, as perhaps to deter others from applying it to uſeful purpoſes. To this I anſwer, that though it ſeem utterly impoſſible to render what is really intricate in its nature, extremely ſimple; yet that the beſt and ſureſt method of arriving at ſimplicity at laſt will, in the firſt place, be to aſcertain the limits of deviation of the rule, by a proper number of good obſervations, made in circumſtances and ſituations as different as poſſible from each other. In the preſent ſtate of the matter, I doubt not but the barometer will be found to give reſults ſufficiently near the truth for all ordinary purpoſes, the nicer buſineſs of levelling alone excepted. It is the only inſtrument by which the relative heights of places, in very great and diſtant tracts of country, can eaſily and ſpeedily be obtained, by the preſſure of the atmoſphere alone. The method of uſing it is attainable by all, requiring only a little habit, and ſome degree of attention to prevent the admiſſion of air into the tube. Few people are qualified for the tedious and very laborious operations of accurate geometrical meaſurements. Mountainous countries rarely afford baſes of ſufficient length, which, to avoid error, muſt be meaſured again and again with the utmoſt care. Inſtruments of the moſt expenſive kinds muſt be employed to take the angles; at the ſame time that a thorough knowledge of their uſe,

 and

and a ſcrupulous attention to their various adjuſtments, become indiſpenſably neceſſary. In ſhort, the facility of one method, compared with the other, is ſo exceedingly obvious as to need nothing elſe to recommend it as a ſubject very curious and uſeful, and therefore well worthy of the reſearches of philoſophers, till, by their united labours, it hath been brought to perfection.

Table shewing the equation depending on the temperature of the column o

inferior

Mean temperature of the column of air.		Mean equated height of quicksilver in the inferior and superior ba													
		Inches 19		20	21	22		23	24	25		26		26½	
92°	Add to the logarithmic altitude.	89.364	—	95.456	101.548	107.640	—	113.733	119.825	125.918	—	132.010	—	135.057	
			1.44				1.73				2.03		2.13		2.
82		74.967	—	80.078	85.189	90.300	—	95.411	100.522	105.633	—	110.744	—	113.299	
			1.49				1.80				2.10		2.21		2.
72		60.028	—	64.120	68.213	72.305	—	76.398	80.491	84.583	—	88.675	—	90.722	
			1.52				1.83				2.14		2.25		2.
62		44.818	—	47.873	50.928	53.983	—	57.039	60.094	63.150	—	66.205	—	67.733	
			1.55				1.87				2.18		2.29		2.
52		29.335	—	31.335	33.335	35.355	—	37.335	39.335	41.335	—	43.335	—	44.335	
			1.49				1.80				2.10		2.21		2
42		14.394	—	15.376	16.358	17.340	—	18.321	19.303	20.284	—	21.266	—	21.757	
			1.44				1.73				2.03		2.13		2
32	When the mean temperature of the column of air to be mea														
	Subtract from the log. altitude.		1.39				1.67				1.95		2.05		2.
22		13.852	—	14.796	15.741	16.685	—	17.630	18.575	19.519	—	20.463	—	20.936	-
			1.33				1.60				1.88		1.97		2.
12		27.162	—	29.014	30.866	32.718	—	34 569	36.421	38.273	—	40.125	—	41.051	-

umn of air, and its elevation above the sea, as denoted by the mean height of
ferior and superior barometers.

perior barometers. Equation in thousandth parts of the logarithmic altitude.

26½		27		27½		28		28½		29		29½		30		3
											2.38					
35.057	—	138.103	—	141.149	—	144.195	—	147.242	—	150.288	—	153.334	—	156.381	—	159.
	2.18		2.22		2.27		2.32		2.37		2.42		2.47		2.52	
3.299	—	115.855	—	118.411	—	120.966	—	123.522	—	126.077	—	128.632	—	131.188	—	133.
	2.26		2.31		2.36		2.41		2.46		2.51		2.56		2.61	
0.722	—	92.768	—	94.814	—	96.860	—	98.907	—	100.953	—	102.999	—	105.047	—	107
	2.30		2.35		2.40		2.45		2.51		2.56		2.61		2.66	
7.733	—	69.261	—	70.789	—	72.316	—	73.844	—	75.372	—	76.900	—	78.427	—	79.
	2.34		2.39		2.45		2.50		2.55		2.60		2.66		2.71	
4.335	—	45.335	—	46.335	—	47.335	—	48.335	—	49.335	—	50.335	—	51.335	—	52.
	2.26		2.31		2.36		2.41		2.46		2.51		2.56		2.61	
1.757	—	22.248	—	22.739	—	23.229	—	23.720	—	24.211	—	24.702	—	25.193	—	25.
	2.18		2.22		2.27		2.32		2.37		2.42		2.47		2.52	

to be measured is at 32°, the differences of the logarithms give the real height in fathoms and 1000th parts.

	2.09		2.14		2.19		2.24		2.28		2.33		2.38		2.42	
0.936	—	21.408	—	21.880	—	22.353	—	22.825	—	23.297	—	23.769	—	24.242	—	24.
	2.01		2.06		2.10		2.15		2.19		2.24		2.28		2.33	
1.051	—	41.976	—	42.902	—	43.828	—	44.754	—	45.680	—	46.606	—	47.532	—	48.
											2.17					

ıt of quickfilver in the

	30½		Rate of diminution for whole and half inches.	
—	159.427	—	6.0925 3.04625	Add to the logarithmic altitude.
·.52		2.57		
—	133.743	—	5.111 2.5555	
·.61		2.66		
—	107.093	—	4.09250 2.04625	
·.66		2.71		
—	79.954	—	3.0555 1.52775	
·.71		2.76		
—	52.335	—	2.000000 1.000000	
·.61		2.66		
—	25.684	—	0.981625 0.490812	
.52		2.57		

.42		2.47		Subtract from the log. altitude.
—	24.714	—	0.47225 0.94450	
.33		2.37		
—	48.458	—	0.925875 1.85175	

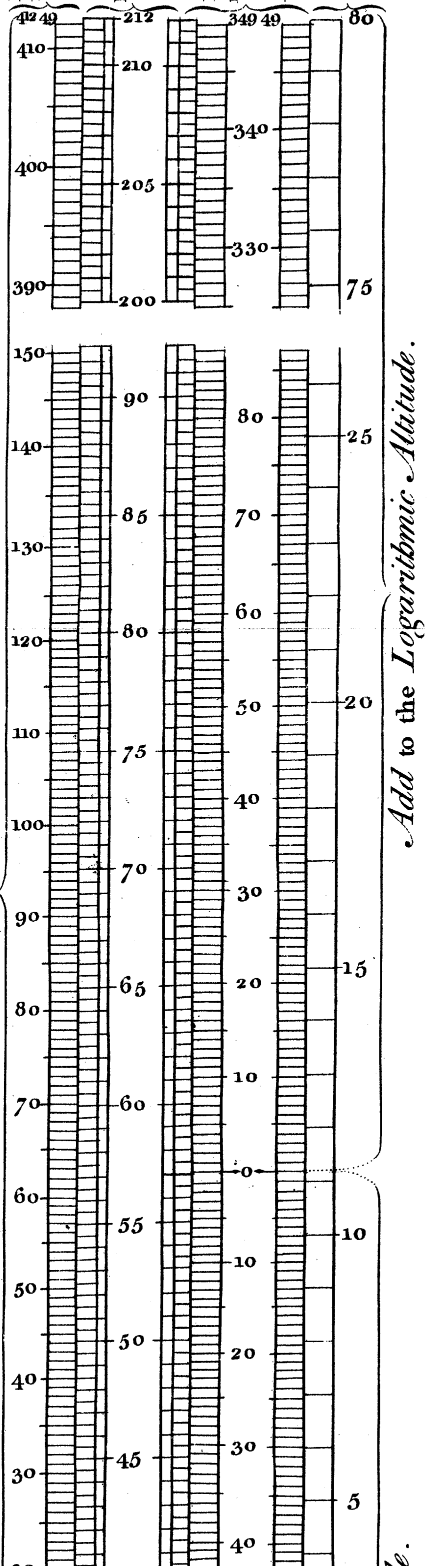
I. Compu-

By means of these numbers expressing the Degrees of Fahr.t below 91.88 answering to every 1000 parts of the Equation for the Air, the unequal Scale may be divided.

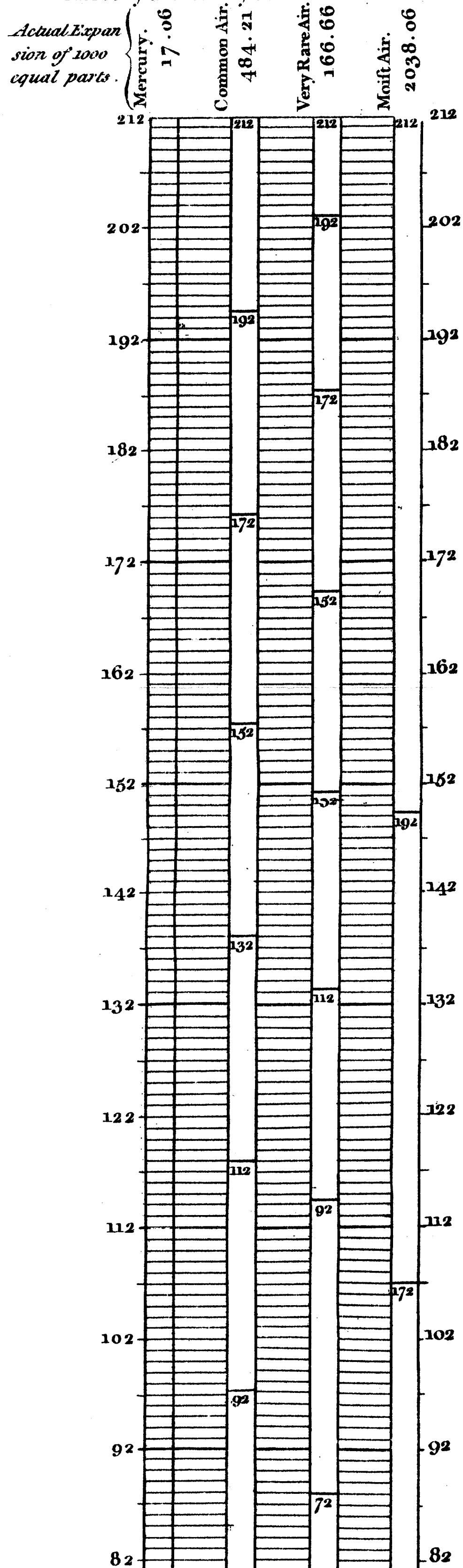
91,88.
4,15
87,73.
4,10
83,63.
4,06
79,57.
4,02
75,55.
3,97
71,58.
3,93
67,65.
3,87
63,78.
3,84
59,94.
3,82
56,12.
3,88
52,24.
3,94
48,30.
3,99
44,31.
4,05
40,26.

Add to the Logarithmic Altitude.

SCALE for the Equation of the Air.



A SCALE expressing the Expansion of different kinds of Air with regard to Mercury affected by 212°. of Fahrenheit.



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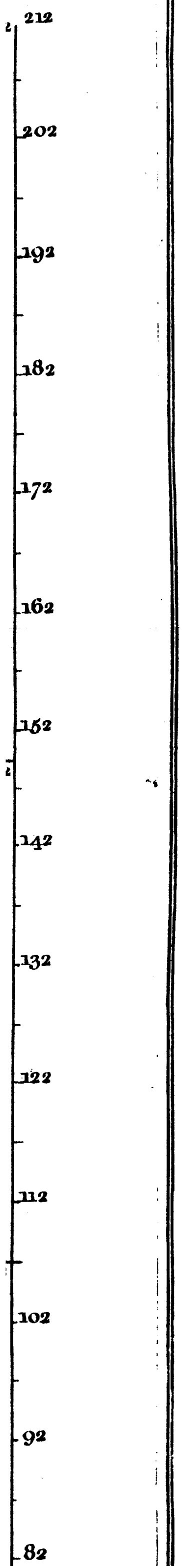
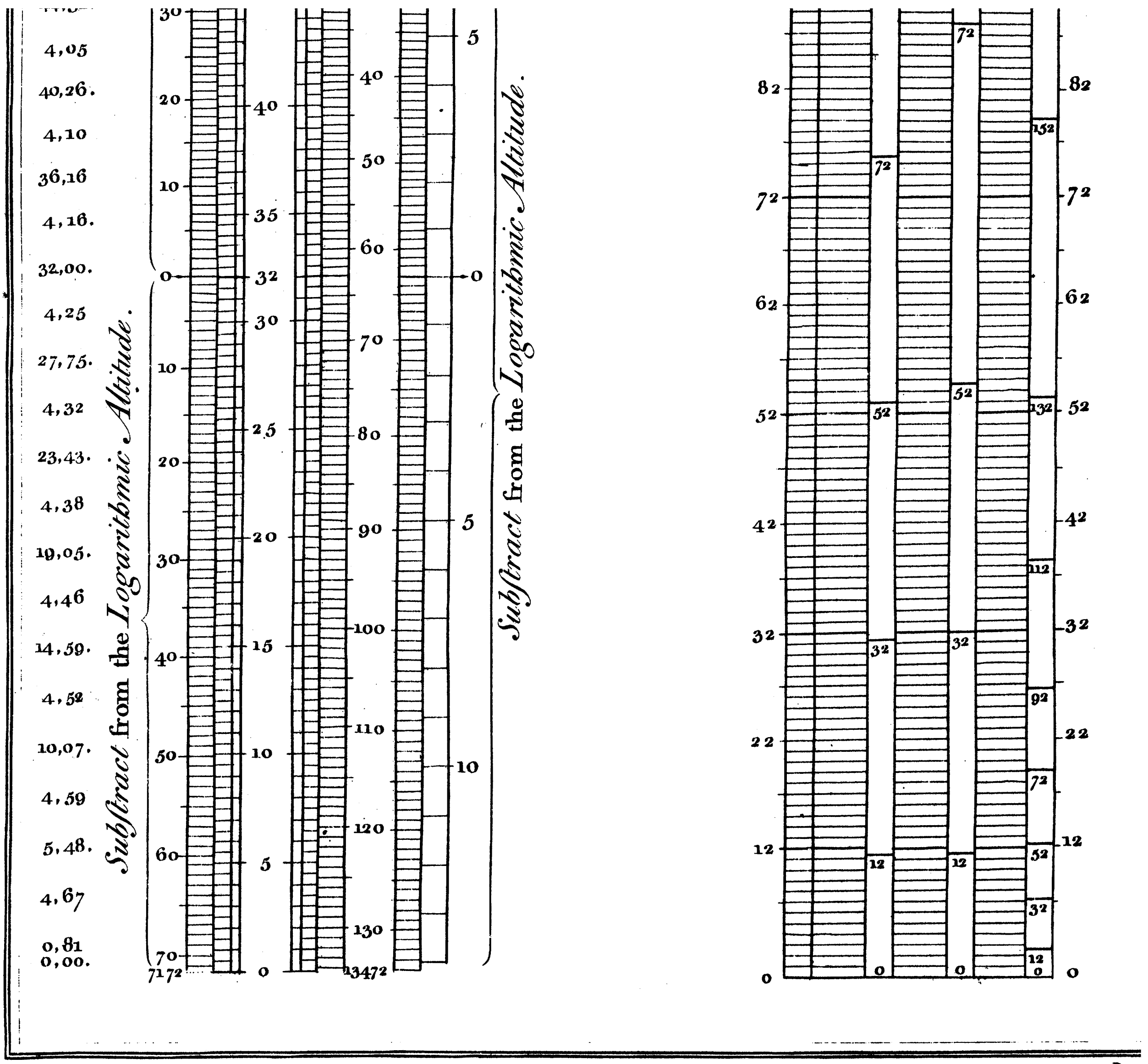
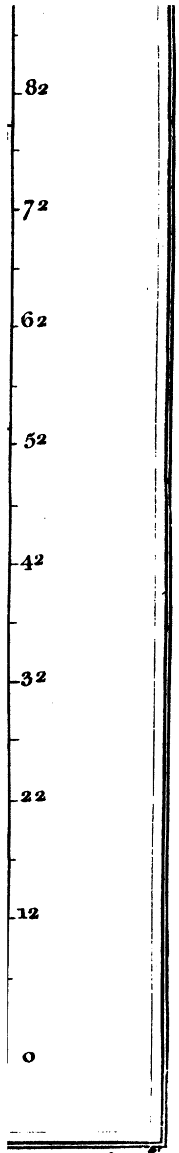



4,05
40,26.
4,10
36,16
4,16.
32,00.
4,25
27,75.
4,32
23,43.
4,38
19,05.
4,46
14,59.
4,52
10,07.
4,59
5,48.
4,67
0,81
0,00.
Subftract from the Logarithmic Altitude.
Subftract from the Logarithmic Altitude.

Baf



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N° I. Computations of barometrical obſervations made on heights in

Geometrical heights of the ſtations in feet.	Date of the obſervations, winds, &c.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar. exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the
St. Paul's Church-yard North-ſide, and iron-gallery over the dome, 281 feet.	1774, Dec. 1. 9^h 27′ wind N.W.	29.659 29.338	33°¾ 34	—006 —006	29.653 29.332	283.6	+2.6ft. = 9/1000	32°¾ 33¾	33°¼	+ =
	Dec. 31. 11^h 52′ A.M. wind N.E.	30.187 29.864	35½ 34¾	—011 —009	30.176 29.855	279.5	— 1.5 = 5.5	33 34	33½	+ =
	April 22. 11^h 55′ A.M. E. wind.	30.136 29.839	50¼ 53	—060 —069	30.076 29.770	266.5	—14.5 =54.4	49 53	51	+ =
Top of Paul's-ſtairs, and the ſaid gallery, 324 feet.	1774, Ap. 22. 0^h 50′ P.M.	30.206 29.842	55¾ 53¾	—080 —071	30.126 29.771	308.9	—15.1 =49.	55¼ 53¾	54½	+ =
	Dec. 1. 10^h 2′ A.M.	29.717 29.344	37 35	—016 —009	29.701 29.335	323.1	— 0.9 = 3.	37¼ 34	35¾	+ =
	Dec. 31. 0^h 22′ P.M.	30.230 29.858	35½ 34¾	—011 —009	30.219 29.849	321.	— 3. = 9.3	34¾ 34¼	34½	[illegible]
Scotland-yard wharf, and Old Spaniard dining-room, 422 feet.	1774, Dec. 24. 10^h 7′ A.M. N.E. wind.	30.844 30.349	33½ 33¼	—005 —004	30.839 30.345	420.8	— 1.2 = 3.5	34¼ 33¼	33¾	[illegible]
Great Pulteney-ſtreet, and the ſaid dining-room, 352 feet.	1774, Nov. 28. 9^h 48′ A.M.	29.684 29.287	35½ 34¾	—011 —009	29.673 29.278	349.2	— 2.8 = 8.5	35¾ 34¼	35	[illegible]
	Dec. 9. 0^h 15′ P.M. N.W. wind, ſnow.	29.647 29.234	27½ 25¼	+015 +022	29.662 29.256	359.	+ 7. =19.7	27½ 23¼	25½	[illegible]
	Dec. 24. 10^h 52′ A.M. N.E. wind.	30.758 30.343	35 33	—010 —003	30.748 30.340	348.1	— 3.9 =11.2	34½ 30¾	32⅝	[illegible]
	1775, June 13. 11^h 7′ A.M. S.W. wind.	30.044 29.674	69 69	—121 —117	29.923 29.557	320.7	—31.3 =97.6	67½ 72½	70	[illegible]
	1776, May 10. 10^h 30′ A.M.	30.096 29.706	53 51¼	—069 —063	30.027 29.643	335.4	—16.6 =50.	51½ 49¾	50¾	[illegible]
	May 30. 11^h 40′ A.M. S.W. wind.	29.900 29.521	66 63	—111 —100	29.789 29.421	323.9	—28.1 =86.7	66 63	64½	[illegible]
	June 20. 0^h 15′ P.M.	30.268 29.898	71½ 71½	—129 —127	30.139 29.771	320.1	—31.9 =99.7	71 71½	71¼	[illegible]
	July 16. 0^h 15′ P.M.	29.625 29.253	67½ 67½	—113 —112	29.512 29.141	329.6	—22.4 =68.	67¾ 65½	66¾	[illegible]
	Aug. 26. 10^h 35′ A.M.	30.132 29.738	59½ 57¼	—092 —082	30.040 29.656	335.2	—16.8 =50.1	59½ 56½	57¾	[illegible]
	Aug. 27. 11^h 45′ A.M.	30.020 29.631	62¼ 60	—099 —091	29.921 29.540	334.	—18. =54.	62 58¼	60	[illegible]
	Sept. 2. 10^h 15′	29.294	60	—089	29.205	333.1	—18.9	59½	[illegible]	[illegible]

hts in and near London.

·ature air, Mean.	Equation by the rule in 1000th parts, and also in feet.	Refult by the rule, Particular.	Mean.	Error of the rule in feet.	Ratio of the weight of quick-filver to air, air being 1.
3°¼	+ 3.8/1000 = 1. ft.	284.6	- -	- -	10505
3½	+ 4. = 1.	280.5	281.4	+0.4	
1	+47.5 =12.7	279.2	- -	- -	11056
4½	+55. =17.	325.9	- -	- -	10860
5¾	+ 6.3 = 2.	325.1	324.6	+0.6	
4½	+ 5.8 = 1.8	322.8	- -	- -	10565
33¾	+ 4. = 0.9	421.7	- -	—0.5	10251
35	+ 7. = 2.4	351.6	- -	- -	10694
25½	—14.5 = 5.2	353.8	- -	- -	10404
32⅝	+ 1.2 = 0.4	348.5	- -	- -	10328
70	+96. =30.8	351.5	- -	- -	11416
50¾	+46.9 =15.7	351.1	- -	- -	10971
64½	+81.8 =26.5	350.4	353.5	+1.5	11447
71¼	+101. =32.3	352.4	- -	- -	11416
66¾	+87.4 =28.8	358.4	- -	- -	11355
57¾	+65. =21.8	357.0	- -	- -	10887
60	+70.2 =23.4	357.4	- -	- -	11028
50½	+69. [illegible]	356.1	[illegible]	[illegible]	[illegible]

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	334.	[illegible]	[illegible]	60	
	A.M.	29.631	60	—091	29.540		=54.	$58\frac{1}{4}$		
	Sept. 2. 10^h 15′	29.294	60	—089	29.205	333.1	—18.9	$59\frac{1}{2}$	$59\frac{1}{2}$	
	AM.	28.918	$58\frac{1}{2}$	—084	28.834		=56.8	$59\frac{1}{2}$		
Pagoda in Kew-gardens, 116.5 feet.	1773, Dec. 20. 1^h 22′ P.M. mean of	29.351	$49\frac{1}{4}$	—052	29.299	111.4	— 5.1	$49\frac{1}{4}$	$49\frac{1}{4}$	
	6 obſervations with 3 barometers.	29.226	$49\frac{1}{4}$	—052	29.174		=45 8	$49\frac{1}{4}$		
Gun-wharf of Woolwich-warren, and upper ſtory of Shooter's-hill inn, 444 feet.	1774. Apr. 27. 4^h	29.762	$57\frac{1}{4}$	—082	29.680	420.4	—23.6	$52\frac{1}{2}$	$55\frac{1}{2}$	
	P.M. mean of 4 obſ.	29.282	$56\frac{1}{2}$	—077	29.205		=56.1	$58\frac{1}{2}$		
	Apr. 27. 6^h 30′ P.M.	29.773	54	—072	29.701	418.3	—25.7	49	$49\frac{1}{4}$	
	mean of 2 obſ.	29.302	$55\frac{1}{4}$	—074	29.228		=61.4	$49\frac{1}{2}$		
	Apr. 28. 5^h A.M.	29.805	$44\frac{1}{2}$	—041	29.764	424.5	—19.5	43	$42\frac{1}{8}$	
	mean of 5 obſ.	29.336	$48\frac{3}{4}$	—053	29.283		=46.	$41\frac{1}{4}$		

60	[illegible] =23.4	357.4	- -	- -	11028
59½	+69. =23.	356.1	- -	- -	11355
49¼	+43.3 = 4.8	116.2	- -	—0.3	11184
55½	+59.2 =24.9	445.3	- -	- -	11170
49¼	+43.5 =18 2	436.5	438.9	—5.1	11217
42⅛	+24.5 =16 4	434.9	- -	- -	11077

N° II.

N° II. Computations of barometrical observations made on heights ne
and N° III. of those near Lanark.

N° II. near Taybridge.

Geometrical heights of the stations in feet.	Date of the observations, winds, &c.	Observed heights of the inferior and superior barometers.	Temperature of the quickfilver.	Equation for the heat of the quick-filver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air, Particular.	Mean.
Station at Weem, and top of Weem-craig, 700¼ feet.	1774, July 16. 11h 30′ A.M. bright Sun-shine.	29.996 29.237	69°½ 65¾	—122 —107	29.874 29.130	657.2	—43.2ft. = $\frac{65.3}{1000}$	65°½ 60	62°¾
Ditto station, and top of Bolfrack's cairn, 1076½ feet.	July 16. 6h 30′ P.M. calm and cloudy.	29.933 28.788	61¾ 58½	—097 —083	29.836 28.705	1007.	— 69.5 = 69.	60 56¾	58½
Ditto station, and top of Dull-craig, 1244¼ feet.	July 18. 7h 20′ A.M.	29.825 28.500	58¼ 55	—086 —072	29.739 28.428	1174.	— 70.2 = 60.	57 55	56
Ditto station, and top of Knock-farle, 1364½ feet.	July 18. 5h 4′ A.M.	29.816 28.347	55¾ 51	—077 —059	29.739 28.288	1303.5	— 61. = 46.8	54 48½	51¼
Ditto station, and that in Glenmore, 1279¼ feet.	July 12. 7h 30′ P.M.	29.528 28.161	58 51¼	—084 —060	29.444 28.101	1216.5	— 62.7 = 51.6	55 51½	53¼
Ditto station, and South observatory on Schihallien, 2098 ft.	July 11. 7h 30′ P.M.	29.643 27.432	58¾ 48	—086 —048	29.557 27.384	1989.8	—108.2 = 54.4	58 47¾	52½
Ditto station, and West summit of Schihallien, 3281 feet.	July 11. 7h 30′ A.M.	29.595 26.194	59½ 46	—089 —040	29.506 26.154	3142.3	—138.7 = 44.1	56 45	50½
	July 12. 5h A.M.	29.610 26.223	50¾ 44	—062 —035	29.548 26.188	3145.5	—135.5 = 43.1	50¼ 42	46⅛
Station in Glenmore, and the South observatory, 818.76.	July 12. 8h P.M.	28.161 27.325	51¼ 48½	—060 —050	28.101 27.275	777.4	— 41.4 = 53.2	51½ 48	49¾

The observation on Schihallien on July 11, by Mr. DE LUC's equation for the air, — — — } 3142.3 50°.5—39°.7=10°.8×2.1

N° III. near Lanark.

Geometrical heights of the stations in feet.	Date of the observations, winds, &c.	Observed heights of the inferior and superior barometers.	Temperature of the quickfilver.	Equation for the heat of the quick-filver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air, Particular.	Mean.
Level of the Clyde at Lanark Bridge, and the station at the garden, 362½ feet.	1774, Aug. 20. 6h 30′ A.M.	29.776 29.383	62½ 61¾	—099 —094	29.677 29.289	342.9	—19.6 =57.1	62 62	62
	Aug. 23. 3h 8′ P.M.	29.956 29.563	64¾ 65	—107 —106	29.849 29.457	344.5	—18. =52.3	63 63	63
	Sept. 5. 8h A.M.	29.626 29.232	52½ 50½	—067 —060	29.559 29.172	343.4	—19.1 =55.6	52½ 49½	51
	Sept. 7. 7h 47′ A.M.	29.864 29.467	50½ 51	—061 —062	29.803 29.405	350.3	—12.2 =34.8	45 44	44½
	Sept. 7. 9h A.M.	29.886 29.488	50½ 51¼	—061 —063	29.825 29.425	351.8	—10.7 =30.4	47 41	44
Level of the Clyde, and Stonebyre-hill, 654 feet.	Sept. 7. 8h 15′ A.M.	29.872 29.148	48½ 46¼	—055 —045	29.817 29.103	631.6	—22.4 =35.4	46¾ 45¾	45¼

:.

…rature … air, Mean.	Equation by the rule in 1000th parts, and also in feet.	Result by the rule, Particular.	Result by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quick-silver to air, air being 1.
62°$\frac{3}{4}$	+ $\frac{77.}{1000}$ = 50.6ft.	707.8	- -	+ 7.6	11249
58$\frac{1}{2}$	+ 67.5 = 68.5	1075.5	- -	— 1.	11382
56	+ 60. = 70.4	1244.4	- -	- -	11354
51$\frac{1}{4}$	+ 47.5 = 62.	1365.5	- -	+ 1.	11254
53$\frac{1}{4}$	+ 52. = 63.2	1279.7	- -	- -	11396
52$\frac{1}{2}$	+ 51. = 101.5	2091.3	- -	— 6.7	11554
50$\frac{1}{2}$	+ 43.5 = 136.7	3279.	- -	— 2.	11693
46$\frac{1}{8}$	+ 34.3 = 107.	3252.5	- -	—29.5	11690
49$\frac{3}{4}$	+ 42. = 32.6	810.	- -	— 8.8	11851
×2.1	+ 22.7 = 71.3	3213.6	- -	—67.4	
52	+ 74. = 25.4	368.3			
53	+ 77.8 = 26.8	371.3	- -	- -	11083
51	+ 46. = 15.8	359.2	364.4	+ 1.9	11182
44$\frac{1}{2}$	+ 30.5 = 10.7	361 0			
44	+ 29. = 10.2	362 0	- -	- -	10875
45$\frac{1}{4}$	+ 32.3 = 20.4	652.	- -	—2.0	10946

Level of the Clyde, and Stonebyre-hill, 654 feet.	Sept. 7. 8h 15′ A.M.	29.872 29.148	48½ 46¼	—055 —045	29.817 29.103	631.6	—22.4 =35.4	46¾ 45¾	45¼	- =
Carmichael-well, and West-end of Carmichael-hill, 451½ feet.	July 30. 5h 40′ P.M. S.W. wind, begin-ning to rain.	29.162 28.690	56 54½	—076 —071	29.086 28.619	421.8	—29.7 =70.3	54¾ 53¼	54	- =
	Aug. 1. 11h 40′ A.M.	29.612 29.135	58¾ 60	—086 —089	29.526 29.046	427.1	—24.4 =57.1	57 54¾	55⅞	- =
Carmichael-well, and top of Tinto, four feet below the summit of the Cairn, 1642.5 ft.	June 30. 1h 30′ P.M.	28.991 27.284	61¼ 55¼	—093 —069	28.898 27.215	1563.6	—78.9 =50.5	58 51	54½	- =
	July 30. 6h A.M.	29 063 27.335	51½ 46¼	—062 —043	29.001 27.292	1582.6	—59.9 =38.	51 44	47½	- =
	Aug. 2. 8h 15′ A.M.	29.608 27.846	54¼ 47½	—072 —048	29.536 27.798	1580.3	—62.2 =39 3	51½ 44½	48	- =
	Aug. 27. 11h 50′ A.M. S.W. wind.	28.710 27.008	59¾ 53¼	—087 —063	28.623 26.945	1570.3	—72.2 =46.	55¾ 47¼	51½	- =
	Aug. 27. 1h 40′ P.M. hail.	28.736 27.032	60¾ 53	—090 —062	28.646 26.970	1571.	—71.5 =45.5	55¼ 50	52¾	- =
	Aug. 27. 1h 50′ P.M.	28.716 27.010	58½ 52¼	—083 —061	28.633 26.949	1579.5	—63. =40.	55¼ 48¾	52	+ =

Mean of the observations on Tinto, with Mr. DE LUC's equation for the air, — — — 1574.5 $51^\circ - 39^\circ.7 = 11.3 \times 2.1$ { +
=

45¼	+ 32.3 = 20.4	652.	- -	—2.0	10946
54	+ 52.3 = 22.	443.8	- -	—7.7	11430
55⅞	+ 57.1 = 24.4	451.5	- -	- -	
54½	+ 53. = 83.3	1646.9	- -	- -	11684
47½	+ 36.4 = 57.4	1640.			
48	+ 39.6 = 62.4	1642.7	- -	- -	11412
51½	+ 45.6 = 72.3	1642.6	1645.5	+ 3.0	
52¾	+ 49. = 76.8	1647.8	- -	- -	11704
52	+ 46.4 = 73.3	1652.8			
2.1	+ 24.8 = 39.	1613.5	- -	—29.	

N° IV.

N° IV. Computations of barometrical obſervations on heights n

Geometrical heights of the ſtations in feet.	Date of the obſervations, winds, &c.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar. exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Mean.
Leith Pier-head, and Calton-hill, 344 feet.	1774, Aug. 12. 5h 20′ A.M.	30.086 29.704	52°½ 49¾	—067 —058	30.019 29.646	325.8	—18.2ft. = 56/1000	50°¾ 49	50°
	Aug. 15. 6h 45′ A.M.	29.568 29.197	55¼ 53½	—075 —068	29.493 29.129	323.6	—20.4 =60.3	54 54½	54¼
	Aug. 15. 0h 15′ P.M. S.W. wind and rain.	29.625 29.282	56¼ 53½	—078 —068	29.547 29.214	319.1	—24.9 =78.	54 54½	54¼
Leith Pier-head, and top of Arthur's Seat, 803 feet.	Aug. 15. 5h 15′ A.M. S.W. wind and rain.	29.567 28.704	55¼ 51¾	—075 —062	29.492 28.642	762.	—41. =53.8	54 50½	52¼
Leith Pier-head, and Kirk Yetton cairn, 1544 feet.	Sept. 15. 10h 30′ A.M. S.W. wind.	29.953 28.291	57½ 52¼	—084 —063	29.869 28.228	1472.5	—71.5 =48.6	54½ 47¼	51
Calton-hill, and Kirk-Yetton cairn, 1200 feet.	Sept. 15. 1h 15′ P.M. S.W. wind.	29.561 28.272	63¼ 54	—100 —068	29.461 28.204	1136.2	—63.8 =56.2	56½ 48½	52½
Level of Hawk-hill ſtudy, and bottom of Small-rock, 7.4 ft. below the top of Arthur's Seat, 702.4 feet.	1774, Dec. 1. 2h 45′ P.M.	29.565 28.770	35 32	—010 — —	29.555 28.770	701.5	— 0.9 = 1.3	33 30½	31¾
	Dec. 10. 9h 46′ A.M.	29.494 28.687	20½ 20½	+038 +037	29.532 28.724	722.9	+20.5 =28.3	20½ 20½	20½
	1775, Jan. 26. 1h 35′ P.M.	29.490 28.674	26½ 24¼	+018 +026	29.508 28.700	723.5	+21.1 =29.	26 23	24½
Baſe of Hawk-hill obſervatory, and bottom of the Small-rock on Arthur's Seat, 684 feet.	Nov. 10. 11h 30′ A.M.	29.959 29.177	38 34	—020 —006	29.939 29.171	677.2	— 6.8 =10.	36¾ 34	35½
	Nov. 17. 9h 30′ A.M.	29.543 28.769	33¼ 30¼	—004 +005	29.539 28.774	683.8	—— ——	32 29¼	30⅝
	1776, Jan. 31. 10h 45′ A.M.	30.009 29.229	15½ 24	+056 +026	30.065 29.225	711.7	+27.7 =39.	14 20	17
	July 25. 2h 20′ P.M.	30.157 29.427	70¼ 66½	—125 —111	30.032 29.316	628.8	—55.2 =87.7	69¾ 67	68½
Hawk-hill garden-door, and bottom of the rock on Arthur's Seat, 730.8 feet.	1775, Dec. 27. 11h 30′ A.M.	29.807 28.985	30¾ 29¾	+004 +007	29.811 28.992	725.9	— 4.9 = 6.7	29½ 29½	29½
	Dec. 27. 8h 40′ A.M.	29.778 28.945	35¾ 33	—013 —003	29.765 28.942	730.6	—— ——	35¾ 32½	34¼
	1776, Feb. 1. 9h 30′ A.M.	29.883 29.032	28¾ 26½	+011 +019	29.894 29.051	745.4	+14.6 =19.6	24½ 26½	25½
	Aug. 3. 2h 20′ P.M.	30.135 29.348	75½ 72	—141 —127	29.994 29.221	680.4	—50.4 =74.	72¾ 69	73¾

ghts near Edinburgh.

…perature …e air, Mean.	Equation by the rule in 1000th parts, and also in feet.	Refult by the rule, Particular.	Mean.	Error of the rule in feet.	Ratio of the weight of quickfilver to air, air being 1.
50°	$+\frac{47.}{1000}$ =15.3f.	341.1	- -	- -	11037
54¼	+54. =17.5	341.1	339.5	—4.5	
54¼	+54. =17.2	336.3	- -	- -	11761
52¼	+50. =38.	800.	- -	—3.	11309
51	+47. =69.2	1541.7	- -	—2.3	11249
52½	+52. =59.	1195.2	- -	—4.8	11410
31¾	— 0.5 = 0.3	701.2	- -	- -	10724
20½	—26.6 =19.2	703.7	705.3	+2.9	11445
24½	—17. =12.4	711.1	- -	- -	10419
35½	+ 8.6 = 5.8	683.	- -	- -	10646
30⅝	— 3.5 = 2.4	681.4	- -	- -	10729
			684.5	+0.5	
17	—35.2 =25.	686.7	- -	- -	10184
68½	+94. =58.2	687.0	- -	- -	11416
29½	— 5.7 = 4.1	721.8	- -	- -	10707
34¼	+ 5.4 = 4.	734.6	- -	- -	10642
			734.7	+3.9	
25½	+15.4 =11.5	733.9	- -	- -	10390
73¾	+100. =68.	748.4	- -	- -	11286
	—29.8				

Aug. 3. 2^h 20′ P.M.	30.135 29.348	$75\frac{1}{2}$ 72	—141 —127	29.994 29.221	680.4	—50.4 =74.	$72\frac{3}{4}$ 69	$73\frac{3}{4}$

In these two last observations Mr. DE LUC's equation for the air being substituted,

1776, Feb. 1. 745.4 $39°.7—25°.5=14°.2 \times 2.1$

Aug. 3. 680.4 $70°.7—39°.7=31°. \times 2.1$

73¾	{ +100. =68. }	748.4	- -	- -	11286
× 2.1	{ —29.8 =22.2 }	723.2	- -	—7.6	
× 2.1	{ +65.1 =44 3 }	724.7	- -	—6.1	

N° V.

N° V. Computations of barometrical obfervations made on heig

and N° VI. of thofe near Carnarvon in North Wal

N° V. near Linhoufe.

Geometrical heights of the ftations in feet.	Date of the obfervations, winds, &c.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in ft. and alfo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.
Linhoufe and Eaft-cairn hill, 5 feet below the fummit, 1176.6 feet.	1775, Nov 11. 8[h] A.M. calm and clear.	29.216 27.912	32° 30	— +006	29.216 27.918	1184.2	+7.6 ft. = $\frac{6.4}{1000}$	32° 29	30°½
	Nov. 15. noon.	28.941 27.632	32 27	— +015	28 941 27.647	1191.9	+ 15.3 = 12.8	32 26	29
Linhoufe, and Eaft-cairn hill, 18 feet below the top, 1165.6 feet.	1776, Dec. 17. 2[h] P.M.	28.990 27.688	31½ 24	+001 +025	28.991 27.713	1174.8	+ 9.2 = 7.9	30¼ 22	26⅛
	Subftituting Mr. DE LUC's equation for the air,					—	39°.7—26°.1=13°.6×2.1		
Linhoufe, and Weft-cairn hill, 11 ft. below the top, 1178.4ft.	1775, Dec. 1. 1[h] P.M. high S.W. wind, fog above.	29.250 28.003	49 45	—055 —042	29.195 27.961	1125.3	— 53.2 = 47.3	48° 45	46°½
Linhoufe, and Corfton hill, 4 feet below the top, 386.5 ft.	Dec. 8. 1[h] P.M. clear and windy.	29.686 29.521	41 39	—029 —023	29.657 29 288	379.7	— 6.8 = 18.	40 39	39½
Corfton hill, and Weft-cairn hill, 792 feet.	1776, Dec. 16[h] 11′ A.M. high N. wind, clear weather.	28.580 27.714	34¾ 32	—009 —	28.571 27.714	793.6	+ 1.6 = 2.	34¼ 30	32⅛
Corfton hill, and Eaft cairn hill, 776.6 feet.	Dec. 17. 1[h] A.M. light W. wind.	28.574 27.710	32 25	— +022	28.574 27.732	779.4	+ 2.8 = 3.6	31 23½	27¼
Linhoufe, and Corfton hill, 388.5 feet.	Nov. 20. 1[h] P.M. fnow had fallen, high W. wind.	27.992 27.582	35 33	—009 —003	27.983 27.579	379.	— 9.5 = 28.2	33 33	33

N° VI. near Carnarvon.

Geometrical heights of the ftations in feet.	Date of the obfervations, winds, &c.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in ft. and alfo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.
Carnarvon Quay, and Moel Eilio, 2371 feet.	1775, Aug. 4. 1[h] 7′ P.M. rain above, clear below.	29.693 27.714	62½ 54	—098 —066	29.595 27.148	2248.8	—122.2 + 54.4	62½ 51	56¾
	Aug. 8. 0[h] 7′ P.M. S. wind, and hazy weather above.	30.036 27.543	68 57	—118 —075	29.918 27.468	2226.3	—194.7 = 65.	68¾ 56	62⅜
	Aug. 8. 2[h] 7′ P.M. S. wind, weather fomething clearer.	30.027 27.533	69½ 58¼	—122 —079	29.905 27.454	2228.3	—142.7 = 64.	69½ 57	63¼
	Subftituting Mr. DE LUC's equation for the air,					2231.1	60°.8—39°.7=21°.1×2.1		
	Aug. 7. 6[h] 7′ A.M.	30.154 26.462	56¾ 47½	—081 —045	30.073 26.417	3377.6	—177.4 = 52.5	56⅜ 45⅛	50¾
	Aug. 7. 9[h] 7′ A.M.	30.165 26.468	60 49¼	—092 —050	30.073 26.418	3376.6	—178.4 = 52.8	60 47¼	53¾
	Aug. 7. 0[h] 7′ P.M.	30.140 26.488	61½ 60½	—097 —083	30.043 26.405	3363.4	—191.6 = 57.	61¾ 54	57⅞

ι heights near Linhoufe.

h Wales.

rature air, Mean.	Equation by the rule in 1000th parts, and alfo in feet.	Refult by the rule, Particular.	Mean.	Error of the rule in feet.	Ratio of the weight of quick-filver to air, air being 1.
30°½	+ $\frac{3.4}{1000}$ = 4. ft.	1180.	1181.3	+ 4.7	10894
29	— 7. = 8.3	1182.6			
26⅛	— 14. = 16.4	1158.4	- -	— 7.2	10910
×2.1	= 28 6 = 33.6	1141.2	- -	—24.4	
46°½	+ 35. = 39.4	1164.7	- -	—13.7	11441
39½	+ 18. = 6.8	386.5	- -	- -	10736
32⅛	+ 0.3 = 0.2	793.8	- -	+ 1.8	11077
27¼	— 10.2 = 9.3	770.1	- -	— 6.5	11068
33	+ 2 2 = 0 8	379.8	- -	— 8.7	11540
;6¾	+ 59.6 =134.	2382.8	- -	- -	11594
›2⅜	+ 75. =167.	2393.3	2391.8	+20.8	
›3¼	+ 76.8 =171.	2399.3	- -	- -	11566
‹2.1	+ 44.3 = 98.8	- -	2330.	—41.	
;0¾	+ 45. =152.6	3530 2	- -	- -	11646
;3¾	+ 52.5 =177.4	3554.			
;7⅞	+ 61. =205.	3568.4	3551.		

	[illegible]	26.400	49¼	—030	26.410		= 52.0	47¼		[illegible]
Carnarvon Quay, and Peak of Snowdon, 3555 feet.	Aug. 7. 0^h 7′ P.M.	30.140 26.488	61½ 60½	—097 —083	30.043 26.405	3363.4	—191.6 = 57.	61¾ 54	57⅞	+ =
	Aug. 7. 2^h 7′ P.M.	30.144 26.478	62 53¾	—099 —063	30.045 26.415	3355.3	—199.7 = 59.5	62 51	56½	+ =
	Aug. 14. 8^h 7′ A.M. fog above.	29.984 26.271	56½ 42¾	—080 —031	29.904 26.240	3405.9	—149.1 = 43.8	55¼ 43	49⅛	+ =
	Aug. 14. 9^h 7′ fog and rain.	29.978 26.279	58½ 44	—087 —035	29.891 26.244	3390.6	—164.4 = 48.5	57¾ 43½	50¼	+ =
	Aug. 14. 10^h 7′.	29.972 26.280	60 44½	—091 —036	29.881 26.244	3381.9	—173.1 = 51.2	60 44¾	52¼	+ =
	Aug. 14. 11^h 7′.	29.974 26.280	61½ 44¾	—097 —037	29.877 26.243	3379.4	—175.6 = 52.	61 45	53	+ =
	Aug. 14. 0^h 7′,	29.976 26.282	62½ 46½	—100 —042	29.876 26.240	3381.5	—173.5 = 51.3	62 46	54	+ =
	Barometrical height of Snowdon from the mean of two days observations, — —					3379.1	—175.9 = 52.1	— —	53.1	=

Mr. DE LUC's equation for the air, — — $53^\circ.1-39^\circ.7=13^\circ.4\times2.1=28.14$ =

	= 177.4				
			3551.		
$57\frac{7}{8}$	+ 61. = 205.	3568.4			
			- -	- -	11704
$56\frac{1}{2}$	+ 58.5 = 196.	3551.3			
$49\frac{1}{8}$	+ 40. = 136.2	3542.1			
			- -	- -	11643
$50\frac{3}{4}$	+ 44.3 = 150.4	3541.			
$52\frac{1}{4}$	+ 48. = 162.7	3544.6	3546.8		
			- -	- -	11704
53	+ 50. = 169.	3548.4			
54	+ 52.3 = 176.2	3557.7			
53.1	= 176.3	- -	3548.9	—6.1	
8.14	= 95.1	- -	3474.2	—80.8	

Compu-

Computations of part of Mr. DE LUC's barometrical observations, answering to the ... of the air.

	Stations with their geometrical heights in feet.	Date of the observations.	Observed heights of the inferior and superior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air, Particular.	Mean	Reduced.	Equation by the ...
Coldest of the Sun-rising Observations.	1st. 230.5	1760, Feb. 9. 8h 30′ A.M.	28.986 28.703	33¾° 26¼	—006 +018	28.980 28.721	233.9	+ 3.4 ft. = 14.5/1000	24¼° 26¼	25¼°	—	— =
		March 9. 6h A.M.	28.875 28.586	37½ 28¼	—018 +012	28.857 28.598	234.9	+ 4.4 = 18.7	27½ 32	29¾	—	— =
	2d. 457.	March 9. 6h 8′ A.M.	28.875 28.342	37½ 30	—018 +006	28.857 28.348	463.7	+ 6.6 = 14.5	27½ 31½	29½	—	— =
	3d. 624.5	March 9. 6h 15′ A.M.	28.875 28.170	37½ 32	—018 ——	28.857 28.170	627.8	+ 4.3 = 7.	27¼ 34	30⅝	—	— =
	4th. 776.7	March 9. 6h 30′ A.M.	28.875 28.009	37½ 32	—018 ——	28.857 28.009	777.2	+ 0.5 = 0.7	27¼ 32½	30	—	— =
	5th. 977.2	March 9. 6h 45′ A.M.	28.875 27.798	37½ 33¾	—018 —005	28.857 27.793	978.9	+ 1.7 = 1.7	27¼ 32	29¾	—	— =
Coldest of the ordinary observations.	2d, 457.	Feb. 9. 9h A.M.	28.997 28.470	32 28¼	—— +012	28.997 28.482	466.9	+ 9.8 = 21.	25¼ 29	27⅛	26°	— =
	3d, 624.5	Feb. 9. 9h 15′ A.M.	28.997 28.298	32 30	—— +006	28.997 28.304	630.3	+ 5 8 = 9.2	28 30	29	28	— =
	4th. 776.7	Feb. 9. 9h 30′ A.M.	28.997 28.142	32 32	—— ——	—— ——	780.2	+ 3.6 = 4.5	40½ 32	36¼	30½	— =
	5th. 977.2	Feb. 9. 10h A.M.	28.997 27.931	33¾ 35½	—006 —011	28.991 27.920	980.8	+ 3.6 = 3.5	40¾ 37	38⅞	31½	— =
	6th. 1298.9	Feb. 9. 10h 15′ A.M.	29.002 27.604	32 37½	—— —017	29.002 27.587	1303.4	+ 4.5 = 3.5	41 36¾	38⅞	31½	— =
	7th. 1513.3	Feb. 9. 10h 30′ A.M.	29.008 27.393	33¾ 41	—006 —027	29.002 27.366	1513.	— 0.3 = 0.2	41 37¾	39⅛	33½	+ =
	8th. 1938.9	Feb. 9. 11h A.M.	29.002 26.955	35½ 39¼	—011 —021	28.991 26.934	1917.7	— 21.2 = 11.0	43½ 37¾	40⅝	34½	+ =
	9th. 2094.5	Feb. 9. 11h 15′ A.M.	28.997 26.771	35½ 39¼	—011 —021	28.986 26.750	2091.8	— 2.7 = 1.5	43¾ 39¾	41¾	35	+ =
	10th. 2356.3	Feb. 9. 11h 45′ A.M.	28.992 26.494	35½ 39¼	—011 —021	28.981 26.473	2358.6	+ 2.3 = 1.	44¾ 38¾	41¾	35	+ =
	11th. 2486.3	Feb. 9. noon.	28 986 26.366	33¾ 37½	—006 —016	28.980 26.350	2479.	— 7.3 = 3.0	44¾ 36	40⅜	34½	+ =
	14th. 2922.	1759, July 15, 4h P.M.	28.759 25.950	74½ 71	—131 —105	28.628 25.845	2664.8	—257.9 = 96.7	88½ 74	81	75½	+1 =2
		July 15. 2h P.M.	28.797 25.778	74½ 71	—131 —108	28.666 25.670	2876.5	—242.7 = 84.5	85 68¾	76¾	73½	+ =2

to the coldeſt and hotteſt temperatures

ed.	Equation by the rule in 1000th parts, and alſo in feet.	Reſult by the rule, Particu-lar.	Mean.	Error of the rule in feet.	Ratio of the weight of quick-ſilver to air, air being 1.
.	— 15.4/1000 = 3 6ft.	229.9	- -	- -	10598
			231.8	+ 1.3	
.	— 4.9 = 1.2	233.7	- -	- -	10598
.	— 5 6 = 2.6	461.1	- -	+ 4.1	10732
-	— 3.5 = 2.3	625.5	- -	+ 1.	10876
-	— 4.4 = 3.4	773.8	- -	— 2.9	10978
-	— 5. = 4.9	974.0	- -	— 3.2	11000
5°	— 14. = 6.5	460.4	- -	+ 3.4	10649
3	— 9. = 5.7	624.6	- -	- -	10814
0½	— 3.5 = 2.7	777.5	- -	- -	10901
1½	— 1.1 = 1.1	979.7	- -	+ 2.5	10949
1½	— 1.1 = 1.4	1302.	- -	+ 3.1	11024
3½	+ 3.3 = 5.	1518.	- -	+ 4.7	11120
4½	+ 6. = 11.5	1929.2	- -	+ 9.7	11306
5	+ 6.6 = 12.6	2104.4	- -	+ 9.9	11241
5	+ 6.6 = 15.6	2374 2	- -	+17.9	11274
4½	+ 5.6 = 14.	2493.	- -	+ 6.7	11357
5½	+101. =269.2	2934.	- -	+12.	12541
3½	+ 96.5 =300.8	3177 3	- -	- -	12439

Hotteſt of the ordinary obſervations on the higheſt ſtations.	2922.	4 P.M.	25.950	71	—105	25.845		— 90.7	74			= 2
	15th. 3119.2	July 15. 2h P.M.	28.797 25.778	74½ 71	—131 —108	28.666 25.670	2876.5	—242.7 = 84.5	85 68¾	76¾	73½	+ =3
		July 15. 3h 30′ P.M.	28.764 25.778	74½ 68¾	—131 —103	28.633 25.675	2841.4	—277.8 = 97.7	90½ 74	82	76	+ 1 = 2
	10th. 2356.3	1760, July 20. 10h 15′ A.M.	28.775 26.499	71 72¾	—121 —117	28.654 26.382	2152.6	—203.7 = 94.7	87¼ 74	80⅝	75	+ 1 = 2
		July 20. 3h 15′ P.M.	28.731 26.460	74½ 72¾	—131 —118	28.600 26.342	2143.	—213 3 = 99.5	91½ 75¾	83⅝	77	+ 1 = 2
	11th. 2486.3	July 20. 10h 45′ A.M.	28.769 26.366	71 68¾	—121 —104	28.648 26.262	2266.	—221.3 = 97.7	87½ 74½	81	75	+ 1 = 2
		July 20. 3h P.M.	28.726 26.327	76½ 72¾	—138 —116	28.588 26.211	2262.	—224.3 = 99.	92¼ 76½	84¼	77	+ 1 = 2
	12th. 2752.	July 20. 11h 30′ A.M.	28.758 26.100	72¾ 68¾	—126 —103	28.632 25.997	2516.3	—235.7 = 94.	88 72½	80¼	74	+ = 2
		July 20. 2h 30′ P.M.	28.720 26.066	76½ 71	—138 —110	28.582 25.956	2511.2	—240.8 = 95.7	92 77	84¼	77	+ 1 = 2
	13th. 2877.5	July 20. noon.	28.747 25.977	72¾ 68¾	—126 —103	28.621 25.874	2629.3	—248.2 = 94.7	89 73½	81¼	75	+ 1 = 2
		July 20. 1h 45′ P.M.	28.720 25.691	74½ 68¾	—131 —105	28.859 25.856	2618.2	—259.3 = 99.	92¾ 75	83⅞	77	+ = 2
						Mean of the hotteſt,		95.7/1000	—	81.7	75.6	

	=209.2				
$3\frac{1}{2}$	+ 96.5 =300.8	3177 3	- -	- -	12439
			3154 4	+35.2	
6	+102. =290 2	3131.6	- -	- -	12603
5	+102. =219.6	2372.2			
			2371.2	+14.9	12429
7	+106. =227.2	2370.2			
5	+101.8 =230.7	2496.7			
			2499.2	+12.9	12468
7	+106. =239.7	2501.7			
4	+ 97 6 =245.6	2761.9			
			2769.6	+17.6	12504
7	+106. =266.2	2777.4			
5	+101.8 =267.6	2897.1			
			2896.4	+18.9	12548
7	+106. =277.5	2895.7			
5.6					

Compu-

Continuation of Mr. DE LUC's barometrical observation

Station's with their geometrical heights n feet.	Date of the observations.	Observed heights of the inferior and superior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Logar excefs or defect in ft. and alfo in 1000th parts.	Temperature of the air, Particular.	Mean	Reduced.	Equation by the rule in 1000th
The Dole, by Sir ;EORGE SHUCK- ıURGH's meafure- nent, is above the ake of Geneva .293 ft. Mr. DE .uc's lowermoft arometer was igher than the ıke 83 ft. hence :e vertical dif- .nce of the baro- eters, 4210 feet.	1764, July 29. 1h P.M.	28.953 24.951	78°¼ 67	—145 - 095	28.808 24.856	3845.	—365 ft. = 94.9/1000	77¾° 64½	71°¼	70°	+ 88/100 =339
	July 29. 1h 30′ P.M.	28.942 24.940	78¼ 65¼	—145 —090	28.797 24.850	3841.	—369. = 96.	78¼ 65	71½	70	+ 88 =338
	1765, July 21. 10h 30′ A.M.	28.698 24.640	67 59¾	—108 —075	28.590 24.565	3954.	—256. = 64.7	67½ 51	59¼	58	+ 6 =23
	1764, July 8. 8h A.M.	28.692 24.636	71 57¾	—121 —070	28.571 24.566	3935.	—275. = 70.	73 56	64½	63	+ 7 =28.
Light-houfe of enoa, 237.6 ft	1757, June 2. 6h A.M.	30.077 29.817	76 76	—142 —141	29.935 29.686	217.7	— 20. = 92.	— —	75¾	73	+10 = 2
	June 2. 4h½ P.M.	30.088 29.846	82½ 84½	—163 —169	29.925 29.677	216.8	— 21. = 96.	— —	82	79	+10 = 2
	June 23. 9h½ A.M.	30.116 29.857	79 75	—152 —138	29.964 29.719	214.8	— 22.8 =107.	— —	79	76	+10 = 2
	June 23. 5h 45′ P.M.	30.041 29.796	79 79	—152 —150	29.889 29.646	212.7	— 24.9 =117.	— —	78	75	+10 = 2
	July 26. 1h P.M.	30.021 29.774	83¾ 83¾	—166 —164	29.855 29.610	214.7	— 22.9 =107.	— —	81	77	+11 = 2
								Mean	76		
For the barometrical height of Turin above Genoa,		30.019 +.071 30.090 29.197 +.069 29.266	77 77	—146 —141	29.944 29.125	722.6	— —	— —	77	—	+11 = 8
For the barometrical height of Mr. DE LUC's room above Turin,		29 319 28.831	72¾ 72¾	—129 —126	29.190 28.705	436.6	— —	— —	72¾	—	+ 9 = 4.

Mr. DE LUC's room above Genoa, — —

Surface of the Lake of Geneva in fummer below Mr. DE LUC's room,

Surface of the Lake of Geneva above the Mediterranean, —

By Mr. DE LUC's rule the Lake is elevated above the Sea 1126 French, or 120

In the obfervations on the Dole, if Mr. DE LUC's equation for the air is fubftituted inftead of that refulting from the Britifh obfervations, the barometrical height will be, } 3894 66°.6—39°.7=

Mr. DE LA CAILLE's barometrical Obfervations, Sept. 22, 1751, at the C vations.

l.	Equation by the rule in 1000th parts, and alfo in feet.	Refult by the rule, Particu-lar.	Mean.	Error of the rule in feet.	Ratio of the weight of quick-filver to air, air being 1.
	+ $\frac{88.2}{1000}$ =339.8f.	4184 8	- -	- -	12714
	+ 88 2 =338.8	4179.8	4194.	—16.	
	+ 60. =237.	4191.	- -	- -	12520
	+ 72.4 =285.	4220.	- -	- -	12551
				Mean	12595
	+ 103. = 22.4	240.1			
	+ 108. = 23.4	240.2			
	+ 104. = 22.3	237.1	238.2	+ 0.6	12672
	+ 106.5 = 22.6	235.3			
	+ 111. = 23 8	238.5			
	+ 111.5 = 80.6	803.2			
	+ 99. = 43.2	479.8			

. 1283.
room, 53.3

— 1229.7

, or 1200 Englifh feet.

—39°.7=26°.9×2.1 { + 56.5 =220. } =4114.—96.0 Error.

t the Cape of Good Hope.

Mr. DE LA CAILLE's barometrical Obſervations, Sept. 22, 1751, at the (

Eaſt ſignal on the Table-hill above the ſea, —	3417	11^h 30′ A.M.	30.174	66°	—111	29.890	3192.	—211.	66°	58	—	+ 6
			—.173									
Height of the obſervatory, —	14		30.001									
Vertical diſtance of the barometers in feet,	3403		26.502	52	—058	26.444		= 66.	50			=19
Veſt ſignal above the ſea, —	3468	0^h 30′ P.M.	30.174	66	—111	29.866	3289.	—179.	66	58	—	+ 6
			—.197									
eight of the obſervatory, —	14		29.977									
rtical diſtance the barometers, —	3454		26.377	50	—053	26.324		=544.	50			=20

ith Mr. DE ...'s Equation ...he air, } Mean 3426 — 3240 $58°—39°.7=18°.3\times 2.1\left\{\begin{matrix}+\ 38.4\\ =124.4\end{matrix}\right\}$ 3364.4 - - - -

.t the Cape of Good Hope.

+ 62.4				
	3391.2	- -	—11.8	11713
=199.2				
+ 62.4				
	3494.2	- -	+40.2	11662
=205.2			Mean	11687
- - -	- -	-	—62.6	

Compu-

Computations of barometrical observations made on heights that have not bee[n measured] geometrically.

Date.	Stations of the barometers.	Observed heights of the inferior and superior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation for the heat of the air
	Level of the fea at Invergourie, and Belmont-caftle.	29.932 29.734	54° 57	—072 —081	29.860 29.653	181.3	54° 54	54°	+ 54/100 =9.8
1773, July 8.	The inferior barometer at Belmont-caftle. Superior barometer, Top of Kinpurney-hill.	29.988 28.974	65 62	—108 —095	29 880 28.879	887.9	63 57	60	+71. =63.
1776, Sept. 12.	Ditto.	30.331 29.275	56¼ 51	—080 —061	30.251 29.214	908.9	57½ 50	53¾	+56. =50.
	Caftle Menzies.	29.756 29.674	60¼ 64½	—092 —104	29 .64 29.570	82.7	61 63	62	+74. = 6.
Sept. 11.	Top of Farragan.	29.794 27.344	63¾ 52½	—102 —062	29.692 27.282	2205.8	65 50	57½	+62. =137
Sept. 17.	Top of Ben Lawers.	29.800 25.830	55 38	—075 —017	29.725 25.813	3677.	54 36	45	+30. =110
	Top of Ben More.	30.000 26.148	55½ 42	—077 —029	29.923 26.119	3542.9	52½ 37	44¾	+31. =109
Sept. 12.	Top of Ben Gloe.	29.712 26.142	62 48	—097 —041	29.615 26.101	3291.3	62 45	53½	+51. =167
Sept. 13.	Blair of Athol-lawn.	29.636 29.380	60 58	—091 —083	29.545 29.297	219.6	58 60½	59¼	+67. =14.
Aug. 22.	Top of King's Seat.	29.904 28.791	68 66½	—116 —108	29.788 28.683	985.	67 64	65½	+84. =83.
1775, Sept. 5.	Hill of Barry.	29.870 29.345	62 56	—098 —076	29.772 29.269	444.	60 56	58	+64. =28.
Sept. 5.	Dunfinane-hill,	29.784 28.913	62 59	—097 —086	29.687 28.827	766.	62 59	60½	+71. =54
1774, Aug. 29 and 30. mean of three obfervations.	Quay at the new bridge of Glafgow, and ftation at Lanark.	29.560 28.850	55¾ 52¾	—077 —066	29.483 28.784	625.2	53¾ 50¾	52¼	+50. =31.
1772, Aug. 6. 2h P.M.	Freeport in the ifland of Ifla, 19 feet above the fea, and fummit of the South-pap of Jura,	30.224 27.642	67 57	—114 —076	30.110 27.566	2300.2	60 57	58½	+66. =152
1772, Sept. 25. 9h 25′ A.M.	Hafniford in Iceland, at the fea-fhore, and fummit of Mount Hecla.	29.859 24.722	49 38	—056 —016	29.803 24.706	4886.8	43 24	33½	+ 3 =16.

ot been determined

n.	Equation for the heat of the air in 1000th parts, and in feet.	Vertical diftance of the barometers.	Horizontal dif-tance of the ba-rometer in miles.
	$+\frac{54.2}{1000}$ =9.8 f.	191.1	$10\frac{1}{4}$
	+71. =63.1	951.	$2\frac{5}{8}$
		955.3	
	+56. =50.8	959.7	$2\frac{5}{8}$
	+74. = 6.1	88.8	$28\frac{1}{2}$
	+62.4 =137.8	2343.6	29
	+30. =110.	3787.	42
	+31. =109.8	3652.7	$53\frac{1}{2}$
	+51. =167.9	3459.2	$27\frac{1}{4}$
	+67. =14.7	234.3	30
	+84.3 =83.	1068.	$6\frac{3}{4}$
	+64. =28.4	472.4	$4\frac{1}{2}$
	+71.5 =54 8	820.8	$7\frac{1}{2}$
	+50.0 =31.3	656.5	$22\frac{1}{2}$
	+66.3 =152.5	2452.7	$4\frac{1}{4}$
	+ 34 =16.6	4903 4	76

mit of Mount Hecla.

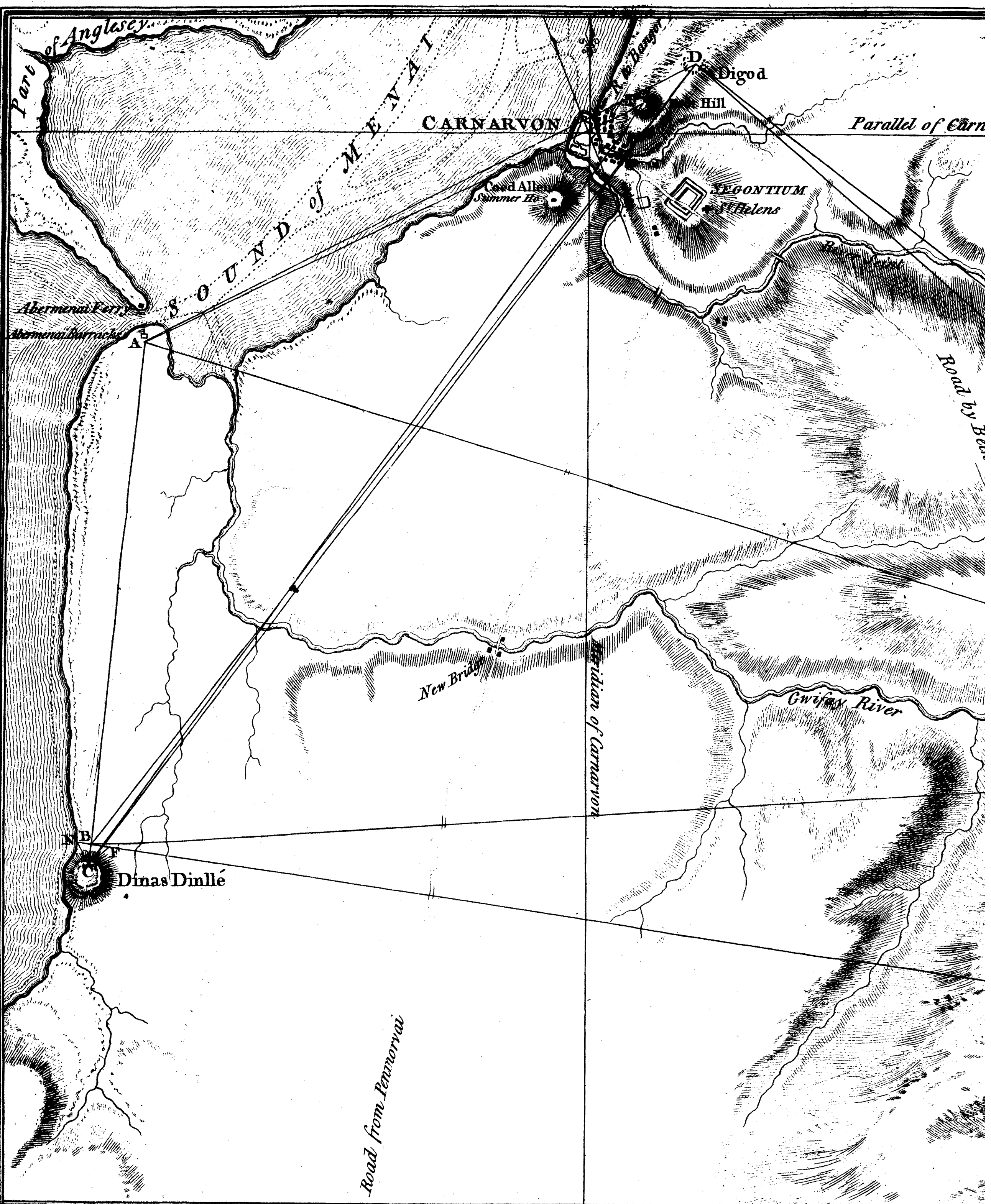
Comptu-

Computations of Mr. BOUGUER's obfervations in Peru, fuppofing them to have be
mean temperature of the day, between the coldeft of the morning

Relative heights of the ftations, with refpect to the South-fea,		Stations of the barometers, with their geometrical diftance in feet.		Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Mean heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in
Heights of the columns of air, whofe bafes ftood at the fea,		15833	South-fea,	29.930	84½°	—169	29.761	23.27	14922.	—9
			Coraçon,	16.808	43½	—022	16.786			=
		15564	South-fea,	——	84½	——	29.761	23.35	14685.6	—87
			Pichincha,	16.963	44½	—024	16.939			= 6
		9374	South-fea,	——	84½	—078	29.761	25.54	8685.5	—68
			Quito,	21.403	65½	——	21.325			= 8
		7840	South-fea,	——	84½	—084	29.761	26.15	7240.5	—59
			Carabourou,	22.625	66½	——	22.541			= 8
Superior fections of the columns of air, with the diftances of their bafes from the fea,	Coraçon, 15833	7993	Carabourou,	——	66½	——	22.541	19.66	7681.6	—31
	Carabourou, 7840		Coraçon,	——	43½	——	16.786			= 4
	Pichincha, 15564	7724	Carabourou,	——	66½	——	22.541	19.74	7445.1	—27
	Carabourou, 7840		Pichincha,	——	44½	——	16.939			= 3
	Coraçon, 15833	6459	Quito,	——	65½	——	21.325	19.05	6236.5	—22
	Quito, 9374		Coraçon,	——	43½	——	16.786			= 3
	Pichincha, 15564	6190	Quito,	——	65½	——	21.325	19.13	6000.1	—18
	Quito, 9374		Pichincha,	——	44½	——	16.939			= 3
			Mean of the four fuperior columns,	- -	- -	- -	- -	- -	- -	
	Quito, 9374	1534	Carabourou,	——	66½	——	22.541	21.93	1445.	— 8
	Carabourou, 7840		Quito,	——	65½	——	21.325			= 6

ave been made at correſponding times, and in the
rning and hotteſt of the afternoon.

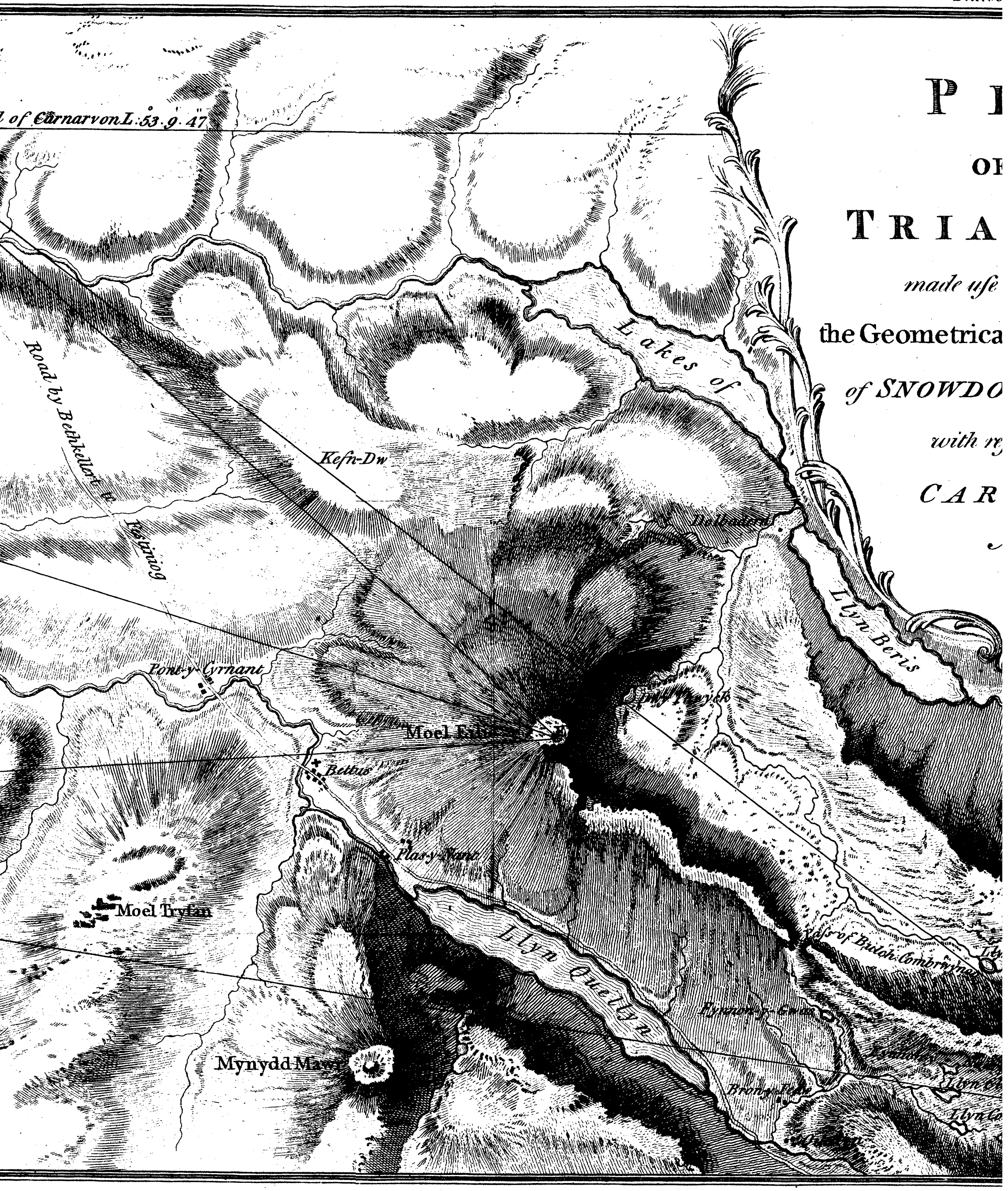
Logar. exceſs or defect in ft. and alſo in 1000th parts.	Mean temperature of the air.	Equation for the heat of the air in 1000th parts, and in feet.	Reſult by the rule in feet.	Error of the rule.	Ratio of the weight of quickſilver to air, Particular	Mean.
— 911 ft. = $\frac{61.}{1000}$	64°	+ $\frac{61.6}{1000}$ =919. ft.	15841.	+ 8.0	14590	14553
—878.4 = 60.	$64\frac{1}{2}$	+ 62. =920.4	15606.	+42.	14517	
—688.5 = 80.	75	+ 90. =781.7	9467.2	+93.2	13273	13120
—599.5 = 83.	$75\frac{1}{2}$	+ 96.5 =698.7	7939.2	+99.2	12968	
—311.4 = 40.5	55	+ 35.2 =274.4	7952.	—41.	16623	16565
—278.9 = 37.3	$55\frac{1}{2}$	+ 36.5 =271.7	7716.8	— 7.2	16507	
—222.5 = 35.7	$54\frac{1}{2}$	+ 33.2 =207.	6443.5	—15.5	17149	17021
—189.9 = 31.6	55	+ 34. =204.	6204.1	+ 14.1	16893	
$\frac{36.3}{1000}$	55	- - -	- -	- -	16793	
— 89. = 61.6	66	+ 61. = 88.	1533.	— 1.	15089	



GEOM

The Base AB, *situated on a perfectly level Plain, was measured twice in contrary directions, between the Barracks of Abermenai and the bottom of Dinas Dinllé, an ancient British Fortification, on the Sea Shore. The length of the Iron Chain made use of on this occasion, was ascertain'd by means of accurate Deal Rods, applied to it every Morning & Evening, before and after the operation of the Field. The two measurements agreed to within less than a Foot, and made the length of the Base —*

Triangles.	Angles			Sides	
			° ′ ″	Feet.	
C B F and C B N *for the prolongation of the Base* B C, *and distance of* N *from* C.	*Obs*.[d]	C BF	84.10.40	B C....482.2	
		B CF	42.55.25		
	Hence	B F C	52.53.55		
	Obs.[d]	NBC	98.46.50	N C....612.5	DI
		B CN	30.8.20		*Fo*
		CNB	51.4.50		*M*
ACD and DBC,	*Obs*.[d]	DAC	123.17.50	AD....[illegible]	D



...EOMETRICAL OPERATIONS.

...es	Triangles	Angles			Sides	Relative Heights			
Feet.				° ′ ″	Feet.			Feet.	
		Obs.d	EBA	79. 49. 10			S above B Trigonometrically	3493. 2	
482.2		—	ABD	31. 24. 36			Curvature & Refraction....	62. 3	
		=	DBE	48. 24. 34			Height of the Instrument..	4. 6	For the Altitude
	DEB and DAE,	Obs.d	EDC	86. 27. 5	DE..29319.6		S above B	3560. 1	of Moel Eilio
612.5	For the distance of	+	CDB	0. 30. 56		For the	C above B Trigy......97.3		above D, and
	Moel Eilio from	=	EDB	86. 58. 1		Altitude of	Instrument..........4.6		the Sea at
...60.5	D and A.		DEB	44. 37. 25		Snowdon	C above B..........101.9		Carnarvon.

P L A N

OF THE

I A N G L E S

de use of for obtaining

etrical Distance and Altitude

WDON and MOEL EILIO

with respect to the Sea at

ARNARVON.

Augt 1775.

Relative Heights

ltitude		Feet.
Eilio	E *above* D *Trigy.*	2183. 8
, and	*Curvature & Refraction*	16. 3
at	*Instrument*	4. 6
rvon.	E *above* D	2204.7
	D *above Carnarvon Quay*	166. 3
	Vertical distance of Baromrs.	2371. 0
	Quay above Neap Tide	13.

The length of the Iron Chain made use of on this occasion, was ascertain'd by means of accurate Deal Rods, applied to it every Morning & Evening, before and after the operation of the Field. The two measurements agreed to within less than a Foot, and made the length of the Base — 14076F. This Base AB, was afterwards prolonged to C, the Top of the Dinas by means of the side Base BF 411.7 feet. Thus the distance BC, being 482.2 feet; the total Base AC amounts to 14558.2 feet.

N, *High Watermark Neap Tide*. D. *a small Eminence called the Digod*, T, *the Toot Hill of Carnarvon*. S, *The Peak of Snowdon*. E, *A Cairn of Stones on Moel Eilio*.

The Latitude of Carnarvon was found to be 53°.9′.47″; *and the Variation of the Needle, by two Azimuths of the Sun, taken on the* 13th *of* Augt. *at* 2h.2m. *and* 3h.12m. *P.M.* 21°.18′.30″ *westerly*.

The Height of Moel Eilio above Carnarvon Quay 2371 *Feet, resulting from the simplest operation on the Digod, the nearest point to the Hill, is to be preferred to that deduced from the Angles of Elevation taken from* A.

… B C, *and distance of* N *from* C.	*Obs.d*	NBC	98.46.50	
		BCN	30.8.20	NC....612.5
		CNB	51.4.50	
ACD and DBC, *for the distance of* D *from* AB and C; *and for the Angles* CBD and BDC.	*Obs.d*	DAC	123.17.50	AD..17169.7
		ADC	26.48.30	CD..27949.7
		ACD	30.53.40	
	Cont.d	DCB	30.53.40	BC....482.2
		CBD	148.35.24	BD..27537.4
		BDC	0.30.56	
DSB *for the distance of Snowdon from* B *and* D.	*Obs.d*	ABS	92.36.15	
	—	ABD	31.24.36	
	=	DBS	61.11.39	BS..57355.2
	Obs.d	SDC	89.35.50	DS..50258.3
	+	CDB	0.30.56	
	=	SDB	90.6.46	
	Hence	DSB	28.41.35	

DI … Fo … Mc … Da … CI … di … Too … A … of … De …

NB. *The time not admitting of any actual Survey of the Envi… to be consider'd as a slight Sketch intended merely to convey a g…*

	DEB and DAE,	*Obs.d*	EDC	86 . 27 . 5	DE..29319.6
612.5	*For the distance of*	+	CDB	0 . 30 . 56	
	Moel Eilio from	=	EDB	86 . 58 . 1	
69.7	D *and* A.		DEB	44 . 37 . 25	
949.7		*Contd*	ADE	112 . 15 . 35	
			DAE	43 . 49 . 10½	AE..39190.2
482.2			DEA	23 . 55 . 14½	
537.4	CAT, *for the*	*Obs.d*	CAT	122 . 9 . 17	
	distance of the		ACT	29 . 56 . 45	AT..15430
	Toot Hill from A.		ATC	27 . 53 . 58	
		From...B...	C	11 . 24 . 37	
55.2	Angles		....S	3 . 29 . 7	
	of Elevation	*From*...C *Dep*	....N	10 . 34 . 23	
258.3	and	*From*..D...	....S	3 . 47 . 54	
	Depression		....E	4 . 15 . 35	
		From..A...	....E	3 . 24 . 17	
			....T	0 . 39 . 47	

of the Environs of Carnarvon & Snowdon to be made; the Plan is only
convey a general Idea of the nature of the Country where the Triangles were situated.

For the Altitude of Snowdon above B *and* N	S *above* B		3560.1	*of Moel Eilio above* D, *and the Sea at Carnarvon.*
	C *above* B *Trigy.*	97.3		
	Instrument	4.6		
	C *above* B	101.9		
	C *above* N *Trigy.*	114.3		
	Instrument	4.6		
	C *above* N	109.7		
	Hence B *above* N		7.8	
	Snowdon above the Sea at N		3567.9	
For the Altitude of Snowdon above D *and the Sea at Carnarvon*	S *above* D *Trigy.*		3336.7	*For the Altitude of Moel Eilio above* A, *and the Sea at Carnarvon.*
	Curvature & Refraction		47.8	
	Instrument		4.6	
	S *above* D		3389.1	
	D *above North Angle of Carnarvon Quay by Levellg*		166.3	
	Vertical distance of the Barometers		3555.4	
	Quay above High Water N: Tide		13.	
	Snowdon above the Sea		3568.4	

. Eilio	E *above* D	*2204.7*
, *and*	D *above Carnarvon Quay*	*166.3*
ı *at*	*Vertical distance* of *Barom.*rs .	*2371.0*
rvon .	*Quay above Neap Tide*	*18.*
	Moel Eilio above the Sea . . .	*2384.*
	E *above* A *Trig.*l	*2331.6*
	Curvature & Refraction	*29.1*
	Instrument	*4.6*
	Moel Eilio above A	*2365.3*
ltitude	T *above* A *Trig.*l	*178.6*
l Eilio	*Curvature & Refraction* . . .	*4.5*
., *and*	*Instrument*	*4.6*
ı *at*	T *above* A	*187.7*
von .	T *above Carnarvon Quay* by *Levelling*	*186.5*
	Quay above A	*1.2*
	Hence the Vertical distance of the Barometers	*2364.1*
	Moel Eilio above Neap Tide .	*2377.1*

Basire Sculp.t

Table, ſhewing the equation to be applied to the obſerved height of quickſilver in the barometer, from 15 to 31 inches; and for differences of temperature extending to 102° of FAHRENHEIT: whereby the column is reduced to the height it would have ſtood at in the temperature of 32°.

Obſerved height of quickſil-ver in the Barom.	Condenſation below 32°; Equation to be added to the height of the quickſilver in the barometer.									Expanſion above 32°; Equation to be ſubtracted from the height of the quickſilver in the Barometer.																				
	0°		Diff.	12°		Diff.	22°		32°	42°		Diff.	52°		Diff.	62°		Diff.	72°		Diff.	82°		Diff.	92°		Diff.	102°	
31	.1136		.0432	.0704		.0355	.0349		When the temperature of the quickſilver in the barometer is 32° of FAHRENHEIT, no equation is neceſſary.	.0344		.0339	.0683		.0334	.1017		.0328	.1345		.0324	.1669		.0317	.1986		.0311	.2297	
30½	.1118		.0425	.0693		.0349	.0344			.0339		.0333	.0672		.0328	.1000		.0323	.1323		.0319	.1642		.0312	.1954		.0306	.2260	
30	.1099		.0418	.0681		.0343	.0338			.0333		.0328	.0661		.0323	.0984		.0318	.1302		.0314	.1616		.0306	.1922		.0301	.2223	
29½	.1081		.0411	.0670		.0338	.0332			.0327		.0323	.0650		.0318	.0968		.0312	.1280		.0309	.1589		.0301	.1890		.0296	.2186	
29	.1063		.0405	.0658		.0331	.0327			.0322		.0317	.0639		.0312	.0951		.0307	.1258		.0304	.1562		.0296	.1858		.0291	.2149	
28½	.1045		.0398	.0647		.0326	.0321			.0316		.0312	.0628		.0307	.0935		.0302	.1237		.0298	.1535		.0291	.1826		.0286	.2112	
28	.1026	.00183	.0390	.0636	.00114	.0321	.0315	.000563		.0311	.000555	.0306	.0617	.001102	.0301	.0918	.00164	.0297	.1215	.00217	.0293	.1508	.002692	.0286	.1794	.003203	.0281	.2075	.003705
27½	.1008		.0384	.0624		.0314	.0310			.0305		.0301	.0606		.0296	.0902		.0291	.1193		.0288	.1481		.0281	.1762		.0276	.2038	
27	.0990		.0377	.0613		.0309	.0304			.0300		.0295	.0595		.0291	.0886		.0285	.1171		.0283	.1454		.0276	.1730		.0271	.2001	
26½	.0971		.0370	.0601		.0302	.0299			.0294		.0290	.0584		.0285	.0869		.0281	.1150		.0277	.1427		.0271	.1698		.0266	.1964	
26	.0953		.0363	.0590		.0297	.0293			.0289		.0284	.0573		.0280	.0853		.0275	.1128		.0272	.1400		.0266	.1666		.0261	.1927	
25½	.0935		.0356	.0579		.0292	.0287			.0283		.0279	.0562		.0275	.0837		.0269	.1106		.0267	.1373		.0261	.1634		.0256	.1890	
25	.0916		.0349	.0567		.0285	.0282			.0278		.0273	.0551		.0269	.0820		.0265	.1085		.0261	.1346		.0256	.1602		.0251	1853	
24	.0880		.0336	.0544		.0273	.0271			.0266		.0263	.0529		.0258	.0787		.0254	.1041		.0252	.1293		.0245	.1538		.0240	.1778	
23	.0843	.00366	.0321	.0522	.00228	.0263	.0259	.001126		.0255	.001110	.0252	.0507	.002204	.0248	.0755	.00328	.0243	.0998	.00434	.0241	.1239	.005384	.0235	.1474	.006406	.0230	.1704	.007410
22	.0807		.0408	.0399		.0251	.0248			.0244		.0241	.0485		.0237	.0722		.0232	.0954		.0231	.1185		.0225	.1410		.0220	.1630	
21	.0770		.0294	.0476		.0239	.0237			.0233		.0230	.0463		.0226	.0689		.0222	.0911		.0220	.1131		.0215	.1346		.0210	.1556	
20	.0733	.0183	.0280	.0453	.0114	.0228	.0225	.00563		.0221	.00555	.0220	.0441	.01102	.0215	.0656	.0164	.0211	.0867	.0217	.0210	.1077	.02692	.0204	.1281	.03203	.0201	.1482	.03705
15	.0550		.0211	.0339		.0170	.0169			.0166		.0165	.0331		.0161	.0492		.0158	.0650		.0158	.0808		.0153	.0961		.0150	.1111	

SECTION

TABLE II. Results of experiments on the expansion of air of the density of five-sixths of the common atmosphere; and of others on air that was extremely rare, being only pressed with about one-fifth of an atmosphere.

Set	N°	Height of the barom.	Inches of quick-silver.	Density in inches.	Total expansion of 1000 equal parts of air by 212°.	Mean rate for each degree.	Expansion for intermediate temperatures. From 0 to 32°.	32° to 52°.	52° to 72°	72° to 92°	92° to 132°	132° to 172°	172° to 212°
First set.	1	29.85	—5.44	24.41	495.455	2.33705	—	—	Not observed.	—	—	—	—
	2	29.76	—3.05	26.71	504.340	2.37896	2.27190	2.41666	2.64060	2.55200	2.46040	2.31850	2.20748
	3	29.79	—0.53	29.26	470.32	2.21849	1.90437	2.48150	2.63150	2.59650	2.15050	2.12000	2.10925
	4	30.09	—5.43	24.66	469.07	2.21259	2.32688	2.53450	2.66250	2.24800	2.25425	2.05325	1.83525
	5	29.93	—9.63	20.30	479.20	2.26038	2.14750	2.49500	2.59850	2.24700	2.25950	2.21375	2.11850
	Mean,			25.17	483.677	2.28140	2.16266	2.48191	2.63327	2.41087	2.28116	2.17637	2.06762

Set	N°	Experiment	Difference of temperature.	from	to	Total expansion.	Mean rate.
First set.	6	Experiment in a heated room in Philpot lane, February 25, barometer 30.°03—4.82=25.21 the density of the air, —	on 113½	48½	162	244.604	2.15510
			51½	48½	100	126.311	2.45264
			62	100	162	118.293	1.90800
Second set.	7	In Philpot lane; tube with a small bore; barometer 30.03—23.2=6.77 the density. The air had been heated red-hot in the bulb before it was sealed, — — —	on 113½	48½	162	138.75	1.22247
			51	48½	101½	71.93	1.41039
			60½	101½	162	66.82	1.10446
		The expansion for 212°, at the mean rate, would be —	—	—	—	259.164	
	8	In Pulteney street, February 28th; with the same manometer that had been used in the same experiment in Philpot lane, barometer 30.08—23.2=6.88 the density of the air, — —	on 212	—	—	330.487	1.55890
			32 above zero.			44.574	1.39294
			20	32	52	37 771	1.88855
			80	52	132	139 784	1.74730
			60	132	192	94.804	1.58007
			20	192	212	13.554	0.67770
	9	In Pulteney street, April 19th; tube with a large bore, barometer 29.8—24.08=5.72 the density of the air, which had been heated red-hot in the bulb before it was sealed, — —	on 180	32	212	141.504	0 78613
			20	32	52	17 845	0 89225
			20	52	72	25.943	1.29715
			20	72	92	20.911	1.04550
			20	92	112	14.937	0.74685
			20	112	132	14.228	0.71140
			20	132	152	14.151	0.70755
			20	152	172	14.150	0.70750
			20	172	192	12.264	0.61320
			20	192	212	7.075	0.35375
		The Expansion for 212° at the mean rate would be, —	—	—	—	166.660	
		Mean of the three means; density 6.46, expansion for 212°,	—	—	—	252.104	1.18917

TABLE IV. Refults of experiments on the expanfion of air, artificially moiftened, by the admiffion of fteam, and fometimes water, into the bulb of the manometer.

	N°	Height of the barom.	Inches of quickfiver confining the air.	Denfity in inches.	Total expanfion of 1000 equal parts of air by 112°.	Mean rate for each degree.	Expanfion for intermediate temperatures. from zero to 32°.	32° to 52°	52° to 72°	72° to 92°.	92° to 112°.	112° to 132°	132° to 152°.	152° to 172°	172° to 192°	192° to 212°
First fet: fteam admitted into the bulb before it was fealed.	1	30.16	+1.6	31.76	———	———	2.059375	2.60700	3.02650	3.38050	4.18300	6.48000	8.67750	11.93600	16.85050	———
	2	29.97	+2.2	32.17	1409.04	6.64642	2.20250	2.59250	2.90950	3.67650	5.16700	6.93300	10.17500	10.64200	16.57850	8.25400
	3	30.00	+2.2	32.20	1350.10	6.36840	2.26875	2.59100	3.04900	3.77550	4 36900	7.60500	8 94400	10.42950	11.92200	11.69000
	4	30.43	+1.92	32.35	———	———	2.20875	2.51450	2.74700	3.25500	3.73700	5.91350	9 18950	11.57550	25.88650	———
	5	30.2	+1.6	31.80	1999.71	9.43259	2.361875	2.51300	2.96400	3.84750	5.76100	7.19450	12.29850	16.69750	19.29500	25.23550
	6	30.32	+2.37	32.69	2576.16	12.15169	2.16250	2.55350	3.11600	3.72300	5.53600	7.83900	12.74100	16 74600	27.84350	45.25000
Second fet: a drop of cold water admitted into the bulb before it was fealed.	7	30.2	+1.3	31.50	1135.48	5.35604	2.22594	2.74450	2.90500	3 47750	5.41900	6.16650	7.98850	8.58950	10.93600	4.98600
	8	30.06	+3.2	33.26	———	———	2.54062	2.63350	2.80850	3.78700	4.60750	———	Tube broken.		———	———
	9	30 32	+1.6	31.92	1538.31	7.25618	2.02156	2.54250	3.22500	3.76500	5 41700	6.79250	9.14350	9.71100	13.75550	19 93270
Mean,				32.18	1668.13	7.86854	2.22799	2.58800	2.97228	3.63194	4.91072	6.86550	9.89494	12.04087	17.88344	19.22470
Mean of the fecond, third, and feventh,				31.96	1298.20	6.12362	2.23239	2.64267	2 95450	3.64317	4.98500	6.90150	9.03583	9.88700	13.14550	8.31000
Mean of the fifth, fixth, and ninth,				32.14	2038.06	9.61349	2.18198	2.53633	3.10167	3.77850	5.57133	7.27533	11.39500	14.38483	20.29800	30.13940

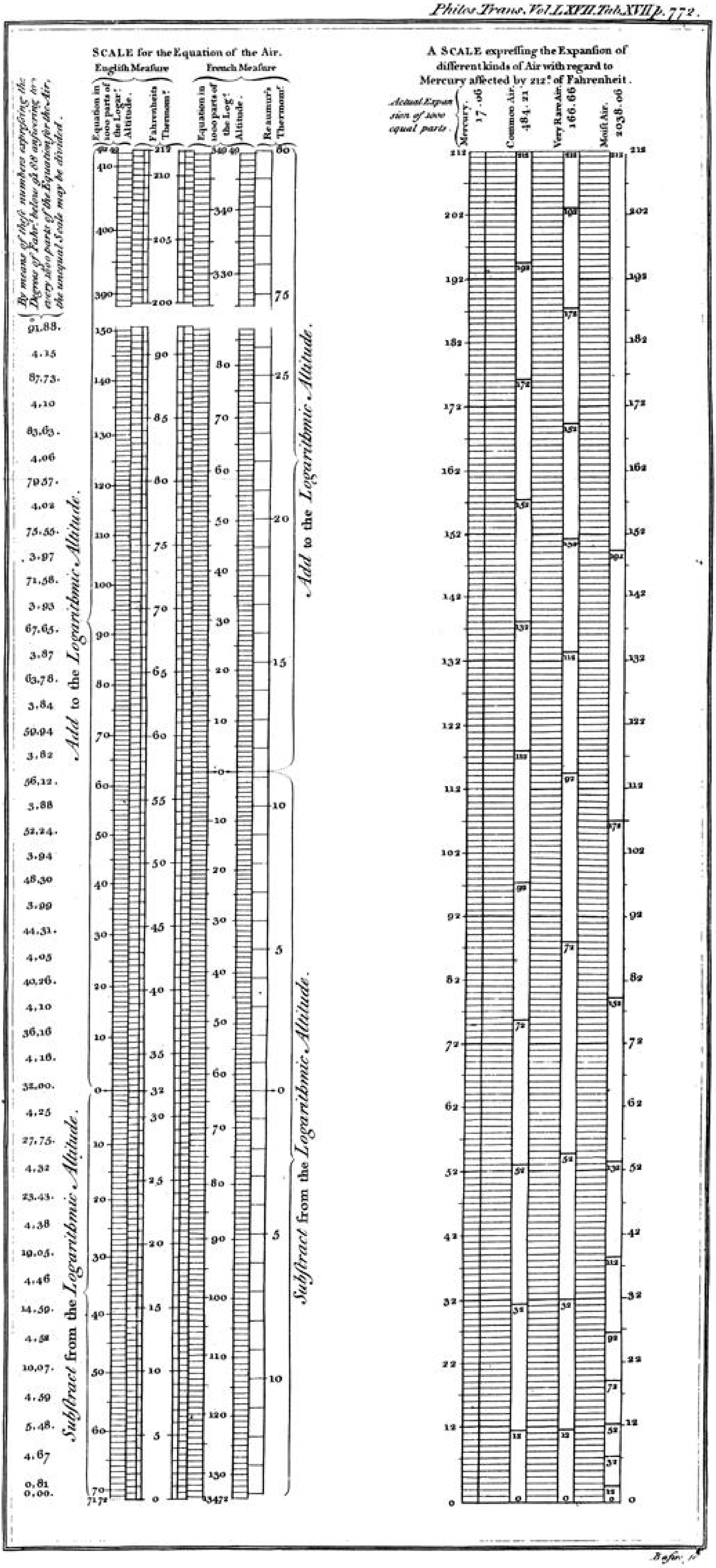
By N° 1. the total expanfion for 192° is 1208.72, whence the mean rate is 6.29542.
4. — — 192° 1367.05, — — 7.12005.
8. — — 112° 358.03, — — 3.19669.

From

Table shewing the equation depending on the temperature of the column of air, and its elevation above the sea, as denoted by the mean height of quickfilver in the inferior and fuperior barometers.

Mean temperature of the column of air.	Mean equated height of quickfilver in the inferior and fuperior barometers. Equation in thoufandth parts of the logarithmic altitude.																														Rate of diminution for whole and half inches.
	Inches 19		20	21	22		23	24	25		26		26½		27		27½		28		28½		29		29½		30		30½		
Add to the logarithmic altitude.																								2.38							
92°	89.364	—	95.456	101.548	107.640	—	113.733	119.825	125.918	—	132.010	—	135.057	—	138.103	—	141.149	—	144.195	—	147.242	—	150.288	—	153.334	—	156.381	—	159.427	—	6.0925 3.04625
		1.44				1.73				2.03		2.13		2.18		2.22		2.27		2.32		2.37		2.42		2.47		2.52		2.57	
82	74.967	—	80.078	85.189	90.300	—	95.411	100.522	105.633	—	110.744	—	113.299	—	115.855	—	118.411	—	120.966	—	123.522	—	126.077	—	128.632	—	131.188	—	133.743	—	5.111 2.5555
		1.49				1.80				2.10		2.21		2.26		2.31		2.36		2.41		2.46		2.51		2.56		2.61		2.66	
72	60.028	—	64.120	68.213	72.305	—	76.398	80.491	84.583	—	88.675	—	90.722	—	92.768	—	94.814	—	96.860	-	98.907	—	100.953	—	102.999	—	105.047	—	107 093	—	4.09250 2 04625
		1.52				1.83				2.14		2.25		2.30		2.35		2.40		2.45		2.51		2.56		2.61		2.66		2 71	
62	44.818	—	47.873	50.928	53.983	—	57.039	60.094	63.150	—	66.205	—	67.733	—	69.261	—	70.789	—	72.316	—	73.844	—	75.372	—	76.900	—	78.427	—	79.954	—	3.0555 1.52775
		1.55				1.87				2.18		2.29		2.34		2.39		2.45		2.50		2.55		2.60		2.66		2.71		2.76	
52	29.335	—	31.335	33.335	35.355	—	37.335	39.335	41.335	—	43.335	—	44.335	—	45.335	—	46.335	—	47.335	—	48.335	—	49.335	—	50.335	—	51.335	—	52.335	—	2.000000 1.000000
		1.49				1.80				2.10		2.21		2.26		2.31		2.36		2.41		2.46		2.51		2.56		2.61		2.66	
42	14.394	—	15.376	16.358	17.340	—	18.321	19.303	20.284	—	21.266	—	21.757	—	22.248	—	22.739	—	23.229	—	23.720	—	24.211	—	24.702	—	25.193	—	25.684	—	0.981625 0.490812
		1.44				1.73				2.03		2.13		2.18		2.22		2.27		2.32		2.37		2.42		2.47		2.52		2.57	
32	When the mean temperature of the column of air to be meafured is at 32°, the differences of the logarithms give the real height in fathoms and 1000th parts.																														
Subtract from the log. altitude.		1.39				1.67				1.95		2.05		2.09		2.14		2.19		2.24		2.28		2.33		2.38		2.42		2.47	
22	13.852	—	14.796	15.741	16.685	—	17.630	18.575	19.519	—	20.463	—	20.936	—	21.408	—	21.880	—	22.353	—	22.825	—	23.297	—	23 769	—	24.242	—	24.714	—	0.47225 0.94450
		1.33				1.60				1.88		1.97		2.01		2.06		2.10		2.15		2.19		2.24		2.28		2.33		2.37	
12	27.162	—	29.014	30.866	32.718	—	34 569	36.421	38.273	—	40.125	—	41.051	—	41.976	—	42.902	—	43.828	—	44.754	—	45,680	—	46.606	—	47.532	—	48.458	—	0.925875 1.85175
																								2.17							

I. Compu-


SCALE for the Equation of the Air.
English Measure
French Measure
Equation in 1000 parts of the Logar. Altitude.
Fahrenheits Thermom.
Equation in 1000 parts of the Log. Altitude.
Reaumur's Thermom.
By means of these numbers expressing the Degrees of Fahr. below 98.88 answering to every 100 parts of the Equation for the Air, the unequal Scale may be divided.
Add to the Logarithmic Altitude.
Subtract from the Logarithmic Altitude.
A SCALE expressing the Expansion of different kinds of Air with regard to Mercury affected by 212° of Fahrenheit.
Actual Expansion of 1000 equal parts.
Mercury. 17.06
Common Air. 484.21
Very Rare Air. 166.66
Moist Air. 2038.06
Basire sc.

N° I. Computations of barometrical obſervations made on heights in and near London.

Geometrical heights of the ſtations in feet.	Date of the obſervations, winds, &c.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar. exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the rule in 1000th parts, and alſo in feet.	Reſult by the rule, Particular.	Reſult by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quickſilver to air, air being 1.
St. Paul's Church-yard North-ſide, and iron-gallery over the dome, 281 feet.	1774, Dec. 1. 9h 27′ wind N.W.	29.659 29.338	33°¼ 34	—006 —006	29.653 29.332	283.6	+2.6ft. = 9/1000	32°¾ 33¾	33°¼	+ 38/1000 = 1. ft.	284.6	- -	- -	10505
	Dec. 31. 11h 52′ A.M. wind N.E.	30.187 29.864	35½ 34¾	—011 —009	30.176 29.855	279.5	— 1.5 = 5.5	33 34	33½	+ 4. = 1.	280.5	281.4	+0.4	
	April 22. 11h 55′ A.M. E. wind.	30.136 29.839	50¼ 53	—060 —069	30.076 29.770	266.5	—14.5 =54.4	49 53	51	+47.5 =12.7	279.2	- -	- -	11056
Top of Paul's-ſtairs, and the ſaid gallery, 324 feet.	1774, Ap. 22. 0h 50′ P.M.	30.206 29.842	55¼ 53¾	—080 —071	30.126 29.771	308.9	—15.1 =49.	55½ 53¾	54½	+55. =17.	325.9	- -	- -	10860
	Dec. 1. 10h 2′ A.M.	29.717 29.344	37 35	—016 —009	29.701 29.335	323.1	— 0.9 = 3.	37½ 34	35¾	+ 6.3 = 2.	325.1	324.6	+0.6	
	Dec. 31. 0h 22′ P.M.	30.230 29.858	35¾ 34¾	—011 —009	30.219 29.849	321.	— 3. = 9.3	34½ 34¾	34½	+ 5.8 = 1.8	322.8	- -	- -	10565
Scotland-yard wharf, and Old Spaniard dining-room, 422 feet.	1774, Dec. 24. 10h 7′ A.M. N.E. wind.	30.844 30.349	33¾ 33¼	—005 —004	30.839 30.345	420.8	— 1.2 = 3.5	34¼ 33¾	33¾	+ 4. = 0.9	421.7	- -	—0.5	10251
Great Pulteney-ſtreet, and the ſaid dining-room, 352 feet.	1774, Nov. 28. 9h 48′ A.M.	29.684 29.287	35½ 34½	—011 —009	29.673 29.278	349.2	— 2.8 = 8.5	35½ 34¼	35	+ 7. = 2.4	351.6	- -	- -	10694
	Dec. 9. 0h 15′ P.M. N.W. wind, ſnow.	29.647 29.234	27½ 25¼	+015 +022	29.662 29.256	359.	+ 7. =19.7	27½ 23¾	25½	—14.5 = 5.2	353.8	- -	- -	10404
	Dec. 24. 10h 52′ A.M. N.E. wind.	30.758 30.343	35 33	—010 —003	30.748 30.340	348.1	— 3.9 =11.2	34½ 30¼	32½	+ 1.2 = 0 4	348.5	- -	- -	10328
	1775, June 13. 11h 7′ A.M. S.W. wind.	30.044 29.674	69 69	—121 —117	29.923 29.557	320.7	—31.3 =97.6	67½ 72½	70	+96. =30.8	351.5	- -	- -	11416
	1776, May 10. 10h 30′ A.M.	30.096 29.706	53 51¼	—069 —063	30.027 29.643	335.4	—16.6 =50.	51½ 49¾	50¾	+46.9 =15.7	351.1	- -	- -	10971
	May 30. 11h 40′ A.M. S.W. wind.	29.900 29.521	66 63	—111 —100	29.789 29.421	323.9	—28.1 =86.7	66 63	64½	+81.8 =26.5	350.4	353.5	+1.5	11447
	June 20. 0h 15′ P.M.	30.268 29.898	71½ 71½	—129 —127	30.139 29.771	320.1	—31.9 =99.7	71 71½	71¼	+101. =32.3	352.4	- -	- -	11416
	July 16. 0h 15′ P.M.	29.625 29.253	67½ 67½	—113 —112	29.512 29.141	329.6	—22.4 =68.	67¼ 65½	66¾	+87.4 =28.8	358.4	- -	- -	11355
	Aug. 26. 10h 35′ A.M.	30.132 29.738	59½ 57¼	—092 —082	30.040 29.656	335.2	—16.8 =50.1	59¼ 56½	57¾	+65. =21.8	357.0	- -	- -	10887
	Aug. 27. 11h 45′ A.M.	30.020 29.631	62¼ 60	—099 —091	29.921 29.540	334.	—18. =54.	62 58¼	60	+70.2 =23.4	357.4	- -	- -	11028
	Sept. 2. 10h 15′ AM.	29.294 28.918	60 58½	—089 —084	29.205 28.834	333.1	—18.9 =56.8	59¾ 59½	59½	+69. =23.	356.1	- -	- -	11355
Pagoda in Kew-gardens, 116.5 feet.	1773, Dec. 20. 1h 22′ P.M. mean of 6 obſervations with 3 barometers.	29.351 29.226	49½ 49¼	—052 —052	29.299 29.174	111.4	— 5.1 =45 8	49¼ 49¼	49¼	+43.3 = 4.8	116.2	- -	—0.3	11184
Gun-wharf of Woolwich-warren, and upper ſtory of Shooter's-hill inn, 444 feet.	1774. Apr. 27. 4h P.M. mean of 4 obſ.	29.762 29.282	57½ 56½	—082 —077	29.680 29.205	420.4	—23.6 =56.1	52½ 58½	55½	+59.2 =24.9	445.3	- -	- -	11170
	Apr. 27. 6h 30′ P.M. mean of 2 obſ.	29.773 29.302	54 55½	—072 —074	29.701 29.228	418.3	—25.7 =61.4	49 49½	49¼	+43.5 =18 2	436.5	438.9	—5.1	11217
	Apr. 28. 5h A.M. mean of 5 obſ.	29.805 29.336	44½ 48¼	—041 —053	29.764 29.283	424.5	—19.5 =46.	43 41½	42½	+24.5 =16 4	434 9	- -	- -	11077

N° II.

N° II. Computations of barometrical obfervations made on heights near Taybridge in Perthfhire; and N° III. of thofe near Lanark.

N° II. near Taybridge.

Geometrical heights of the ftations in feet.	Date of the obfervations, winds, &c.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in ft. and alfo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the rule in 1000th parts, and alfo in feet.	Refult by the rule, Particular.	Refult by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quickfilver to air, air being 1.
Station at Weem, and top of Weem-craig, 700½ feet.	1774, July 16. 11h 30′ A.M. bright Sun-fhine.	29.996 29.237	69°½ 65¼	−122 −107	29.874 29.130	657.2	−43.2ft. = 66/1000	65°½ 60	62°¼	+ 77/1000 = 50.0ft.	707.8	- -	+ 7.6	11249
Ditto ftation, and top of Bolfrack's cairn, 1076½ feet.	July 16. 6h 30′ P.M. calm and cloudy.	29.933 28.788	61½ 58½	−097 −083	29.836 28.705	1007.	− 69.5 = 69.	60 56¼	58½	+ 67.5 = 68.5	1075.5	- -	− 1.	11382
Ditto ftation, and top of Dull-craig, 1244½ feet.	July 18. 7h 20′ A.M.	29.825 28.500	58¼ 55	−086 −072	29.739 28.428	1174.	− 70.2 = 60.	57 55	56	+ 60. = 70.4	1244.4	- -	- -	11354
Ditto ftation, and top of Knock-farle, 1364½ feet.	July 18. 5h 4′ A.M.	29.816 28.347	55¼ 51	−077 −059	29.739 28.288	1303.5	− 61. = 46.8	54 48½	51¼	+ 47.5 = 62.	1365.5	- -	+ 1.	11254
Ditto ftation, and that in Glenmore, 1279½ feet.	July 12. 7h 30′ P.M.	29.528 28.161	58 51¼	−084 −060	29.444 28.101	1216.5	− 62.7 = 51.6	55 51½	53¼	+ 52. = 63.2	1279.7	- -	- -	11396
Ditto ftation, and South obfervatory on Schihallien, 2098 ft.	July 11. 7h 30′ P.M.	29.643 27.432	58¾ 48	−086 −048	29.557 27.384	1989.8	−108.2 = 54.4	58 47¼	52½	+ 51. = 101.5	2091.3	- -	− 6.7	11554
Ditto ftation, and Weft fummit of Schihallien, 3281 feet.	July 11. 7h 30′ A.M.	29.595 26.194	59½ 46	−089 −040	29.506 26.154	3142.3	−138.7 = 44.1	56 45	50½	+ 43.5 = 136.7	3279.	- -	− 2.	11693
	July 12. 5h A.M.	29.610 26.223	50¼ 44	−062 −035	29.548 26.188	3145.5	−135.5 = 43.1	50¼ 42	46⅛	+ 34.3 = 107.	3252.5	- -	−29.5	11690
Station in Glenmore, and the South obfervatory, 818 76.	July 12. 8h P.M.	28.161 27.325	51¼ 48½	−060 −050	28.101 27.275	777.4	− 41.4 = 53.2	51½ 48	49¾	+ 42. = 32.6	810.	- -	− 8.8	11851
The obfervation on Schihallien on July 11, by Mr. DE LUC's equation for the air, — — —						3142.3	50°.5−39°.7=10°.8×2.1			+ 22.7 = 71.3	3213.6	- -	−67.4	

N° III. near Lanark.

Geometrical heights of the ftations in feet.	Date of the obfervations, winds, &c.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in ft. and alfo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the rule in 1000th parts, and alfo in feet.	Refult by the rule, Particular.	Refult by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quickfilver to air, air being 1.
Level of the Clyde at Lanark Bridge, and the ftation at the garden, 362½ feet.	1774, Aug. 20. 6h 30′ A.M.	29.776 29.383	62½ 61¼	−099 −094	29.677 29.289	342.9	−19.6 =57.1	62 62	62	+ 74. = 25.4	368.3	- -	- -	11083
	Aug. 23. 3h 8′ P.M.	29.956 29.563	64¼ 65	−107 −106	29.849 29.457	344.5	−18. =52.3	63 63	63	+ 77.8 = 26.8	371.3			
	Sept. 5. 8h A.M.	29.626 29.232	52½ 50½	−067 −060	29.559 29.172	343.4	−19.1 =55.6	52½ 49½	51	+ 46. = 15.8	359.2	364.4	+1.9	11182
	Sept. 7. 7h 47′ A.M.	29.864 29.467	50¼ 51	−061 −062	29.803 29.405	350.3	−12.2 =34.8	45 44	44½	+ 30.5 = 10.7	361 0	- -	- -	10875
	Sept. 7. 9h A.M.	29.886 29.488	50¼ 51¼	−061 −063	29.825 29.425	351.8	−10.7 =30.4	47 41	44	+ 29. = 10.2	362 0			
Level of the Clyde, and Stonebyre-hill, 654 feet.	Sept. 7. 8h 15′ A.M.	29.872 29.148	48¼ 46¼	−055 −045	29.817 29.103	631.6	−22.4 =35.4	46¼ 45¼	45¼	+ 32.3 = 20.4	652.	- -	−2.0	10946
Carmichael-well, and Weft-end of Carmichael-hill, 451½ feet.	July 30. 5h 40′ P.M. S.W. wind, beginning to rain.	29.162 28.690	56 54½	−076 −071	29.086 28.619	421.8	−29.7 =70.3	54¼ 53¼	54	+ 52.3 = 22.	443.8	- -	−7.7	11430
	Aug. 1. 11h 40′ A.M.	29.612 29.135	58¼ 60	−086 −089	29.526 29.046	427.1	−24.4 =57.1	57 54¼	55⅛	+ 57.1 = 24.4	451.5	- -	- -	
Carmichael-well, and top of Tinto, four feet below the fummit of the Cairn, 1642.5 ft.	June 30. 1h 30′ P.M.	28.991 27.284	61¼ 55¼	−093 −069	28.898 27.215	1563.6	−78.9 =50.5	58 51	54½	+ 53. = 83.3	1646 9	- -	- -	11684
	July 30. 6h A.M.	29 063 27.335	51½ 46¼	−062 −043	29.001 27.292	1582.6	−59.9 =38.	51 44	47½	+ 36.4 = 57.4	1640.	- -	- -	11412
	Aug. 2. 8h 15′ A.M.	29.608 27.846	54¼ 47½	−072 −048	29.536 27.798	1580.3	−62.2 =39 3	51½ 44½	48	+ 39.6 = 62.4	1642.7	1645.5	+3.0	
	Aug. 27. 11h 50′ A.M. S.W. wind.	28.710 27.008	59½ 53¼	−087 −063	28.623 26.945	1570.3	−72.2 =46.	55½ 47¼	51½	+ 45.6 = 72.3	1642.6	- -	- -	11704
	Aug. 27. 1h 40′ P.M. hail.	28.736 27.032	60¼ 53	−090 −062	28.646 26.970	1571.	−71.5 =45.5	55½ 50	52¾	+ 49. = 76.8	1647.8			
	Aug. 27. 1h 50′ P.M.	28.716 27.010	58½ 52¼	−083 −061	28.633 26.949	1579.5	−63. =40.	55½ 48¼	52	+ 46.4 = 73.3	1652.8			
Mean of the obfervations on Tinto, with Mr. DE LUC's equation for the air, — — —						1574.5	51°−39°.7=11.3×2.1			+ 24.8 = 39.	1613.5	- -	−29.	1

N° IV.

N° IV. Computations of barometrical obfervations on heights near Edinburgh.

Geometrical heights of the ftations in feet.	Date of the obfervations, winds, &c.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in ft. and alfo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the rule in 1000th parts, and alfo in feet.	Refult by the rule, Particular.	Refult by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quickfilver to air being 1.
Leith Pier-head, and Calton-hill, 344 feet.	1774, Aug. 12. 5^{h} 20′ A.M.	30.086 29.704	52°¾ 49¼	−067 −058	30.019 29.646	325.8	−18.2ft. $=\frac{56}{1000}$	50°¾ 49	50°	$+\frac{47}{1000}$ =15.3f.	341.1	– –	– –	11037
	Aug. 15. 6^{h} 45′ A.M.	29.568 29.197	55½ 53½	−075 −068	29.493 29.129	323.6	−20.4 =60.3	54 54½	54¼	+54. =17.5	341.1	339.5	−4.5	
	Aug. 15. 0^{h} 15′ P.M. S.W. wind and rain.	29.625 29.282	56½ 53½	−078 −068	29.547 29.214	319.1	−24.9 =78.	54 54½	54¼	+54. =17.2	336.3	– –	– –	11761
Leith Pier-head, and top of Arthur's Seat, 803 feet.	Aug. 15. 5^{h} 15′ A.M. S.W. wind and rain.	29.567 28.704	55½ 51¼	−075 −062	29.492 28.642	762.	−41. =53.8	54 50¾	52¼	+50. =38.	800.	– –	−3.	11309
Leith Pier-head, and Kirk Yetton cairn, 1544 feet.	Sept. 15. 10^{h} 30′ A.M. S.W. wind.	29.953 28.291	57½ 52¼	−084 −063	29.869 28.228	1472.5	−71.5 =48.6	54½ 47¼	51	+47. =69.2	1541.7	– –	−2.3	11249
Calton-hill, and Kirk-Yetton cairn, 1200 feet.	Sept. 15. 1^{h} 15′ P.M. S.W. wind.	29.561 28.272	63¾ 54	−100 −068	29.461 28.204	1136.2	−63.8 =56.2	56¼ 48¼	52¼	+52. =59.	1195.2	– –	−4.8	11410
Level of Hawk-hill ftudy, and bottom of Small-rock, 7.4 ft. below the top of Arthur's Seat, 702.4 feet.	1774, Dec. 1. 2^{h} 45′ P.M.	29.565 28.770	35 32	−010 — —	29.555 28.770	701.5	− 0.9 = 1.3	33 30½	31¾	− 0.5 = 0.3	701.2	– –	– –	10724
	Dec. 10. 9^{h} 46′ A.M.	29.494 28.687	20½ 20¼	+038 +037	29.532 28.724	722.9	+20.5 =28.3	20¾ 20¼	20½	−26.6 =19.2	703.7	705.3	+2.9	11445
	1775, Jan. 26. 1^{h} 35′ P.M.	29.490 28.674	26½ 24¼	+018 +026	29.508 28.700	723.5	+21.1 =29.	26 23	24½	−17. =12.4	711.1	– –	– –	10419
Bafe of Hawk-hill obfervatory, and bottom of the Small-rock on Arthur's Seat, 684 feet.	Nov. 10. 11^{h} 30′ A.M.	29.959 29.177	38 34	−020 −006	29.939 29.171	677.2	− 6.8 =10.	36½ 34	35¼	+ 8.6 = 5.8	683.	– –	– –	10646
	Nov. 17. 9^{h} 30′ A.M.	29.543 28.769	33½ 30¼	−004 +005	29.539 28.774	683.8	— —	32 29½	30¾	− 3.5 = 2.4	681.4	– –	– –	10729
	1776, Jan. 31. 10^{h} 45′ A.M.	30.009 29.229	15½ 24	+056 +026	30.065 29.225	711.7	+27.7 =39.	14 20	17	−35.2 =25.	686.7	684.5 – –	+0.5 – –	10184
	July 25. 2^{h} 20′ P.M.	30.157 29.427	70½ 66½	−125 −111	30.032 29.316	628.8	−55.2 =87.7	69½ 67	68¼	+94. =58.2	687.0	– –	– –	11416
Hawk-hill garden-door, and bottom of the rock on Arthur's Seat, 730.8 feet.	1775, Dec. 27. 11^{h} 30′ A.M.	29.807 28.985	30¼ 29¼	+004 +007	29.811 28.992	725.9	− 4.9 = 6.7	29½ 29½	29½	− 5.7 = 4.1	721.8	– –	– –	10707
	Dec. 27. 8^{h} 40′ A.M.	29.778 28.945	35¼ 33	−013 −003	29.765 28.942	730.6	— —	35½ 32½	34¼	+ 5.4 = 4.	734.6	– –	– –	10642
	1776, Feb. 1. 9^{h} 30′ A.M.	29.883 29.032	28½ 26½	+011 +019	29.894 29.051	745.4	+14.6 =19.6	24½ 26½	25½	+15.4 =11.5	733.9	734.7 – –	+3.9 – –	10390
	Aug. 3. 2^{h} 20′ P.M.	30.135 29.348	75½ 72	−141 −127	29.994 29.221	680.4	−50.4 =74.	72½ 69	73¼	+100. =68.	748.4	– –	– –	11286
In thefe two laft obfervations Mr. DE LUC's equation for the air being fubftituted,	1776, Feb. 1.					745.4		39°.7—25°.5=14°.2×2.1		−29.8 =22.2	723.2	– –	−7.6	
	Aug. 3.					680.4		70°.7—39°.7=31°. ×2.1		+65.1 =44.3	724.7	– –	−6.1	

N° V.

N° V. Computations of barometrical obſervations made on heights near Linhouſe. and N° VI. of thoſe near Carnarvon in North Wales.

N° V. near Linhouſe.

Geometrical heights of the ſtations in feet.	Date of the obſervations, winds, &c.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar. exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the rule in 1000th parts, and alſo in feet.	Reſult by the rule, Particular.	Reſult by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quickſilver to air, air being 1.
Linhouſe and Eaſt-cairn hill, 5 feet below the ſummit, 1176.6 feet.	1775, Nov 11. 8h A.M. calm and clear.	29.216 27.912	32° 30	— +006	29.216 27.918	1184.2	+7.6 ft. = 6.4/1000	32° 29	30°½	+ 3.4/1000 = 4. ft.	1180.	1181.3	+ 4.7	10894
	Nov. 15. noon.	28.941 27.632	32 27	— +015	28 941 27.647	1191.9	+ 15.3 = 12.8	32 26	29	— 7. = 8.3	1182.6			
Linhouſe, and Eaſt-cairn hill, 18 feet below the top, 1165.6 feet.	1776, Dec. 17. 2h P.M.	28.990 27.688	31½ 24	+001 +025	28.991 27.713	1174.8	+ 9.2 = 7.9	30¾ 22	26½	— 14. = 16 4	1158.4	- -	— 7.2	10910
	Subſtituting Mr. DE LUC's equation for the air,					—	39°.7—26°.1=13°.6×2.1			= 28 6 = 33.6	1141.2	- -	—24.4	
Linhouſe, and Weſt-cairn hill, 11 ft. below the top, 1178.4 ft.	1775, Dec. 1. 1h P.M. high S.W. wind, fog above.	29.250 28.003	49 45	—055 —042	29.195 27.961	1125.3	— 53.2 = 47.3	48° 45	46°½	+ 35. = 39.4	1164.7	- -	—13.7	11441
Linhouſe, and Corſton hill, 4 feet below the top, 386.5 ft.	Dec. 8. 1h P.M. clear and windy.	29.686 29.521	41 39	—029 —023	29.657 29 288	379.7	— 6.8 = 18.	40 39	39½	+ 18. = 6.8	386.5	- -	- -	10736
Corſton hill, and Weſt-cairn hill, 792 feet.	1776, Dec. 16h 11′ A.M. high N. wind, clear weather.	28.580 27.714	34½ 32	—009 —	28.571 27.714	793.6	+ 1.6 = 2.	34½ 30	32½	+ 0.3 = 0.2	793.8	- -	+ 1.8	11077
Corſton hill, and Eaſt cairn hill, 776.6 feet.	Dec. 17. 1h A.M. light W. wind.	28.574 27.710	32 25	— +022	28.574 27.732	779.4	+ 2.8 = 3.6	31 23½	27¼	— 10.2 = 9.3	770.1	- -	— 6.5	11068
Linhouſe, and Corſton hill, 388.5 feet.	Nov. 20. 1h P.M. ſnow had fallen, high W. wind.	27.992 27.582	35 33	—009 —003	27.983 27.579	379.	— 9.5 = 28.2	33 33	33	+ 2 2 = 0 8	379.8	- -	— 8.7	11540

N° VI. near Carnarvon.

Geometrical heights of the ſtations in feet.	Date of the obſervations, winds, &c.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar. exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation by the rule in 1000th parts, and alſo in feet.	Reſult by the rule, Particular.	Reſult by the rule, Mean.	Error of the rule in feet.	Ratio of the weight of quickſilver to air, air being 1.
Carnarvon Quay, and Moel Eilio, 2371 feet.	1775, Aug. 4. 1h 7′ P.M. rain above, clear below.	29.693 27.714	62½ 54	—098 —066	29.595 27.148	2248.8	—122.2 + 54.4	62¾ 51	56¾	+ 59.6 =134.	2382.8	- -	- -	11594
	Aug. 8. 0h 7′ P.M. S. wind, and hazy weather above.	30.036 27.543	68 57	—118 —075	29.918 27.468	2226.3	—194.7 = 65.	68¾ 56	62⅜	+ 75. =167.	2393.3	2391.8	+20.8	
	Aug. 8. 2h 7′ P.M. S. wind, weather ſomething clearer.	30.027 27.533	69½ 58¼	—122 —079	29.905 27.454	2228.3	—142.7 = 64.	69½ 57	63¼	+ 76.8 =171.	2399.3	- -	- -	11566
	Subſtituting Mr. DE LUC's equation for the air,					2231.1	60°.8—39°.7=21°.1×2.1			+ 44.3 = 98.8	- -	2330.	—41.	
Carnarvon Quay, and Peak of Snowdon, 3555 feet.	Aug. 7. 6h 7′ A.M.	30.154 26.462	56½ 47½	—081 —045	30.073 26.417	3377.6	—177.4 = 52.5	56¾ 45¼	50¼	+ 45. =152.6	3530 2	- -	- -	11646
	Aug. 7. 9h 7′ A.M.	30.165 26.468	60 49¼	—092 —050	30.073 26.418	3376.6	—178.4 = 52.8	60 47¼	53¾	+ 52.5 =177.4	3554.			
	Aug. 7. 0h 7′ P.M.	30.140 26.488	61½ 60½	—097 —083	30.043 26.405	3363.4	—191.6 = 57.	61¾ 54	57⅞	+ 61. =205.	3568.4	3551.		
	Aug. 7. 2h 7′ P.M.	30.144 26.478	62 53½	—099 —063	30.045 26.415	3355.3	—199.7 = 59.5	62 51	56½	+ 58.5 =196.	3551.3	- -	- -	11704
	Aug. 14. 8h 7′ A.M. fog above.	29.984 26.271	56½ 42¼	—080 —031	29.904 26.240	3405.9	—149.1 = 43.8	55¼ 43	49⅞	+ 40. =136.2	3542.1			
	Aug. 14. 9h 7′ fog and rain.	29.978 26.279	58½ 44	—087 —035	29.891 26.244	3390.6	—164 4 = 48.5	57¼ 43½	50½	+ 44.3 =150.4	3541.	- -	- -	11643
	Aug. 14. 10h 7′.	29.972 26.280	60 44½	—091 —036	29.881 26.244	3381.9	—173.1 = 51.2	60 44¼	52¼	+ 48. =162.7	3544.6	3546.8		
	Aug. 14. 11h 7′.	29.974 26.280	61½ 44¾	—097 —037	29.877 26.243	3379.4	—175.6 = 52.	61 45	53	+ 50. =169.	3548.4	- -	- -	11704
	Aug. 14. 0h 7′,	29.976 26.282	62½ 46½	—100 —042	29.876 26.240	3381.5	—173.5 = 51.3	62 46	54	+ 52.3 =176.2	3557.7			
	Barometrical height of Snowdon from the mean of two days obſervations,	—	—			3379.1	—175.9 = 52.1	— —	53.1	=176.3	- -	3548.9	—6.1	
Mr. DE LUC's equation for the air,		—	—				53°.1—39°.7=13°.4×2.1=28.14			= 95.1	- -	3474.2	—80.8	

Compu-

Computations of part of Mr. DE LUC's barometrical obſervations, anſwering to the coldeſt and hotteſt temperatures of the air.

	Stations with their geometrical heights in feet.	Date of the obſervations.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar. exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Mean	Reduced.	Equation by the rule in 1000th parts, and alſo in feet.	Reſult by the rule, Particular.	Mean.	Error of the rule in feet.	Ratio of the weight of quickſilver to air, air being 1.
Coldeſt of the Sun-riſing Obſervations.	1ſt. 230.5	1760, Feb. 9. 8h 30′ A.M.	28.986 28.703	33°¾ 26¼	−006 +018	28.980 28.721	233.9	+ 3.4 ft. = $\frac{14.8}{1000}$	24½° 26¼	25°⅜	—	− $\frac{15.4}{1000}$ = 3 0ft.	229.9	- - 231.8	- - + 1.3	10598
		March 9. 6h A.M.	28.875 28.586	37½ 28¼	−018 +012	28.857 28.598	234.9	+ 4.4 = 18.7	27½ 32	29¾	—	− 4.9 = 1.2	233.7	- -	- -	10598
	2d. 457.	March 9. 6h 8′ A.M.	28.875 28.342	37½ 30	−018 +006	28.857 28.348	463.7	+ 6.6 = 14.5	27½ 31½	29½	—	− 5 6 = 2.6	461.1	- -	+ 4.1	10732
	3d. 624.5	March 9. 6h 15′ A.M.	28.875 28.170	37½ 32	−018 —	28.857 28.170	627.8	+ 4.3 = 7.	27½ 34	30½	—	− 3.5 = 2.3	625.5	- -	+ 1.	10876
	4th. 776.7	March 9. 6h 30′ A.M.	28.875 28.009	37½ 32	−018 —	28.857 28.009	777.2	+ 0.5 = 0.7	27½ 32½	30	—	− 4.4 = 3.4	773.8	- -	− 2.9	10978
	5th. 977.2	March 9. 6h 45′ A.M.	28.875 27.798	37½ 33¼	−018 −005	28.857 27.793	978.9	+ 1.7 = 1.7	27½ 32	29½	—	− 5. = 4.9	974.0	- -	− 3.2	11000
Coldeſt of the ordinary obſervations.	2d, 457.	Feb. 9. 9h A.M.	28.997 28.470	32 28¼	— +012	28.997 28.482	466.9	+ 9.8 = 21.	25¼ 29	27⅛	26°	− 14. = 6.5	460.4	- -	+ 3.4	10649
	3d, 624.5	Feb. 9. 9h 15′ A.M.	28.997 28.298	32 30	— +006	28.997 28.304	630.3	+ 5 8 = 9.2	28 30	29	28	− 9. = 5.7	624.6	- -	- -	10814
	4th. 776.7	Feb. 9. 9h 30′ A.M.	28.997 28.142	32 32	— —	— —	780.2	+ 3.6 = 4.5	40½ 32	36¼	30½	− 3.5 = 2 7	777.5	- -	- -	10901
	5th. 977.2	Feb. 9. 10h A.M.	28.997 27.931	33½ 35½	−006 −011	28.991 27.920	980.8	+ 3.6 = 3.5	40¼ 37	38⅝	31½	− 1.1 = 1.1	979.7	- -	+ 2.5	10949
	6th. 1298.9	Feb. 9. 10h 15′ A.M.	29.002 27.604	32 37½	— −017	29.002 27.587	1303.4	+ 4.5 = 3.5	41 36¼	38⅝	31½	− 1.1 = 1.4	1302.	- -	+ 3.1	11024
	7th. 1513.3	Feb. 9. 10h 30′ A.M.	29.008 27.393	33½ 41	−006 −027	29.002 27.366	1513.	− 0.3 = 0.2	41 37¼	39⅛	33½	+ 3.3 = 5.	1518.	- -	+ 4.7	11120
	8th. 1938.9	Feb. 9. 11h A.M.	29.002 26.955	35½ 39¼	−011 −021	28.991 26.934	1917.7	− 21.2 = 11.0	43¾ 37¼	40½	34½	+ 6. = 11.5	1929.2	- -	+ 9.7	11306
	9th. 2094.5	Feb. 9. 11h 15′ A.M.	28.997 26.771	35½ 39¼	−011 −021	28.986 26.750	2091.8	− 2.7 = 1.5	43¾ 39¼	41½	35	+ 6.6 = 12.6	2104.4	- -	+ 9.9	11241
	10th. 2356.3	Feb. 9. 11h 45′ A.M.	28.992 26.494	35½ 39¼	−011 −021	28.981 26.473	2358.6	+ 2.3 = 1.	44¾ 38¼	41½	35	+ 6.6 = 15.6	2374 2	- -	+17.9	11274
	11th. 2486.3	Feb. 9. noon.	28 986 26.366	33½ 37½	−006 −016	28.980 26.350	2479.	− 7.3 = 3.0	44¾ 36	40⅜	34½	+ 5.6 = 14.	2493.	- -	+ 6.7	11357
Hotteſt of the ordinary obſervations on the higheſt ſtations.	14th. 2922.	1759, July 15, 4h P.M.	28.759 25.950	74½ 71	−131 −105	28.628 25.845	2664.8	−257.9 = 96.7	88½ 74	81	75½	+101. =269.2	2934.	- -	+12.	12541
	15th. 3119.2	July 15. 2h P.M.	28.797 25.778	74½ 71	−131 −108	28.666 25.670	2876.5	−242.7 = 84.5	85 68¼	76¾	73½	+ 96.5 =300.8	3177 3	- - 3154 4	- - +35.2	12439
		July 15. 3h 30′ P.M.	28.764 25.778	74½ 68¼	−131 −103	28.633 25.675	2841.4	−277.8 = 97.7	90½ 74	82	76	+102. =290 2	3131.6	- -	- -	12603
	10th. 2356.3	1760, July 20. 10h 15′ A.M.	28.775 26.499	71 72¼	−121 −117	28.654 26.382	2152.6	−203.7 = 94.7	87½ 74	80¾	75	+102. =219.6	2372.2	2371.2	+14.9	12429
		July 20. 3h 15′ P.M.	28.731 26.460	74½ 72¼	−131 −118	28.600 26.342	2143.	−213 3 = 99.5	91½ 75¼	83⅜	77	+106. =227.2	2370.2			
	11th. 2486.3	July 20. 10h 45′ A.M.	28.769 26.366	71 68¼	−121 −104	28.648 26.262	2266.	−221.3 = 97.7	87½ 74½	81	75	+101.8 =230.7	2496.7	2499.2	+12.9	12468
		July 20. 3h P.M.	28.726 26.327	76½ 72¼	−138 −116	28.588 26.211	2262.	−224.3 = 99.	92½ 76½	84½	77	+106. =239.7	2501.7			
	12th. 2752.	July 20. 11h 30′ A.M.	28.758 26.100	72½ 68¼	−126 −103	28.632 25.997	2516.3	−235.7 = 94.	88 72½	80¼	74	+ 97 6 =245.6	2761.9	2769.6	+17.6	12504
		July 20. 2h 30′ P.M.	28.720 26.066	76½ 71	−138 −110	28.582 25.956	2511.2	−240.8 = 95.7	92 77	84½	77	+106. =266.2	2777.4			
	13th. 2877.5	July 20. noon.	28.747 25.977	72½ 68¼	−126 −103	28.621 25.874	2629.3	−248.2 = 94.7	89 73½	81¼	75	+101.8 =267.6	2897.1	2896.4	+18 9	12548
		July 20. 1h 45′ P.M.	28.720 25.691	74½ 68¼	−131 −105	28.859 25.856	2618.2	−259.3 = 99.	92¼ 75	83⅜	77	+106. =277.5	2895.7			
						Mean of the hotteſt,		$\frac{95.7}{1000}$	—	81.7	75.6					

Compu-

Continuation of Mr. DE LUC's barometrical obſervations.

Stations with their geometrical heights in feet.	Date of the obſervations.	Obſerved heights of the inferior and ſuperior barometers.	Temperature of the quickſilver.	Equation for the heat of the quickſilver.	Equated heights of the barometers.	Logarithmic reſult in feet.	Logar exceſs or defect in ft. and alſo in 1000th parts.	Temperature of the air, Particular.	Mean	Reduced.	Equation by the rule in 1000th parts, and alſo in feet.	Reſult by the rule, Particular.	Mean.	Error of the rule in feet.	Ratio of the weight of quickſilver to air, air being 1.
The Dole, by Sir GEORGE SHUCKBURGH's meaſurement, is above the lake of Geneva 4293 ft. Mr. DE LUC's lowermoſt barometer was higher than the lake 83 ft. hence the vertical diſtance of the barometers, 4210 feet.	1764, July 29. 1h P.M.	28.953 24.951	78°¼ 67	—145 - 095	28.808 24.856	3845.	—365 ft. = 94.9/1000	77¾° 64½	71°¼	70°	+ 88.2/1000 =339.8f.	4184 8		- -	12714
	July 29. 1h 30' P.M.	28.942 24.940	78¼ 65½	—145 —090	28.797 24.850	3841.	—369. = 96.	78¼ 65	71½	70	+ 88 2 =338.8	4179.8	4194.	—16.	
	1765, July 21. 10h 30' A.M.	28.698 24.640	67 59¼	—108 —075	28.590 24.565	3954.	—256. = 64.7	67½ 51	59¼	58	+ 60. =237.	4191.	- -	- -	12520
	1764, July 8. 8h A.M.	28.692 24.636	71 57½	—121 —070	28.571 24.566	3935.	—275. = 70.	73 56	64½	63	+ 72.4 =285.	4220.	- -	- -	12551
														Mean	12595
Light-houſe of Genoa, 237.6 ft	1757, June 2. 6h A.M.	30.077 29.817	76 76	—142 —141	29.935 29.686	217.7	— 20. = 92.	— —	75½	73	+ 103. = 22.4	240.1			
	June 2. 4h½ P.M.	30.088 29.846	82¼ 84½	—163 —169	29.925 29.677	216.8	— 21. = 96.	— —	82	79	+ 108. = 23.4	240.2			
	June 23. 9h½ A.M.	30.116 29.857	79 75	—152 —138	29.964 29.719	214.8	— 22.8 =107.	— —	79	76	+ 104. = 22.3	237.1	238.2	+ 0.6	12672
	June 23. 5h 45' P.M.	30.041 29.796	79 79	—152 —150	29.889 29.646	212.7	— 24.9 =117.	— —	78	75	+ 106.5 = 22.6	235.3			
	July 26. 1h P.M.	30.021 29.774	83¾ 83¾	—166 —164	29.855 29.610	214.7	— 22.9 =107.	— —	81	77	+ 111. = 23 8	238.5			
								Mean	76						
For the barometrical height of Turin above Genoa,		30.019 +.071 30.090 29.197 +.069 29.266	77 77	—146 —141	29.944 29.125	722.6	—— ——	— —	77	—	+ 111.5 = 80.6	803.2			
For the barometrical height of Mr. DE LUC's room above Turin,		29 319 28.831	72¾ 72¾	—129 —126	29.190 28.705	436.6	══	— —	72¾	—	+ 99. = 43.2	479.8			

Mr. DE LUC's room above Genoa,	— —	1283.
Surface of the Lake of Geneva in ſummer below Mr. DE LUC's room,		53.3
Surface of the Lake of Geneva above the Mediterranean,	—	1229.7

By Mr. DE LUC's rule the Lake is elevated above the Sea 1126 French, or 1200 Engliſh feet.

In the obſervations on the Dole, if Mr. DE LUC's equation for the air is ſubſtituted inſtead of that reſulting from the Britiſh obſervations, the barometrical height will be, } 3894 66°.6—39°.7=26°.9×2.1 { + 56.5 =220. } =4114. Error. —96.0

Mr. DE LA CAILLE's barometrical Obſervations, Sept. 22, 1751, at the Cape of Good Hope.

Stations	Heights	Date	Obſerved heights	Temp. of quickſilver	Equation	Equated heights	Logarithmic reſult	Logar exceſs	Temp. Particular	Mean	Reduced	Equation by the rule	Reſult Particular	Mean	Error	Ratio
Eaſt ſignal on the Table-hill above the ſea, — Height of the obſervatory, — Vertical diſtance of the barometers in feet,	3417 14 3403	11h 30' A.M.	30.174 —.173 30.001 26.502	66° 52	—111 —058	29.890 26.444	3192.	—211. = 66.	66° 50	58	—	+ 62.4 =199.2	3391.2	- -	—11.8	11713
Weſt ſignal above the ſea, — Height of the obſervatory, — Vertical diſtance of the barometers, —	3468 14 3454	0h 30' P.M.	30.174 —.197 29.977 26.377	66 50	—111 —053	29.866 26.324	3289.	—179. =544.	66 50	58	—	+ 62.4 =205.2	3494.2	- -	+40.2	11662
															Mean	11687

...ith Mr. DE ...'s Equation ...he air, } Mean 3426 — 3240 58°—39°.7=18°.3×2.1 { + 38.4 =124.4 } 3364.4 - - - - - - - - —62.6

Compu-

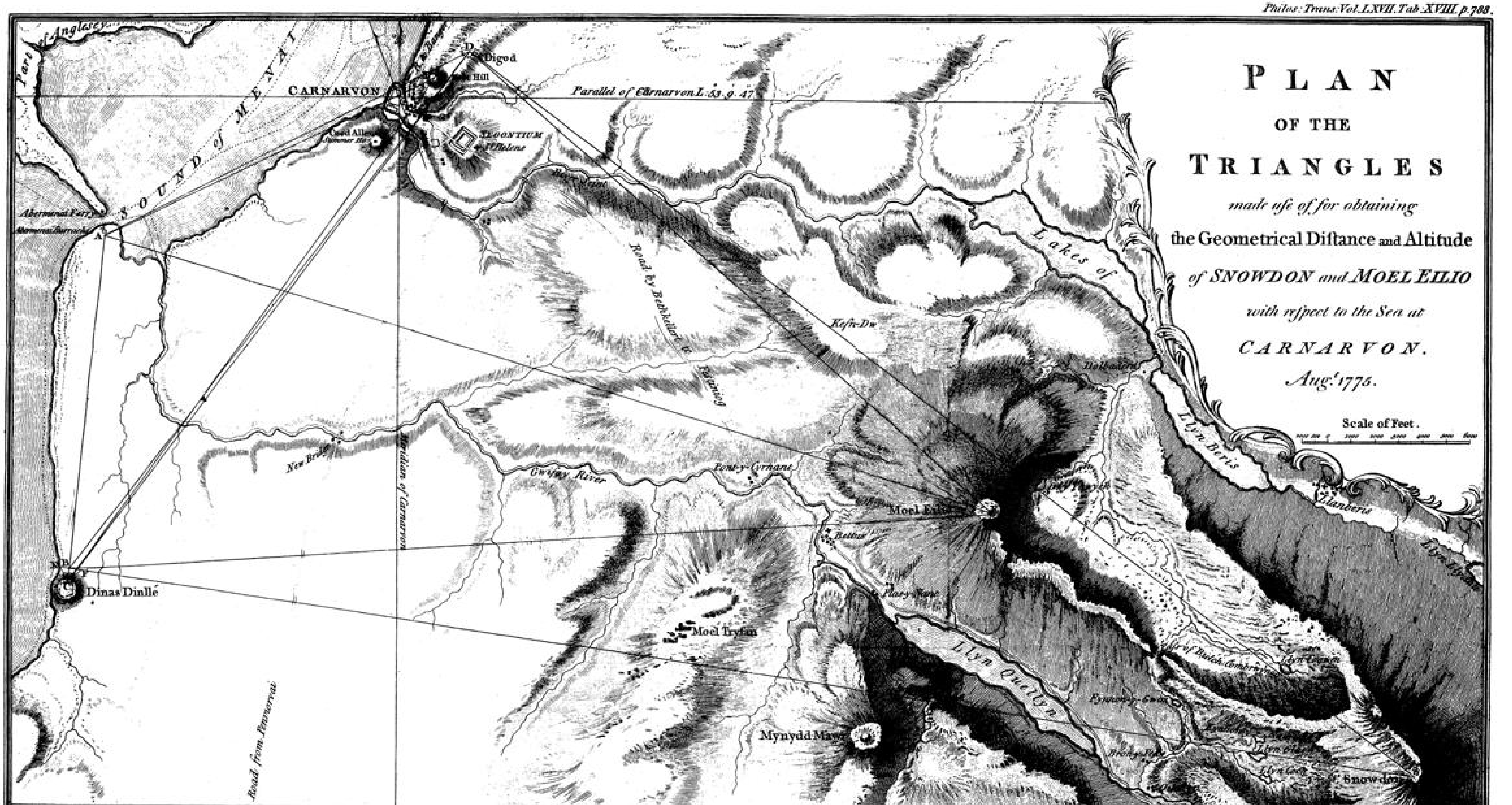
Computations of barometrical obfervations made on heights that have not been determined geometrically.

Date.	Stations of the barometers.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Logarithmic refult in feet.	Temperature of the air, Particular.	Temperature of the air, Mean.	Equation for the heat of the air in 1000th parts, and in feet.	Vertical diftance of the barometers.	Horizontal diftance of the barometer in miles.
	Level of the fea at Invergourie, and Belmont-caftle.	29.932 29.734	54° 57	—072 —081	29.860 29.653	181.3	54° 54	54°	+ 54.4/1000 =9.8 f.	191.1	10¼
1773. July 8.	The inferior barometer at Belmont-caftle. Superior barometer, Top of Kinpurney-hill.	29.988 28.974	65 62	—108 —095	29 880 28.879	887.9	63 57	60	+71. =63.1	951.	2½
1776, Sept. 12.	Ditto.	30.331 29.275	56½ 51	—080 —061	30.251 29.214	908.9	57½ 50	53¾	+56. =50.8	955.3 959.7	2½
	Caftle Menzies.	29.756 29.674	60½ 64½	—092 —104	29 .64 29.570	82.7	61 63	62	+74. = 6.1	88.8	28½
Sept. 11.	Top of Farragan.	29.794 27.344	63½ 52½	—102 —062	29.692 27.282	2205.8	65 50	57½	+62.4 =137.8	2343.6	29
Sept. 17.	Top of Ben Lawers.	29.800 25.830	55 38	—075 —017	29.725 25.813	3677.	54 36	45	+30. =110.	3787.	42
	Top of Ben More.	30.000 26.148	55½ 42	—077 —029	29.923 26.119	3542.9	52½ 37	44¾	+31. =109.8	3652.7	53½
Sept. 12.	Top of Ben Gloe.	29.712 26.142	62 48	—097 —041	29.615 26.101	3291.3	62 45	53½	+51. =167.9	3459.2	27½
Sept. 13.	Blair of Athol-lawn.	29.636 29.380	60 58	—091 —083	29.545 29.297	219.6	58 60½	59¼	+67. =14.7	234.3	30
Aug. 22.	Top of King's Seat.	29.904 28.791	68 66½	—116 —108	29.788 28.683	985.	67 64	65½	+84.3 =83.	1068.	6½
1775, Sept. 5.	Hill of Barry.	29.870 29.345	62 56	—098 —076	29.772 29.269	444.	60 56	58	+64. =28.4	472.4	4½
Sept. 5.	Dunfinane-hill,	29.784 28.913	62 59	—097 —086	29.687 28.827	766.	62 59	60½	+71.5 =54 8	820.8	7½
1774, Aug. 29 and 30. mean of three obfervations.	Quay at the new bridge of Glafgow, and ftation at Lanark.	29.560 28.850	55½ 52½	—077 —066	29.483 28.784	625.2	53½ 50¾	52¼	+50.0 =31.3	656.5	22½
1772, Aug. 6. 2h P.M.	Freeport in the ifland of Ifla, 19 feet above the fea, and fummit of the South-pap of Jura,	30.224 27.642	67 57	—114 —076	30.110 27.566	2300.2	60 57	58½	+66.3 =152.5	2452.7	4½
1772, Sept. 25. 9h 25′ A.M.	Hafniford in Iceland, at the fea fhore, and fummit of Mount Hecla.	29.859 24.722	49 38	—056 —016	29.803 24.706	4886.8	43 24	33½	+ 3 4 =16.6	4903 4	76

Comput-

Computations of Mr. BOUGUER's obfervations in Peru, fuppofing them to have been made at correfponding times, and in the mean temperature of the day, between the coldeft of the morning and hotteft of the afternoon.

Relative heights of the ftations, with refpect to the South-fea,	Stations of the barometers, with their geometrical diftance in feet.	Obferved heights of the inferior and fuperior barometers.	Temperature of the quickfilver.	Equation for the heat of the quickfilver.	Equated heights of the barometers.	Mean heights of the barometers.	Logarithmic refult in feet.	Logar. excefs or defect in ft. and alfo in 1000th parts.	Mean temperature of the air.	Equation for the heat of the air in 1000th parts, and in feet.	Refult by the rule in feet.	Error of the rule.	Ratio of the weight of quickfilver to air, Particular	Mean.
Heights of the columns of air, whofe bafes ftood at the fea,	15833 South-fea, Coraçon,	29.930 16.808	84½° 43½	—169 —022	29.761 16.786	23.27	14922.	— 911 ft. = 61./1000	64°	+ 61.4/1000 =919. ft.	15841.	+ 8.0	14590	14553
	15564 South-fea, Pichincha,	— 16.963	84½ 44½	— —024	29.761 16.939	23.35	14685.6	—878.4 = 60.	64½	+ 62. =920.4	15606.	+42.	14517	
	9374 South-fea, Quito,	— 21.403	84½ 65½	—078 —	29.761 21.325	25.54	8685.5	—688.5 = 80.	75	+ 90. =781.7	9467.2	+93.2	13273	13120
	7840 South-fea, Carabourou,	— 22.625	84½ 66½	—084 —	29.761 22.541	26.15	7240.5	—599.5 = 83.	75½	+ 96.5 =698.7	7939.2	+99.2	12968	
Superior fections of the columns of air, with the diftances of their bafes from the fea, Coraçon, 15833 Carabourou, 7840	7993 Carabourou, Coraçon,	— —	66½ 43½	— —	22.541 16.786	19.66	7681.6	—311.4 = 40.5	55	+ 35.2 =274.4	7952.	—41.	16623	16565
Pichincha, 15564 Carabourou, 7840	7724 Carabourou, Pichincha,	— —	66½ 44½	— —	22.541 16.939	19.74	7445.1	—278.9 = 37.3	55½	+ 36.5 =271.7	7716.8	— 7.2	16507	
Coraçon, 15833 Quito, 9374	6459 Quito, Coraçon,	— —	65½ 43½	— —	21.325 16.786	19.05	6236.5	—222.5 = 35.7	54½	+ 33.2 =207.	6443.5	—15.5	17149	17021
Pichincha, 15564 Quito, 9374	6190 Quito, Pichincha,	— —	65½ 44½	— —	21.325 16.939	19.13	6000.1	—189.9 = 31.6	55	+ 34. =204.	6204.1	+14.1	16893	
	Mean of the four fuperior columns,	- -	- -	- -	- -	- -	- - -	36.3/1000	55	- - -	- -	- -	16793	
Quito, 9374 Carabourou, 7840	1534 Carabourou, Quito,	— —	66½ 65½	— —	22.541 21.325	21.93	1445.	— 89. = 61.6	66	+ 61. = 88.	1533.	— 1.	15089	



GEOMETRICAL OPERATIONS.

The Base AB, *situated on a perfectly level Plain, was measured twice in contrary directions, between the Barracks of Abermenai and the bottom of Dinas Dinlle, an ancient British Fortification, on the Sea Shore. The length of the Iron Chain made use of on this occasion, was ascertain'd by means of accurate Deal Rods, applied to it every Morning & Evening, before and after the operation of the Field. The two measurements agreed to within less than a Foot, and made the length of the Base — 14076F. This Base* AB, *was afterwards prolonged to* C, *the Top of the Dinas by means of the side Base* BF *411.7 feet. Thus the distance* BC, *being 482.2 feet; the total Base* AC *amounts to 14558.2 feet.*

N, *High Watermark Neap Tide.* D. *a small Eminence called the Digod.* T, *the Toot Hill of Carnarvon.* S, *The Peak of Snowdon* E, *A Cairn of Stones on Moel Eilio.*

The Latitude of Carnarvon was found to be 53.°9.′47″; and the Variation of the Needle, by two Azimuths of the Sun, taken on the 15.th of Aug. *at 2.h 5. and 3.h 12. P.M. 21.18.50 westerly.*

The Height of Moel Eilio above Carnarvon Quay 2371 Feet, resulting from the simplest operation on the Digod, the nearest point to the Hill, is to be preferred to that deduced from the Angles of Elevation taken from A.

Triangles.		Angles	° ′ ″	Sides (Feet.)
CBF and CBN *for the prolongation of the Base* BC, *and distance of* N *from* C.	Obs.d	CBF	84.10.40	BC....482.2
		BCF	42.55.25	
	Hence	BFC	52.53.55	
	Obs.d	NBC	98.46.50	
		BCN	30.8.20	NC....612.5
		CNB	51.4.50	
ACD and DBC, *for the distance of* D *from* AB *and* C; *and for the Angles* CBD *and* BDC.	Obs.d	DAC	123.17.50	AD..17169.7
		ADC	25.48.50	CD..17949.7
		ACD	30.53.40	
	Cont.d	DCB	30.53.40	BC....482.2
		CBD	148.35.24	BD..27557.4
		BDC	0.30.56	
DSB *for the distance of Snowdon from* B *and* D.	Obs.d	ABS	92.36.15	
	—	ABD	31.24.36	
	=	DBS	61.11.39	BS..27588.2
	Obs.d	SDC	89.36.50	DS..50258.3
	+	CDB	0.30.56	
	=	SDB	90.6.46	
	Hence	DSB	28.41.35	

Triangles		Angles	° ′ ″	Sides (Feet.)
DEB and DAE, *For the distance of Moel Eilio from* D *and* A.	Obs.d	EBA	79.49.10	
	—	ABD	31.24.36	
	=	DBE	48.24.34	
	Obs.d	EDC	86.27.5	DE..19519.6
	+	CDB	0.30.56	
	=	EDB	86.58.1	
		DEB	44.37.25	
	Cont.d	ADE	112.15.55	
		DAE	43.49.10½	AE..19190.2
		DEA	23.55.14½	
CAT, *for the distance of the Toot Hill from* A.	Obs.d	CAT	122.9.17	
		ACT	29.56.45	AT..15430
		ATC	27.53.58	
Angles of Elevation and Depression	From..B..	C	11.14.37	
		....S	5.29.7	
	From..C Dep	....N	10.34.25	
	From..D..	....S	3.47.54	
		....E	4.15.35	
	From..A..	....E	5.24.17	
		....T	0.39.47	

NB. *The time not admitting of any actual Survey of the Environs of Carnarvon & Snowdon to be made: the Plan is only to be consider'd as a slight Sketch intended merely to convey a general Idea of the nature of the Country where the Triangles were situated.*

Relative Heights			Feet.
For the Altitude of Snowdon above B *and* N	S above B *Trigonometrically*		3493.2
	Curvature & Refraction		62.3
	Height of the Instrument		4.6
	S above B		3560.1
	C above B *Trig.l*	97.3	
	Instrument	4.6	
	C above B	101.9	
	C above N *Trig.l*	114.3	
	Instrument	4.6	
	C above N	109.7	
	Hence B above N		7.8
	Snowdon above the Sea at N		3567.9
For the Altitude of Snowdon above D *and the Sea at Carnarvon*	S above D *Trig.l*		3336.7
	Curvature & Refraction		47.5
	Instrument		4.6
	S above D		3389.1
	D above *North Angle of Carnarvon Quay by Levell.g*		166.3
	Vertical distance of the Barometers		3555.4
	Quay above High Water N. Tide		13.
	Snowdon above the Sea		3568.4

Relative Heights		Feet.
For the Altitude of Moel Eilio above D, *and the Sea at Carnarvon.*	E *above* D *Trig.l*	2183.8
	Curvature & Refraction	16.3
	Instrument	4.6
	E above D	2204.7
	D *above Carnarvon Quay*	166.3
	Vertical distance of Barom.rs	2371.0
	Quay above Neap Tide	13.
	Moel Eilio above the Sea	2384.
For the Altitude of Moel Eilio above A, *and the Sea at Carnarvon.*	E *above* A *Trig.l*	2331.6
	Curvature & Refraction	29.1
	Instrument	4.6
	Moel Eilio above A	2365.3
	T *above* A *Trig.l*	178.6
	Curvature & Refraction	4.5
	Instrument	4.6
	T above A	187.7
	T *above Carnarvon Quay by Levelling*	186.5
	Quay above A	1.2
	Hence the Vertical distance of the Barometers	2364.1
	Moel Eilio above Neap Tide	2377.1

Basire Sculp.t